

ANNUAL REPORT ON VITAL SIGNS MONITORING OF SHALLOW LAKES IN
YUKON-CHARLEY RIVERS NATIONAL PRESERVE

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Key Words

INTRODUCTION

This report reviews three years of pilot monitoring data collected in Yukon-Charley Rivers National Preserve from 2003-2005. The impetus of the pilot study was to determine the feasibility of monitoring shallow lakes in remote regions of the Parks, identify protocols that would capture the natural variability of these systems, and to identify methods and analyses that would maximize sampling efficiency and minimize expenditures.

Measurable Objectives`

The Shallow Lake and Pond Limnology Monitoring Protocol of the CAKN Vital Signs monitoring program has four objectives.

1. Detect decadal-scale trends in the area, distribution, and number of shallow lakes and ponds in Central Alaska Network Parks.
2. Detect decadal-scale trends in the water quality of shallow lakes and ponds in Central Alaska Network Parks.
3. Detect decadal-scale trends in the structure and composition of vegetation in shallow lakes and ponds in Central Alaska Network Parks.
4. Detect decadal-scale trends in macroinvertebrate taxa richness and relative abundance in shallow lakes and ponds in Central Alaska Network Parks.

METHODS AND MATERIALS

The methods presented in the shallow lake monitoring protocols were developed by the Central Alaska Network in 2004 in cooperation with Hart Crowser Inc. The protocols that resulted were modified from pilot work conducted in 2003 and 2004 and contained a variety of untested methods. In 2005 we attempted to collect data according to these protocols. In this document we present a summary of the data collected in this pilot work and discuss the protocols that worked well and identify procedures that need further research and development.

The shallow lake monitoring program has chosen to monitor the physical and chemical attributes of shallow lakes as well as the plants and macroinvertebrates. This will allow us to detect changes in the physical and chemical habitat of the lake ecosystem and track any corresponding changes in macroinvertebrate populations and vegetation. This detailed evaluation of lake ecosystems has required a complex array of methodologies to satisfactorily monitor each ecosystem component. As a result there are a large number of standard operating procedures that must be followed to complete this project. To reduce the complexity of monitoring we have tried to select simple methodologies that require relatively limited personnel training. Despite our valiant efforts to simplify the process is

still quite complex. There are 29 SOP's ranging from data entry and analysis to sample collection. The status of the SOP's varies greatly (Table 1.) Many of the SOP's have been field tested and approved while others still need to be developed or modified to meet the logistic challenges of the project.

There are four major aspects to this project that correspond to the four objectives:

1. Monitoring the water quantity
 - a. Surface area
 - b. Distribution
 - c. Number
 - d. Water level
2. Monitoring the physical and chemical attributes of lakes
 - a. Core parameters
 - b. Trophic state: chla, TN, TP
 - c. Alkalinity, hardness, DOC, water color
3. Monitoring the macroinvertebrate populations in lakes
 - a. Composition
 - b. Relative abundance
4. Monitoring the vegetation of the littoral zone in lakes
 - a. Composition
 - b. Relative abundance

Each of these objectives has a selection of associated SOP's

Table 1. Status of shallow lake and pond monitoring protocols.

Protocol	Status: brief description of modification to be made
Field Season Preparation	Minor changes that result from changes in other protocols
Delineation of Study Region	Expand study region in Denali to encompass majority of lakes
Acquisition of Recent Imagery	Modify proposal from NASA to include additional coverage
Image Rectification	None
Delineation of Shallow Lakes	None
Locating Hot Spots of Lake Change	None
Sampling Frame and Lake Selection	None
Continuous Lake Monitoring	Minor modifications (completed)
Training Personnel	None
Field Trip Mobilization	Minor changes that result from changes in other protocols
Daily Field Startup	Minor changes that result from changes in other protocols
Using the Trimble GPS	None
Installing Benchmark and Establishing Sampling Transect	None
Relocating Lake and Sampling Locations	None
Photo-documentation	None
Water Level Determination	None
Water Chemistry Field Data and Sample Collection	Minor modifications to be completed spring 2006: increase number of samples taken per lake
Vegetation Field Sampling	Major modifications to be completed spring 2006: protocol tested in 2005 too cumbersome and time consuming
Aquatic Invertebrate Field Sampling	Minor modifications to be completed spring 2006: remove use of permanent transects to minimize site impacts
Preserving Plant Samples	None
Field Processing of Water Chemistry Samples	None
Field Trip Demobilization	Minor changes that result from changes in other protocols
Macroinvertebrate Processing and Identification	None
Data Management	Minor changes to be completed spring 2006: file names have changed slightly
Data Analysis	TO BE DEVELOPED
Reporting	TO BE DEVELOPED
After the Field Season	Minor changes that result from changes in other protocols
Revising the Protocol	None
QA/QC	TO BE DEVELOPED

Water Quantity Monitoring

Remote Sensing Techniques

The methodologies established for monitoring lake surface area, size, number and distribution have been well articulated in the SOP's (2-6). Only two minor changes to these SOP's are expected in 2006. The first change is to expand the study region in DENA to capture a larger number of lakes. We expect this will result in the acquisition of 5 additional RADARSAT frames. To accomplish this we will need to submit a proposal to NASA to acquire the additional frames. The proposal will be submitted in 2006. The second protocol change requires identifying an index time period when estimates of water quantity are made annually. This modification will be reflected in the 2006 protocols.

In 2005 we captured our first images using remote sensing techniques described in the SOP's. Radarsat data from April through September 2005 were acquired for the Michumina Basin area of Denali (DENA) and the Copper River Basin of Wrangell St. Elias (WRST) National Park and Preserve (Table 2). In addition to Radarsat images we captured a series of Landsat images to compare to the Radarsat images to determine if this would be a more useful platform for monitoring.

Table 2. Radarsat acquisitions from 2005 growing season.

DENA		WRST	
Date / Time	Radarsat Frame#	Date / Time	Radarsat Frame#
8-April2005 16:33	290	16April2005 16:00	295
15April2005 16:29	290	21April2005 03:13	155
27April2005 03:38	160	10May2005 16:00	295
2May2005 16:33	290	15May2005 03:12	155
9May2005 16:29	290	3June2005 16:00	295
21May2005 03:38	290	8June2005 03:13	155
26May2005 16:33	290	27June2005 16:00	295
2June2005 16:29	290	2July2005 03:12	155
7June2005 03:43	160	21July2005 16:00	295
14June2005 03:38	160	26July2005 03:12	155
19June2005 16:33	290	14August2005 16:00	295
26June2005 16:29	290	19August2005 03:12	155
1July2005 03:43	160		
8July2005 03:38	160	7Sept2005 16:00	295
13July2005 16:33	290	12Sept2005 03:12	155
20July2005 16:29	160	6Oct2005 16:00	155
25July2005 03:42	160		
1Aug2005 03:38	160		
6Aug2005 16:33	290		
13Aug2005 16:29	290		
18Aug2005 03:42	160		
25Aug2005 03:38	160		
30Aug2005 16:33	290		

6Sep2005 16:29	290		
11Sep2005 03:42	160		
18Sep2005 03:38	160		
23Sep2005 16:33	290		
30Sep2005 16:29	290		

Radarsat Fine Beam data were ordered thru the Alaska Satellite Facility (<http://www.asf.alaska.edu/>) as a data acquisition request for the period of April 1-September 30, 2005. Each data frame was 65mb in size and transferred via FTP. Each data frame was radiometrically calibrated using a conversion tool (Figure 5) provided by the Alaska Satellite Facility website. The conversion tool provides several options for processing each Radarsat image.

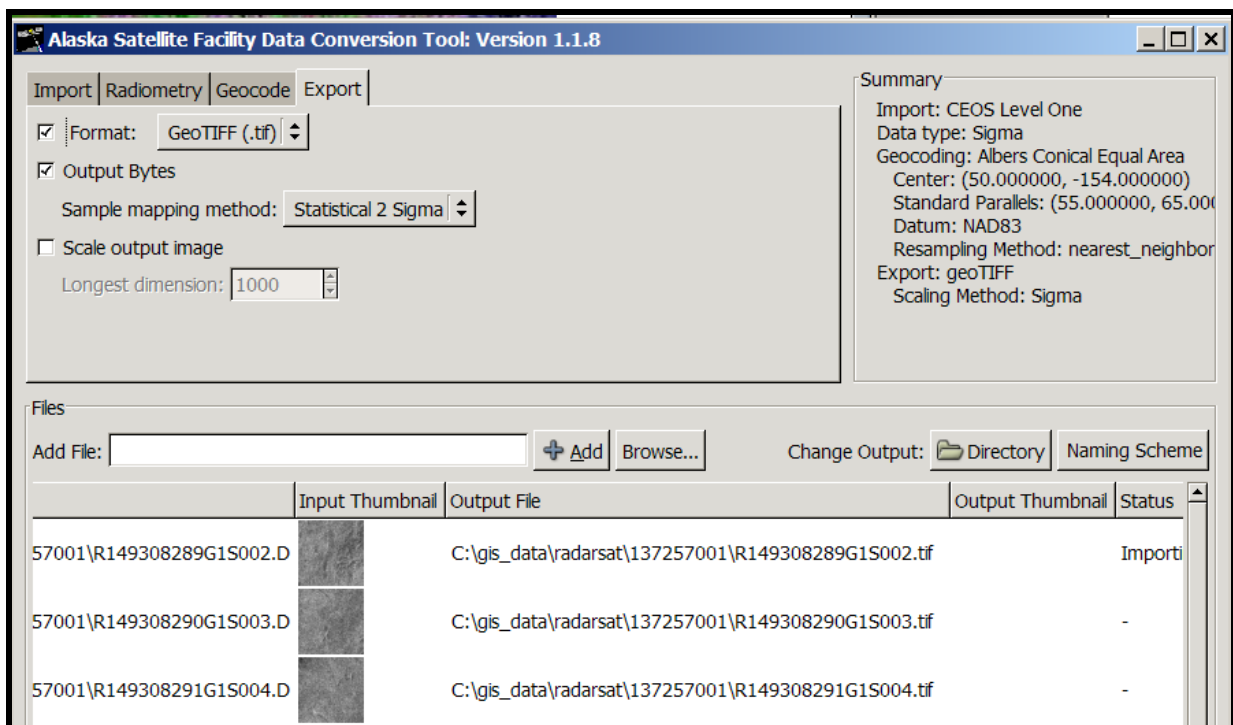


Figure 5. Data conversion tool provided by the Alaska Satellite Facility website for processing Radarsat images.

The resulting Geotiff file generated by the conversion process was approximately 90 mb in size. Each Geotiff image was 6.25 m pixels and covered a 50 km² area on the ground. The images can be displayed in most GIS packages, including ArcGIS and require subsequent georeferencing for image to image spatial alignment or image coregistration.

Synoptic Sampling

The only physical attribute we monitor during the field sampling is water level. This methodology has not been changed. In 2005 we decided to take bathymetric measurements along the longest and shortest axis of the lake to help estimate mean depth

and to identify the deepest portion of the lake for chemical sampling. We will modify SOP 17: Water Chemistry Field Data and Sample Collection to include bathymetric mapping.

Monitoring Physical and Chemical Attributes of Water

Synoptic lake monitoring

There are six protocols associated with monitoring the physical and chemical attributes of shallow lakes using synoptic sampling techniques (SOP: 8, 9, 10, 11, 17, 21, and 23). These include preparation, training personnel and collecting the samples. These protocols are relatively straight forward and are typically easily completed by properly trained technicians. The collection and treatment of water samples does require some important training to insure that the quality of the sample is maintained and or the sample is properly collected and analyzed. In the pilot effort we identified a few weaknesses in the protocols.

In our preliminary analysis we found that often several of the nutrient sample analyses were well below detection limits of the laboratory methods we were employing. Total phosphorus and nitrate-nitrite nitrogen were typically below detection limits. This is not unusual in Alaska; however, we expected that these productive wetland ecosystems would likely have higher nutrient concentrations than more oligotrophic systems commonly found here. This has required us to reevaluate the laboratory we are currently using. In 2006 we will be sending our nutrient samples to CCAL the analytical laboratory at Oregon State University in Corvallis, Oregon. CCAL is not an EPA certified laboratory but it has been approved by WRD for analyses in the Pacific Northwest and other Alaskan Parks.

A second problem we experienced with field protocols is collecting accurate field titrations for alkalinity and hardness. These titrations are simple colorimetric titrations with a weak acid. If properly trained field titrations are as accurate as lab titrations and are considerably less expensive. To test our effectiveness at field titrations we estimated alkalinity in the field and in the lab. We found (Figure 2) that when the principal investigator or a properly trained technician completes the titration we get very accurate results when an untrained technician completes the titration data quality is severely compromised. In 2006, we will continue collecting both field and lab alkalinity estimates to insure that we get good results. When we are consistently achieving a 95% accuracy ratio we plan to discontinue lab analysis.

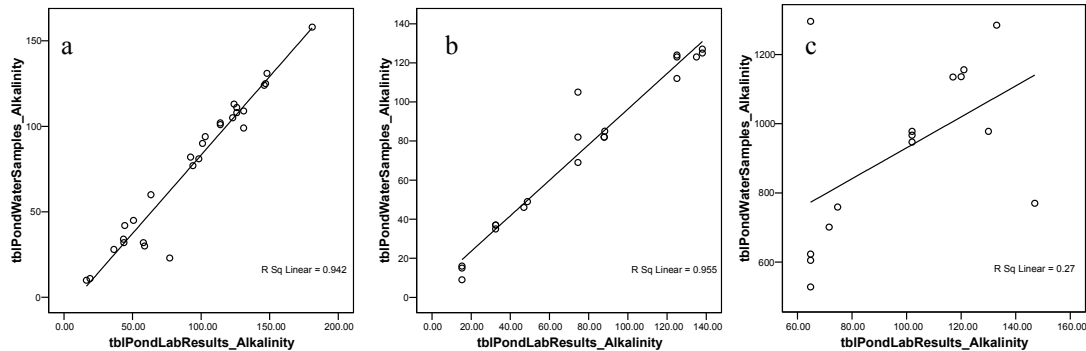


Figure 1. Comparison of alkalinity determined in the laboratory to alkalinity estimated by field titration completed by principal investigator (a), properly trained field technician (b) and non-trained technician (c).

The final change to be made to the water quality protocols is to increase the number of water samples collected at each lake from 1 to 3. Initially we decided to collect only one sample to reduce expenses but this doesn't provide us with an estimate of variation within the lake and it reduces our power to detect change in a single lake and limits the statistical analyses we can perform. This change was adopted in 2005 and will be reflected in the SOP's in 2006.

Continuous lake monitoring

There is one protocol associated with monitoring physical and chemical attributes of water using data sondes to collect continuous data on the four core water quality parameters (SOP: 8). This protocol was modified in 2005 prior to the field season.

In 2005 we deployed two experimental data sondes a YSI 6920 and a Hyrdolab 4a in lake 4 and lake 8 from early June to late July. The purpose of this experimental deployment was to assess the utility of the two different sondes, identify a sonde that would collect good quality data despite the remote setting, and determine if the sondes would provide useful data for shallow lake monitoring. Sondes were checked and calibrated on three occasions throughout this time period. Continuous data were collected on the four core water quality parameters (ph, DO, specific conductance and temperature).

In addition to data sondes we deployed a chain of HOBO temperature sensors through the water column. The sensors were set up to record temperature °C every 15 minutes. Five sensors were distributed through the water column of each lake.

Macroinvertebrate Monitoring

Macroinvertebrate sample collection requires the use of several SOP's (9, 10, 11, 19, 22, 23, and 27). Pilot sampling has identified only a couple problems thus far. The vegetation community surrounding many of the lakes appears to be quite sensitive to trampling. During the pilot study we frequently observed paths from previous years sampling events (Figure 3). The vegetation found in the floating mats surrounding the lake appears to flood easily and recover very slowly. As a response we reduced the number of macroinvertebrate transects to one and decided to eliminate the use of

permanent transects to reduce the impacts and create trails in these sensitive communities.

In 2005 we sought advice from the Environment and Natural Resources Institute (ENRI) at University of Alaska Anchorage regarding the identification and processing of our macroinvertebrate samples. They advised us to modify our identification procedure to include identification of the midges (chironomidae) to genus. We were identifying this group to subfamily. We adopted this strategy in 2005 field season and changes will be reflected in the 2006 protocols. In 2006 we intend to verify the accuracy of the lab we are currently using for macroinvertebrate identification. This will be accomplished by sending already processed taxa to ENRI for verification.



Figure 2. The vegetation that forms the floating mat surrounding shallow lakes is very sensitive to trampling. Here the effects can be seen a year after sampling. The transect tape bisects the transect line from the previous year.

Vegetation Monitoring

The most difficult protocol to carry out for this project is the SOP related to vegetation monitoring (18). This protocol was particularly troublesome because it involved installing a permanent transect over water. Due to wind and lack of a good anchoring device we were unable to collect good repeatable data in 2005 using these techniques. After several aborted efforts at completing the transects we reverted to methods employed in 2004 where we simply completed nested frequency and point intersect transects in the littoral zone. These methods are simple and easily carried out but do not garner any information regarding submersed vegetation. This protocol will be revised in spring 2006 and test implementation and protocol revision will take place in summer 2006.

Study Site

Pilot monitoring was conducted in Yukon-Charley Rivers National Preserve. Nineteen lakes distributed within the Yukon-River valley were sampled over a three year time period (Figure 3). All lakes were located within the Yukon River Valley ecological subsection (Swanson 1999). Although all lakes were within the same subsection the lake origins varied substantially. Lakes origins included thermokarst (depression formed by melting permafrost), periglacial frost thaw basins, old slough channels, depressional wetlands, and a variety of lakes formed by organic processes (beaver and vegetation dams) were also found.

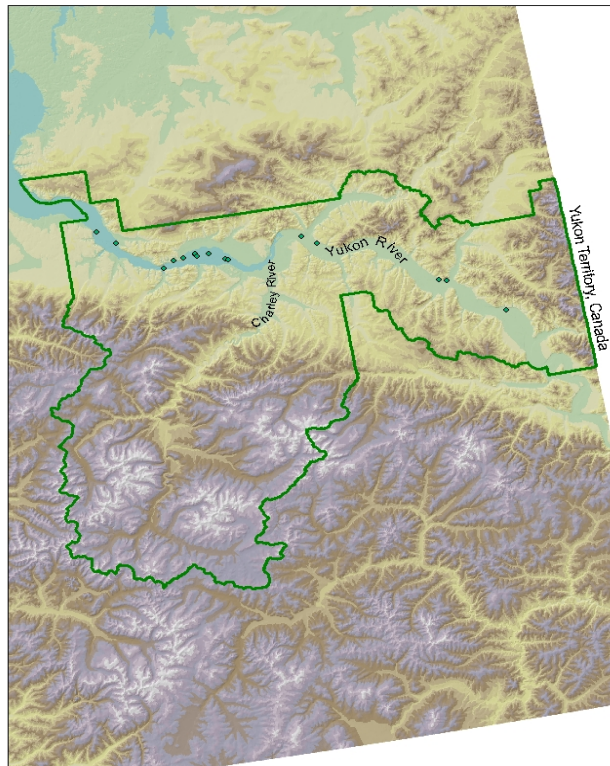


Figure 3. Ponds sampled along the Yukon River in Yukon-Charley Rivers National Preserve.

The sampling design of the pilot study has not followed that outlined in the 2004 protocols rather lakes were selected based on proximity to navigable water. The strategy was used to minimize logistic expenditures. Lakes were selected based on two modes of accessibility fixed wing aircraft or river access. Nine lakes were within walking distance (< 2.5 km) of the river and the remaining 10 were accessed via floatplane. Crew size varied between 2 and 3 persons depending on the season and means of access. We determined the optimal crew size to be three persons. This crew size was chosen for three major reasons 1) it reduces the sampling time required at each lake 2) each technician can be trained in one of the specialty areas (water quality, macroinvertebrates, and

vegetation) and 3) distributes the sampling gear and samples among crew members so each person is carrying a significantly lighter load decreasing the risk of crew injury.

Fire plays a pivotal role in the ecosystem dynamics in YUCH. Fire creates a diverse mosaic of vegetation in different successional stages, interacts with the depth of organic layer influencing the depth to permafrost and thaw layer, and alters water flow across the landscape. These processes directly and indirectly influence aquatic ecosystems. In 2004 several large fires occurred within the Preserve. One of the fires, Edwards Creek Fire (Figure 4), encompassed a large portion of Andrew Creek Flats the wetland complex where the vast majority of shallow lakes in Yukon-Charley occur. We sampled seven lakes within this burn in late summer approximately one week following the burn and twice in 2005 approximately 1 year after the burn.

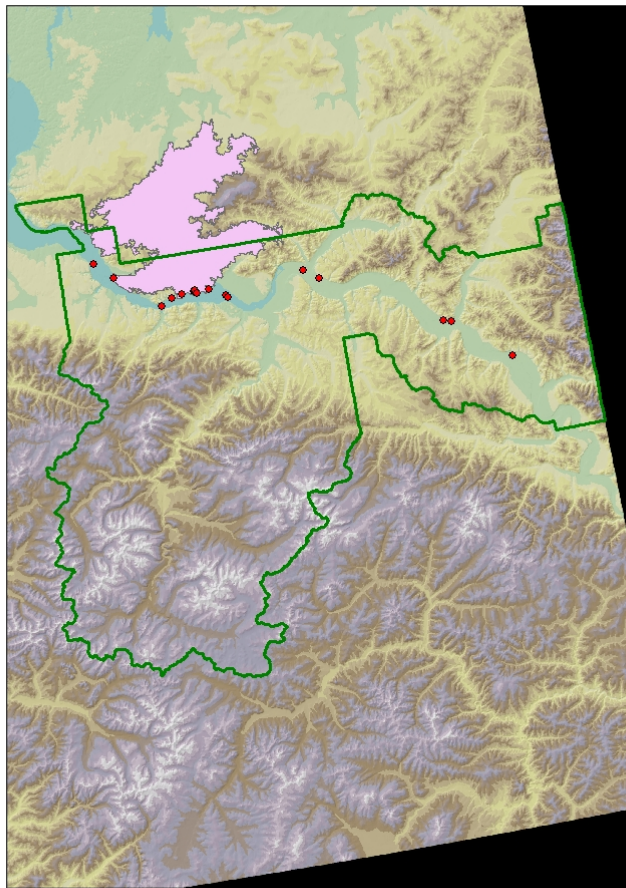


Figure 4. Seven lakes sampled in 2004 were within the Edwards Creek burn perimeter.

RESULTS

Water Quantity

Remote Sensing

Radarsat images collected in 2005 (Figure 6) illustrate fluctuating water levels. No estimates of water quantity have yet been made on these images. Landsat images collected in 2005 (Figure 7) show interference due to cloud cover not encountered in Radarsat images.

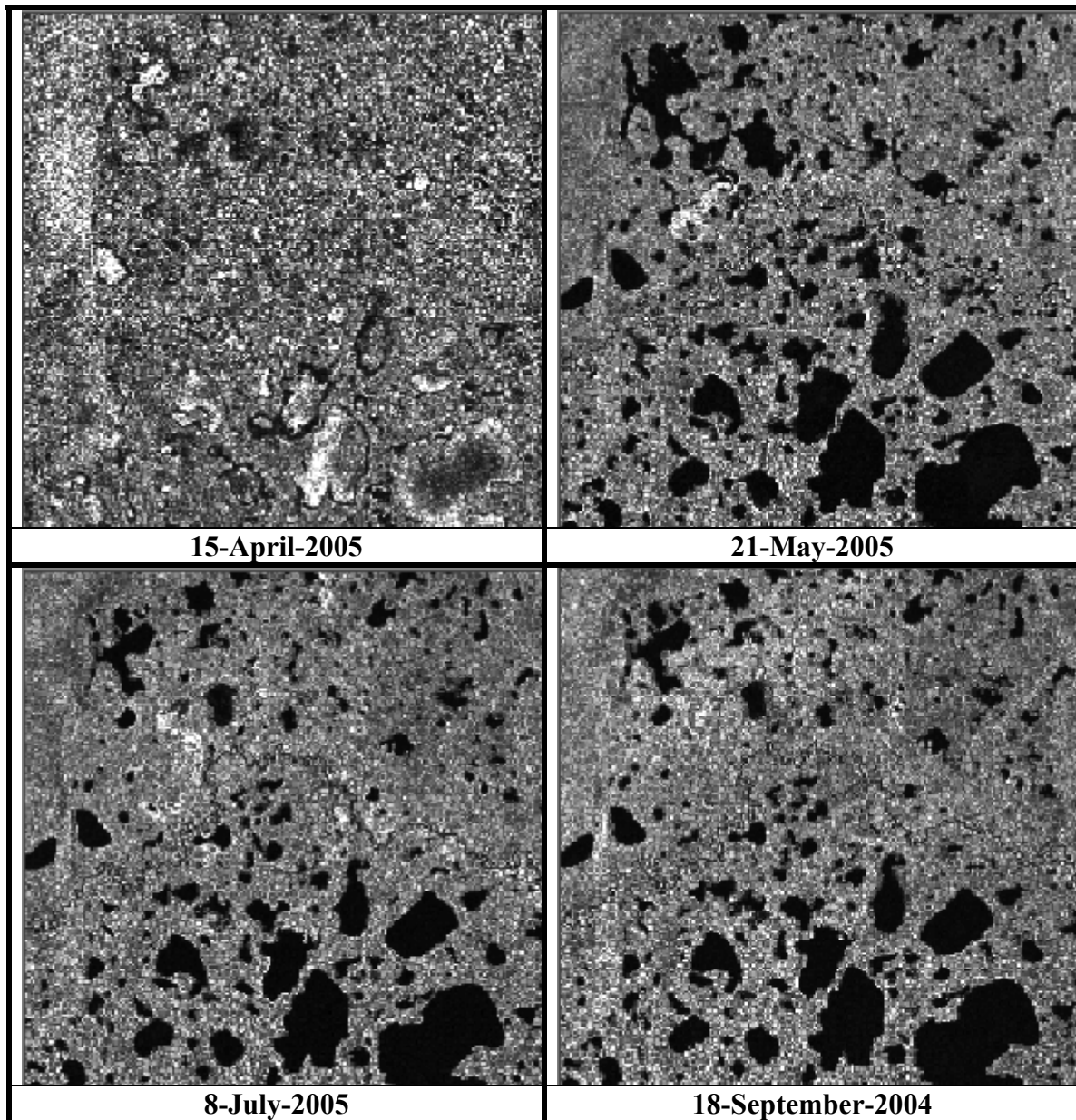


Figure 6. Example of fine beam Radarsat imagery from the Michumina Basin area, Denali National Park and Preserve.

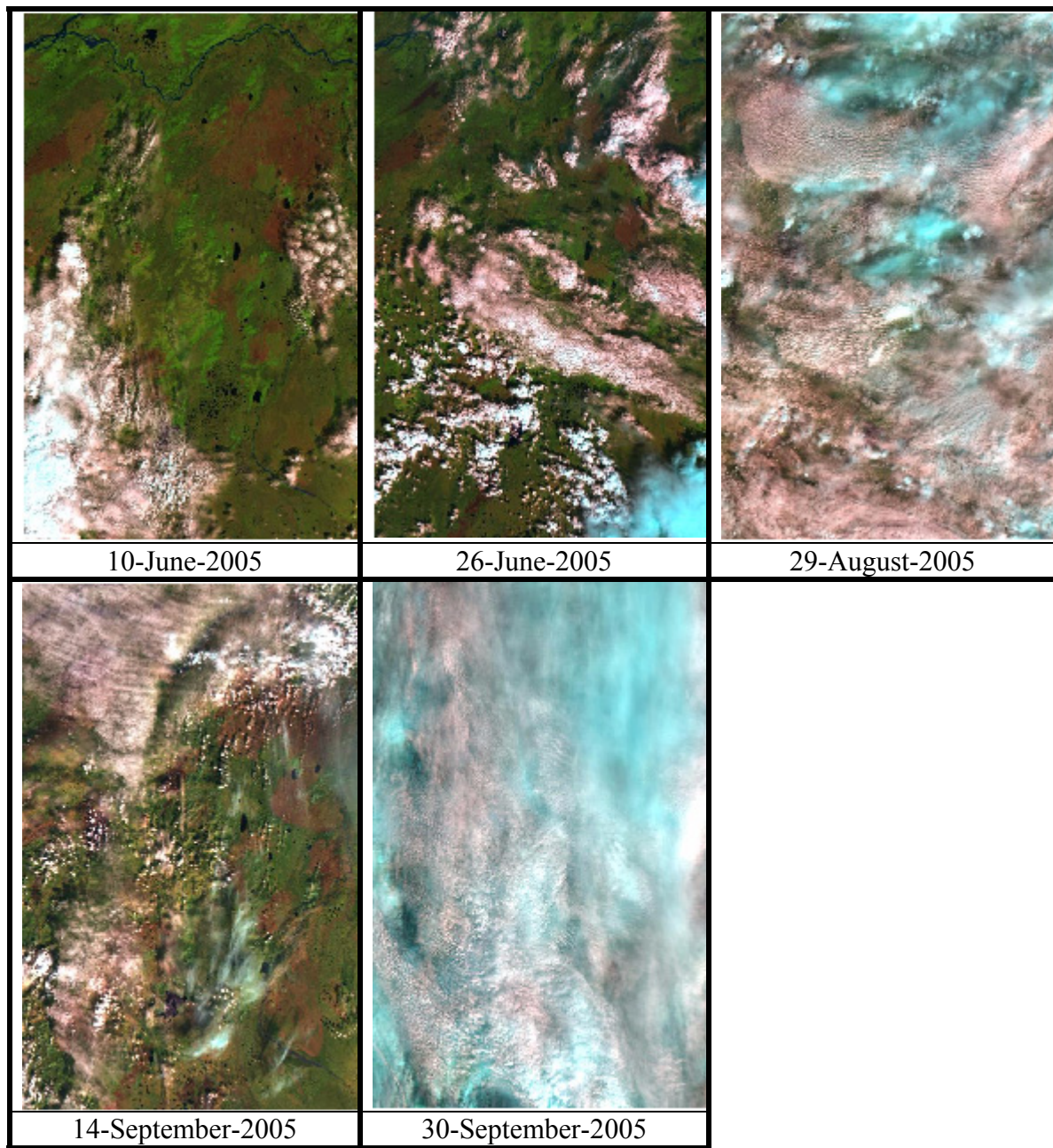


Figure 7. Available Landsat TM scenes from Michumina Basin, summer 2005.

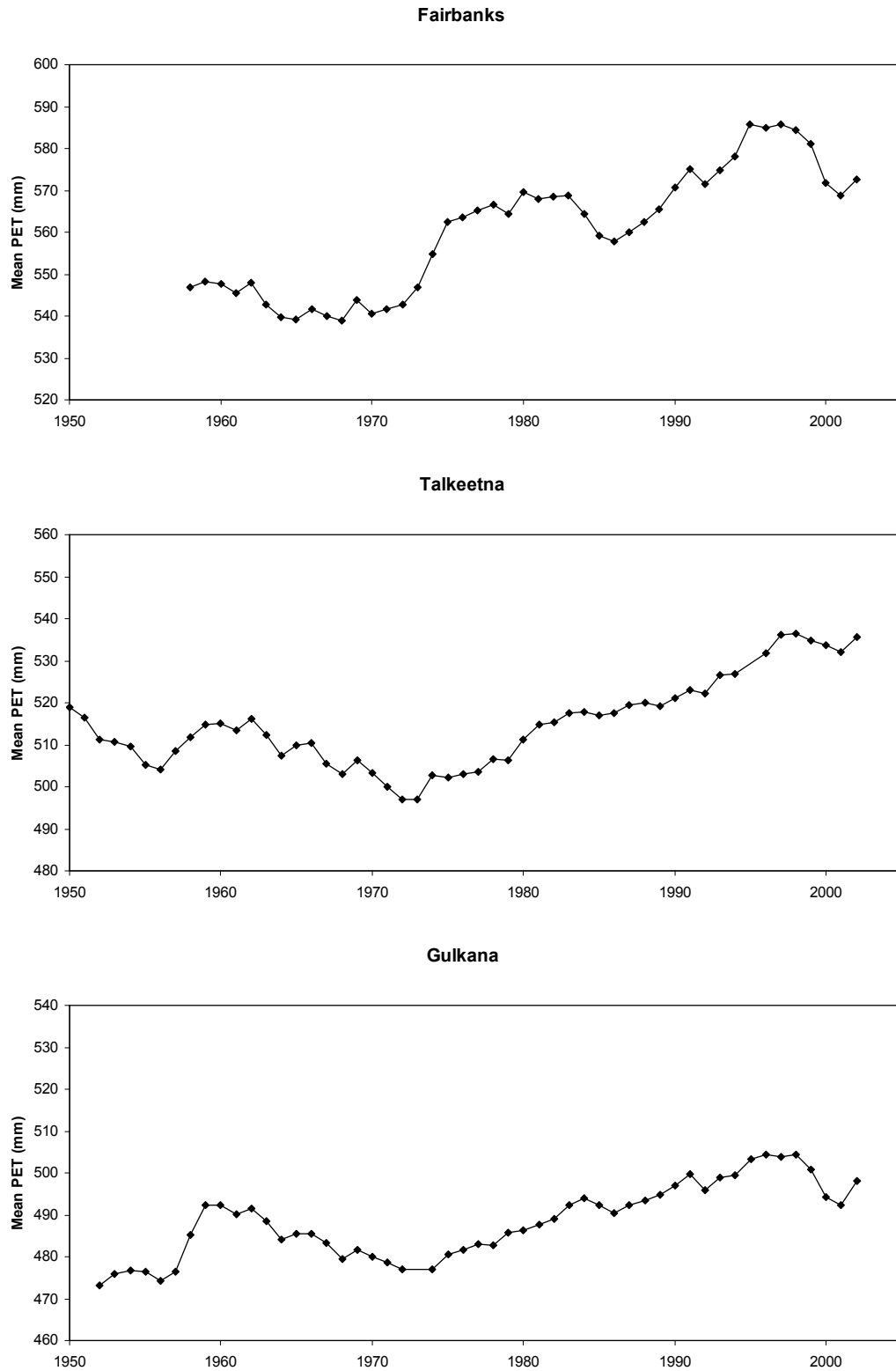


Figure 8. 10-year running means of potential evapotranspiration (PET) from Fairbanks, Talkeetna, and Gulkana first-order weather stations.

Synoptic Sampling

Water level measurements were taken in 2005 for the first time so we have no comparative data to present however; photographs taken over the past three years (prior to implementing water level measurements) indicate that water levels fluctuate considerably from year to year and that all lakes are not responding uniformly. Lake 2 demonstrated a steady decline in water level between 2003 and 2005 whereas a two year drawdown in Lake 8 was followed by a high water year (Figure 9). We also observed a single catastrophic draining of a lake in YUCH in 2003 and were informed by a Circle resident about a draining that occurred in 2000 (Figure 10).

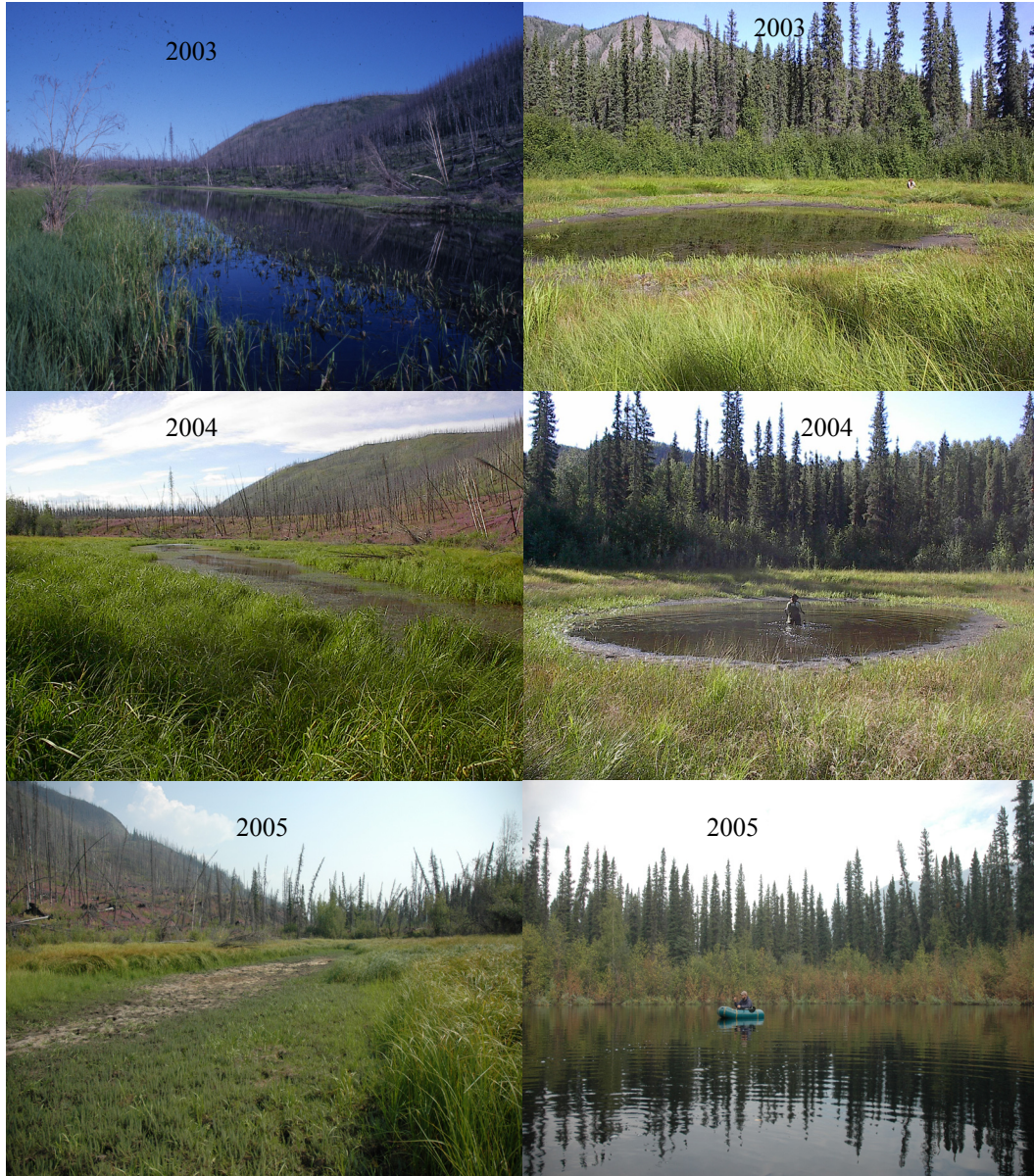


Figure 9. Photographs taken from Lakes 2 (left column) and 8 (right column) in each year of the pilot study. Water levels fluctuated significantly from year to year.

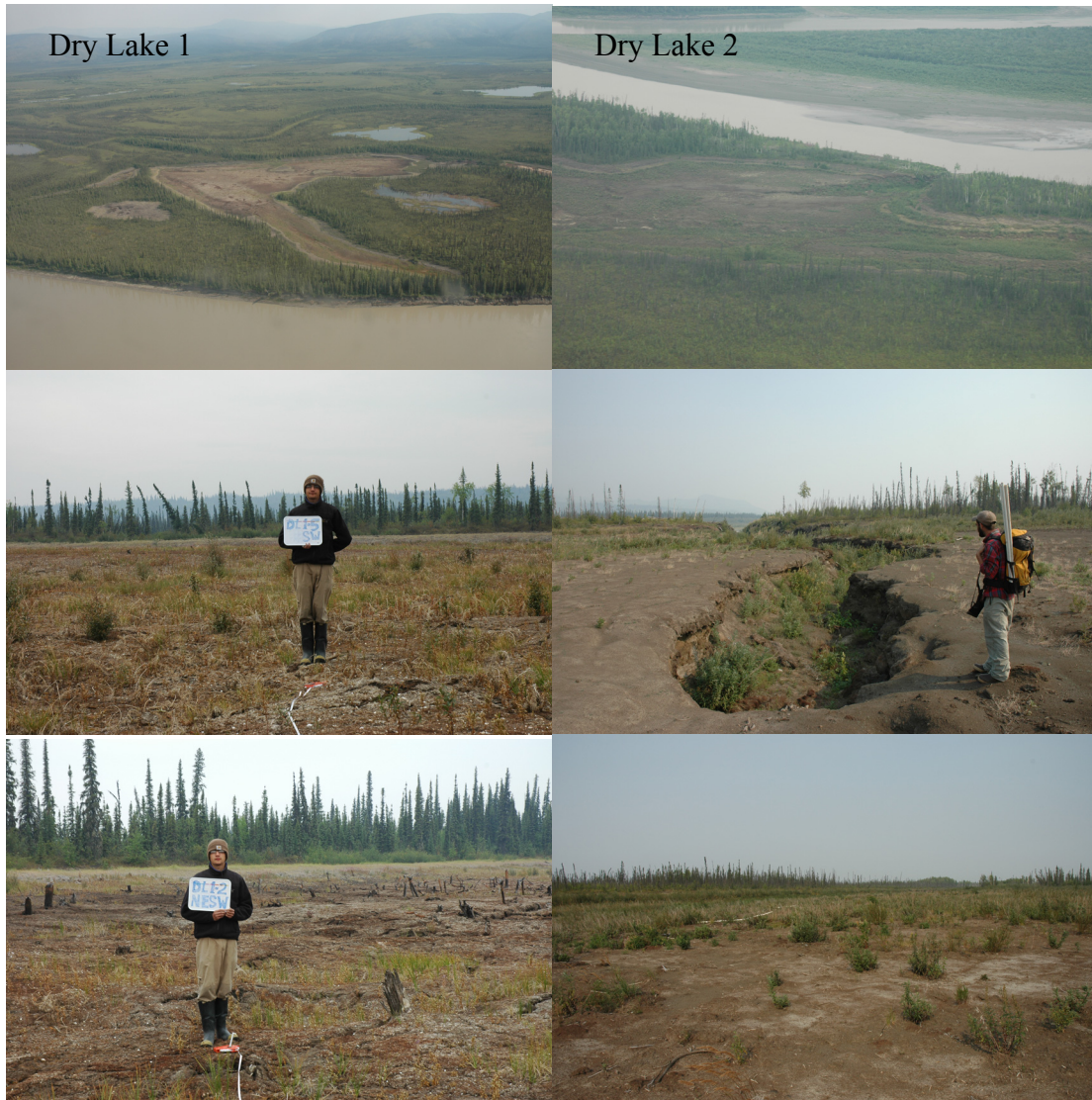


Figure 10. Dry lake 1 (left column) and dry lake 2 (right column) catastrophically drained in 2003 and 2000 respectively. Degradation to permafrost surrounding the lakes likely lead to lake drainage.

No data were collected on either of the drained lakes prior to drainage. YUCH staff did set up long term vegetation monitoring plots on each drained lake in 2005 to monitor successional processes. These plots will be measured every other year.

Physical and Chemical Attributes Of Water

Continuous Lake Monitoring

In general the quality of data collected using the sondes was high. Seasonal variation (expressed as range) in the four core water quality parameters was considerably less in lake 4 than Lake 10 for all parameters save dissolved oxygen (Table 3.) Several problems were encountered with the sondes over the course of the deployment (Figure 11) including the gradual failure of the DO probe (lake 4) and significant jumps in the data due to calibration. Neither significant biofouling nor instrument drift appeared to affect the quality of data collected from either lake.

Data from the thermal chains showed that both lakes were stratified when the sondes were deployed in early June and remained thermally stratified until early August (Figure 12). Data from the thermal chain in lake 4 showed surface water (epilimnion) was positively related to ambient air temperature ($R^2 = 0.48$). Water temperature in the thermocline was not significantly related to ambient air temperature and the water in the hypolimnion was negatively related ($R^2 = 0.17$) (Figure 13).

Table 3. Seasonal variation (June 7 – July 27, 2004) in the four core water quality parameters collected in two lakes in Yukon-Charley Rivers National Preserve.

	Temperature °C	Specific conductance mS	DO (mg/L)	pH
Lake 4	8.35	0.009	9.19 (sonde failure)	0.49
Lake 10	10.72	0.5	8.66	2.17

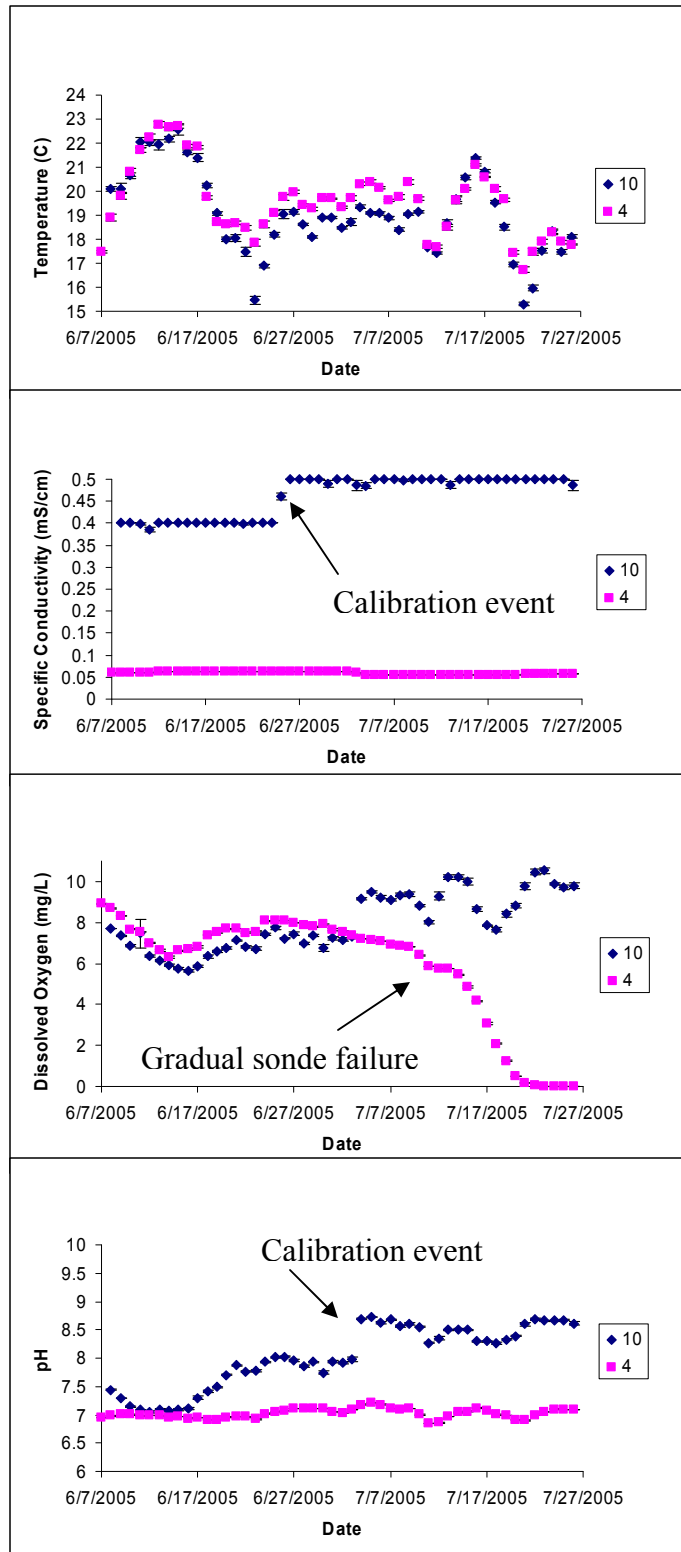


Figure 11. Water chemistry data collected from lake 4 and 10 using the YSI 6920 and the Hydrolab 4a respectively. A few operational errors were experienced over the course of the summer. These data will provide important information regarding seasonal variation.

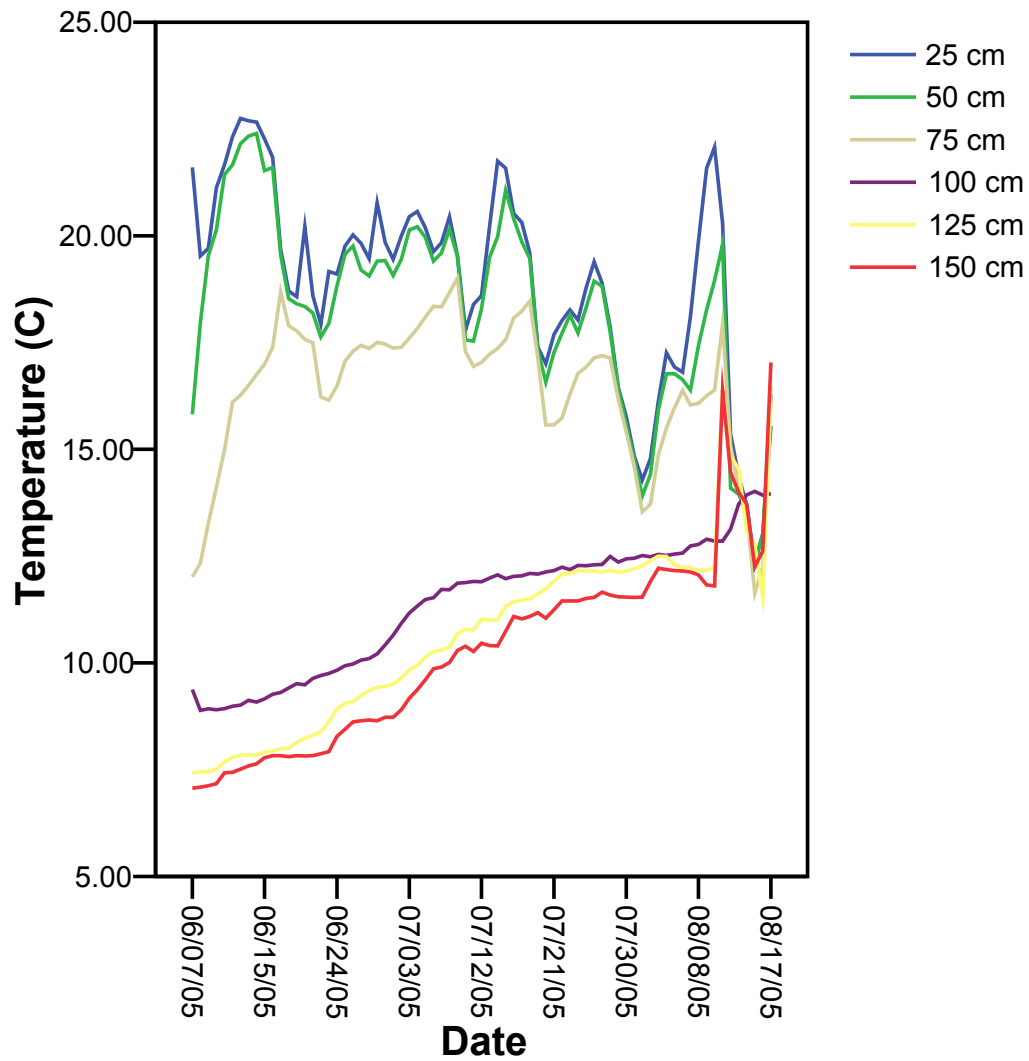


Figure 12. Temperature data collected at various depths in lake 4 shows clear thermal stratification beginning early June and ending early August.

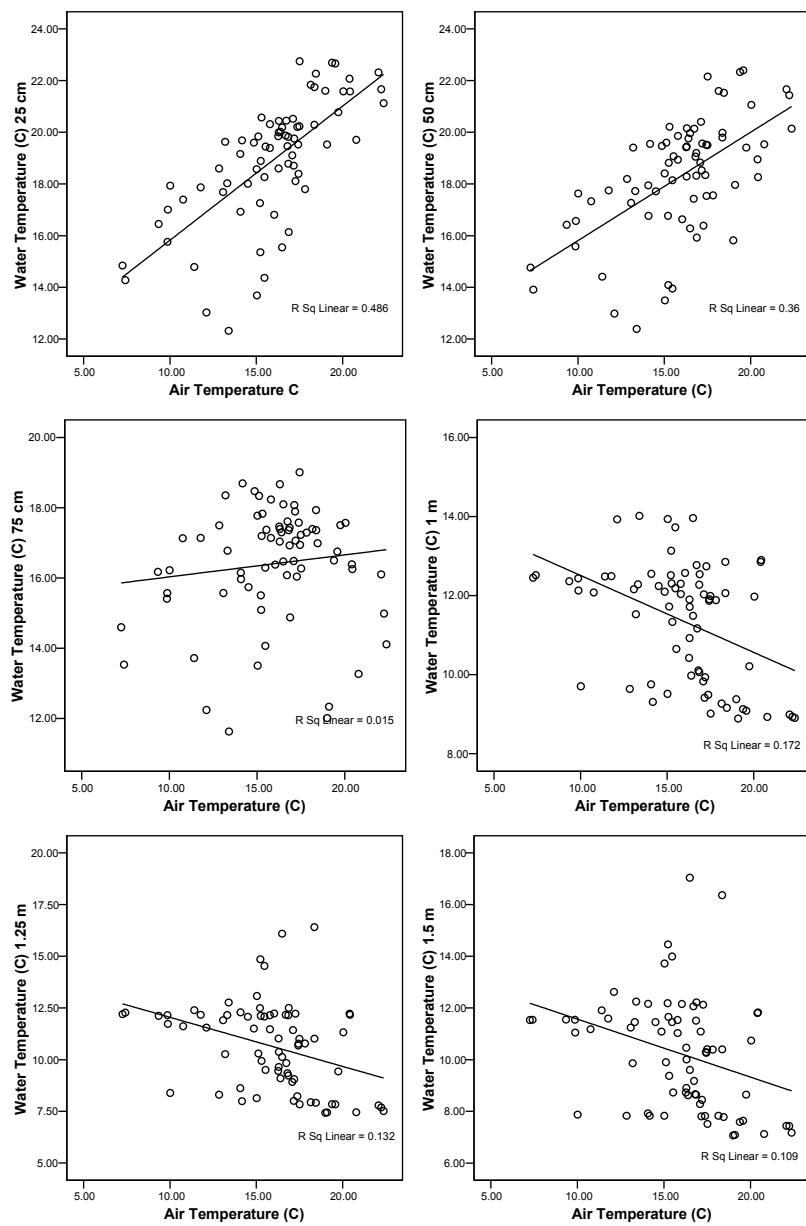


Figure 13. Comparison of mean daily air temperature and mean daily water temperature at 25 cm, 50 cm, 75 cm, 1 m, 1.25 m, and 1.5m.

Synoptic Lake Monitoring

A Pearson correlation matrix revealed many significant correlations among water chemistry data (Table 4). Typically water chemistry varied only slightly within a lake. This allowed us to easily detect change among years and between sampling periods. Variation among lakes was considerably greater and increased significantly for most parameters when additional lakes were added in summer 2004 (Figure 14). Two-way ANOVA between year and sampling season (spring or summer) showed significant differences in temperature, pH, and alkalinity between spring and summer. All other variables appear to be stable (TN, TP, Chl_a, and specific conductance) both among years and between seasons.

Table 4. Results from Pearson correlation matrix for water chemistry parameters

		Temperature	pH	DOC	Chl_a
Specific conductance	Pearson Correlation Sig. (2-tailed) N	-.234 .002 173	.203 .007 174	.255 .005 118	
Chl_a	Pearson Correlation Sig. (2-tailed) N	-.195 .040 111			
Alkalinity	Pearson Correlation Sig. (2-tailed) N		.238 .011 112		
TN	Pearson Correlation Sig. (2-tailed) N	-.323 .001 97			.565 .000 86
TKN	Pearson Correlation Sig. (2-tailed) N	-.436 .000 90			.597 .000 80
TP	Pearson Correlation Sig. (2-tailed) N				.706 .000 66
DO	Pearson Correlation Sig. (2-tailed) N		.582 .000 174		

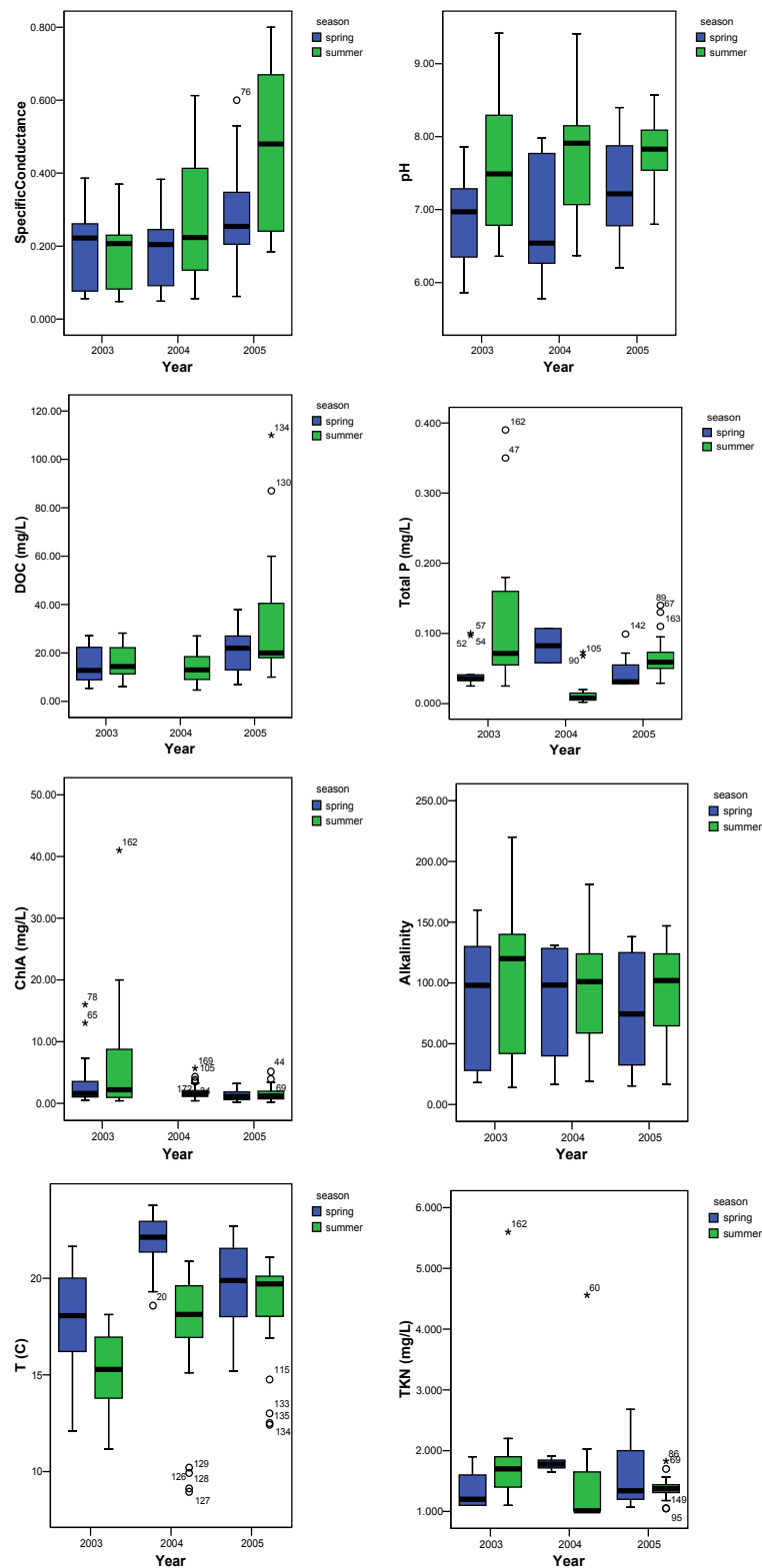


Figure 14. Seasonal variation of eight water chemistry parameters.

Burn data

Several of the lakes sampled late in 2004 were within the Edwards Creek burn area. Most of the vegetation surrounding lakes sampled in this region were burned up to the littoral zone (Figure 15). The burn appeared to have few significant impacts that uniformly changed water chemistry with the exception of total phosphorus and dissolved organic carbon (Figure 16) both of which increased significantly in the year following the burn. Individual lakes had significant changes in chemistry following fire but change varied from lake to lake. Chl *a* was significantly higher one week following the burn in lakes 12, 13 and 16 and tended to be higher in lakes 11 and 17 (Figure 17).



Figure 15. Vegetation was burned up to the lush meadows that surround many lakes.

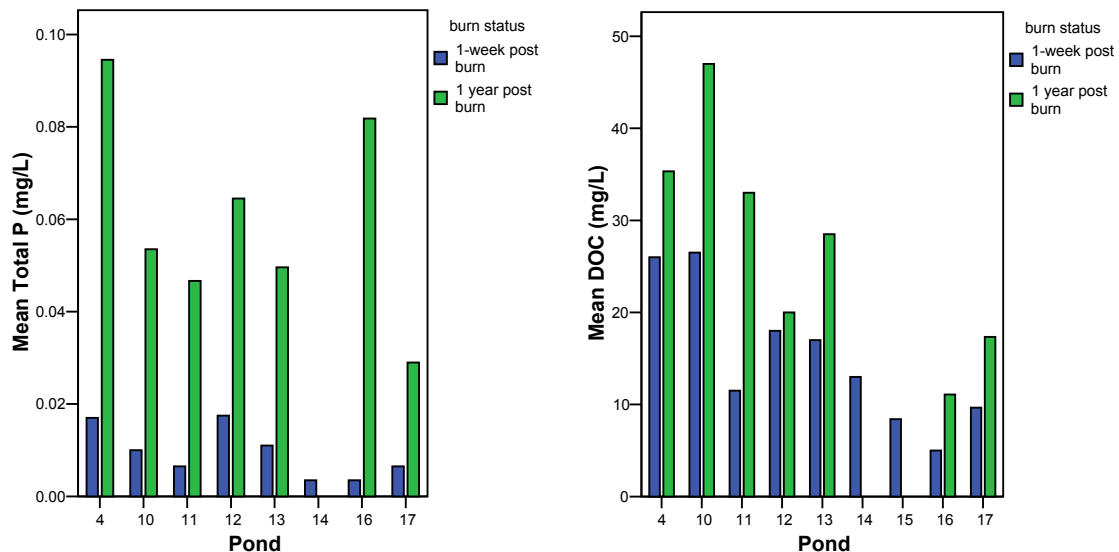


Figure 16. Mean total P and DOC in each lake one week and one year following the Edwards Creek Burn.

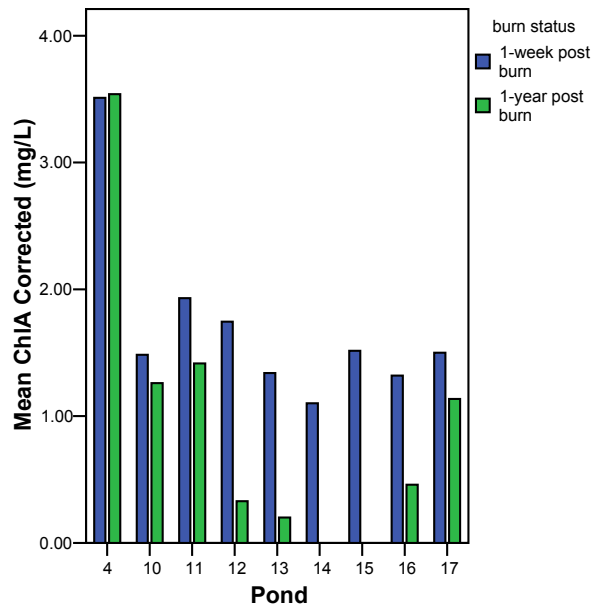


Figure 17. Chla concentrations in each lake one week and one year following the Edwards Creek Burn.

Two-step cluster analysis of all burn lake data separated lakes into two major clusters based on specific conductance (Figure 18). Careful evaluation of classified lakes indicates lake clustering corresponds to degree of hydrologic connectedness (Figure 19). Lakes 10, 12 and 13 have inlets/outlets and the remaining lakes are closed to major hydrologic inputs.

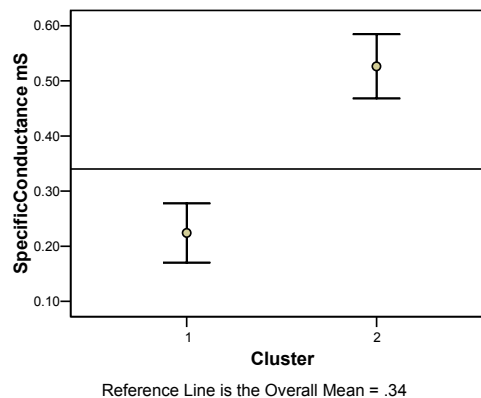


Figure 18. Mean specific conductance with 95% confidence intervals

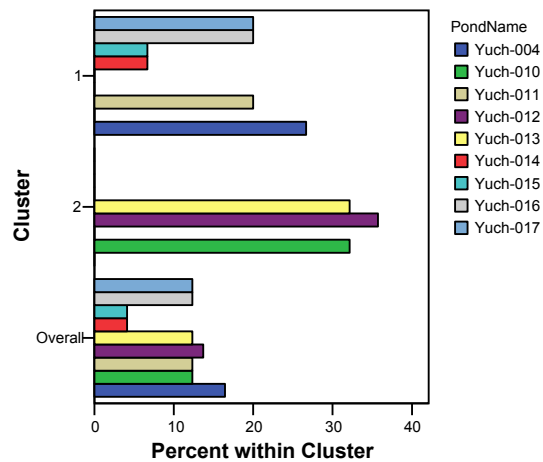


Figure 19. Cluster analysis showing lakes in each cluster.

Invertebrate Sampling

Taxa richness varied between 20-43 taxa per sampling event in 2003-2004. Mean richness was 31 taxa. Taxa richness did not differ significantly between seasons or years. The composition of major taxa did appear to differ between seasons (Figure 20). The number of families represented by each order did not differ significantly among sampling events (Figure 21).

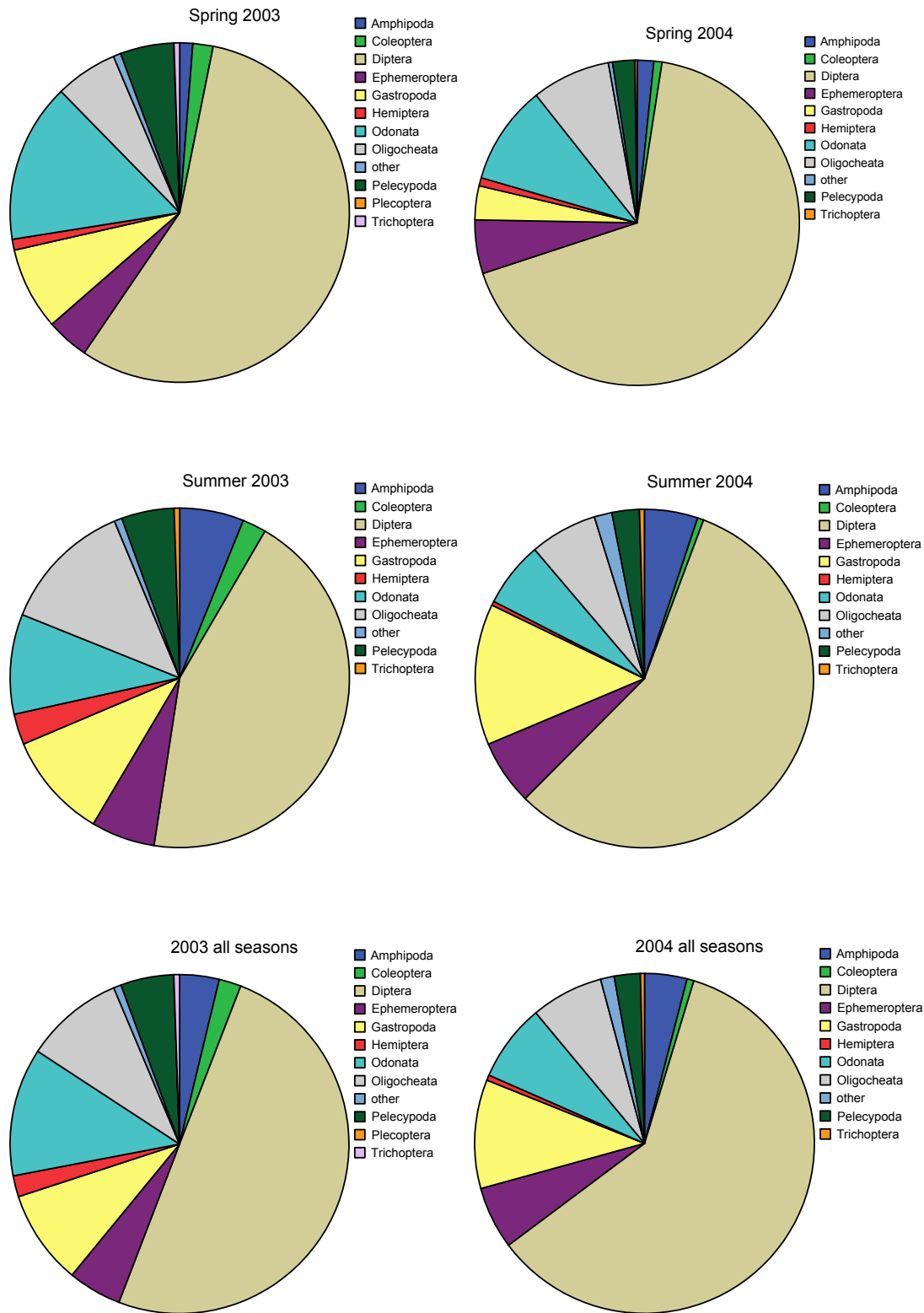


Figure 20. Relative proportion of invertebrates found in each of the primary macroinvertebrate orders.

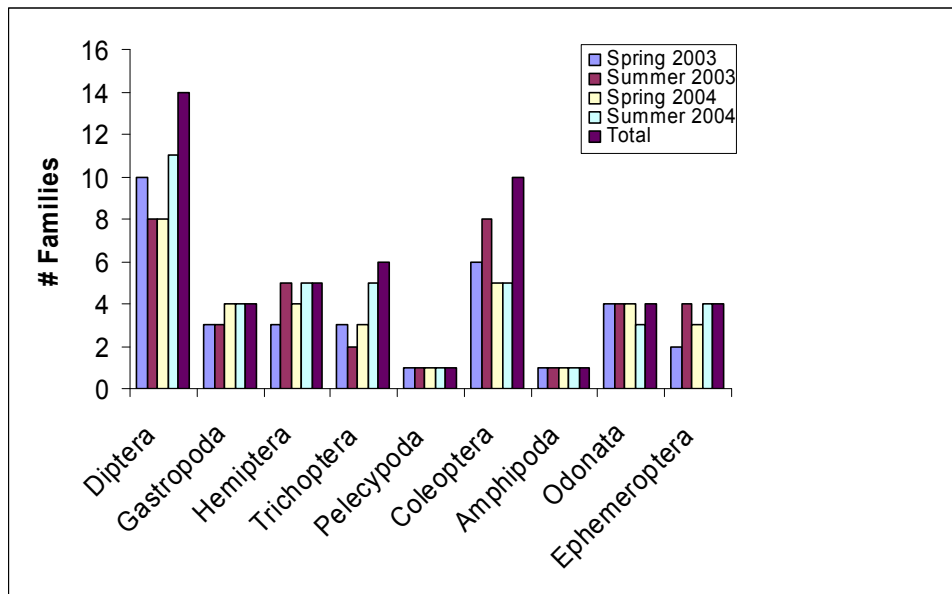


Figure 21. Number of unique families found in each of the major orders during each sampling event.

DISCUSSION

Still working this up