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1997 ELEMENTAL ANALYSIS OF BOUNDARY WATERS CANOE AREA LICHENS OF THE SUPERIOR NATIONAL FOREST

Final Report

Supported by

USDA Forest Service

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ABSTRACT

In the final report of the first study of the lichens and air quality in the Boundary Waters Canoe Area (Wetmore, 1987) it was recommended that a restudy of the elemental analysis of lichens be done every five years. A restudy was done in 1992 (Wetmore 1993a) and the present report is on the second restudy done in 1997.

In the present study four species of lichens were collected during August, 1997 at the same localities as the previous studies. The methods used were the same as in the previous studies.

Statistical analyses of data from all three years showed that species differences are highly significant but locality and year differences are of much less significance. The Isabella Lake and the Trap Lake localities have unusually high levels of some elements and that the enriched levels of Cd in *Hypogymnia physodes* at Basswood Lake, Isabella Lake, and Lake La Croix may be nearing damaging levels for this species.

The recommendation is made that the periodic five-year restudy of elemental analysis be continued. USFS staff should attempt to determine the reasons for the high levels of some elements at Isabella Lake and Trap Lake.

ACKNOWLEDGMENTS

The U. S. Forest Service personnel have been very helpful in assisting with the field work and analysis of the data. The second author did the statistical analysis. The study was made possible by funds from the U. S. Forest Service, Superior National Forest. The assistance of all of these is gratefully acknowledged.

INTRODUCTION

Lichens are able to accumulate chemical elements in the excess of their metabolic needs depending on the levels in the substrate and air and, since lichens are slow growing and long lived, they serve as good summarizers of the environmental conditions in which they are growing. Chemical analysis of the thallus of lichens growing in areas of high fallout of certain elements will show elevated levels in the thallus. Toxic substances (such as sulfur) are also

accumulated and determination of the levels of these toxic elements can provide indications of sub-lethal but elevated levels in the air (Wetmore, 1987).

During 1986 a complete study of lichens and air quality was done in the Boundary Waters Canoe Area (BWCA), including a species list and elemental analysis of three species at six localities. The report showed no elevated accumulation of elements at any locality. The report recommended that a restudy of elemental analysis be done every five years.

In 1992 all six of the elemental analysis localities used in the earlier study were re-visited for new collections. One lichen species was added in the study for a better comparison with other regional studies (Wetmore, 1985, 1988a, 1988b, 1988c, 1992, 1993b). The report for the 1992 restudy showed a significant increase in Al, Fe, Cr, and S but the significance of these increases was uncertain. During August, 1997 the same sites were visited and the same four species were collected for analysis.

METHODS

Methods used in the present study were the same as those of the previous studies (Wetmore, 1987, 1993a). All six of the previous localities were again sampled in August, 1997. These localities were: Saganaga Lake, Trap Lake, Isabella Lake, Basswood Lake, Trout Lake, Lac La Croix. GPS readings of latitude and longitude were taken at each site and are given in Appendix I. One bag of each species was collected from conifer branches at each site, cleaned, ground, and analyzed for chemical constituents. Lichens were cleaned but not washed. Three replicates were obtained from each bag of each species for each locality. Multi element analysis was by ICP and sulfur by infra red absorption by the same methods as used in the previous two studies (Wetmore 1987, 1993a). In the 1987 study three species were analyzed (*Cladina rangiferina*, *Evernia mesomorpha*, and *Hypogymnia physodes*). In the 1992 study and the present study *Parmelia sulcata* was added to the three species previously used to provide a better comparison with other regional studies at Isle Royale National Park (Wetmore, 1985), Voyageurs National Park (Wetmore, 1984), and Grand Portage National Monument (Wetmore, 1992). Standards were also included with the unknowns.

RESULTS AND DISCUSSION

Table 1 gives the results of the analysis for all replicates for the 1997 study arranged by species. Table 2 gives the means and standard deviations for each set of replicates. When one of the replicates was below the detection limits of the instruments the value was included as 0.7 X the value, when more than one was below the detection limits none of the values were used in the calculations.

STATISTICAL ANALYSIS

Results

The data from this study are complex. There are 3 independent variables: species (4 levels), year (3 levels) and locality (6 levels). For each of these there are 16 dependent variables, which are the chemical element concentrations in the lichens. In addition, up to three sample replicates were taken at some sites in some years. This makes for a theoretical possible total of 3,456 data points. However, the actual total is 2,774 because *Parmelia* was not collected in 1986, less than three replicates were collected at some sites in some years, and some measurements were below detection limits of the lab instruments. These below detection limit values were omitted from the statistical analyses because they add nothing to them and are so low as to be biologically meaningless.

The first analyses were the calculations of means of all chemical elements in the study design. This resulted in 80 tables, which are included in Appendix II. There were hundreds of patterns of trends in this analysis, and they were almost impossible to interpret. They are provided for reference purposes only and will not be discussed.

The next analysis performed was a multivariate analysis of variance of the 16 chemical elements in a three-way design with all possible interactions (i.e. species, year, locality and their two and three way interactions). This analysis failed to execute because the design was unbalanced and unorthogonal. This was followed by four separate multivariate analyses of variance for each species separately, and with only year and locality and their interaction in the design. These four analyses resulted in highly significant F values for year, locality and year by locality for all four species. This meant that everything in the design was significant, and

again little interpretation was possible.

It was then decided to reduce the 16 chemical element variables to a smaller number by means of principal component analysis. The first principal component analysis resulted in three factors with eigenvalues greater than one. However, it was not clear how to interpret the third factor, and it only explained 8% of the total variance, so a second principal component analysis was performed so that only two factors would be computed. The loading values of the 16 chemical elements on these two components, after equamax rotation, are shown in Table 3 and plotted in Figure 1. These two components accounted for 68% of the total variance in the data. The interpretation of these components follows.

Six elements were highly loaded on component one and not on the other component: Al, B, Cr, Fe, Ni and S. All six loadings are positive, indicating that a higher score on this component would mean higher concentrations of the elements in the lichens. The appearance of Cr, Ni and S on this component signifies the presence of anthropogenic influences because these are not common elements in lichens. The presence of Al and Fe indicates the possibility of the influence of soil particles.

Four elements were highly loaded on component two and not on the other component: Ca, Cd, Mg and Mn, and all four loadings are positive. Three of these, Ca, Mg and Mn, are nutritional elements, although Ca can also be found in wind-blown dust. The presence of Cd should be indicative of pollutants, but appears ambiguous in this component because it occurs with the nutritional elements.

The remaining six elements, Cu, K, Na, P, Pb and Zn, appeared on both components. All but Na are positive on both, while Na is positive on component one, but negative on component two. These elements are a mixture of nutritional (P and K) and pollutant (Cu, Pb, Zn) elements. Because their loadings are moderate and their presence on both components hard to interpret, their position on the components is ambiguous and difficult to interpret. It was concluded that their positions on the components were not important and their presence was not interpreted.

It was now possible to compute scores on each component for the 176 treatment cases

in the data matrix. This represents the species by year by locality design matrix minus missing cells. The component scores were then analyzed by conventional analyses of variance (Table 4). All three single factors (species, year, locality) had significant effects on the two components. As can be seen from the mean squares, species had the greatest effects, with year and locality having comparable effects. Figures 2 - 7 show the effects of these factors on the component means. Component one decreased significantly across years and across localities, while component two did the opposite. As can be seen in Figure 8, the two components are inversely related to one another. This figure also illustrates the pronounced grouping of the four species in relationship to the two components, as confirmed by the analyses of variance. For component one, the descending order of species is *Parmelia* > *Evernia* > *Hypogymnia* > *Cladina*. For component two, the order is *Hypogymnia* > *Parmelia* > *Cladina* > *Evernia*.

Discussion

The principal component analysis enables us to draw some generalizations about trends in this large data set. It appears that elements associated with soil in the atmosphere and possibly some pollutants, i.e. Al, Cr, Fe, Ni and S, have declined over the 11 years of the this study in all four lichen species. In addition, these elements appear to decline from west to east, which might be explained by the greater proximity of the western end of the BWCA to the Great Plains. The decline over time may be explained by general patterns of climate change during the last decade which contribute to a decrease in wind-blown dust in the area.

Conversely, three nutritional elements and one heavy metal, i.e. Ca, Mg, Mn and Cd, have increased significantly over the 11 years in all four species. The elements also increase from west to east, the opposite of the elements in component one. These inverse responses between these elements and those in component one are obviously correlated, and may be related physiologically as well. However, the cause and effect relationship is unknown. That is, it is impossible to tell if these lichens are healthier in time and space because of a decline in stresser elements, or whether the stresser elements declined because the lichens became healthier.

Another important finding is that all the four elements in component 2 in *Hypogymnia*

are above enrichment thresholds for this species, while those elements in component 1 are below the thresholds for those elements (Bennett, 1998, In Press). These enrichment thresholds are tissue concentrations that exceed the 95% confidence level of the mean of all known values in the literature for that element in this species. Values that exceed these levels are values that probably are abnormal and indicate some external influence on the lichen. Principal component analysis itself is not able to determine which values are beyond thresholds, but the fact that this principal component analysis detected the enriched values in a group as separate from the values that were not enriched is significant and may indicate that they are acting somehow together. If this pattern continues through time, it is possible that Cd will become a problem for *Hypogymnia* and could lead to the demise of this species. Cd is elevated in *Hypogymnia* at Isabella, Basswood and Lake La Croix. The primary source of Cd in the earth is in Zn, Pb and Cu sulphide ores. Soils derived from such ore bodies may be enriched in Cd (Fergusson 1990). The principal uses of Cd by man are in electroplating, pigments, batteries, andfertilizers. Cd is also enriched in fly ash from combustion of fossil fuels, and in municipal liquid and solid waste. All of these possible sources should be explored in the vicinities of Isabella, Basswood, Lac La Croix, and Trap Lakes.

CONCLUSIONS

When the two principal components are plotted against each other, the species are very clearly grouped in the element space (Figure 8), while the year and locality factors are not (Figures 9 and 10). This suggests that locality and year do not have any strong influence at Isabella, Basswood and Lake La Croix. In general, Isabella and Trap appear to be problem sites for *Hypogymnia* overall, and should be studied further. There is also some evidence that Isabella Lake may be the site with the most elevated levels of elements in component 2 for all species, and this should be examined. Some of the elements in component 2 are the major elements found in wood ash (Misra et al, 1993), which may indicate that forest fires have occurred in recent time in this area.

When the two principal components are plotted against each other, the species are very clearly grouped in the element space (Figure 8), while the year factors are not (Figures 9 and

10). This suggests that locality and year do not have strong influences on these components of elements, but species does. This must reflect something about the biology of these species, not the environment they are growing in. The most notable pattern is the position of the two foliose species high on component two, and the two fruticose species low on component two. Further study will be needed to elucidate this pattern more.

RECOMMENDATIONS

The original recommendation that elemental analyses be restudied every five years is again made here. Continued periodic study will help to determine whether the increase in certain elements is due to random changes or part of a trend with some significance.

USFS staff should attempt to determine the reasons for the high levels of some elements at Isabella Lake and Trap Lake.

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Table 1. 1997 Analysis of BWCA Lichens
Values in ppm of thallus dry weight

Species	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
C. rangiferina	434	1323	534	244	251	298	16.9	52.0	15.6	1.2	1.5	#	#	0.4	#	435	Saganaga
C. rangiferina	463	1542	542	265	250	299	17.3	54.5	16.9	1.4	1.8	#	#	0.4	#	540	Saganaga
C. rangiferina	446	1372	560	252	255	313	16.6	52.6	15.7	1.3	2.0	#	#	0.4	#	530	Saganaga
C. rangiferina	875	2186	1056	395	230	269	18.0	38.0	23.0	2.1	1.2	#	0.5	0.4	0.1	560	Trap L
C. rangiferina	922	2279	1078	406	248	306	18.3	35.8	22.7	2.1	1.4	#	0.5	0.6	0.1	710	Trap L
C. rangiferina	874	2208	1118	410	227	273	16.9	38.7	24.6	2.1	1.3	#	0.6	0.6	0.2	730	Trap L
C. rangiferina	430	1278	742	225	208	407	15.1	47.0	15.6	1.2	0.6	#	#	0.4	#	440	Basswood L
C. rangiferina	448	1269	768	236	210	429	15.1	44.5	15.2	1.5	0.6	#	#	0.4	#	440	Basswood L
C. rangiferina	512	1428	785	244	210	407	16.0	48.2	16.9	1.4	0.7	#	#	0.5	#	360	Basswood L
C. rangiferina	561	1641	786	339	264	501	21.8	65.8	17.0	1.5	0.9	#	0.4	0.6	#	480	Lac La Croix
C. rangiferina	512	1470	707	310	300	568	21.2	56.2	16.1	1.5	0.9	#	0.5	0.6	#	457	Lac La Croix
C. rangiferina	544	1561	775	335	310	574	23.5	62.9	17.6	1.7	1.0	#	0.5	0.6	#	510	Lac La Croix
C. rangiferina	639	1989	780	326	198	649	20.1	56.6	18.7	1.8	1.2	#	0.6	0.4	*0.1	570	Trout L
C. rangiferina	670	2153	753	333	184	574	20.3	55.2	18.3	1.9	1.2	#	0.6	0.4	0.1	500	Trout L
C. rangiferina	647	2034	766	326	198	569	21.7	56.0	18.1	1.9	1.3	#	0.5	0.5	0.1	490	Trout L
C. rangiferina	297	1088	631	252	237	283	15.5	29.2	9.4	1.2	0.6	#	#	0.3	#	440	Isabella L
C. rangiferina	297	1053	648	283	253	342	16.3	30.2	9.4	1.3	0.6	#	#	0.4	#	310	Isabella L
C. rangiferina	289	1052	583	245	280	363	15.8	27.8	9.2	1.3	0.7	#	#	0.4	#	420	Isabella L
E. mesomorpha	691	2133	1083	312	440	653	32.4	44.6	27.7	3.8	2.6	2.5	1.3	1.0	0.1	1080	Saganaga
E. mesomorpha	600	2121	1039	338	546	853	36.8	44.7	31.0	5.5	2.8	2.6	1.9	1.2	0.1	1340	Saganaga
E. mesomorpha	587	1992	1115	313	469	751	31.9	42.0	27.4	4.4	2.5	2.8	0.8	1.0	0.1	1230	Saganaga
E. mesomorpha	863	2652	1729	372	420	565	31.3	61.0	41.3	6.0	2.6	3.3	3.3	1.4	0.3	960	Trap L
E. mesomorpha	991	2773	2422	392	437	561	31.1	65.0	41.6	5.4	2.5	3.0	1.5	2.1	0.3	960	Trap L
E. mesomorpha	721	2445	2330	362	475	600	29.1	54.1	52.4	17.5	2.6	3.6	2.0	1.0	0.3	1020	Trap L
E. mesomorpha	550	2163	1167	334	482	1254	47.3	40.7	28.8	5.3	3.1	2.7	1.4	1.2	0.2	1120	Basswood L
E. mesomorpha	476	1883	685	303	540	1335	43.2	32.4	27.6	4.2	2.8	2.9	1.0	1.2	0.2	1100	Basswood L
E. mesomorpha	525	2219	964	331	556	1425	38.8	42.1	30.4	5.2	3.4	2.8	2.3	1.2	0.4	1320	Basswood L
E. mesomorpha	615	2610	1061	410	652	1151	43.1	32.7	29.5	3.9	3.3	2.7	1.1	1.3	0.2	1380	Lac La Croix
E. mesomorpha	622	2740	1025	442	791	1360	45.4	29.2	33.0	4.9	3.6	3.1	1.3	1.5	0.2	1470	Lac La Croix
E. mesomorpha	683	2747	1507	435	690	1297	49.2	29.6	31.8	4.0	3.2	3.1	1.2	1.5	0.2	1350	Lac La Croix
E. mesomorpha	620	2680	2023	372	420	1321	33.9	41.2	31.1	3.7	3.2	2.4	1.0	1.1	0.2	1255	Trout L
E. mesomorpha	635	2679	2453	367	420	1385	30.7	44.9	32.0	3.7	3.3	2.3	1.1	1.2	0.2	1340	Trout L
E. mesomorpha	1041	3508	4439	458	428	1402	31.6	85.3	41.2	4.1	3.5	1.7	0.9	1.1	0.2	1350	Trout L
E. mesomorpha	573	2359	2301	405	250	368	19.9	112.3	30.7	3.3	1.5	#	0.5	0.7	0.2	690	Isabella L
E. mesomorpha	590	2483	2915	419	256	379	19.4	116.0	33.3	3.1	1.6	#	0.6	0.6	0.2	740	Isabella L
E. mesomorpha	756	2635	2852	481	251	355	21.3	131.4	30.9	2.8	1.7	#	0.6	0.6	0.2	830	Isabella L
H. physodes	653	2659	21275	645	547	731	22.2	235.4	61.7	5.0	2.3	10.1	1.2	0.9	0.6	880	Saganaga
H. physodes	723	2864	24360	714	523	700	26.7	242.0	66.0	5.0	2.4	9.4	1.3	1.0	0.8	950	Saganaga
H. physodes	717	2740	27590	689	533	732	25.8	281.3	60.1	4.6	2.7	9.8	1.1	1.0	0.7	1130	Saganaga
H. physodes	931	3131	31040	682	391	443	21.2	250.1	90.2	5.2	2.3	10.3	1.0	0.6	1.4	730	Trap L
H. physodes	912	3209	28410	686	366	421	21.5	212.0	89.6	4.8	2.2	9.4	1.0	0.7	1.3	775	Trap L
H. physodes	813	2948	33070	605	348	396	21.0	197.0	91.4	5.0	2.2	9.6	0.9	0.6	1.3	850	Trap L
H. physodes	799	2957	30120	583	372	597	22.9	311.0	55.3	4.2	2.0	9.9	1.0	0.7	1.5	860	Basswood L
H. physodes	746	2951	22950	661	518	812	23.7	247.7	61.2	4.4	2.0	9.3	1.1	0.8	1.2	800	Basswood L
H. physodes	853	3048	26870	687	488	769	24.0	365.4	62.4	4.4	2.2	9.1	0.9	0.9	1.4	710	Basswood L
H. physodes	1020	3872	22115	1098	399	687	35.1	389.4	65.9	4.4	2.2	5.3	1.2	0.8	1.0	810	Lac La Croix
H. physodes	1093	4032	22200	1112	390	687	35.2	385.6	60.4	5.0	2.3	5.4	1.4	0.8	0.9	1140	Lac La Croix
H. physodes	1008	3658	29520	954	362	639	32.0	362.8	62.8	4.4	2.5	6.7	1.5	0.9	1.1	940	Lac La Croix

H. physodes	559	2987	22740	724	418	1143	24.9	138.5	55.2	4.5	2.0	6.5	1.2	0.8	0.6	750	Trout L
H. physodes	542	2843	25275	726	396	981	23.2	135.5	56.0	4.1	2.2	7.0	1.1	0.8	0.6	880	Trout L
H. physodes	606	2899	27180	655	424	1117	24.0	121.2	57.7	4.5	2.2	7.8	1.3	0.8	0.7	1070	Trout L
H. physodes	857	3137	19490	854	591	737	24.8	569.1	86.3	5.1	2.8	8.8	1.3	0.9	1.2	860	Isabella L
H. physodes	1026	3423	18350	1043	656	848	27.4	664.7	103.0	4.9	3.1	8.9	1.2	0.9	1.4	870	Isabella L
H. physodes	788	3102	14640	904	676	838	25.8	546.8	85.7	4.8	2.9	9.0	1.3	1.2	0.9	710	Isabella L
P. sulcata	1137	3098	4315	557	763	928	21.7	249.8	87.9	5.1	4.6	10.5	1.2	1.0	0.3	1075	Saganaga
P. sulcata	1002	2857	4147	537	847	1050	25.8	227.6	86.6	5.1	4.5	10.7	1.4	1.3	0.3	1180	Saganaga
P. sulcata	1082	3113	4286	571	817	1000	24.0	251.8	86.6	4.8	4.3	9.3	1.2	1.0	0.3	1157	Saganaga
P. sulcata	1932	4022	4978	794	762	858	24.5	270.5	129.2	6.5	6.4	13.9	1.0	1.0	0.5	1170	Trap L
P. sulcata	2051	4278	4845	870	815	956	24.7	294.8	135.3	6.7	6.8	14.4	1.2	1.1	0.6	1330	Trap L
P. sulcata	1937	4029	4978	892	892	1051	25.7	278.8	131.3	6.8	6.9	12.9	1.2	1.3	0.6	1345	Trap L
P. sulcata	1523	3537	3361	626	798	1326	22.4	571.6	107.0	4.9	4.4	8.4	0.8	1.0	0.5	1160	Basswood L
P. sulcata	1507	3556	3516	621	842	1416	23.7	504.8	97.6	5.0	4.0	7.9	0.9	1.1	0.5	1070	Basswood L
P. sulcata	1704	3676	3731	659	834	1486	24.4	684.6	110.0	4.9	4.3	7.4	0.7	1.2	0.5	1090	Basswood L
P. sulcata	1505	4209	3179	727	787	1362	30.2	153.0	74.4	5.2	3.7	8.7	1.8	1.1	0.3	1560	Lac La Croix
P. sulcata	1722	4483	3692	797	842	1489	31.3	165.0	77.4	5.8	4.3	9.5	2.0	1.3	0.3	1480	Lac La Croix
P. sulcata	1799	4609	3463	811	882	1591	31.9	170.0	75.4	5.9	4.1	8.1	1.9	1.3	0.3	1530	Lac La Croix
P. sulcata	867	2881	4673	517	712	1716	22.6	135.8	88.1	4.7	4.0	9.7	1.4	1.1	0.3	1320	Trout L
P. sulcata	1030	3308	4294	588	858	2085	25.8	155.7	85.9	5.1	4.6	10.0	1.8	1.3	0.4	1280	Trout L
P. sulcata	938	2950	4547	569	948	2228	27.6	190.3	87.1	5.0	4.7	11.1	1.7	1.3	0.4	1280	Trout L
P. sulcata	1453	3488	4011	711	674	767	20.1	340.8	96.4	4.6	4.8	10.5	1.2	0.8	0.7	950	Isabella L
P. sulcata	1488	3501	4178	727	772	873	24.5	321.4	93.5	5.0	4.7	11.8	1.3	0.9	0.8	1073	Isabella L
P. sulcata	1409	3373	4449	760	908	1029	29.5	368.5	96.4	5.4	5.1	12.1	1.4	1.0	0.8	1100	Isabella L
C. stellaris	195	672	241	270	469	611	78.8	20.6	17.3	2.7	0.8	13.1	1.1	1.0	0.1	472	C Stand
C. stellaris	192	666	238	267	457	582	78.3	20.3	17.0	2.3	0.9	13.3	1.0	0.9	0.2	472	C Stand
C. stellaris	192	680	239	268	459	599	78.2	20.5	17.6	2.4	0.8	13.4	1.1	1.1	0.2	468	C Stand
NBS-P	1227	3716	4607	1194	488	201	19.2	722.2	78.1	3.3	17.8	11.2	1.7	1.9	0.2	NA	NBS Pine
NBS-P	1162	3568	4419	1148	462	182	17.8	691.9	195.1	3.2	17.0	11.8	1.7	1.7	0.4	NA	NBS Pine
NBS-P	1223	3739	4597	1198	484	190	19.3	722.4	67.4	3.3	17.4	11.5	1.8	1.7	0.2	NA	NBS Pine

* = one value at or below detection limit; included as 0.7 of detection limit
# = two or more values at or below detection limit; not included in calculations

Table 2. Summary of 1997 Analysis of BWCA Lichens
Values in ppm of thallus dry weight

Cladina rangiferina

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Mean	448	1412	545	254	252	303	17.0	53.0	16.0	1.3	1.8	#	#	0.4	#	502	Saganaga
Std. dev.	15	115	13	10	3	8	0.3	1.3	0.7	0.1	0.3	#	#	<.1	#	58	Saganaga
Mean	891	2224	1084	403	235	283	17.7	37.5	23.4	2.1	1.3	#	0.5	0.5	0.1	667	Trap L
Std. dev.	27	49	31	8	12	20	0.8	1.5	1.0	<.1	0.1	#	0.1	0.1	<.1	93	Trap L
Mean	463	1325	765	235	210	414	15.4	46.6	15.9	1.4	0.6	#	#	0.4	#	413	Basswood L
Std. dev.	43	89	22	10	1	13	0.5	1.9	0.9	0.1	<.1	#	#	0.1	#	46	Basswood L
Mean	539	1557	756	328	291	547	22.2	61.6	16.9	1.6	0.9	#	0.5	0.6	#	482	Lac La Croix
Std. dev.	25	86	43	16	24	41	1.2	4.9	0.8	0.1	0.1	#	<.1	<.1	#	27	Lac La Croix
Mean	652	2059	766	328	193	597	20.7	55.9	18.4	1.9	1.2	#	0.5	0.4	*0.1	520	Trout L
Std. dev.	16	85	13	4	8	44	0.8	0.7	0.3	0.1	0.1	#	<.1	<.1	<.1	44	Trout L
Mean	294	1064	621	260	257	329	15.8	29.1	9.3	1.3	0.6	#	#	0.4	#	390	Isabella L
Std. dev.	4	21	34	20	22	42	0.4	1.2	0.1	0.1	0.1	#	#	0.1	#	70	Isabella L

Evernia mesomorpha

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Mean	626	2082	1079	321	485	752	33.7	43.7	28.7	4.5	2.6	2.6	1.3	1.1	0.1	1217	Saganaga
Std. dev.	57	78	38	15	55	100	2.7	1.5	2.0	0.9	0.2	0.2	0.5	0.1	<.1	131	Saganaga
Mean	858	2623	2160	375	444	575	30.5	60.0	45.1	9.6	2.5	3.3	2.3	1.5	0.3	980	Trap L
Std. dev.	135	166	376	15	28	22	1.2	5.5	6.3	6.8	<.1	0.3	0.9	0.6	<.1	35	Trap L
Mean	517	2088	938	323	526	1338	43.1	38.4	28.9	4.9	3.1	2.8	1.6	1.2	0.2	1180	Basswood L
Std. dev.	38	180	242	17	39	86	4.2	5.2	1.4	0.6	0.3	0.1	0.7	<.1	0.1	122	Basswood L
Mean	640	2699	1198	429	711	1269	45.9	30.5	31.4	4.3	3.4	3.0	1.2	1.4	0.2	1400	Lac La Croix
Std. dev.	38	77	268	17	72	107	3.1	1.9	1.8	0.6	0.2	0.2	0.1	0.1	<.1	62	Lac La Croix
Mean	765	2956	2972	399	423	1369	32.1	57.1	34.8	3.9	3.3	2.1	1.0	1.1	0.2	1315	Trout L
Std. dev.	239	478	1289	51	4	43	1.6	24.5	5.6	0.2	0.1	0.4	0.1	0.1	<.1	52	Trout L
Mean	639	2492	2689	435	252	367	20.2	119.9	31.6	3.1	1.6	#	0.6	0.7	0.2	753	Isabella L
Std. dev.	101	138	338	41	3	12	1.0	10.1	1.5	0.3	0.1	#	<.1	0.1	<.1	71	Isabella L

Hypogymnia physodes

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Mean	698	2754	24408	683	534	721	24.9	252.9	62.6	4.9	2.5	9.8	1.2	1.0	0.7	987	Saganaga
Std. dev.	39	103	3158	35	12	18	2.4	24.8	3.0	0.2	0.2	0.4	0.1	<.1	0.1	129	Saganaga
Mean	885	3096	30840	658	368	420	21.3	219.7	90.4	5.0	2.2	9.7	1.0	0.6	1.3	785	Trap L
Std. dev.	64	134	2336	46	21	24	0.3	27.4	0.9	0.2	0.1	0.5	<.1	0.1	0.1	61	Trap L
Mean	800	2985	26647	644	459	726	23.5	308.0	59.6	4.3	2.1	9.4	1.0	0.8	1.4	790	Basswood L
Std. dev.	53	54	3590	54	77	114	0.5	58.9	3.8	0.1	0.1	0.4	0.1	0.1	0.2	75	Basswood L
Mean	1040	3854	24612	1055	384	671	34.1	379.3	63.1	4.6	2.3	5.8	1.4	0.9	1.0	963	Lac La Croix
Std. dev.	46	188	4251	87	19	28	1.8	14.4	2.8	0.3	0.2	0.8	0.2	<.1	0.1	166	Lac La Croix
Mean	569	2910	25065	702	412	1080	24.0	131.7	56.3	4.4	2.1	7.1	1.2	0.8	0.6	900	Trout L
Std. dev.	33	73	2227	41	15	87	0.9	9.2	1.3	0.2	0.1	0.7	0.1	<.1	0.1	161	Trout L
Mean	891	3221	17493	934	641	807	26.0	593.5	91.7	4.9	2.9	8.9	1.3	1.0	1.2	813	Isabella L
Std. dev.	122	176	2536	98	44	61	1.3	62.6	9.8	0.2	0.1	0.1	0.1	0.2	0.2	90	Isabella L

Parmelia sulcata

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Mean	1074	3023	4249	555	809	993	23.8	243.1	87.0	5.0	4.5	10.2	1.3	1.1	0.3	1137	Saganaga
Std. dev.	68	144	90	17	43	61	2.1	13.4	0.8	0.2	0.2	0.7	0.1	0.2	<.1	55	Saganaga
Mean	1973	4110	4934	852	823	955	25.0	281.4	131.9	6.7	6.7	13.7	1.1	1.1	0.6	1282	Trap L
Std. dev.	67	146	77	52	65	96	0.7	12.4	3.1	0.1	0.3	0.7	0.1	0.1	<.1	97	Trap L
Mean	1578	3590	3536	636	824	1409	23.5	587.0	104.9	4.9	4.2	7.9	0.8	1.1	0.5	1107	Basswood L
Std. dev.	109	75	186	21	23	80	1.0	90.9	6.5	0.1	0.2	0.5	0.1	0.1	<.1	47	Basswood L
Mean	1675	4434	3445	778	837	1481	31.1	162.7	75.7	5.6	4.0	8.8	1.9	1.3	0.3	1523	Lac La Croix
Std. dev.	152	205	257	45	48	115	0.9	8.7	1.6	0.3	0.3	0.7	0.1	0.1	<.1	40	Lac La Croix
Mean	945	3046	4505	558	839	2010	25.3	160.6	87.0	4.9	4.4	10.3	1.6	1.2	0.4	1293	Trout L
Std. dev.	82	229	193	37	119	264	2.5	27.6	1.1	0.2	0.4	0.8	0.2	0.1	0.1	23	Trout L
Mean	1450	3454	4213	733	785	890	24.7	343.6	95.4	5.0	4.9	11.5	1.3	0.9	0.8	1041	Isabella L
Std. dev.	40	70	221	25	117	132	4.7	23.7	1.7	0.4	0.2	0.8	0.1	0.1	<.1	80	Isabella L

Standards

Cladina stellaris

	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd	S	Locality
Mean	193	673	239	268	461	597	78.4	20.4	17.3	2.5	0.8	13.3	1.1	1.0	0.2	471	C Stand
Std. dev.	2	7	2	1	7	14	.4	<.1	0.3	0.2	<.1	0.1	<.1	0.1	<.1	2	C Stand
NBS Pine																	
Mean	1204	3674	4541	1180	478	191	18.8	712.2	113.5	3.3	17.4	11.5	1.7	1.8	0.3	NA	NBS Pine
Std. dev.	36	93	106	28	14	10	0.8	17.6	70.8	0.1	0.4	0.3	0.1	0.1	0.1	NA	NBS Pine

* = one value at or below detection limit; included as 0.7 of detection limit
# = two or more values at or below detection limit; not included in calculations

Table 3. Loadings in descending order of 16 chemical elements on two components from a principal component analysis of element concentration data from four lichen species in the Boundary Waters Canoe Area Wilderness. Elements highly loaded on one component but not the other are shown in bold.

Chemical element	Component 1	Component 2
Cr	**.884**	-.075
S	**.877**	.051
Al	**.860**	.197
Fe	**.803**	.063
B	**.732**	.165
Ni	**.718**	.297
K	.574	.696
P	.548	.541
Cu	.547	.442
Na	.509	-.449
Zn	.492	.789
Pb	.378	.659
Mg	.228	**.892**
Cd	-.017	**.857**
Ca	-.183	**.794**
Mn	.060	**.792**

Table 4. Analyses of variance of two chemical element components in the lichens sampled in the Boundary Waters Canoe Area Wilderness. The F probability gives the probability that the source of variation in the table affects the component due to chance. Very small probabilities indicate that the source of variation is probably due to the source of variation, not chance.

Source of variation	Component 1 mean square	F probability	Component 2 mean square	F probability
Species	25.76	.000	26.78	.000
Year	0.16	.040	0.67	.000
Species x year	0.27	.000	0.13	.000
Locality	0.51	.000	0.32	.000
Species x locality	0.29	.000	0.21	.000
Year x locality	0.02	.716	0.08	.000
Error	0.04		0.02	

LIST OF FIGURES

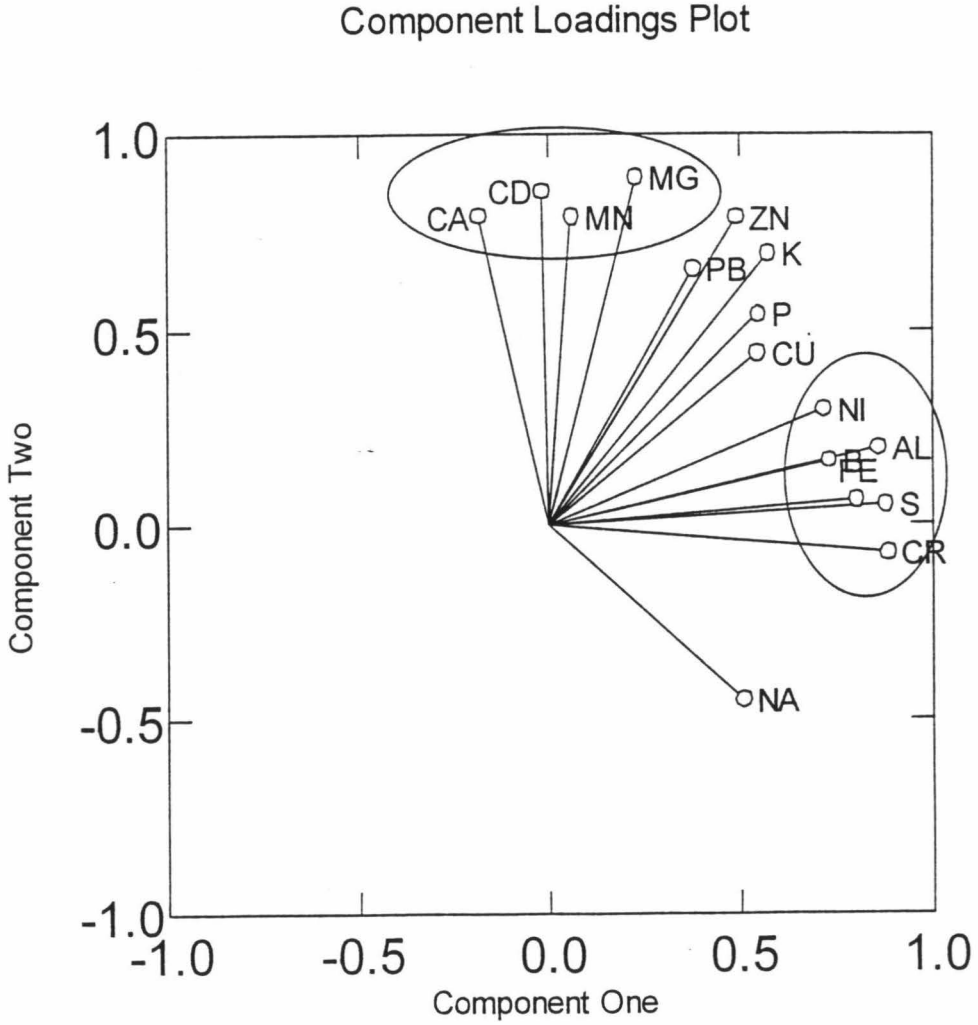

Figure 1. Principal component loadings plot of 16 chemical elements measured in four lichen species from the Boundary Waters Canoe Area Wilderness. The principal components were extracted from the 16 x 15 chemical element correlation matrix of 176 cases after equamax rotation and limited to two components, that together accounted for 68% of the variance. Ellipses are drawn around the groups of elements that are heavily loaded on either matrix but not the other, and these elements were used to interpret the components.

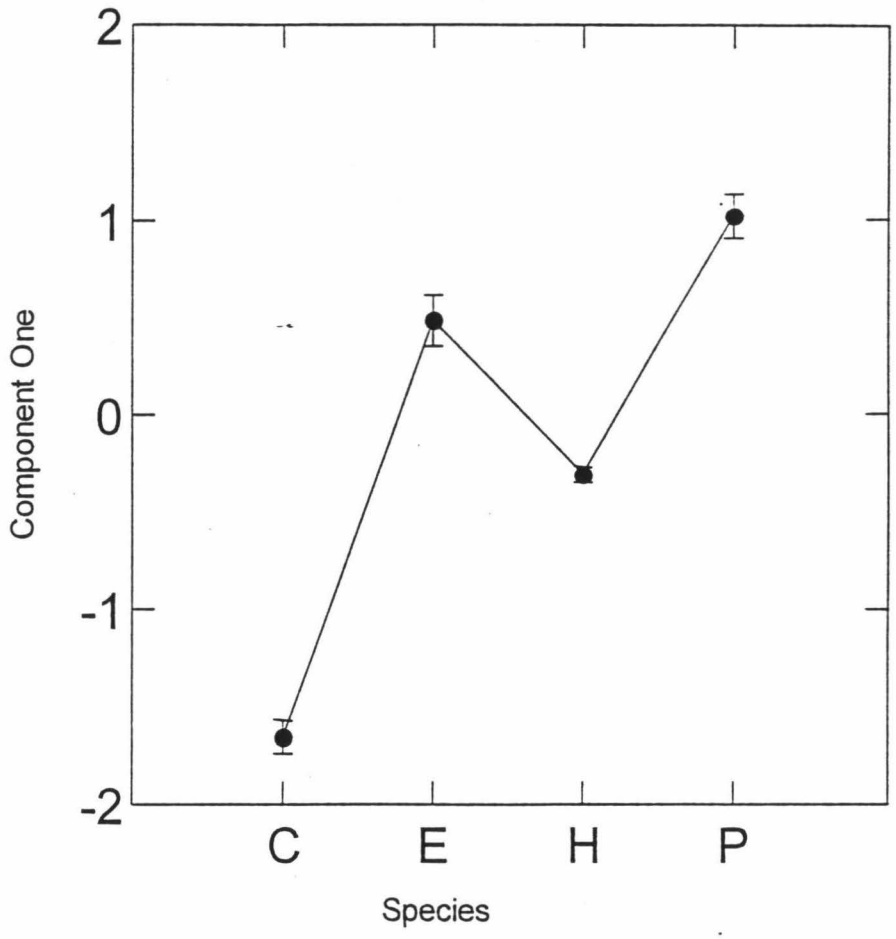

Figure 2. Effects of species on principal component one. C = *Cladina*, E = *Evernia*, H = *Hypogymnia*, and P = *Parmelia*. Points represent least squares means bounded by standard error bars.

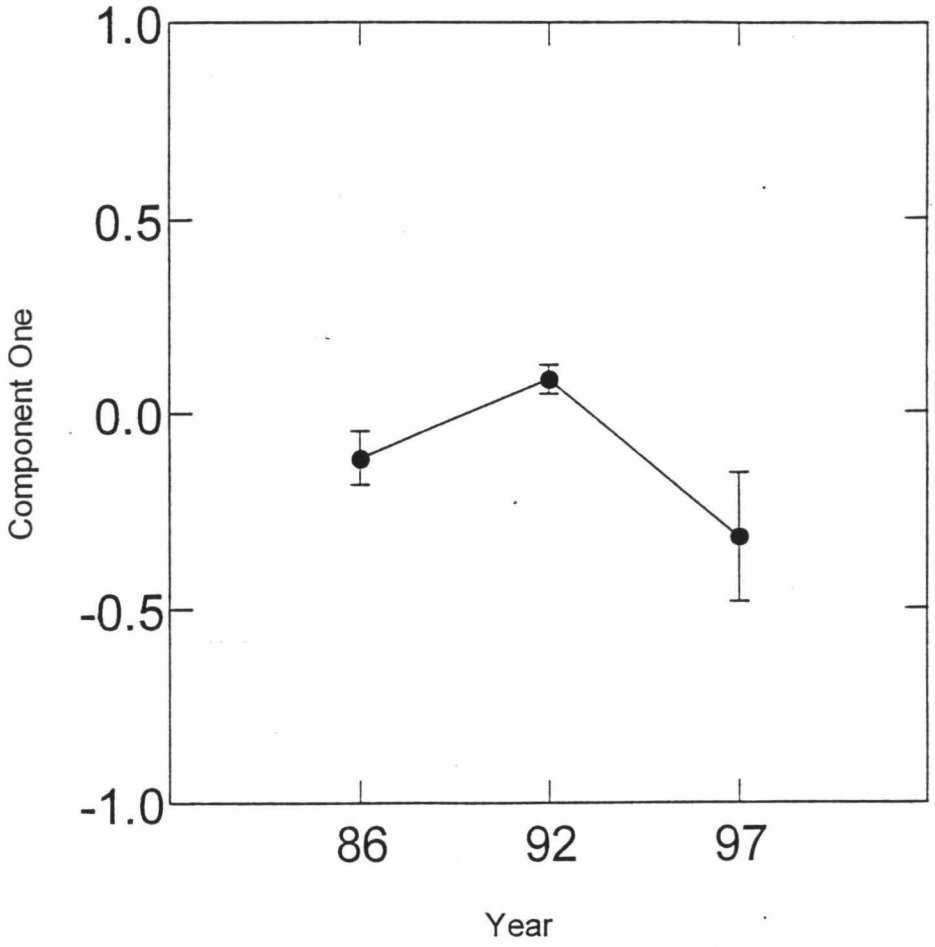

Figure 3. Effects of year on principal component one. The years sampled were 1986, 1992 and 1997. Symbols as in Figure 2.

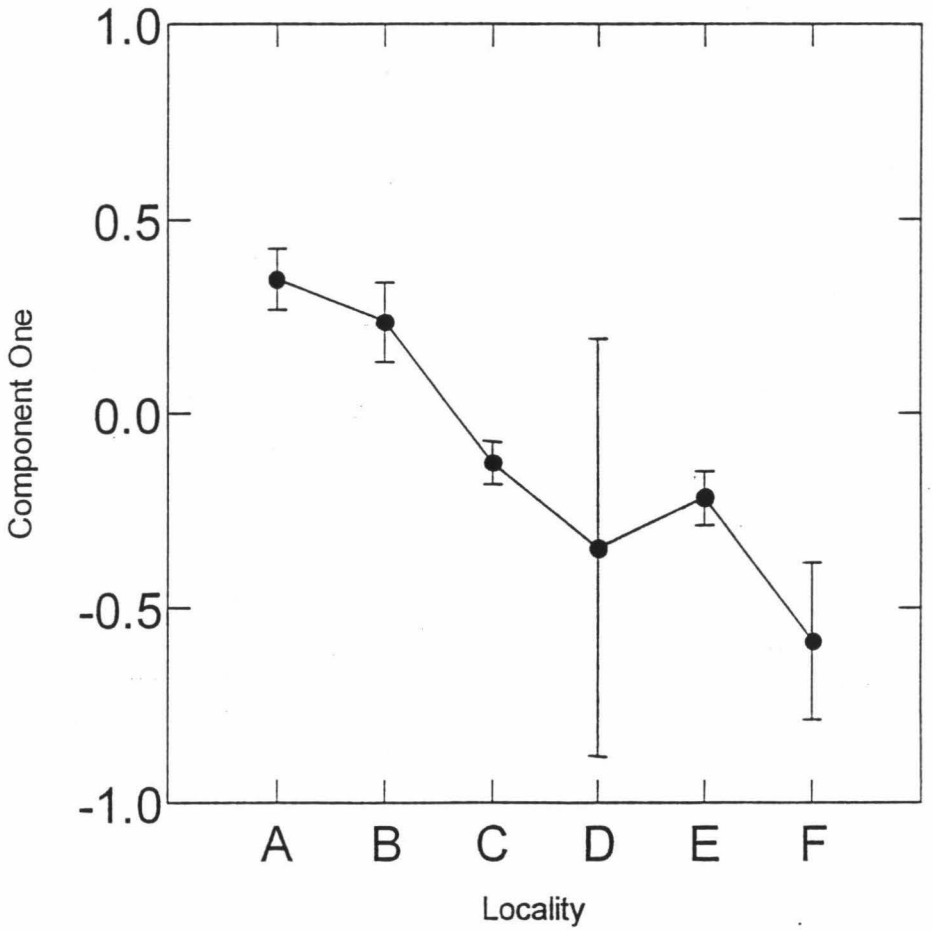

Figure 4. Effects of locality on principal component one. The localities, oriented west to east, are Lac La Croix (A), Trout Lake (B), Basswood Lake (C), Isabella Lake (D), Saganaga Lake (E), and Trap Lake (F). Symbols as in Figure 2.

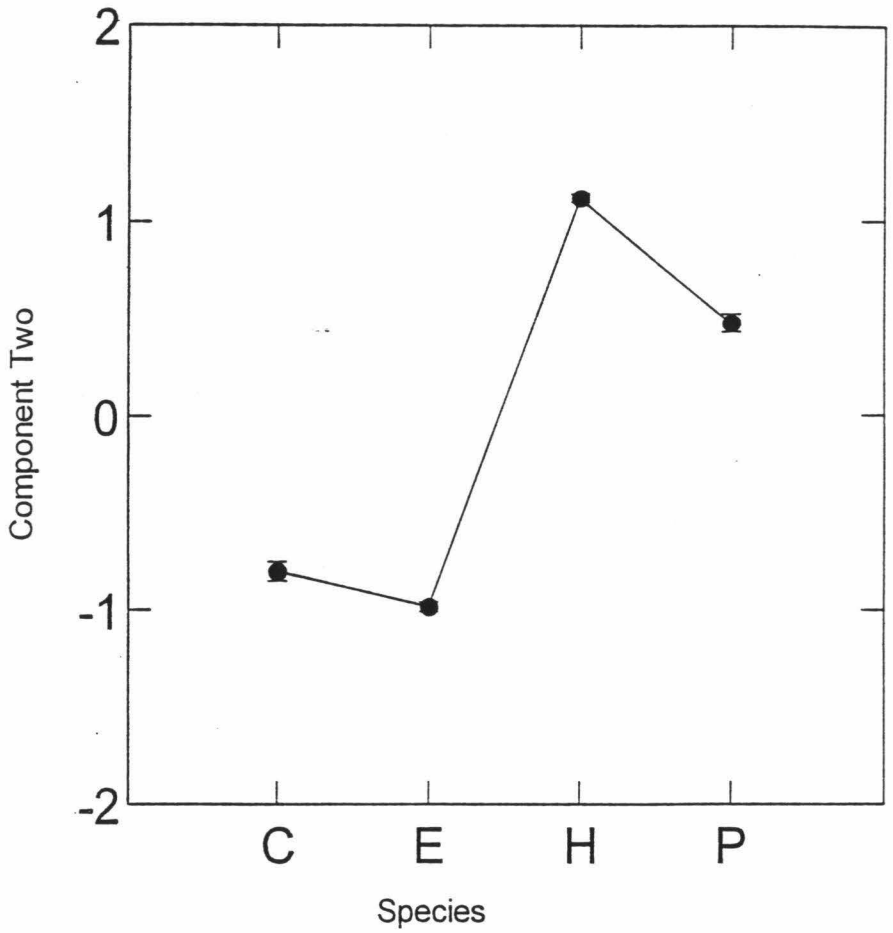

Figure 5. Effects of species on principal component two. Species and symbols as in Figure 2.

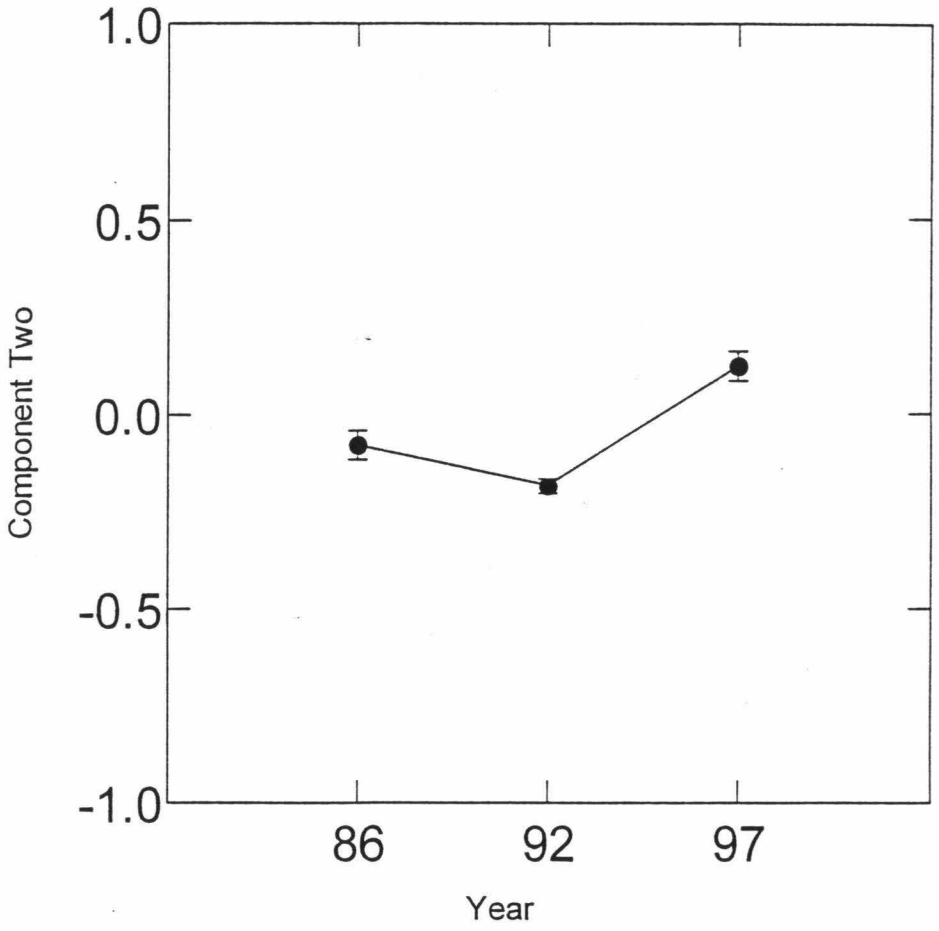

Figure 6. Effects of year on principal component two. Years as in Figure 3 and symbols as in Figure 2.

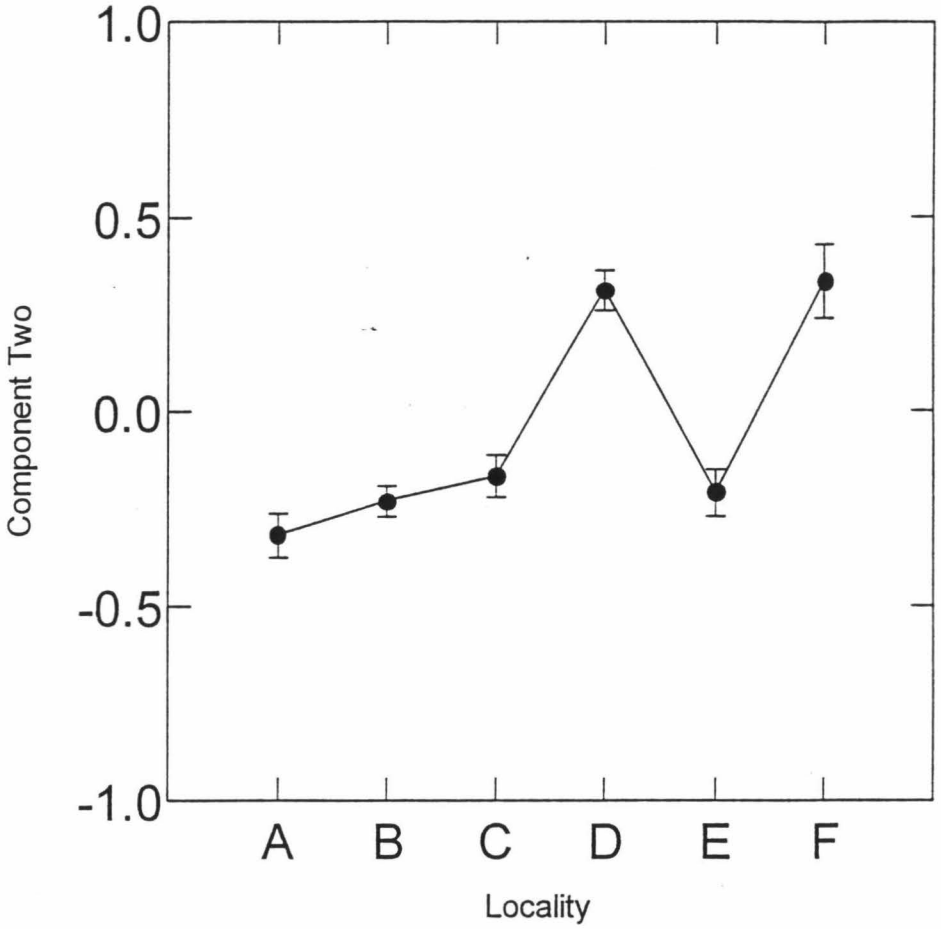

Figure 7. Effects of locality on principal component two. Localities as in Figure 4 and symbols as in Figure 2.

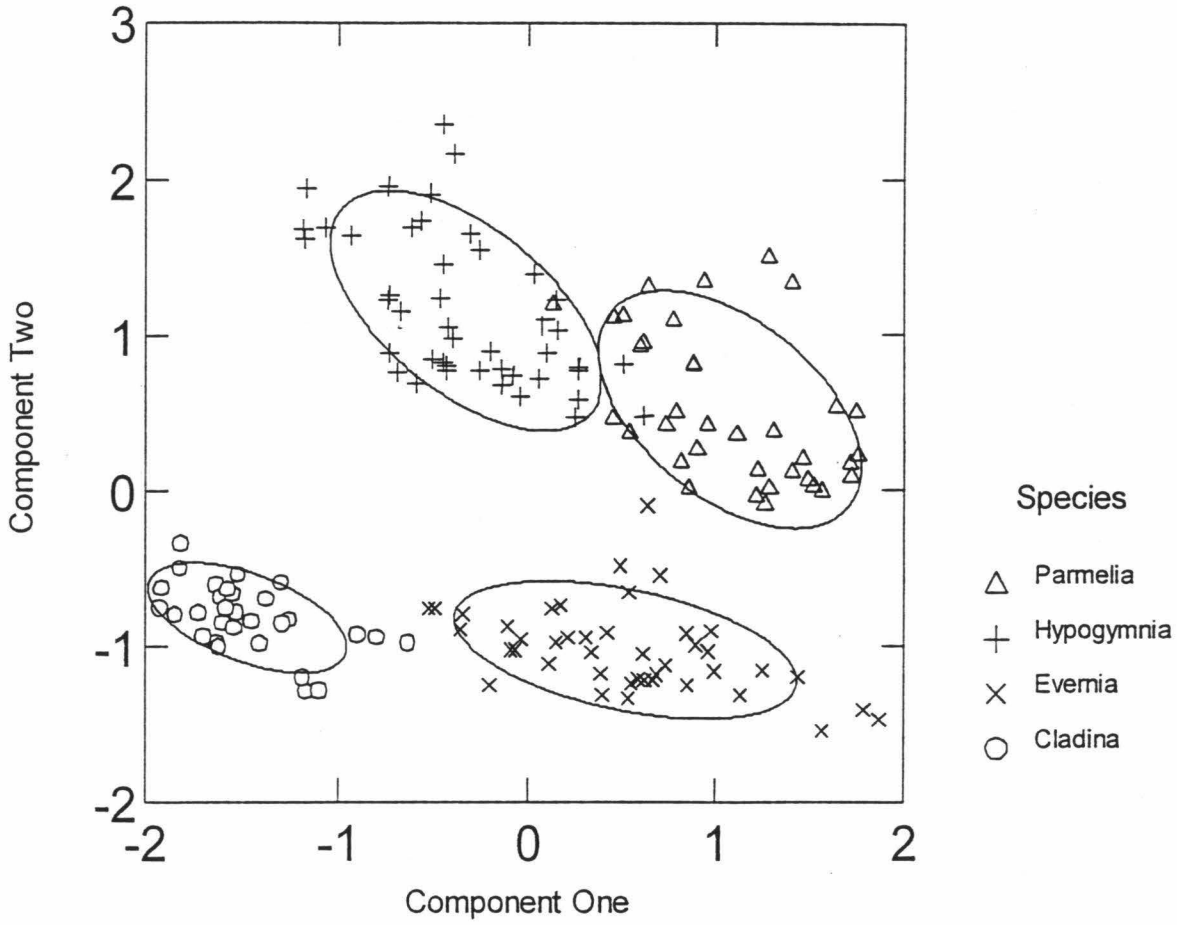

Figure 8. Scatterplot of scores of principal component two versus component one with symbols keyed to the four lichen species. Ellipses indicate 70% confidence intervals.

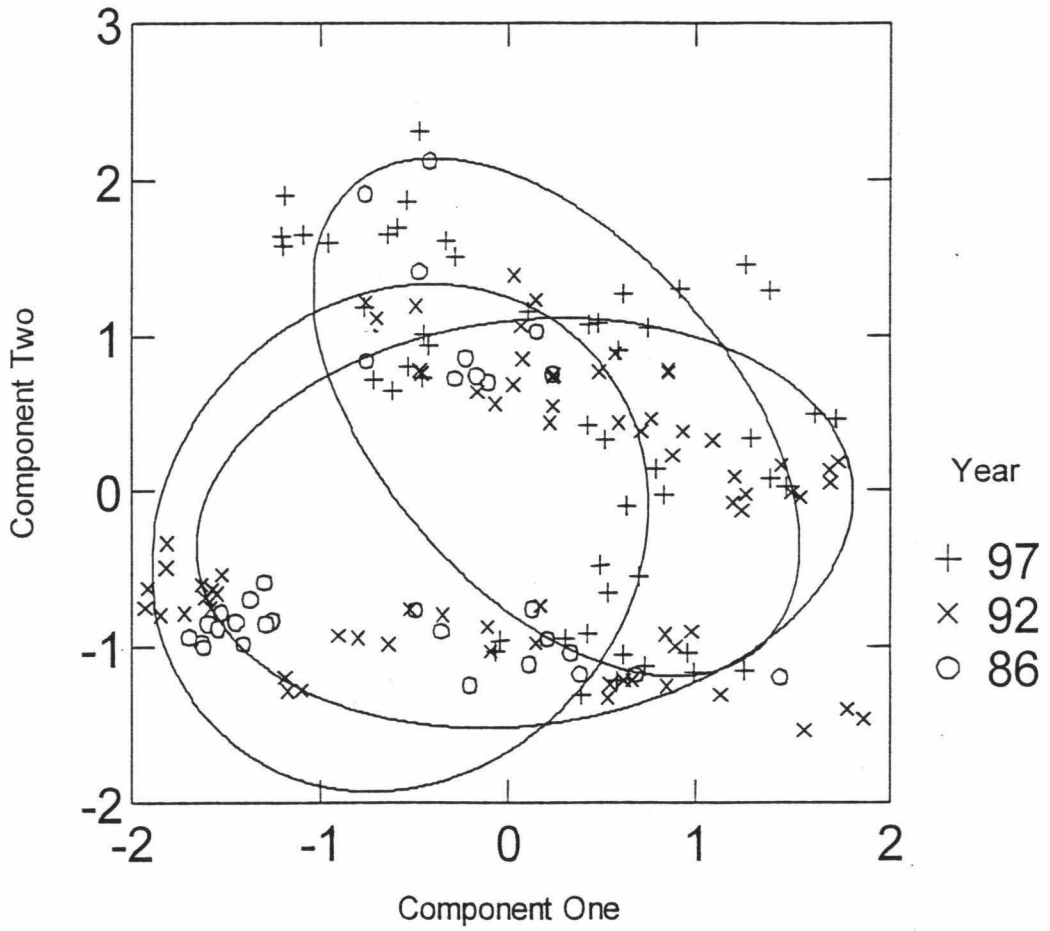

Figure 9. Scatterplot of scores of principal component two versus component one with symbols keyed to the three sampling years. Ellipses as in Figure 8.

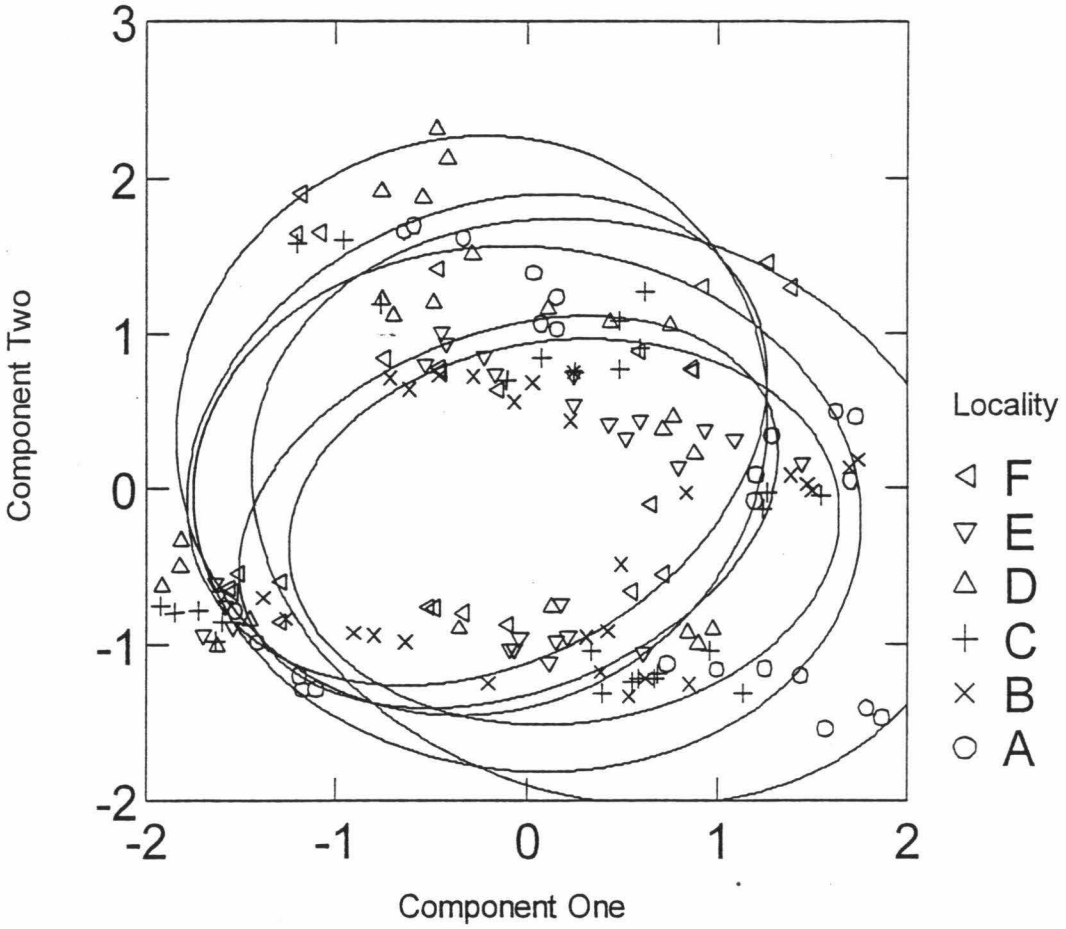

Figure 10. Scatterplot of scores of principal component two versus component one with symbols keyed to the six sampling localities. Ellipses as in Figure 8.

APPENDIX I

Latitude and Longitude of Elemental Analysis Localities

The following latitudes and longitudes were obtained during the 1997 survey by GPS.

LATITUDE	LONGITUDE	
48°13'19"N	90°52'47"W	Saganaga Lake
48°00'56"N	90°22'06"W	Trap Lake
48°04'06"N	91°40'40"W	Basswood Lake
48°19'35"N	92°17'25"W	Lac La Croix
47°55'44"N	92°17'48"W	Trout Lake
47°48'40"N	91°19'06"W	Isabella Lake

APPENDIX II

Tables showing the means of all chemical elements in the study design. Tables arranged first by chemical element then alphabetically by species. CLRA = *Cladina rangiferina*, EVME = *Evernia mesomorpha*, HYPH = *Hypogymnia physodes*, PASU = *Parmelia sulcata*.

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of AI	472.41	754.13	504.90	602.43
	Count of AI	5	12	12	29
Isabella	Average of AI	494.23	628.50	483.63	543.70
	Count of AI	6	12	12	30
LLCroix	Average of AI	515.11	771.19	555.68	642.25
	Count of AI	4	12	12	28
Saganaga	Average of AI	393.12	732.17	519.98	579.49
	Count of AI	6	12	12	30
Trap	Average of AI	286.68	567.98	467.58	477.93
	Count of AI	5	12	12	29
Trout	Average of AI	431.60	699.09	466.93	552.73
	Count of AI	6	12	12	30
Total Average of AI		430.30	692.18	499.78	565.86
Total Count of AI		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Al	256.02	261.71	209.62	240.75
	Count of Al	2	3	3	8
Isabella	Average of Al	260.69	276.24	256.67	265.01
	Count of Al	2	3	3	8
LLCroix	Average of Al	256.04	388.38	291.07	318.80
	Count of Al	2	3	3	8
Saganaga	Average of Al	225.34	359.09	251.70	285.38
	Count of Al	2	3	3	8
Trap	Average of Al	209.59	310.18	234.83	256.78
	Count of Al	2	3	3	8
Trout	Average of Al	231.37	451.20	193.40	299.57
	Count of Al	2	3	3	8
Total Average of Al		239.84	341.13	239.55	277.72
Total Count of Al		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Al	660.10	700.02	526.10	624.82
	Count of Al	2	3	3	8
Isabella	Average of Al	644.59	762.20	252.10	541.51
	Count of Al	2	3	3	8
LLCroix	Average of Al	966.32	859.85	710.80	811.18
	Count of Al	1	3	3	7
Saganaga	Average of Al	492.60	596.08	484.77	528.47
	Count of Al	2	3	3	8
Trap	Average of Al	371.48	460.12	444.13	440.60
	Count of Al	1	3	3	7
Trout	Average of Al	577.64	633.16	422.50	540.28
	Count of Al	2	3	3	8
Total Average of Al		608.77	668.57	473.40	579.20
Total Count of Al		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of AI	529.80	851.97	459.43	637.72
	Count of AI	1	3	3	7
Isabella	Average of AI	577.42	604.26	641.03	611.34
	Count of AI	2	3	3	8
LLCroix	Average of AI	582.04	780.92	383.87	582.34
	Count of AI	1	3	3	7
Saganaga	Average of AI	461.41	820.59	534.43	623.49
	Count of AI	2	3	3	8
Trap	Average of AI	321.36	619.01	368.17	450.53
	Count of AI	2	3	3	8
Trout	Average of AI	485.78	675.96	412.47	529.60
	Count of AI	2	3	3	8
Total Average of AI		480.38	725.45	466.57	570.87
Total Count of AI		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of AI	1202.80	824.47	1013.63
	Count of AI	3	3	6
Isabella	Average of AI	871.29	784.70	828.00
	Count of AI	3	3	6
LLCroix	Average of AI	1055.61	837.00	946.31
	Count of AI	3	3	6
Saganaga	Average of AI	1152.93	809.03	980.98
	Count of AI	3	3	6
Trap	Average of AI	882.59	823.18	852.89
	Count of AI	3	3	6
Trout	Average of AI	1036.03	839.37	937.70
	Count of AI	3	3	6
Total Average of AI		1033.54	819.63	926.58
Total Count of AI		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of B	3.77	2.76	2.51	2.83
	Count of B	5	12	12	29
Isabella	Average of B	3.73	2.24	2.51	2.64
	Count of B	6	12	12	30
LLCroix	Average of B	3.81	2.93	2.67	2.95
	Count of B	4	12	12	28
Saganaga	Average of B	3.54	3.25	2.83	3.14
	Count of B	6	12	12	30
Trap	Average of B	3.31	2.55	3.20	2.95
	Count of B	5	12	12	29
Trout	Average of B	3.69	3.12	2.77	3.10
	Count of B	6	12	12	30
Total Average of B		3.64	2.81	2.75	2.93
Total Count of B		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of B	1.32	1.21	0.60	1.01
	Count of B	2	3	3	8
Isabella	Average of B	1.77	1.03	0.62	1.06
	Count of B	2	3	3	8
LLCroix	Average of B	1.94	1.29	0.93	1.32
	Count of B	2	3	3	8
Saganaga	Average of B	1.59	1.29	1.75	1.54
	Count of B	2	3	3	8
Trap	Average of B	1.67	1.12	1.29	1.32
	Count of B	2	3	3	8
Trout	Average of B	2.01	1.49	1.22	1.52
	Count of B	2	3	3	8
Total Average of B		1.72	1.24	1.07	1.30
Total Count of B		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of B	6.04	3.08	3.13	3.84
	Count of B	2	3	3	8
Isabella	Average of B	4.88	2.57	1.61	2.79
	Count of B	2	3	3	8
LLCroix	Average of B	6.59	3.73	3.38	3.99
	Count of B	1	3	3	7
Saganaga	Average of B	5.40	3.83	2.64	3.78
	Count of B	2	3	3	8
Trap	Average of B	5.02	2.31	2.54	2.80
	Count of B	1	3	3	7
Trout	Average of B	4.94	3.27	3.33	3.71
	Count of B	2	3	3	8
Total Average of B		5.41	3.13	2.77	3.49
Total Count of B		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of B	4.14	2.68	2.08	2.63
	Count of B	1	3	3	7
Isabella	Average of B	4.53	1.87	2.92	2.93
	Count of B	2	3	3	8
LLCroix	Average of B	4.77	2.77	2.35	2.87
	Count of B	1	3	3	7
Saganaga	Average of B	3.63	3.20	2.47	3.04
	Count of B	2	3	3	8
Trap	Average of B	4.10	2.25	2.25	2.71
	Count of B	2	3	3	8
Trout	Average of B	4.12	2.61	2.14	2.81
	Count of B	2	3	3	8
Total Average of B		4.17	2.56	2.37	2.84
Total Count of B		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of B	4.08	4.23	4.15
	Count of B	3	3	6
Isabella	Average of B	3.47	4.87	4.17
	Count of B	3	3	6
LLCroix	Average of B	3.93	4.03	3.98
	Count of B	3	3	6
Saganaga	Average of B	4.69	4.46	4.57
	Count of B	3	3	6
Trap	Average of B	4.51	6.72	5.61
	Count of B	3	3	6
Trout	Average of B	5.12	4.40	4.76
	Count of B	3	3	6
Total Average of B		4.30	4.78	4.54
Total Count of B		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ca	3580.43	4959.59	7971.52	5968.12
	Count of Ca	5	12	12	29
Isabella	Average of Ca	12114.31	6346.75	6253.99	7463.16
	Count of Ca	6	12	12	30
LLCroix	Average of Ca	6055.32	6552.18	7502.45	6888.46
	Count of Ca	4	12	12	28
Saganaga	Average of Ca	7182.12	6086.42	7570.51	6899.20
	Count of Ca	6	12	12	30
Trap	Average of Ca	10525.88	4590.88	9754.50	7750.82
	Count of Ca	5	12	12	29
Trout	Average of Ca	6984.19	7484.29	8326.87	7721.30
	Count of Ca	6	12	12	30
Total Average of Ca		7888.64	6003.35	7896.64	7120.66
Total Count of Ca		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ca	455.23	667.88	764.98	651.13
	Count of Ca	2	3	3	8
Isabella	Average of Ca	600.79	1043.29	620.63	774.17
	Count of Ca	2	3	3	8
LLCroix	Average of Ca	529.07	398.72	755.80	565.21
	Count of Ca	2	3	3	8
Saganaga	Average of Ca	494.64	754.44	545.37	611.09
	Count of Ca	2	3	3	8
Trap	Average of Ca	739.52	1031.04	1084.00	978.02
	Count of Ca	2	3	3	8
Trout	Average of Ca	607.37	657.79	766.13	685.82
	Count of Ca	2	3	3	8
Total Average of Ca		571.10	758.86	756.15	710.91
Total Count of Ca		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ca	779.85	695.91	938.43	807.84
	Count of Ca	2	3	3	8
Isabella	Average of Ca	1524.15	643.83	2689.33	1630.97
	Count of Ca	2	3	3	8
LLCroix	Average of Ca	1159.15	1057.76	1197.67	1132.21
	Count of Ca	1	3	3	7
Saganaga	Average of Ca	676.98	1577.77	1079.00	1165.53
	Count of Ca	2	3	3	8
Trap	Average of Ca	1006.35	966.83	2160.33	1483.98
	Count of Ca	1	3	3	7
Trout	Average of Ca	656.94	996.85	2971.67	1652.43
	Count of Ca	2	3	3	8
Total Average of Ca		944.13	989.82	1839.41	1312.34
Total Count of Ca		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ca	15432.00	15934.33	26646.67	20453.57
	Count of Ca	1	3	3	7
Isabella	Average of Ca	34218.00	19237.33	17493.33	22328.50
	Count of Ca	2	3	3	8
LLCroix	Average of Ca	22004.00	22106.00	24611.67	23165.29
	Count of Ca	1	3	3	7
Saganaga	Average of Ca	20374.75	18561.67	24408.33	21207.44
	Count of Ca	2	3	3	8
Trap	Average of Ca	25072.00	13434.33	30840.00	22870.88
	Count of Ca	2	3	3	8
Trout	Average of Ca	19688.25	23902.00	25065.00	23284.69
	Count of Ca	2	3	3	8
Total Average of Ca		23614.20	18862.61	24844.17	22236.17
Total Count of Ca		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Ca	2540.23	3536.00	3038.12
	Count of Ca	3	3	6
Isabella	Average of Ca	4462.53	4212.67	4337.60
	Count of Ca	3	3	6
LLCroix	Average of Ca	2646.23	3444.67	3045.45
	Count of Ca	3	3	6
Saganaga	Average of Ca	3451.80	4249.33	3850.57
	Count of Ca	3	3	6
Trap	Average of Ca	2931.30	4933.67	3932.48
	Count of Ca	3	3	6
Trout	Average of Ca	4380.53	4504.67	4442.60
	Count of Ca	3	3	6
Total Average of Ca		3402.11	4146.83	3774.47
Total Count of Ca		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cd	0.29	0.48	0.69	0.52
	Count of Cd	5	12	9	26
Isabella	Average of Cd	0.56	0.55	0.71	0.60
	Count of Cd	6	12	9	27
LLCroix	Average of Cd	0.31	0.61	0.52	0.53
	Count of Cd	4	12	9	25
Saganaga	Average of Cd	0.41	0.32	0.37	0.36
	Count of Cd	6	12	9	27
Trap	Average of Cd	0.41	0.43	0.58	0.49
	Count of Cd	5	12	12	29
Trout	Average of Cd	0.31	0.29	0.33	0.31
	Count of Cd	6	12	12	30
Total Average of Cd		0.39	0.45	0.53	0.46
Total Count of Cd		32	72	60	164

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cd	0.14	0.16		0.15
	Count of Cd	2	3		5
Isabella	Average of Cd	0.17	0.16		0.16
	Count of Cd	2	3		5
LLCroix	Average of Cd	0.14	0.20		0.17
	Count of Cd	2	3		5
Saganaga	Average of Cd	0.18	0.14		0.15
	Count of Cd	2	3		5
Trap	Average of Cd	0.15	0.20	0.15	0.17
	Count of Cd	2	3	3	8
Trout	Average of Cd	0.12	0.12	0.11	0.12
	Count of Cd	2	3	3	8
Total Average of Cd		0.15	0.16	0.13	0.15
Total Count of Cd		12	18	6	36

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cd	0.21	0.24	0.24	0.23
	Count of Cd	2	3	3	8
Isabella	Average of Cd	0.16	0.40	0.20	0.26
	Count of Cd	2	3	3	8
LLCroix	Average of Cd	0.30	0.43	0.23	0.33
	Count of Cd	1	3	3	7
Saganaga	Average of Cd	0.33	0.15	0.14	0.19
	Count of Cd	2	3	3	8
Trap	Average of Cd	0.17	0.29	0.29	0.27
	Count of Cd	1	3	3	7
Trout	Average of Cd	0.16	0.18	0.21	0.19
	Count of Cd	2	3	3	8
Total Average of Cd		0.22	0.28	0.22	0.24
Total Count of Cd		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cd	0.76	1.03	1.35	1.13
	Count of Cd	1	3	3	7
Isabella	Average of Cd	1.35	1.04	1.15	1.16
	Count of Cd	2	3	3	8
LLCroix	Average of Cd	0.65	1.31	1.01	1.09
	Count of Cd	1	3	3	7
Saganaga	Average of Cd	0.71	0.59	0.70	0.66
	Count of Cd	2	3	3	8
Trap	Average of Cd	0.79	0.73	1.33	0.97
	Count of Cd	2	3	3	8
Trout	Average of Cd	0.63	0.51	0.63	0.59
	Count of Cd	2	3	3	8
Total Average of Cd		0.84	0.87	1.03	0.92
Total Count of Cd		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Cd	0.48	0.49	0.48
	Count of Cd	3	3	6
Isabella	Average of Cd	0.59	0.77	0.68
	Count of Cd	3	3	6
LLCroix	Average of Cd	0.49	0.33	0.41
	Count of Cd	3	3	6
Saganaga	Average of Cd	0.40	0.27	0.34
	Count of Cd	3	3	6
Trap	Average of Cd	0.49	0.56	0.53
	Count of Cd	3	3	6
Trout	Average of Cd	0.36	0.36	0.36
	Count of Cd	3	3	6
Total Average of Cd		0.47	0.46	0.47
Total Count of Cd		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cr	0.78	1.19	0.88	0.99
	Count of Cr	5	12	12	29
Isabella	Average of Cr	0.75	1.13	0.74	0.90
	Count of Cr	6	12	12	30
LLCroix	Average of Cr	0.86	1.32	1.03	1.13
	Count of Cr	4	12	12	28
Saganaga	Average of Cr	0.76	1.11	0.87	0.95
	Count of Cr	6	12	12	30
Trap	Average of Cr	0.54	0.91	0.94	0.86
	Count of Cr	5	12	12	29
Trout	Average of Cr	0.80	1.14	0.89	0.97
	Count of Cr	6	12	12	30
Total Average of Cr		0.75	1.13	0.89	0.96
Total Count of Cr		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cr	0.43	0.53	0.42	0.47
	Count of Cr	2	3	3	8
Isabella	Average of Cr	0.39	0.50	0.39	0.43
	Count of Cr	2	3	3	8
LLCroix	Average of Cr	0.44	0.72	0.57	0.60
	Count of Cr	2	3	3	8
Saganaga	Average of Cr	0.40	0.55	0.41	0.46
	Count of Cr	2	3	3	8
Trap	Average of Cr	0.40	0.61	0.54	0.53
	Count of Cr	2	3	3	8
Trout	Average of Cr	0.42	0.63	0.43	0.50
	Count of Cr	2	3	3	8
Total Average of Cr		0.41	0.59	0.46	0.50
Total Count of Cr		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cr	1.06	1.51	1.19	1.27
	Count of Cr	2	3	3	8
Isabella	Average of Cr	0.96	1.65	0.66	1.11
	Count of Cr	2	3	3	8
LLCroix	Average of Cr	1.54	2.01	1.43	1.69
	Count of Cr	1	3	3	7
Saganaga	Average of Cr	1.01	1.06	1.06	1.05
	Count of Cr	2	3	3	8
Trap	Average of Cr	0.67	1.04	1.48	1.17
	Count of Cr	1	3	3	7
Trout	Average of Cr	0.99	1.33	1.10	1.16
	Count of Cr	2	3	3	8
Total Average of Cr		1.02	1.43	1.15	1.23
Total Count of Cr		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cr	0.93	1.27	0.80	1.02
	Count of Cr	1	3	3	7
Isabella	Average of Cr	0.89	0.95	1.00	0.95
	Count of Cr	2	3	3	8
LLCroix	Average of Cr	1.03	1.19	0.85	1.02
	Count of Cr	1	3	3	7
Saganaga	Average of Cr	0.89	1.42	0.96	1.11
	Count of Cr	2	3	3	8
Trap	Average of Cr	0.63	0.85	0.63	0.71
	Count of Cr	2	3	3	8
Trout	Average of Cr	0.98	1.07	0.79	0.94
	Count of Cr	2	3	3	8
Total Average of Cr		0.87	1.12	0.84	0.96
Total Count of Cr		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Cr	1.47	1.09	1.28
	Count of Cr	3	3	6
Isabella	Average of Cr	1.42	0.92	1.17
	Count of Cr	3	3	6
LLCroix	Average of Cr	1.35	1.25	1.30
	Count of Cr	3	3	6
Saganaga	Average of Cr	1.40	1.07	1.23
	Count of Cr	3	3	6
Trap	Average of Cr	1.12	1.12	1.12
	Count of Cr	3	3	6
Trout	Average of Cr	1.53	1.25	1.39
	Count of Cr	3	3	6
Total Average of Cr		1.38	1.12	1.25
Total Count of Cr		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cu	2.38	3.74	3.88	3.56
	Count of Cu	5	12	12	29
Isabella	Average of Cu	2.73	4.69	3.56	3.85
	Count of Cu	6	12	12	30
LLCroix	Average of Cu	2.40	3.45	4.01	3.54
	Count of Cu	4	12	12	28
Saganaga	Average of Cu	2.23	3.27	3.92	3.32
	Count of Cu	6	12	12	30
Trap	Average of Cu	2.92	3.92	5.86	4.55
	Count of Cu	5	12	12	29
Trout	Average of Cu	2.26	3.24	3.76	3.25
	Count of Cu	6	12	12	30
Total Average of Cu		2.48	3.72	4.16	3.68
Total Count of Cu		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cu	1.36	1.50	1.36	1.41
	Count of Cu	2	3	3	8
Isabella	Average of Cu	1.60	1.58	1.26	1.46
	Count of Cu	2	3	3	8
LLCroix	Average of Cu	1.38	1.65	1.55	1.55
	Count of Cu	2	3	3	8
Saganaga	Average of Cu	1.54	1.49	1.29	1.43
	Count of Cu	2	3	3	8
Trap	Average of Cu	2.09	1.87	2.11	2.02
	Count of Cu	2	3	3	8
Trout	Average of Cu	1.63	1.87	1.87	1.81
	Count of Cu	2	3	3	8
Total Average of Cu		1.60	1.66	1.57	1.61
Total Count of Cu		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cu	3.00	3.76	4.88	3.99
	Count of Cu	2	3	3	8
Isabella	Average of Cu	2.77	4.81	3.06	3.64
	Count of Cu	2	3	3	8
LLCroix	Average of Cu	3.34	3.59	4.26	3.84
	Count of Cu	1	3	3	7
Saganaga	Average of Cu	2.36	2.60	4.53	3.26
	Count of Cu	2	3	3	8
Trap	Average of Cu	2.51	3.23	9.64	5.87
	Count of Cu	1	3	3	7
Trout	Average of Cu	2.14	3.06	3.85	3.13
	Count of Cu	2	3	3	8
Total Average of Cu		2.64	3.51	5.04	3.92
Total Count of Cu		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Cu	3.18	4.33	4.33	4.16
	Count of Cu	1	3	3	7
Isabella	Average of Cu	3.81	5.51	4.94	4.87
	Count of Cu	2	3	3	8
LLCroix	Average of Cu	3.49	4.19	4.60	4.27
	Count of Cu	1	3	3	7
Saganaga	Average of Cu	2.78	4.54	4.87	4.23
	Count of Cu	2	3	3	8
Trap	Average of Cu	3.94	4.70	4.99	4.62
	Count of Cu	2	3	3	8
Trout	Average of Cu	3.01	3.92	4.38	3.86
	Count of Cu	2	3	3	8
Total Average of Cu		3.37	4.53	4.69	4.34
Total Count of Cu		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Cu	5.38	4.93	5.16
	Count of Cu	3	3	6
Isabella	Average of Cu	6.87	4.99	5.93
	Count of Cu	3	3	6
LLCroix	Average of Cu	4.38	5.63	5.01
	Count of Cu	3	3	6
Saganaga	Average of Cu	4.43	5.01	4.72
	Count of Cu	3	3	6
Trap	Average of Cu	5.89	6.69	6.29
	Count of Cu	3	3	6
Trout	Average of Cu	4.12	4.92	4.52
	Count of Cu	3	3	6
Total Average of Cu		5.18	5.36	5.27
Total Count of Cu		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Fe	476.36	1114.11	971.97	945.34
	Count of Fe	5	12	12	29
Isabella	Average of Fe	461.57	684.87	598.43	605.63
	Count of Fe	6	12	12	30
LLCroix	Average of Fe	512.97	1122.52	992.08	979.54
	Count of Fe	4	12	12	28
Saganaga	Average of Fe	344.01	815.27	692.20	671.79
	Count of Fe	6	12	12	30
Trap	Average of Fe	239.46	571.72	558.18	508.83
	Count of Fe	5	12	12	29
Trout	Average of Fe	506.09	1428.89	1264.09	1178.41
	Count of Fe	6	12	12	30
Total Average of Fe		421.91	956.23	846.16	814.05
Total Count of Fe		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Fe	210.22	333.55	414.30	333.00
	Count of Fe	2	3	3	8
Isabella	Average of Fe	213.63	246.62	329.10	269.30
	Count of Fe	2	3	3	8
LLCroix	Average of Fe	213.44	543.24	547.40	462.35
	Count of Fe	2	3	3	8
Saganaga	Average of Fe	171.78	351.62	303.33	288.55
	Count of Fe	2	3	3	8
Trap	Average of Fe	155.98	277.29	282.70	248.99
	Count of Fe	2	3	3	8
Trout	Average of Fe	262.83	944.24	597.23	643.76
	Count of Fe	2	3	3	8
Total Average of Fe		204.65	449.43	412.34	374.33
Total Count of Fe		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Fe	726.44	1287.83	1338.00	1166.30
	Count of Fe	2	3	3	8
Isabella	Average of Fe	584.68	901.85	367.40	622.14
	Count of Fe	2	3	3	8
LLCroix	Average of Fe	1037.45	1344.13	1269.33	1268.26
	Count of Fe	1	3	3	7
Saganaga	Average of Fe	429.19	723.27	752.13	660.57
	Count of Fe	2	3	3	8
Trap	Average of Fe	295.80	498.26	575.10	502.27
	Count of Fe	1	3	3	7
Trout	Average of Fe	667.56	1389.87	1369.33	1201.59
	Count of Fe	2	3	3	8
Total Average of Fe		614.90	1024.20	945.22	904.32
Total Count of Fe		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Fe	508.48	1379.73	726.23	975.20
	Count of Fe	1	3	3	7
Isabella	Average of Fe	586.41	680.56	807.33	704.56
	Count of Fe	2	3	3	8
LLCroix	Average of Fe	587.55	1233.97	670.92	900.31
	Count of Fe	1	3	3	7
Saganaga	Average of Fe	431.06	988.95	720.72	748.89
	Count of Fe	2	3	3	8
Trap	Average of Fe	294.77	692.91	420.07	491.06
	Count of Fe	2	3	3	8
Trout	Average of Fe	587.88	1514.57	1080.30	1120.04
	Count of Fe	2	3	3	8
Total Average of Fe		489.62	1081.78	737.59	818.37
Total Count of Fe		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Fe	1455.33	1409.33	1432.33
	Count of Fe	3	3	6
Isabella	Average of Fe	910.45	889.87	900.16
	Count of Fe	3	3	6
LLCroix	Average of Fe	1368.73	1480.67	1424.70
	Count of Fe	3	3	6
Saganaga	Average of Fe	1197.23	992.60	1094.92
	Count of Fe	3	3	6
Trap	Average of Fe	818.41	954.87	886.64
	Count of Fe	3	3	6
Trout	Average of Fe	1866.90	2009.50	1938.20
	Count of Fe	3	3	6
Total Average of Fe		1269.51	1289.47	1279.49
Total Count of Fe		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of K	2215.71	2247.22	2497.08	2345.18
	Count of K	5	12	12	29
Isabella	Average of K	2145.00	2252.33	2557.83	2353.07
	Count of K	6	12	12	30
LLCroix	Average of K	2541.11	2513.84	3135.96	2784.36
	Count of K	4	12	12	28
Saganaga	Average of K	2339.77	2373.84	2317.79	2344.61
	Count of K	6	12	12	30
Trap	Average of K	2825.33	2488.89	3013.29	2763.89
	Count of K	5	12	12	29
Trout	Average of K	2550.86	2485.10	2742.54	2601.23
	Count of K	6	12	12	30
Total Average of K		2424.48	2393.54	2710.75	2528.93
Total Count of K		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of K	1496.45	1024.86	1325.00	1255.31
	Count of K	2	3	3	8
Isabella	Average of K	1568.43	1271.37	1064.33	1267.99
	Count of K	2	3	3	8
LLCroix	Average of K	1821.70	998.29	1557.33	1413.78
	Count of K	2	3	3	8
Saganaga	Average of K	1505.38	1444.67	1412.33	1447.72
	Count of K	2	3	3	8
Trap	Average of K	2327.63	1519.37	2224.33	1985.79
	Count of K	2	3	3	8
Trout	Average of K	2327.78	1894.77	2058.67	2064.48
	Count of K	2	3	3	8
Total Average of K		1841.23	1358.89	1607.00	1572.51
Total Count of K		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of K	2379.65	2054.07	2088.33	2148.31
	Count of K	2	3	3	8
Isabella	Average of K	2057.13	2346.40	2492.33	2328.81
	Count of K	2	3	3	8
LLCroix	Average of K	2745.95	2549.63	2699.00	2641.69
	Count of K	1	3	3	7
Saganaga	Average of K	2324.18	2388.50	2082.00	2257.48
	Count of K	2	3	3	8
Trap	Average of K	2561.80	2266.50	2623.33	2461.61
	Count of K	1	3	3	7
Trout	Average of K	1825.90	2122.57	2955.67	2360.81
	Count of K	2	3	3	8
Total Average of K		2248.15	2287.94	2490.11	2358.40
Total Count of K		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of K	3326.35	3003.20	2985.33	3041.71
	Count of K	1	3	3	7
Isabella	Average of K	2809.45	2693.13	3220.67	2920.04
	Count of K	2	3	3	8
LLCroix	Average of K	3775.10	3106.00	3853.83	3522.09
	Count of K	1	3	3	7
Saganaga	Average of K	3189.75	2519.00	2754.17	2774.88
	Count of K	2	3	3	8
Trap	Average of K	3454.80	2898.37	3096.00	3111.59
	Count of K	2	3	3	8
Trout	Average of K	3498.90	2683.67	2909.67	2972.23
	Count of K	2	3	3	8
Total Average of K		3300.73	2817.23	3136.61	3047.31
Total Count of K		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of K	2906.73	3589.67	3248.20
	Count of K	3	3	6
Isabella	Average of K	2698.43	3454.00	3076.22
	Count of K	3	3	6
LLCroix	Average of K	3401.43	4433.67	3917.55
	Count of K	3	3	6
Saganaga	Average of K	3143.20	3022.67	3082.93
	Count of K	3	3	6
Trap	Average of K	3271.33	4109.50	3690.42
	Count of K	3	3	6
Trout	Average of K	3239.40	3046.17	3142.78
	Count of K	3	3	6
Total Average of K		3110.09	3609.28	3359.68
Total Count of K		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mg	361.76	474.31	459.19	448.65
	Count of Mg	5	12	12	29
Isabella	Average of Mg	472.16	561.19	590.26	555.01
	Count of Mg	6	12	12	30
LLCroix	Average of Mg	503.74	537.40	647.49	579.77
	Count of Mg	4	12	12	28
Saganaga	Average of Mg	390.81	477.46	453.06	450.37
	Count of Mg	6	12	12	30
Trap	Average of Mg	422.66	487.69	572.00	511.37
	Count of Mg	5	12	12	29
Trout	Average of Mg	438.80	521.74	496.70	495.14
	Count of Mg	6	12	12	30
Total Average of Mg		429.61	509.96	536.45	506.19
Total Count of Mg		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mg	229.76	278.90	235.02	250.16
	Count of Mg	2	3	3	8
Isabella	Average of Mg	254.47	531.72	259.87	360.46
	Count of Mg	2	3	3	8
LLCroix	Average of Mg	315.15	238.25	328.20	291.20
	Count of Mg	2	3	3	8
Saganaga	Average of Mg	244.67	321.61	253.80	276.95
	Count of Mg	2	3	3	8
Trap	Average of Mg	345.91	390.36	403.47	384.16
	Count of Mg	2	3	3	8
Trout	Average of Mg	330.74	380.06	328.20	348.28
	Count of Mg	2	3	3	8
Total Average of Mg		286.78	356.82	301.43	318.54
Total Count of Mg		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mg	343.22	370.24	322.50	345.58
	Count of Mg	2	3	3	8
Isabella	Average of Mg	355.14	367.88	434.90	389.83
	Count of Mg	2	3	3	8
LLCroix	Average of Mg	479.43	438.49	428.80	440.19
	Count of Mg	1	3	3	7
Saganaga	Average of Mg	310.50	371.85	320.97	337.43
	Count of Mg	2	3	3	8
Trap	Average of Mg	277.26	329.94	375.10	341.77
	Count of Mg	1	3	3	7
Trout	Average of Mg	290.17	366.84	398.83	359.67
	Count of Mg	2	3	3	8
Total Average of Mg		335.47	374.21	380.18	368.13
Total Count of Mg		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mg	662.87	736.54	643.67	686.21
	Count of Mg	1	3	3	7
Isabella	Average of Mg	806.87	792.99	933.73	849.24
	Count of Mg	2	3	3	8
LLCroix	Average of Mg	905.25	854.57	1054.77	947.61
	Count of Mg	1	3	3	7
Saganaga	Average of Mg	617.27	652.55	682.60	655.00
	Count of Mg	2	3	3	8
Trap	Average of Mg	572.10	597.75	657.80	613.86
	Count of Mg	2	3	3	8
Trout	Average of Mg	695.48	692.36	701.77	696.67
	Count of Mg	2	3	3	8
Total Average of Mg		695.15	721.13	779.06	738.15
Total Count of Mg		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Mg	511.55	635.57	573.56
	Count of Mg	3	3	6
Isabella	Average of Mg	552.19	732.53	642.36
	Count of Mg	3	3	6
LLCroix	Average of Mg	618.28	778.20	698.24
	Count of Mg	3	3	6
Saganaga	Average of Mg	563.81	554.87	559.34
	Count of Mg	3	3	6
Trap	Average of Mg	632.70	851.65	742.18
	Count of Mg	3	3	6
Trout	Average of Mg	647.71	558.02	602.86
	Count of Mg	3	3	6
Total Average of Mg		587.71	685.14	636.42
Total Count of Mg		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mn	63.19	89.16	245.00	149.17
	Count of Mn	5	12	12	29
Isabella	Average of Mn	148.87	69.33	271.51	166.11
	Count of Mn	6	12	12	30
LLCroix	Average of Mn	52.91	96.44	158.51	116.83
	Count of Mn	4	12	12	28
Saganaga	Average of Mn	122.05	124.37	148.18	133.43
	Count of Mn	6	12	12	30
Trap	Average of Mn	65.73	70.15	149.65	102.28
	Count of Mn	5	12	12	29
Trout	Average of Mn	92.33	96.91	101.34	97.77
	Count of Mn	6	12	12	30
Total Average of Mn		94.87	91.06	179.03	127.74
Total Count of Mn		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mn	59.49	90.94	46.57	66.44
	Count of Mn	2	3	3	8
Isabella	Average of Mn	47.46	40.79	29.06	38.06
	Count of Mn	2	3	3	8
LLCroix	Average of Mn	26.68	15.11	61.61	35.44
	Count of Mn	2	3	3	8
Saganaga	Average of Mn	27.64	83.46	53.02	58.09
	Count of Mn	2	3	3	8
Trap	Average of Mn	52.40	47.41	37.50	44.94
	Count of Mn	2	3	3	8
Trout	Average of Mn	57.85	34.02	55.93	48.19
	Count of Mn	2	3	3	8
Total Average of Mn		45.25	51.95	47.28	48.53
Total Count of Mn		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mn	25.40	28.01	38.41	31.25
	Count of Mn	2	3	3	8
Isabella	Average of Mn	69.04	20.76	119.90	70.01
	Count of Mn	2	3	3	8
LLCroix	Average of Mn	23.77	38.57	30.52	33.01
	Count of Mn	1	3	3	7
Saganaga	Average of Mn	67.27	32.26	43.74	45.32
	Count of Mn	2	3	3	8
Trap	Average of Mn	29.75	28.10	60.05	42.03
	Count of Mn	1	3	3	7
Trout	Average of Mn	31.60	33.95	57.14	42.05
	Count of Mn	2	3	3	8
Total Average of Mn		44.01	30.27	58.29	44.22
Total Count of Mn		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Mn	146.18	143.01	308.03	214.19
	Count of Mn	1	3	3	7
Isabella	Average of Mn	330.11	111.88	593.53	347.06
	Count of Mn	2	3	3	8
LLCroix	Average of Mn	134.50	222.71	379.25	277.20
	Count of Mn	1	3	3	7
Saganaga	Average of Mn	271.25	182.43	252.88	231.06
	Count of Mn	2	3	3	8
Trap	Average of Mn	97.06	107.45	219.70	146.95
	Count of Mn	2	3	3	8
Trout	Average of Mn	187.55	181.76	131.72	164.44
	Count of Mn	2	3	3	8
Total Average of Mn		205.26	158.21	314.19	229.47
Total Count of Mn		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Mn	94.69	587.00	340.85
	Count of Mn	3	3	6
Isabella	Average of Mn	103.89	343.57	223.73
	Count of Mn	3	3	6
LLCroix	Average of Mn	109.39	162.67	136.03
	Count of Mn	3	3	6
Saganaga	Average of Mn	199.34	243.07	221.21
	Count of Mn	3	3	6
Trap	Average of Mn	97.63	281.37	189.50
	Count of Mn	3	3	6
Trout	Average of Mn	137.92	160.58	149.25
	Count of Mn	3	3	6
Total Average of Mn		123.81	296.38	210.09
Total Count of Mn		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Na	31.84	29.34	26.38	28.54
	Count of Na	5	12	12	29
Isabella	Average of Na	25.36	26.08	21.68	24.18
	Count of Na	6	12	12	30
LLCroix	Average of Na	34.60	45.40	33.33	38.68
	Count of Na	4	12	12	28
Saganaga	Average of Na	37.12	25.80	24.86	27.69
	Count of Na	6	12	12	30
Trap	Average of Na	30.76	22.57	23.62	24.41
	Count of Na	5	12	12	29
Trout	Average of Na	34.12	34.04	25.53	30.65
	Count of Na	6	12	12	30
Total Average of Na		32.22	30.54	25.90	28.95
Total Count of Na		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Na	24.49	16.18	15.41	17.97
	Count of Na	2	3	3	8
Isabella	Average of Na	28.04	13.21	15.84	17.90
	Count of Na	2	3	3	8
LLCroix	Average of Na	27.55	35.88	22.17	28.65
	Count of Na	2	3	3	8
Saganaga	Average of Na	25.49	15.96	16.96	18.72
	Count of Na	2	3	3	8
Trap	Average of Na	36.35	17.36	17.74	22.25
	Count of Na	2	3	3	8
Trout	Average of Na	31.52	29.83	20.70	26.83
	Count of Na	2	3	3	8
Total Average of Na		28.91	21.40	18.14	22.05
Total Count of Na		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Na	38.79	46.17	43.09	43.17
	Count of Na	2	3	3	8
Isabella	Average of Na	25.38	41.83	20.21	29.61
	Count of Na	2	3	3	8
LLCroix	Average of Na	50.36	76.53	45.91	59.67
	Count of Na	1	3	3	7
Saganaga	Average of Na	45.29	31.71	33.69	35.85
	Count of Na	2	3	3	8
Trap	Average of Na	26.08	31.89	30.50	30.46
	Count of Na	1	3	3	7
Trout	Average of Na	38.34	45.59	32.06	38.70
	Count of Na	2	3	3	8
Total Average of Na		37.20	45.62	34.24	39.34
Total Count of Na		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Na	32.62	25.95	23.53	25.87
	Count of Na	1	3	3	7
Isabella	Average of Na	22.67	21.63	25.97	23.52
	Count of Na	2	3	3	8
LLCroix	Average of Na	32.95	31.10	34.10	32.65
	Count of Na	1	3	3	7
Saganaga	Average of Na	40.57	29.63	24.94	30.61
	Count of Na	2	3	3	8
Trap	Average of Na	27.50	20.35	21.26	22.48
	Count of Na	2	3	3	8
Trout	Average of Na	32.51	27.32	24.01	27.37
	Count of Na	2	3	3	8
Total Average of Na		31.21	26.00	25.63	26.99
Total Count of Na		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Na	29.04	23.47	26.26
	Count of Na	3	3	6
Isabella	Average of Na	27.64	24.70	26.17
	Count of Na	3	3	6
LLCroix	Average of Na	38.10	31.14	34.62
	Count of Na	3	3	6
Saganaga	Average of Na	25.91	23.84	24.88
	Count of Na	3	3	6
Trap	Average of Na	20.66	24.99	22.83
	Count of Na	3	3	6
Trout	Average of Na	33.45	25.34	29.39
	Count of Na	3	3	6
Total Average of Na		29.13	25.58	27.36
Total Count of Na		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ni	0.97	1.19	1.13	1.12
	Count of Ni	5	12	9	26
Isabella	Average of Ni	1.00	1.17	1.04	1.09
	Count of Ni	6	12	9	27
LLCroix	Average of Ni	0.96	1.42	1.22	1.27
	Count of Ni	4	12	12	28
Saganaga	Average of Ni	1.07	1.17	1.27	1.18
	Count of Ni	6	12	9	27
Trap	Average of Ni	0.88	1.03	1.22	1.08
	Count of Ni	5	12	12	29
Trout	Average of Ni	1.08	1.27	1.10	1.16
	Count of Ni	6	12	12	30
Total Average of Ni		1.00	1.21	1.17	1.15
Total Count of Ni		32	72	63	167

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ni	0.67	0.51		0.57
	Count of Ni	2	3		5
Isabella	Average of Ni	0.57	0.43		0.49
	Count of Ni	2	3		5
LLCroix	Average of Ni	0.57	0.75	0.46	0.60
	Count of Ni	2	3	3	8
Saganaga	Average of Ni	0.56	0.53		0.54
	Count of Ni	2	3		5
Trap	Average of Ni	0.60	0.56	0.53	0.56
	Count of Ni	2	3	3	8
Trout	Average of Ni	0.61	0.62	0.54	0.59
	Count of Ni	2	3	3	8
Total Average of Ni		0.60	0.57	0.51	0.56
Total Count of Ni		12	18	9	39

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ni	0.94	1.19	1.57	1.27
	Count of Ni	2	3	3	8
Isabella	Average of Ni	0.78	1.57	0.55	0.99
	Count of Ni	2	3	3	8
LLCroix	Average of Ni	1.16	1.58	1.18	1.35
	Count of Ni	1	3	3	7
Saganaga	Average of Ni	1.09	0.88	1.34	1.10
	Count of Ni	2	3	3	8
Trap	Average of Ni	0.70	0.85	2.29	1.44
	Count of Ni	1	3	3	7
Trout	Average of Ni	0.96	1.07	1.01	1.02
	Count of Ni	2	3	3	8
Total Average of Ni		0.94	1.19	1.32	1.19
Total Count of Ni		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Ni	1.63	1.45	1.01	1.29
	Count of Ni	1	3	3	7
Isabella	Average of Ni	1.66	1.01	1.27	1.27
	Count of Ni	2	3	3	8
LLCroix	Average of Ni	1.57	1.59	1.35	1.48
	Count of Ni	1	3	3	7
Saganaga	Average of Ni	1.56	1.73	1.20	1.49
	Count of Ni	2	3	3	8
Trap	Average of Ni	1.26	1.28	0.96	1.16
	Count of Ni	2	3	3	8
Trout	Average of Ni	1.66	1.42	1.22	1.40
	Count of Ni	2	3	3	8
Total Average of Ni		1.55	1.42	1.17	1.35
Total Count of Ni		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Ni	1.59	0.81	1.20
	Count of Ni	3	3	6
Isabella	Average of Ni	1.66	1.30	1.48
	Count of Ni	3	3	6
LLCroix	Average of Ni	1.76	1.89	1.82
	Count of Ni	3	3	6
Saganaga	Average of Ni	1.55	1.27	1.41
	Count of Ni	3	3	6
Trap	Average of Ni	1.43	1.11	1.27
	Count of Ni	3	3	6
Trout	Average of Ni	1.98	1.63	1.80
	Count of Ni	3	3	6
Total Average of Ni		1.66	1.33	1.50
Total Count of Ni		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of P	475.74	634.02	839.29	691.67
	Count of P	5	12	12	29
Isabella	Average of P	428.30	660.30	818.46	677.16
	Count of P	6	12	12	30
LLCroix	Average of P	631.72	739.57	973.53	824.43
	Count of P	4	12	12	28
Saganaga	Average of P	545.81	731.96	711.35	686.49
	Count of P	6	12	12	30
Trap	Average of P	703.29	810.99	1151.75	933.42
	Count of P	5	12	12	29
Trout	Average of P	577.94	709.58	732.87	692.57
	Count of P	6	12	12	30
Total Average of P		554.20	714.40	871.21	749.42
Total Count of P		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of P	367.12	326.86	463.00	387.98
	Count of P	2	3	3	8
Isabella	Average of P	335.17	503.67	293.97	382.91
	Count of P	2	3	3	8
LLCroix	Average of P	497.27	294.02	538.97	436.69
	Count of P	2	3	3	8
Saganaga	Average of P	392.16	541.39	448.00	469.06
	Count of P	2	3	3	8
Trap	Average of P	770.34	545.31	890.50	731.01
	Count of P	2	3	3	8
Trout	Average of P	638.99	382.75	652.10	547.82
	Count of P	2	3	3	8
Total Average of P		500.17	432.33	547.76	492.58
Total Count of P		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of P	481.91	499.41	516.67	501.51
	Count of P	2	3	3	8
Isabella	Average of P	398.08	559.73	639.33	549.17
	Count of P	2	3	3	8
LLCroix	Average of P	603.12	699.93	639.67	660.27
	Count of P	1	3	3	7
Saganaga	Average of P	520.82	589.21	625.90	585.87
	Count of P	2	3	3	8
Trap	Average of P	534.07	553.76	858.28	681.46
	Count of P	1	3	3	7
Trout	Average of P	383.17	528.11	765.27	580.81
	Count of P	2	3	3	8
Total Average of P		470.52	571.69	674.19	589.80
Total Count of P		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of P	680.64	711.60	799.50	744.85
	Count of P	1	3	3	7
Isabella	Average of P	551.66	682.56	890.53	727.82
	Count of P	2	3	3	8
LLCroix	Average of P	929.22	732.52	1040.17	892.47
	Count of P	1	3	3	7
Saganaga	Average of P	724.44	647.52	697.83	685.62
	Count of P	2	3	3	8
Trap	Average of P	720.85	705.17	885.03	776.54
	Count of P	2	3	3	8
Trout	Average of P	711.65	641.15	568.95	631.70
	Count of P	2	3	3	8
Total Average of P		702.70	686.75	813.67	739.88
Total Count of P		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of P	998.20	1578.00	1288.10
	Count of P	3	3	6
Isabella	Average of P	895.22	1450.00	1172.61
	Count of P	3	3	6
LLCroix	Average of P	1231.80	1675.33	1453.57
	Count of P	3	3	6
Saganaga	Average of P	1149.73	1073.67	1111.70
	Count of P	3	3	6
Trap	Average of P	1439.73	1973.17	1706.45
	Count of P	3	3	6
Trout	Average of P	1286.30	945.17	1115.73
	Count of P	3	3	6
Total Average of P		1166.83	1449.22	1308.03
Total Count of P		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Pb	5.79	8.82	6.70	7.50
	Count of Pb	5	12	9	26
Isabella	Average of Pb	11.52	11.89	10.19	11.37
	Count of Pb	6	12	6	24
LLCroix	Average of Pb	7.06	8.31	5.86	7.23
	Count of Pb	4	12	9	25
Saganaga	Average of Pb	8.39	10.38	7.53	8.99
	Count of Pb	6	12	9	27
Trap	Average of Pb	8.74	11.22	8.93	9.95
	Count of Pb	5	12	9	26
Trout	Average of Pb	7.75	7.82	6.49	7.36
	Count of Pb	6	12	9	27
Total Average of Pb		8.34	9.74	7.47	8.70
Total Count of Pb		32	72	51	155

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Pb	1.54	2.05		1.85
	Count of Pb	2	3		5
Isabella	Average of Pb	1.56	1.74		1.67
	Count of Pb	2	3		5
LLCroix	Average of Pb	1.08	2.87		2.15
	Count of Pb	2	3		5
Saganaga	Average of Pb	2.18	2.21		2.20
	Count of Pb	2	3		5
Trap	Average of Pb	1.22	2.23		1.82
	Count of Pb	2	3		5
Trout	Average of Pb	0.96	1.72		1.41
	Count of Pb	2	3		5
Total Average of Pb		1.42	2.14		1.85
Total Count of Pb		12	18		30

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Pb	4.87	4.80	2.81	4.07
	Count of Pb	2	3	3	8
Isabella	Average of Pb	6.06	10.13		8.50
	Count of Pb	2	3		5
LLCroix	Average of Pb	5.29	5.58	2.98	4.42
	Count of Pb	1	3	3	7
Saganaga	Average of Pb	4.97	4.40	2.63	3.88
	Count of Pb	2	3	3	8
Trap	Average of Pb	4.41	3.98	3.34	3.76
	Count of Pb	1	3	3	7
Trout	Average of Pb	6.51	4.74	2.13	4.20
	Count of Pb	2	3	3	8
Total Average of Pb		5.45	5.61	2.78	4.58
Total Count of Pb		10	18	15	43

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Pb	16.11	13.63	9.39	12.17
	Count of Pb	1	3	3	7
Isabella	Average of Pb	26.94	16.14	8.91	16.13
	Count of Pb	2	3	3	8
LLCroix	Average of Pb	20.80	11.49	5.82	10.39
	Count of Pb	1	3	3	7
Saganaga	Average of Pb	18.02	18.01	9.77	14.92
	Count of Pb	2	3	3	8
Trap	Average of Pb	18.44	15.14	9.74	13.94
	Count of Pb	2	3	3	8
Trout	Average of Pb	15.78	9.35	7.07	10.10
	Count of Pb	2	3	3	8
Total Average of Pb		19.52	13.96	8.45	13.01
Total Count of Pb		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Pb	14.79	7.91	11.35
	Count of Pb	3	3	6
Isabella	Average of Pb	19.53	11.48	15.50
	Count of Pb	3	3	6
LLCroix	Average of Pb	13.30	8.78	11.04
	Count of Pb	3	3	6
Saganaga	Average of Pb	16.89	10.18	13.53
	Count of Pb	3	3	6
Trap	Average of Pb	23.55	13.72	18.63
	Count of Pb	3	3	6
Trout	Average of Pb	15.46	10.28	12.87
	Count of Pb	3	3	6
Total Average of Pb		17.25	10.39	13.82
Total Count of Pb		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of S	845.50	878.17	872.50	870.19
	Count of S	5	12	12	29
Isabella	Average of S	759.17	845.67	749.44	789.88
	Count of S	6	12	12	30
LLCroix	Average of S	831.88	925.92	1092.22	983.76
	Count of S	4	12	12	28
Saganaga	Average of S	838.33	858.00	960.56	895.09
	Count of S	6	12	12	30
Trap	Average of S	756.00	852.67	928.33	867.31
	Count of S	5	12	12	29
Trout	Average of S	860.00	998.75	1007.08	974.33
	Count of S	6	12	12	30
Total Average of S		815.00	893.19	935.02	896.09
Total Count of S		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of S	435.00	277.33	413.33	367.75
	Count of S	2	3	3	8
Isabella	Average of S	470.00	359.00	390.00	398.38
	Count of S	2	3	3	8
LLCroix	Average of S	461.25	409.33	482.22	449.65
	Count of S	2	3	3	8
Saganaga	Average of S	460.00	372.67	501.67	442.88
	Count of S	2	3	3	8
Trap	Average of S	512.50	466.33	666.67	553.00
	Count of S	2	3	3	8
Trout	Average of S	490.00	794.00	520.00	615.25
	Count of S	2	3	3	8
Total Average of S		471.46	446.44	495.65	471.15
Total Count of S		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of S	1221.25	1146.67	1180.00	1177.81
	Count of S	2	3	3	8
Isabella	Average of S	1005.00	1273.33	753.33	1011.25
	Count of S	2	3	3	8
LLCroix	Average of S	1372.50	1143.33	1400.00	1286.07
	Count of S	1	3	3	7
Saganaga	Average of S	1041.25	1104.00	1216.67	1130.56
	Count of S	2	3	3	8
Trap	Average of S	947.50	990.33	980.00	979.79
	Count of S	1	3	3	7
Trout	Average of S	1028.75	1173.33	1315.00	1190.31
	Count of S	2	3	3	8
Total Average of S		1091.25	1138.50	1140.83	1129.14
Total Count of S		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of S	915.00	942.00	790.00	873.00
	Count of S	1	3	3	7
Isabella	Average of S	802.50	751.67	813.33	787.50
	Count of S	2	3	3	8
LLCroix	Average of S	1032.50	934.33	963.33	960.79
	Count of S	1	3	3	7
Saganaga	Average of S	1013.75	875.33	986.67	951.69
	Count of S	2	3	3	8
Trap	Average of S	903.75	922.33	785.00	866.19
	Count of S	2	3	3	8
Trout	Average of S	1061.25	966.00	900.00	965.06
	Count of S	2	3	3	8
Total Average of S		951.00	898.61	873.06	900.00
Total Count of S		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of S	1146.67	1106.67	1126.67
	Count of S	3	3	6
Isabella	Average of S	998.67	1041.11	1019.89
	Count of S	3	3	6
LLCroix	Average of S	1216.67	1523.33	1370.00
	Count of S	3	3	6
Saganaga	Average of S	1080.00	1137.22	1108.61
	Count of S	3	3	6
Trap	Average of S	1031.67	1281.67	1156.67
	Count of S	3	3	6
Trout	Average of S	1061.67	1293.33	1177.50
	Count of S	3	3	6
Total Average of S		1089.22	1230.56	1159.89
Total Count of S		18	18	36

Species	(All)

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Zn	30.57	49.53	52.34	47.42
	Count of Zn	5	12	12	29
Isabella	Average of Zn	39.16	54.18	57.02	52.31
	Count of Zn	6	12	12	30
LLCroix	Average of Zn	25.36	49.05	46.79	44.70
	Count of Zn	4	12	12	28
Saganaga	Average of Zn	34.72	51.81	48.60	47.11
	Count of Zn	6	12	12	30
Trap	Average of Zn	50.26	60.55	72.71	63.81
	Count of Zn	5	12	12	29
Trout	Average of Zn	32.66	54.55	49.12	48.00
	Count of Zn	6	12	12	30
Total Average of Zn		35.78	53.28	54.43	50.57
Total Count of Zn		32	72	72	176

Species	CLRA

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Zn	14.20	14.41	15.94	14.93
	Count of Zn	2	3	3	8
Isabella	Average of Zn	16.60	18.60	9.33	14.63
	Count of Zn	2	3	3	8
LLCroix	Average of Zn	12.54	11.37	16.91	13.74
	Count of Zn	2	3	3	8
Saganaga	Average of Zn	13.69	14.69	16.04	14.95
	Count of Zn	2	3	3	8
Trap	Average of Zn	20.19	20.88	23.39	21.65
	Count of Zn	2	3	3	8
Trout	Average of Zn	16.74	29.40	18.37	22.10
	Count of Zn	2	3	3	8
Total Average of Zn		15.66	18.23	16.66	17.00
Total Count of Zn		12	18	18	48

Species	EVME

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Zn	30.12	37.45	28.93	32.42
	Count of Zn	2	3	3	8
Isabella	Average of Zn	32.62	38.88	31.63	34.60
	Count of Zn	2	3	3	8
LLCroix	Average of Zn	29.04	39.01	31.45	34.34
	Count of Zn	1	3	3	7
Saganaga	Average of Zn	27.44	35.67	28.72	31.01
	Count of Zn	2	3	3	8
Trap	Average of Zn	34.09	38.83	45.13	40.85
	Count of Zn	1	3	3	7
Trout	Average of Zn	24.25	33.95	34.79	31.84
	Count of Zn	2	3	3	8
Total Average of Zn		29.20	37.30	33.44	34.03
Total Count of Zn		10	18	18	46

Species	HYPH

		Year			
Locality	Data	86	92	97	Grand Total
Basswood	Average of Zn	64.22	69.00	59.63	64.30
	Count of Zn	1	3	3	7
Isabella	Average of Zn	68.27	72.53	91.68	78.65
	Count of Zn	2	3	3	8
LLCroix	Average of Zn	47.33	72.23	63.07	64.75
	Count of Zn	1	3	3	7
Saganaga	Average of Zn	63.03	71.73	62.59	66.13
	Count of Zn	2	3	3	8
Trap	Average of Zn	88.42	74.87	90.41	84.08
	Count of Zn	2	3	3	8
Trout	Average of Zn	57.00	71.78	56.29	62.28
	Count of Zn	2	3	3	8
Total Average of Zn		66.50	72.02	70.61	70.27
Total Count of Zn		10	18	18	46

Species	PASU

		Year		
Locality	Data	92	97	Grand Total
Basswood	Average of Zn	77.25	104.87	91.06
	Count of Zn	3	3	6
Isabella	Average of Zn	86.72	95.44	91.08
	Count of Zn	3	3	6
LLCroix	Average of Zn	73.58	75.74	74.66
	Count of Zn	3	3	6
Saganaga	Average of Zn	85.15	87.04	86.10
	Count of Zn	3	3	6
Trap	Average of Zn	107.63	131.92	119.77
	Count of Zn	3	3	6
Trout	Average of Zn	83.08	87.04	85.06
	Count of Zn	3	3	6
Total Average of Zn		85.57	97.01	91.29
Total Count of Zn		18	18	36