FRPA Effectiveness Monitoring within the Willer-Kash State Forest Harvest Area:

Spring 2007

ALASKA
Department of
Environmental
Conservation

ARRI
Aquatic Restoration & Research Institute

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Summary

Forest Resources and Practices Act (FRPA) effectiveness monitoring initiated in July of 2006 within the Willer-Kash Harvest Area was resumed in May and continued through June of 2007. Spring sampling was conducted to obtain water chemistry measures during high spring flows, continuous measures of discharge and temperature, and to replicate measures of the invertebrate and fish community. Discharge decreased approximately 50% from values ranging from 10 to 17 cfs. Average daily temperatures were near 5°C at the end of May and increased to near 10°C. Stream water chemistry during spring high flows differed from fall 2006 high flows, and 2006 and 2007 base flow values. Stream water pH and specific conductivity were lower during spring flows and increased as flows declined. Turbidity was only slightly higher with measures up to 2 NTU, with no signs of extensive suspended sediment. Dissolved oxygen was near saturation on all sampling dates. Phosphorus and nitrate-nitrogen concentrations were high in the spring and declined over the sampling period. Ammonia nitrogen was below detection limits during spring flows but increased by the final sampling date. The macroinvertebrate community composition was very similar to samples collected in July of 2006. Alaska Stream Condition Index (ASCI) scores and rankings were consistent with previous findings. Coho salmon, rainbow trout, and Dolly Varden Char were captured in baited minnow traps. Coho salmon dominated the catch and were composed of three age classes. Total catch and catch per trap increased with an increase in soak time from 1 to 24 hours.

Introduction

The Aquatic Restoration and Research Institute (ARRI) has developed methods to monitor the effectiveness of the FRPA under direction of the Alaska Departments of Environmental Conservation, Natural Resources, and Fish and Game. Effectiveness monitoring methods were developed for implementation within the Willer-Kash Forest Harvest area near Willow, Alaska, but were designed for general application. Monitoring methods compare multiple stream characteristics prior to and following timber harvest. A Quality Assurance Project Plan and sampling plans have been submitted and approved by the State.

Pre-harvest data collection was conducted through the summer and fall of 2006 (Davis and Davis (2006). The evaluation methodology; however, recommends documentation of seasonal differences in water chemistry, hydrology, and temperatures. This project was conducted to augment 2006 data collection. Spring 2007 objectives were to:

- Obtain baseline chemical measures during high spring flows,
- Collect continuous temperature and discharge data,
- Replicate biotic measures.

Methods

Site locations, sampling methods, and analyses have been described previously and within the sampling plan (Appendix A). Continuous pressure and temperature loggers were installed at all 4 stream locations on May 29 and May 30, 2007. Stream discharge was measured concomitant with logger placement. Stream discharge measures were repeated on June 11 or June 18 following measured reductions in water depth at the logger locations.

Stream water samples were collected on May 29 (WK3 and WK4) or May 30 (WK1 and WK2), June 6 and June 11 at WK1 and WK2 only, and on June 18 (WK3 and WK4) or June 19 (WK1 and WK2). Measures of photosynthetically active radiation (PAR) were obtained at all sites in May and repeated at sites WK1 and WK2 in June. Macroinvertebrates were collected at WK1 and WK2 on June 5.

Fish sampling was conducted at WK1 and WK2 on June 18 and June 19. Fish were sampled using baited minnow traps. Nine traps were placed in each stream extending over approximately 100-m. The traps were removed after 1 hour, all captured fish were identified and measured and then returned to the trap and the trap was returned to the stream. The traps were left in place for an additional 23 hours, upon which all fish were removed, identified, measured, and released.

Results

Discharge, Temperature and Solar Radiation

Stream water discharge for the measurement dates is shown in Figure 1. Discharge at all sites decreased from the end of May to the middle of June. Discharge at all sites in June of 2007 was very similar to July 2006 values. Stream average water temperatures were very similar among sites and increased from near 4°C to near 10°C (Figure 2). Maximum stream temperatures did not exceed 13°C in 2006.

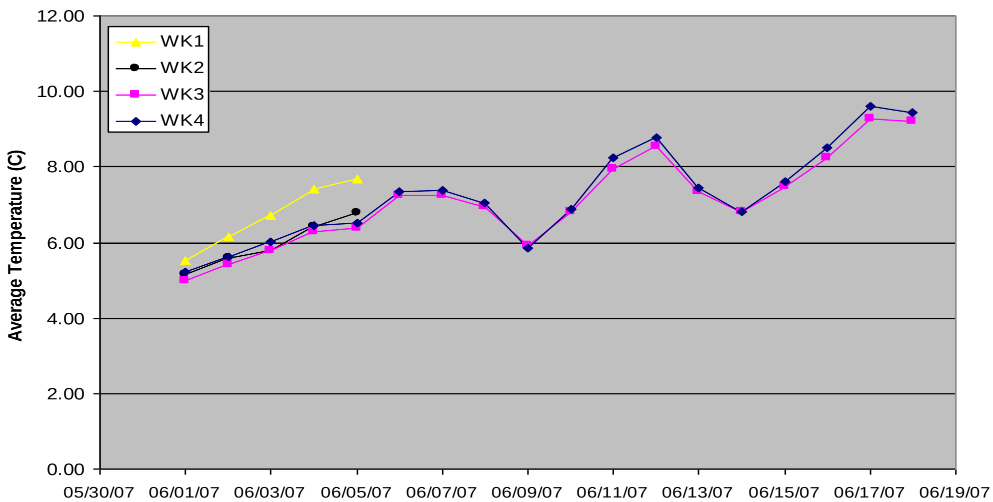

Figure 1. Average daily water temperatures for the 4 sampling locations.

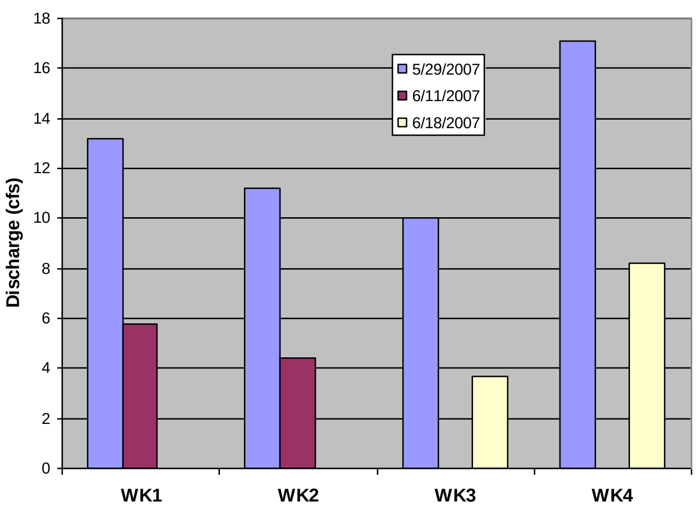

Figure 2. Changes in stream discharge from May to mid-June.

The percent of total PAR that penetrated the riparian vegetation at the 4 sites ranged from 34 to 70 percent. The variability in percent transmission within each sites was low, even though data collection occurred at during both sunny and cloudy days and at different times of the day from May through September.

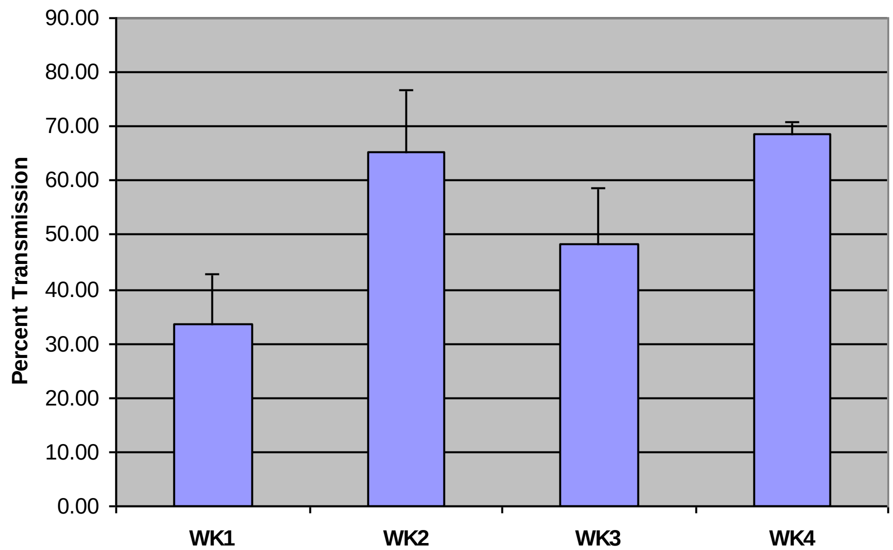

Figure 3. Percent of total available PAR reaching the stream surface.

Water Chemistry

Stream water chemistry values met the laboratory accuracy and analytical precision objectives for all sampling dates with the following exceptions. Ammonia-nitrogen and nitrate-nitrogen did not meet the precision objective on one sampling date (Table 1). On these dates the lower of the two values is reported. On one date turbidity did not meet the precision objective. For turbidity, the higher of the two values is reported.

Table 1. Precision calculations for replicate measures.

Measure	Value 1	Value 2	Precision
Ammonia Nitrogen	0.69	0.005	1.97
Ammonia Nitrogen	0.005	0.005	0.00
Dissolved Organic Carbon	0.5	0.5	0.00
Nitrate + Nitrite	0.012	0.021	0.55
Nitrate + Nitrite	0.074	0.072	0.03
pH	6.93	6.95	0.00
pH	6.93	6.95	0.00
Specific Conductivity	37.2	37	0.01
Specific Conductivity	42.6	42.5	0.00
Total Phosphorus	0.019	0.019	0.00
Total Phosphorus	0.045	0.044	0.02
Tot-Diss Phosphorus	0.009	0.01	0.11
Tot-Diss Phosphorus	0.04	0.041	0.02
Turbidity	2.1	1.6	0.27
Turbidity	1.1	1.2	0.09

Stream water chemistry is shown in Table 2 and 3. Stream water pH was lower in May than June at sites WK1 and WK2 but did not change at WK3 or WK4. Values during the spring; however, were not as low as those obtained following flood flows in 2006.

Dissolved organic carbon was above detection limits at WK1 and WK2, but not at WK3 and WK4, and was less than increases observed following 2006 high flows. Specific conductivity increased over time at all sites along with decreasing discharge. Turbidity was low on all dates but slightly higher during high flows. Turbidity in WK1 and WK2 was similar to high values obtained following flood flows; however, at WK3 and WK4 turbidity increased to 4.5 NTU in 2006.

Nutrient concentrations appear to be following consistent patterns. Ammonia concentrations were below detection limits during the spring but increase as the season progresses. Nitrate reacts in the opposite way decreasing as upland production increases. Total and total dissolved concentrations of phosphorus decreased at all sites from late may to the end of June. Concentrations of dissolved phosphorus were similar to total phosphorus; therefore most of the phosphorus is dissolved and not particulate.

Foam accumulations were observed in all streams with the largest accumulations observed on May 29 and May 30. We did not see signs of an oily sheen within any of the streams.

Table 2. Stream chemical characteristics for the 4 sampling sites.

pH	WK1	WK2	WK3	WK4
5/29/07	6.93	6.92	6.99	6.93
6/5/07	7.05	6.99		
6/11/07	7.04	6.96		
6/19/07	7.02	6.98	6.99	6.93
Specific Conductance (µS/cm)				
5/29/07	39.4	41.4	39.9	37.2
6/5/07	44.6	44.9		
6/11/07	48.5	49.1		
6/19/07	52.5	52.8	45.9	42.6
Turbidity (NTU)				
5/29/07	1.5	1.5	1.2	2.1
6/5/07	1.0	1.1		
6/11/07	1.0	0.9		
6/19/07	1.1	0.9	0.8	1.1
Dissolved Oxygen (Percent Saturation)				
5/29/07	96.3	97.3	97.3	98
6/5/07	103	103		
6/11/07	99.9	100.1		
6/19/07	95.9	101.3	98.1	96.6
Temperature (°C)				
5/29/07	5.4	5.7	4.7	5.8
6/5/07				
6/11/07	10.0	8.5		
6/19/07	11.6	9.2	8.5	9.5

Table 3. Stream water macro-nutrient concentrations.

Ammonia-N (mg/L)				
	WK1	WK2	WK3	WK4
5/29/07	<0.005	<0.005	<0.005	<0.005
6/5/07	<0.005	<0.005		
6/11/07	<0.005	0.08		
6/19/07	0.018	0.020	<0.005	<0.005
Nitrate+Nitrite-N (mg/L)				
5/29/07	0.056	0.24	0.21	0.074
6/5/07	<0.01	0.15		
6/11/07	<0.01	0.14		
6/19/07	<0.01	0.14	0.15	0.012
Total Phosphorus (mg/L)				
5/29/07	0.063	0.034	0.031	0.045
6/5/07	0.042	0.03		
6/11/07	0.012	0.016		
6/19/07	0.022	0.016	0.024	0.019
Total Dissolved Phosphorus (mg/L)				
5/29/07	0.058	0.027	0.033	0.04
6/5/07	0.034	0.028		
6/11/07	0.009	<0.001		
6/19/07	0.005	0.007	0.007	0.009
Dissolved Organic Carbon (mg/L)				
5/29/07	1.4	2.3	<0.5	<0.5
6/5/07	N/A	N/A	N/A	N/A
6/11/07	N/A	N/A	N/A	N/A
6/19/07	N/A	N/A	N/A	N/A

Macroinvertebrates and Fish

Select macroinvertebrate metrics and ASCI metrics are shown in Table 4. Metrics and ASCI scores and ranking were very consistent with 2006 data. Similar to 2006, WK1 was ranked "Excellent", and WK2 was ranked "Good". Differences between the two sites were in the percent non-baetid Ephemeroptera, percent Plecoptera, and the percent of invertebrates that obtain food resources by scraping algae from the substrate.

Three different fish species were captured in both tributaries to Iron Creek. The fish community was dominated by juvenile coho salmon (*Oncorhynchus kisutch*) followed by rainbow trout (*Oncorhynchu mykiss*) and Dolly Varden Char (*Salvelinus malma*). There were three age classes of juvenile coho salmon. Fry, or age 0 fish, measured from 35 to 45 mm. Parr, or age 1+, measured 55 to 90 mm, and age 2+ fish, measured greater than 90 mm (Figure 4).

Table 4. Macroinvertebrate metrics and ASCI scores for 2007 spring samples.

Invertebrate Metrics	**WK1**	**WK2**
Ephemeroptera	133	142
Plecoptera	50	15
Trichoptera	10	8
Diptera	65	73
Richness	15	14
Ephemeroptera Taxa	5	4
Trichoptera Taxa	3	2
% Plectopera	19.16	6.25
% Ephemptera (no Baetidae)	16.48	6.25
% Diptera	24.90	30.42
Baetidae/Ephemeroptera	0.68	0.89
% Non-insects	1.15	0.83
HBI	3.75	4.18
%Scrapers	8.05	2.92
% Collectors	60.92	77.50
% EPT no Baetids or Zapada	24.90	13.33
ASCI Scores **Low /Gradient Coarse Substrate**	**Low Gradient Coarse**	**Low Gradient Coarse**
Ephemeroptera taxa 100 * X / 5.5	90.91	72.73
% Ephemeroptera (no Baetidae) 100 * X / 20	82.38	31.25
% Plecoptera 100 * X / 14	100.00	44.64
Baetidae / Ephemeroptera 100 * (100 - X) / 100	32.33	10.56
% non-insects 100 * (30 - X) / 30	96.17	97.22
O/E (family 75%) 2 100 * X	90	80
% scrapers 100 * X / 15	53.64	19.44
HBI 100 * (6.5 - X) / 2	100.00	100.00
Average	**80.68**	**56.98**
Ranking	**Excellent**	**Good**

Coho fry were not observed until the June 5 water sampling date, after which they were common in slow water habitats. Total catches by species for the 1 hour and 24 hour soak times are shown in Table 5. Coho salmon made up 87% of the catch within WK1, rainbow trout 8%, and Dolly Varden 5%. Within WK2 coho salmon were 79%, rainbow trout 18% and Dolly Varden 3% of the total catch. Total catches of coho salmon were similar between sites. Individual catch rate within traps was highly variable with 24 hour capture rates varying from 0 to 21 and coefficients of variation greater than 1.

Total coho catches after 1 hour were 42% and 27% of 24 hour catches in WK1 and WK2, respectively. One hour sets did not capture any Dolly Varden in WK1. Coho salmon fry (less than 45-mm fork length) made up 36% of the coho salmon catch after 24 hours but only 17% of the coho salmon catch after 1 hour.

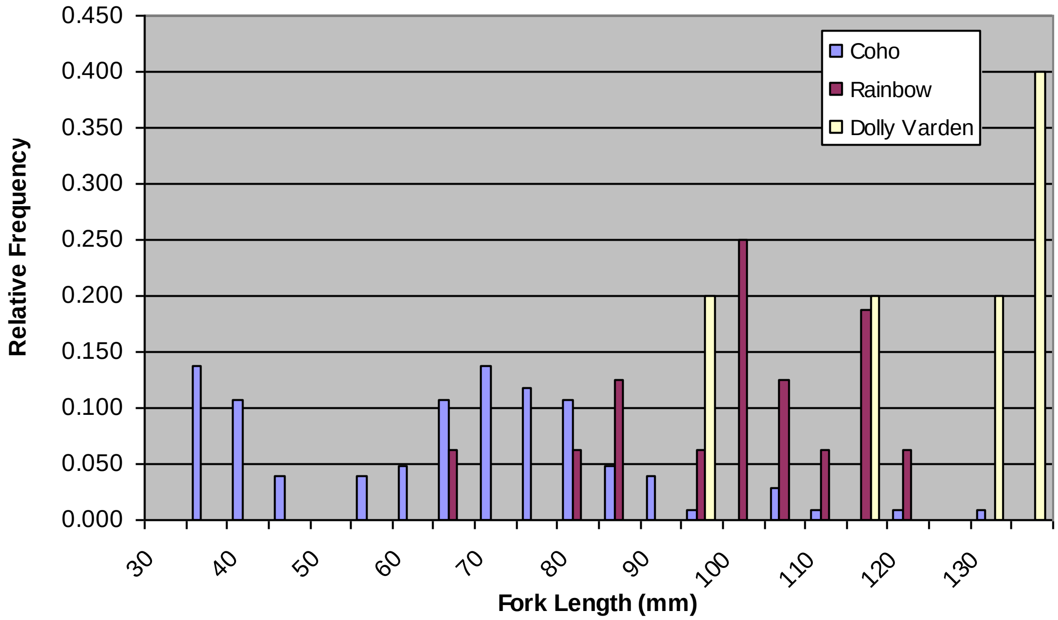

Figure 4. Relative frequency by size class of fish captured in baited minnow traps.

Discussion

Steam temperatures were very low, near 4°C and discharge was high when spring sampling was initiated on May 28. We are uncertain if discharge measured on this date was at or near peak spring runoff values. Ephemeral tributary channels were flowing and riparian vegetation had not completely leafed out.

Stream chemistry was distinct from measures obtained during low flows in June of 2007 and July of 2006. Low pH during spring flows and following storm events has been observed in a number of regional streams (Davis et al. 2006a, 2006b, 2006c) and reported elsewhere (Boyer et al. 1997). The flushing of organic acids from wetlands and upland vegetation soils best explains changes in pH. Phosphorus responds similarly to changes in flow with concentrations increasing during high spring and fall flows particularly in wetland dominated streams as water-soluble reduced phosphorus compounds are flushed into stream systems. Dissolved organic carbon also was present in spring flows but was not as high as previously measured during peak flood flows in August 2006.

Nitrogen concentrations appear to respond more to changes in upland productivity. Ammonia concentrations are low during the spring and nitrate concentrations are high. As the season progresses, ammonia-nitrogen concentrations increase and nitrate-nitrogen concentrations decrease. Similar trends have been observed in other regional streams.

The macroinvertebrate community appears to consistently reflect stream conditions. Community composition and ASCI scores were very similar to previous values. It did not appear that extreme flood flows in August of 2006 influenced the biotic community. Similarly, fish catch rates were high. Direct comparisons could not be made with 2006 samples because we increased the number of traps for the 1 hour soak time. However, sampling in 2007 recorded a large number of both age 0 and age 1+ coho salmon. Therefore, large flows did not result in the loss of either year class. Due the higher number of fish captured and the multiple species, future Level 2 sampling should include 10 traps at each site and 12-24 hour soak times. Alternately, fish population estimates could be obtained through summation removal methods (e.g. Bryant 2000).

Table 5. Number of fish in each trap after 1 and 24 hours within the stream. SD is standard deviation.

Catch per Trap		6/18/2007	1 Hour Soak	6/19/2007	24 Hour Soak	
Site-Trap	Coho	Rainbow	Dolly Varden	Coho	Rainbow	Dolly Varden
WK1-1	7	2	0	18	1	1
WK1-2	0	0	0	4	0	0
WK1-3	1	1	0	4	1	2
WK1-4	0	0	0	8	0	0
WK1-5	9	1	0	12	1	0
WK1-6	4	0	0	3	1	0
WK1-7	0	0	0	0	0	0
WK1-8	0	2	0	0	0	0
WK1-9	1	0	0	3	1	0
WK2-1	1	0	0	5	0	0
WK2-2	1	1	0	3	0	0
WK2-3	0	1	0	0	2	1
WK2-4	0	0	0	0	3	0
WK2-5	0	0	0	0	0	0
WK2-6	4	1	1	17	1	0
WK2-7	0	0	0	0	1	0
WK2-8	2	0	0	3	2	0
WK2-9	5	0	1	21	2	1
WK1 Total	22	6	0	52	5	3
Average	2.44	0.67	0.00	5.78	0.56	0.33
SD	3.43	0.87	0.00	5.93	0.53	0.71
WK2 Total	13	3	2	49	11	2
Average	1.44	0.33	0.22	5.44	1.22	0.22
SD	1.88	0.50	0.44	7.95	1.09	0.44

Literature Cited

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Appendix A. Sampling Plan

MAT-SU FRPA EFFECTIVENESS MONITORING

WILLER-KASH STATE HARVEST AREA

SAMPLE PLAN Final

Contract 18-2011-21

Version 4.0 updated May 2007

Prepared For

ALASKA Department of Environmental Conservation

by

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Project Manager: ________________________________ **Date:** ______________

Introduction

This document describes a monitoring plan to determine the effectiveness of forestry management practices in maintaining fish habitat and water quality. The Alaska Department of Environmental Conservation (ADEC) along with the Alaska Department of Natural Resources has established goals for Forest Resources and Practices Act (FRPA) effectiveness monitoring. These goals are to determine if there are significant changes in water quality following timber harvest and whether State water quality standards are maintained. Implementation of the management practices also must meet the statutory intent for riparian areas (AS 41.17.115) harvested under the guidelines of the Region II riparian standards (AS 41.17.118) or best management practices (BMP). The proposed methods to develop an effectiveness monitoring plan are designed for stream types located within, and applied to, state-owned lands of the Willer-Kash timber harvest area. The monitoring plan must be cost-effective and address potential short- and long-term effects to fish habitat and water quality. Effectiveness monitoring is being designed and implemented due to a paucity of monitoring data, predicted increases in harvest activity, and the development of new riparian standards within Region II.

Forestry effectiveness monitoring involves determining if best management practices and riparian management guidelines avoid or limit changes to stream channel characteristics during and after timber harvest. Most monitoring approaches are “reference based” in that stream conditions following timber harvest are compared to conditions within the same system prior to harvest or to similar unharvested stream systems (McDonald et al. 1991, Davis et al. 2001, Martin 1995). Natural variability in dynamic stream systems can be addressed by obtaining data from both harvested and unharvested stream systems over time. As characteristics vary among streams that differ physically and chemically, it is important that comparisons are made among similar stream classification types (i.e. Rosgen 1994). This sampling plan also is reference based, with reference data collected from stream systems prior to the initiation of harvest activities. The selection of stream characteristics has been chosen based upon water quality standards, and the riparian management intent of the Forest Resources and Practices Act (FRPA). Relevant literature will be reviewed to select standard and established measurement methods and dependent variables that are independent of annual variability.

Methods

Study Area and Sampling Locations

The Willer-Kash harvest area is bounded roughly by the Kashwitna River to the north and Willow Creek to the south (Figure 1). The Willow Mountain Critical Habitat Area lies to the east and the western boundary generally is the Range line between 3 and 4 West. Although Forest Land Use Plans (FLUPs) have not been developed under the proposed stream classification system, the Kashwitna River, Little Willow Creek, and Willow Creek will be classified as Type IIA streams (large dynamic non-glacial rivers).

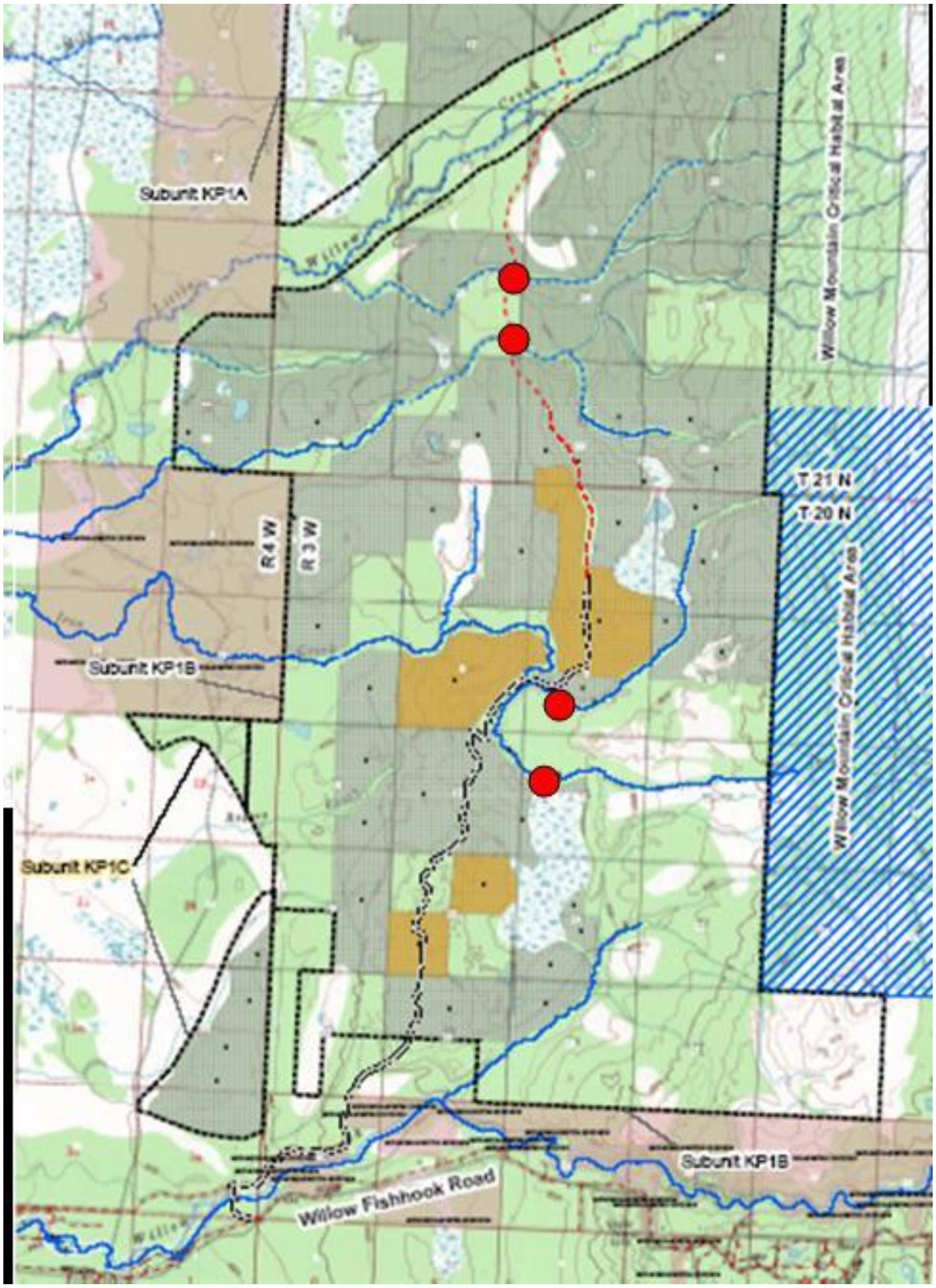

Figure 5. Map of the Willer-Kash Harvest Area showing sampling locations (red dots).

Proposed timber harvest along Willow Creek and the Kashwitna River will not be sufficient to evaluate BMP effectiveness. Based upon the Five-Year Harvest Schedule maps, the majority of proposed timber harvest will occur along tributaries to Little Willow and Willow Creeks. Stream sampling locations are proposed for the following streams based upon similar physical characteristics, classification as Type IIC under the FRPA, and proposed harvest within the drainage. The characteristics of which are summarized as follows:

Iron Creek and its two tributaries above the road crossing occur within the harvest area. Both of these tributary streams are likely Type IIC. The southern channel, within Sections 15 and 16 is the main fork of Iron Creek (Anadromous Stream No. 247-41-10200-2130-3030) and is a second-order stream flowing into Little Willow Creek. The north fork of Iron Creek (Anadromous Stream No. 247-41-10200-2130-3030-4025) is within Sections 3, 9, and 10, and is a first order stream. Timber harvest is proposed along most of the upper reaches of the north fork, but only along the lower portions of the main fork. Therefore, these two tributaries provide both reference and potentially impacted sites.

The two tributaries to Little Willow Creek are unnamed; however, the first tributary flows through Sections 27 and 28 before crossing the proposed Willer-Kash road extension within Section 29 (T. 21 N., R. 3 W.) (Anadromous Stream No. 247-41-10200-2130-3036). The northern tributary drains off of Willow Mountain and through Sections 21, 22, and 28 before crossing the proposed road extension in the northern half of Section 29. Both of these are second order streams and appear to be Type IIC based upon aerial photography. Significant timber harvest is proposed within both of these drainages allowing for evaluation of potential harvest-related impacts.

Sample Measurements, Frequency, and Dependent Variables

The monitoring plan requires the description of the physical, chemical, and biological parameters to be measured, measurement frequency and duration, and methods of parameter measurement (qualitative or quantitative). Stream parameters were selected based upon applicable State Water Quality Standards (18 AAC 70) and the statutory regulatory intent for riparian areas. The management intent for riparian areas is the maintenance of large woody debris (LWD), bank stability and channel morphology, water temperature, water quality including nutrient cycling, food sources (for fish), clean (free of fine sediment and organics) spawning gravel, and sunlight (AS 41.17.115). Applicable water quality parameters include dissolved oxygen, pH, specific conductance (surrogate for total dissolved solids (TDS)), fine sediment, petroleum hydrocarbons, and debris. Sampling frequency for water chemistry is hierarchical so that level 1 sampling frequency is obtained at all stream sites with more detailed level 2 sampling at a portion of the total sites. For the Willer-Kash Harvest area, level 2 sampling will occur at two of the four sampling locations. However, for general application, level 2 sampling should occur at one of every five sites. Proposed sample parameters, frequency, and measurement methods are listed in Table 2.

Physical Characteristics

Substratum Size Distribution

The stream bed material provides the primary habitat for aquatic organisms. The size and stability of the channel material is a function of the sediment source and the stream transport capacity. The removal of upland vegetation through timber harvest operations can alter evapotranspiration processes leading to changes in the timing and amplitude of stream hydrographs and channel transport capacity. Mechanical disruption of soil layers and the exposure of mineral soil through yarding and road construction have the potential to increase sediment delivery rates to adjacent streams. Increases in fine sediment (< 2 mm) above transport capacity can have negative effects on aquatic biota through the restriction of water and dissolved oxygen movement through the stream bed material.

Stream substrate and the distribution of fines will be determined through Wolman pebble counts, estimates of percent embeddedness and measures of turbidity (see water chemistry section). Wolman pebble counts will measure the intermediate axis of 100 randomly selected stones within a 100-m long sampling section. Embeddedness is recorded concomitant with pebble counts, and is a semi-qualitative estimate of the portion of the selected stones that are embedded within fine material. As substratum is largely a function of peak flows, initial sampling frequency should be annual. Potential forestry effects should diminish with regeneration, so sampling frequency can decrease to every other year following the first 5 years.

Dependent variables will include D20, D50, and D70 (cumulative percent of bed material with diameters less than or equal to 20 mm, 50 mm, and 70 mm, respectively) and size distribution relative to critical grain size. For embeddedness, the relative percent of the particles embedded over 30% will be used as the dependent variable.

<u>Large Woody Debris</u>
Woody debris provides a number of different functions within stream systems. Woody debris can reduce stream energy and contain sediments (Estep and Beschta 1985, Buffington and Montgomery 1999). Wood alters flow paths and creates diverse habitats. Large wood is a site of nutrient and organic matter storage and provides a substrate for aquatic invertebrates. The amount of large woody debris within a stream is a function of inputs and transport. Changes in the density of streamside woody vegetation and hydrologic changes can influence the amount and type of debris within a stream.

Large woody debris will be counted and measured (length and width) and identified by plant species within each stream system. An index of woody debris influence on the stream system will be calculated. Dependent variables will include total amount of woody debris per length of stream and the large woody debris index (Davis et al. 2001).

<u>Water Temperature</u>
Stream water temperatures affects most biochemical processes and further defines the physical habitat of biotic organisms. Stream water temperatures are the result of a number of factors. Some of these include the surface area exposed to solar energy, which can be affected by the density of riparian vegetation as well as channel width, confinement and aspect (Johnson 2004, Poole and Berman 2001). Total stream volume and the portion of surface or subsurface recharge can influence stream water temperatures. Many of these factors are influenced by the community of riparian and upland vegetation.

Stream water temperatures will be measured using Onset Stowaway temperature loggers, Onset combined temperature and water level loggers. Loggers will be placed within a well-mixed portion of each stream sampling site within proposed harvest units and on the stream margin to record air temperature. Loggers will be set to record water temperature every hour. Dependent variables will be the daily maximum change in temperature, longitudinal temperature differences, and daily maximums as a function of air temperature recorded at the Talkeetna Airport and local air temperatures.

Turbidity

Turbidity is a measure of the reflective properties of water and is influenced by the amount of inorganic and organic sediment within the water column. High turbidity levels can affect the feeding and survival of fish and invertebrates. High turbidity is often associated with increased fines within the sediment which can alter the flow path and transport of nutrients and oxygen within and below the stream bed. This has a direct and negative effect on aquatic organisms and incubating fish eggs that are living within the substrate.

Stream water turbidity will be measured during the rising limb of the hydrograph during storm events using meters and automated samplers. Maximum turbidity and the change in turbidity following storms and spring runoff will be used as dependent variables.

Discharge

Stream flow or discharge provides the living space for stream organisms, affects substrate and channel form, water temperatures and sedimentation. Discharge can change with the removal of upland vegetation due to modified rates of snowmelt, interception of precipitation, evapotranspiration, and soil infiltration.

Discharge will be monitored continuously using pressure gauges and data recorders or directly measured concurrent with water sampling. A rating curve will be developed through the relationship between physical measures of discharge on multiple occasions (4 to 5) at flow extremes. Dependent variables will be timing and volume of peak and base flows relative to total yield, and discharge response to precipitation events.

Solar Radiation

For small streams, the density of riparian vegetation and surrounding forest absorbs solar radiation reducing the amount reaching the stream surface. The amount of solar radiation reaching a stream surface affects water temperature and primary productivity. Stream water temperatures can affect the distribution, development rates, and health of fish and invertebrates. Increasing the amount of solar radiation and instream production relative to external organic food sources can cause a change in the invertebrate community.

Solar radiation at the stream surface will be obtained by taking 20 measures distributed systematically throughout the 100-m sampling reach. Concurrent measures will be taken of direct solar radiation adjacent to the stream site not shaded by riparian vegetation. Dependent variables will be the portion of total daily solar radiation at stream sites relative to open locations.

Chemical Characteristics

Dissolved Oxygen

Oxygen affects the chemical state and physical properties of elements and is required for the respiration of aquatic organisms. The saturation point of oxygen in water varies with water temperature. Oxygen enters the water through diffusion and as a product of photosynthesis. Oxygen is consumed through chemical reactions and biotic respiration. Oxygen concentration should be near saturation in most turbulent streams; however, excessive organic matter, high temperatures, and low turbulence can result in concentrations well below saturation.

Dissolved oxygen concentrations will be measured in the field using oxygen probes and meters concomitant with water chemistry sampling during spring runoff, summer baseflow, and in the fall during plant senescence. Dissolved oxygen reading will be corrected for differences in water temperature and pressure.

Specific Conductance, pH, Hydrocarbons and Foam

Specific conductance is a measure of total ion concentrations and is used as a surrogate for total dissolved solids. Specific conductance is a gross indication of the availability of elements necessary for the growth and survival of biotic organisms. Ion concentrations within streams reflect the underlying geology as modified by terrestrial processes. Ion concentrations can change as the flow paths from the catchment change. Ion concentrations often decrease when streamflow is composed of surface runoff in greater proportion than groundwater. Similarly, pH is a measure of hydrogen ion concentrations and can be affected by geology, flow pathways, and biological processes. High and low concentrations of hydrogen ions can affect the survival of aquatic organisms.

Water sampling will be conducted to document water chemistry during snowmelt, base flow conditions, and fall precipitation. Weekly sampling will be conducted in May, bi-weekly for June, July and August, and weekly in September (May sampling will be excluded in 2006; however it should be conducted in 2007 prior to harvest if possible). May and September discrete sampling will be linked with the rising hydrograph when possible. Sampling should be conducted prior to forestry activities, annually following timber harvest for the first three to five years, and then every five years.

Qualitative observations will be made looking for the presence of foam deposits and any oily sheen, which may be indicative of hydrocarbon pollution. The presence of an oily sheen prior to road construction and timber harvest will be an indication of natural causes.

Macronutrients

The macronutrients, nitrogen and phosphorus, along with solar radiation, often control the rates of autochthonus production. Nitrogen, while the dominant atmospheric gas, requires microbial fixation prior to use by biological organisms. Nitrogen is made available through the decomposition and release of nitrogen from organic material. Stream nitrogen concentrations often decrease during summer as biological uptake in terrestrial systems increases. Forest timber removal can increase nitrogen availability through increased decomposition while reducing terrestrial uptake resulting in increasing stream concentrations and total annual flux. Phosphorus is primarily from geological sources, but can increase as more mobile oxidized forms are flushed from storage within saturated riparian and wetland soils. Stream increases in nutrients can cause short-term increases in production followed by reduced productivity as soil storage is diminished and terrestrial uptake increases with forest regeneration.

Nitrogen (nitrate + nitrite, ammonium, and organic) and phosphorus (total and dissolved) will be measured at the same frequency as pH and conductivity described above.

Biological Characteristics

Periphyton Algae

Instream or autochthonus production in the form of algae or aquatic plants is one of the two major energetic pathways supporting stream organisms. The amount of algae within a stream can increase when productivity is greater than losses to grazing insects and sloughing. As mentioned previously, productivity can increase following forest harvest with increasing temperatures, solar radiation, and nutrients. Chlorophyll-a, a pigment used in photosynthesis, while not a true measure of algal biomass, can be used to indicate increases in stream periphyton.

Algae will be collected from accumulations on artificial substrates. Non-glazed ceramic tiles will be placed within the stream at 5 locations, 4 weeks prior to sampling. Sample will be conducted during mid summer when algal biomass should be near maximum seasonal high. Algae will be collected on filters, frozen, and transported to an analytical laboratory for chlorophyll-a analyses. Samples will be collected once a year for three to five years following harvest and then on five year intervals. Sampling will be conducted in late July during the peak growing season. Mean chlorophyll-a concentrations will be the dependent variable.

Benthic and Dissolved Organic Matter

Organic matter derived from terrestrial sources, or allochthonous organic matter, is the other major energy source for stream systems. Organic matter on the stream bed is the result of leaves and other terrestrial material deposited in the stream by wind or water. The amount of debris at a given location can be influenced by factors that retain organic material. These include large woody debris and debris dams, stable substrate, and diverse flow habitats (i.e. side channels and pools). The loss of terrestrial vegetation within a watershed can increase discharge during storm events and flush organic material from the stream channel. Dissolved organic matter is leached from terrestrial vegetation or is a product of decomposition and transported in water to streams. Dissolved organic matter; therefore, is also affected by processes which influence decomposition rates and hydrology.

Benthic organic matter will be collected on one occasion in mid-summer by dislodging the bed material at 5 randomly selected points within the sampling reach and collecting the resuspended material in mesh nets. The material will be divided into coarse and fine fractions. The amount of organic material will be based upon the mass lost upon ignition or the ash free dry mass. Dissolved organic matter will be collected concomitantly with water samples collected for chemical analyses.

Dependent variables will be the mean total, coarse, and fine benthic organic matter, the maximum dissolved organic matter and the variability in dissolved organic matter with changes in stream flow.

Macroinvertebrates

The larval stage of aquatic insects and other invertebrates are a diverse group of organisms. The abundance, diversity, feeding habits, and relative density of the many different aquatic organisms have been used to assess changes in water quality and habitat (Allen et al. 2003, Plafkin et al. 1989). Macroinvertebrates have been used because of their relative immobility, and differential responses to stream conditions.

Macroinvertebrates will be sampled using the technical level Alaska Stream Condition Index (ASCI) methodology. Sample collection will be conducted either in the spring, autumn, or both occasions. Dependent variables will include multiple different invertebrate metrics as well as the ASCI score.

Juvenile Fish

Similar to aquatic insects, egg incubation and juvenile salmon survival depends upon a consistent source of water. Changes in water temperature, dissolved oxygen concentration, volume, turbidity, pH, and food abundance can all affect the distribution and development of resident and anadromous juvenile fish (Murphy and Milner 1997).

Juvenile fish will be collected in baited minnow traps in the Spring and Fall. Fish will be identified to species and fork-length measured. Fish will be inspected for any deformities, eroded fins, lesions, or tumors. Dependent variables will be the total number of juvenile fish by species and the relative amount of different species collected per sample effort.

Riparian Vegetation and Coarse Woody Debris

The plant community surrounding streams often differs from the surrounding forest. Retaining a buffer of natural vegetation around streams is one of the primary means used to maintain natural water chemistry and physical characteristics of streams draining timber harvest areas. The riparian plant community can intercept groundwater flow and nutrients, provide shade, reduce stream energy and retain sediment and nutrients during floodplain inundation. Coarse wood on the forest floor also provides diverse habitat for terrestrial animals. The riparian plant community and trees can be modified following timber harvest by changes in solar input and wind speed, which can affect soil moisture, humidity, and cause blowdowns.

The riparian plant community within the unharvested buffer zone along a the sampling reach will be classified lateral to channel-morphometry transects to 100 m. Coarse wood surveys will be conducted along one bank. All coarse woody debris (>10 cm diameter and 1-m long) on the forest floor within the riparian area along the 100-m sampling reach and extending 30-m lateral to the channel will be counted and identified by species. Coarse wood will be placed into three distinct diameter categories (greatest diameter is from 10 to 20 cm, 21 to 30 cm, and > 30 cm) and three distinct length categories (1 to 5 m, 6 to 10 m, and > 11 m).

Table 6. Stream sample parameters and sampling frequency.

Sample Parameter	Frequency (prior to and 1-5years post harvest)	Frequency (6 to 10+ years post harvest)	Methods
Physical			
Substratum	Annual	Biannual	Wolman Pebble Counts, Percent Embeddedness
Temperature	Continuous (May - Oct)	Continuous for One Year, Every 5 years.	Data Loggers
Flow (Level 1)	Concurrent with Water Chemistry Sampling	Concurrent with Water Chemistry Sampling, Every 5 years.	Direct Measure
Flow	Continuous (May – Oct)	Continuous (May – Oct)	Pressure Data Logger and rating curve
Morphometery (cross-section, confinement, sinuosity)	Annual	Every 5 years	Surveys
Large Woody Debris	Annual	Every 5 years	Counts/LWDI
Solar Radiation	Three times a year, spring, summer, and fall	Three times a year, spring, summer, and fall, Every 5 years	Pyranometer or PAR meters with Data Loggers
Level 1 Water Chemistry			
Turbidity	Three times a year, spring breakup, summer baseflow, and fall storm events)	Three times a year, spring, summer, and fall, Every 5 years	Water Sample Analyses—Meter Measurement
Dissolved Oxygen	Three times a year, spring breakup, summer baseflow, and fall storm events)	Three times a year, spring, summer, and fall, Every 5 years	Water Sample Analyses—Meter Measurement
pH		Three times a year, spring, summer, and fall, Every 5	Water Sample Analyses—Meter Measurement

Sample Parameter	**Frequency (prior to and 1-5years post harvest)**	**Frequency (6 to 10+ years post harvest)**	**Methods**
		years	
Specific Conductance	Three times a year, spring breakup, summer baseflow, and fall storm events)	Three times a year, spring, summer, and fall, Every 5 years	Water Sample Analyses—Meter Measurement
Hydrocarbons/Foam	Concurrent with water sampling	Concurrent with water sampling	Qualitative Observations
Nutrients (NO_3-N, NH_4-N, Total-P, Dissolved P)	Three times a year, spring breakup, summer baseflow, and fall storm events)	Three times a year, spring, summer, and fall, Every 5 years	Water Sample Laboratory Analyses
Level 2 Water Chemistry			
Turbidity	Weekly (Spring) Biweekly or Continuous (May – Oct)	Weekly (Spring) Biweekly Every 5 years (May – Oct)	Water Sample Analyses—Meter Measurement
Dissolved Oxygen	Weekly (Spring), Biweekly (May – Oct)	Weekly (Spring) Biweekly Every 5 years (May – Oct)	Water Sample Analyses—Meter Measurement
pH	Weekly (Spring), Biweekly or Continuous (May – Oct)	Biweekly Every 5 years (May – Oct)	Water Sample Analyses—Meter Measurement
Specific Conductance	Biweekly (May – Oct)	Biweekly Every 5 years (May – Oct)	Water Sample Analyses—Meter Measurement
Hydrocarbons/Foam	Biweekly (May – Oct)	Biweekly Every 5 years (May – Oct)	Qualitative Observations
Nutrients (NO_3-N, NH_4-N, Total-P, Dissolved P)	Weekly (Spring), Biweekly (May – Oct)	Biweekly Every 5 years (May – Oct)	Water Sample Laboratory Analyses
Biological Organisms/Food Sources			
Fish (juvenile)	Biannual (Spring and Fall)	Biannual (Spring and Fall)	Baited Minnow Traps
Macroinvertebrates	Annual	Every 5 years	ASCI
Periphyton Biomass	Annual	Every 5 years	Accumulation on tiles
Benthic Organic Matter	Annual	Every 5 years	Substrate Samples

Sample Parameter	**Frequency (prior to and 1-5years post harvest)**	**Frequency (6 to 10+ years post harvest)**	**Methods**
			(AFDM)
Dissolved Organic Matter	Spring Runoff, Base Flow, and Fall Storm Events (May – Oct)	Every 5 years	Water sample analyses
Riparian Vegetation Community Composition	Annual	Every 5 years	Qualitative classification
Riparian Coarse Wood	Annual	Every 5 years	Counts of Coarse Wood Within Riparian.

Study Design

Treatment

The treatment at three of the four sites will be timber harvest conducted under the guidelines of the FRPA and regulations for State land within Region II. Actual timber harvest operations will be determined by the timber operator. Therefore, actual treatment can vary considerably. Sources of variation include the number, location, density, and type of spur roads, landings, and material sites; whether the area will be harvested in summer or winter, how the wood will be processed (on- or off-site), and the harvest's proximity to buffers and stream terraces. Therefore, the type of harvest will be closely monitored and recorded. Information on harvest activities will likely be obtained from the State Forester.

Hypothesis and Statistical Approach

A paired (pre- and post-harvest) sampling approach will be applied. This approach would allow for statistical comparisons using paired T-test or non-parametric alternatives for the first post-treatment measure with repeated measures using ANOVA thereafter. The approach will provide a means for evaluation of BMP effectiveness within the Willer-Kash harvest area that could be expanded over time and space to include harvests occurring along other stream types and over a larger geographical area. In addition, over time, the approach would allow for comparisons of sites for multiple stream types with different levels of area harvested and road construction methods. Under this approach, stream types within a harvest area would be identified through the Forest Land Use Plan (FLUP) development or upon the submission of Detailed Plans of Operation (if the harvest is on private land). Sampling reaches would be identified on each stream type or a subset of available stream types. Sample reaches would be selected with reference to the area of proposed upstream harvest and miles and type of proposed road construction (winter or all season, number of crossings, etc.). Pre-harvest data would be collected from each sampling reach. Following timber harvest, sampling would be repeated. Changes between pre- and post-harvest parameters would be analyzed; however, similar trends would need to be observed among all stream types for differences to be statistically significant. This approach is more cost efficient and more sensitive to change than the comparison of means or variability among reference and treatment groups, and does not require a large set of reference streams within a timber harvest area. In addition, by tracking the amount and type of harvest within each stream drainage, like comparisons can be ensured.

Method Requirements

Field Data Collection

Field data collection will be conducted by Aquatic Restoration and Research Institute (ARRI) staff. Latitude and longitude of sampling locations will be recorded using a GPS recorder. Photographs will be used to further identify locations and conditions during field sampling. Measures of dissolved oxygen, pH, specific conductance and temperature will be conducted in the field. Samples for turbidity and alkalinity will be collected in clean sample bottles and returned to the ARRI laboratory for analyses. Samples will be collected from a well-mixed area at each sampling site. Water-column integrated samples will be collected by drawing water into a 60 ml syringe while drawing the syringe up from near the stream bottom to near the water surface. The water within the syringes will be discharged into pre-labeled sample bottles.

pH, Specific Conductance, Turbidity, and Dissolved Oxygen

Depth integrated water samples will be collected in 500 ml sample bottles. The sample bottles will be filled and emptied 3 times before a sample is retained. Water characteristics will be measured using appropriate meters. Meters, pH, Hanna HI 9023, conductivity, SPER Scientific model 840039, and turbidity, HACH Chemical Co. Model 16800. Support equipment will include extra batteries and sample bottles. Clean sample bottles will be used. All meters will be tested and calibrated prior to use.

Materials Required: Data book, pencils, sharpie, 500-ml sample bottles (16 minimum), labels, 60-ml syringe, cooler, gel-paks, pH meter with standards, dissolved oxygen meter, thermometer, extra batteries, and camera.

Weather Conditions

Weather conditions for the 24 hours previous to sampling will be obtained through direct observations and from on-line National Weather Service Website for Talkeetna.

Site Locations and Photographs

Latitude and longitude of sampling locations will be recorded using a GPS recorder. Photographs will be used to further identify locations and changing seasonal riparian and stream conditions during field sampling.

Materials Required: Garmin GPS III and Nikon Coolpix L5 digital camera.

Nitrogen and Phosphorus

Water samples will be collected in sample containers provided by AM Test, Inc. Sample bottles will contain preservative where required (H_2SO_4 for nitrogen and total phosphorus, 4°C for dissolved phosphorus). Samples will be collected using the “clean hands” method. This method required two samplers, one to handle sample labels, containers and other equipment. The second sampler, while wearing sterile gloves, collects the sample and within sterile syringes or other sampling device and discharges the sample into the sample container. Sterile procedures are maintained. Samples will be sealed within a cooler with frozen gel-packs and shipped by Federal Express or UPS to the laboratory for analyses. Chain of custody forms will be used by ARRI staff and the receiving laboratory to track sample handling.

Materials Required: sample bottles, labels, markers, chain-of-custody forms, cooler, frozen gel-packs, 60-cc syringe, syringe filters, thermometer, and sterile gloves.

Temperature

Stream water temperature data loggers (Stowaway by Onset Corporation) will be placed within each stream within the area of proposed harvest units. Loggers will be secured to the bank using plastic coated wire rope. Loggers will be downloaded concurrent with water samples.

Materials Required: 4-m sections of wire rope (3), clamps (6), stowaway temperature data loggers with backup (4), software, base station, coupler, and shuttle.

Solar Radiation

Solar radiation at the stream surface will be obtained by taking 20 measures distributed systematically throughout the 100-m sampling reach. Concurrent measures will be taken of direct solar radiation adjacent to the stream site not shaded by riparian vegetation. Dependent variables will be the portion of total daily solar radiation at stream sites relative to open locations.

Materials Required. Light meter and sensor.

Discharge

Discharge will be measured using the methods of Rantz et al. (1982). A meter tape will be suspended across the stream. Water velocity will be measured at multiple intervals across the stream using a Price AA velocity meter. The meter will be spin tested prior to use. A top-setting wading rod will be used to ensure velocity is measured at 0.6 depth. Staff gauges will be secured at each discharge sampling points and a rating curve developed to calculate discharge when direct measurements are not possible. Discharge will be measured or estimated from the rating curve on each sampling date.

Materials Required: Rite-in-the-Rain data book, pencils, Onset water level loggers, nylon rope, 2”pvc vented with caps, 100-meter tape, top-setting wading rod, and velocity meter.

Substratum/Embeddedness

Substratum size distribution will be determined through Wolman (Wolman 1954) pebble counts of 100 stones as modified by Bevenger and King (1995). Beginning at the downstream end of the sampling reach, the intermediate axis of rocks is measured at roughly one-meter intervals as the investigator moves upstream, continually moving at an angle from bank to bank. The rock axis will be determined using an aluminum measuring template. The portion of each rock submerged below the substrate will be estimated from differences in algae or other markings on the rock and recorded as percent embedded (Davis et al. 2001).

Materials Required: Rite-in-the-Rain data book, pencils, aluminum template, meter stick.

Morphometry

Stream cross-sections will be measured using a laser level and leveling rod. A meter tape will be secured across the stream channel. Elevations will be measured at 0.5 to 1.0 m intervals beginning and ending above bankfull flows. The location of bankfull flows, ordinary high water and undercut depth will be noted or measured.

Materials Required: Rite-in-the-Rain data book, pencils, 100-meter tape, laser level and tripod, leveling rod, meter stick.

Algae/Benthic Organic Matter

Algae will be sampled by scraping a known area of stone and collecting the dislodged material on to a Whatman GF/C filter with 0.45 µm pore site (Davis et al. 2001). The algal sample will be analyzed for chlorophyll-*a*, and AFDM. Benthic organic matter will be collected in nested nets of different pore size held onto a Surber sampler frame. The sampler will be held on the stream bottom and the substrate from a known area upstream of the sampler will be disturbed, dislodging organic matter from the bottom, which will be carried into the nets by the current. The material from each net will be transferred into 500-ml nalgene bottles and preserved with alcohol. The AFDM of both the large and small size fractions will be determined through weight loss upon combustion at 500 C.

Materials Required. Surber sampler with nested nets, squirt bottle, whirl-pak bags, 500 ml poly bottles, alcohol, sharpies, pencils, labels.

Large Woody Debris and Coarse Woody Debris

Large woody debris (LWD) will be measures using the methods described in Davis et al. (2001). All large wood within the bankfull channel will be counted and scored based upon size and position in the stream relative to channel size. All debris dams are counted and scored relative to size and position in the stream. Scored values are converted into a large woody debris index (LWDI).

Coarse wood within the riparian area will be quantified by species within the sampling reach. Coarse wood is counted along one bank for 100-m length of stream extending out 30-m lateral to the channel. Downed coarse wood on the forest floor is identified by species and placed into one of three diameter and length categories (greatest diameter is from 10 to 20 cm, 21 to 30 cm, and > 30 cm) and three distinct length categories (1 to 5 m, 6 to 10 m, and > 11 m)..

Materials Required. Data book, meter stick or calipers, meter tape, distance finder.

Macroinvertebrates/Habitat Assessment

Macroinvertebrates will be collected, processed, and analyzed using the Standard operating procedures for the Alaska Stream Condition Index (ASCI) (Major and Barbour 2001). Composite invertebrate samples will be placed within pre-labeled 500-ml nalgene bottles. Paper labels will be placed into the bags with the sample and the sample preserved with 95% ethanol. Labels will include date, time, location, and investigators.

Stream invertebrate collections will be returned to the ARRI laboratory, sorted, and identified to genus (except for Chironomidae, Simuliidae, and Oligochaeta). .

Materials Required: ASCI Habitat Assessment Data Sheets, nalgene bottles, 5-gallon bucket, ethanol, D-Nets, gauntlets, labels, pencils, sieve, and sharpies.

Juvenile Fish

Fish will be collected in 4 baited minnow traps soaked for 4 to 6-hours. Captured fish will be identified, measured to fork length, and observed for deformities, eroded fins, lesions or tumors (DELT anomalies) using the USGS NAWQA methodology (Moulton II et al. 2002).

Materials Required: Minnow traps, salmon roe, buckets (2), small net, plastic bags, collection permit, measuring device.

Quality Objectives and Criteria for Measurement of Data

The parameters in the following table will be measured at the indicated performance level. All parameters are critical to meeting project objectives. Criteria for Measurements of Data are the performance criteria: accuracy, precision, comparability, representativeness and completeness of the tests. These criteria must be met to ensure that the data are verifiable and that project quality objectives are met.

Table 7. Accuracy, precision, and completeness objectives for measurement parameters.

Parameter	Method	Resolution/ Limit*	Expected Range	Accuracy% *	Precision	Completeness
pH	Meter	0.01	6.5 to 8.5	95 to 105 @ 7.0	5%	95%
Turbidity (NTU)	Meter	0.1	1 to 6	75 to 125	20%	95%
Conductivity (µS/cm)	Meter	0.1	100 to 200	95 to 105 @ 100µS/cm	5%	95%
DO (mg/L)	Meter	0.01	8 to 16	95 to 105 @ 10mg/L	5%	95%
Nitrate-N (mg/L)	EPA 353.2	0.010	0.05 to 0.5	75 to 125	20%	95%
Ammonia-N (mg/L)	EPA 350.1	0.005 (0.01 HL)	0.01 to 0.05	75 to 125	20%	95%
Total-P (mg/L)	EPA 365.2	0.005	0.001 to 0.005	75 to 125	20%	95%
Dissolved-P (mg/L)	EPA 365.2	0.001	0.001 to 0.005	75 to 125	20%	95%
Chlorophyll-a (mg/m^2)	SM 1002G	0.03	1 to 50	75 to 125	20%	95%
Substratum (mm)	Counts	N/A	0.2 to 500	N/A	10%	95%
Macroinvertebrates	ASCI	N/A	N/A	N/A	20%	95%
Juvenile Fish	Minnow Traps	1.0	0 to 20/hr	N/A	25%	95%
Large Woody Debris	LWDI	1	50 to 500	N/A	25%	95%
Coarse Woody Debris	Counts	1	1 to 200 per 100m	N/A	25%	95%
Solar Radiaition ($\mu mol/m^2/s$)	Meter	0.01	20 to 2000	75 to 125	N/A	95%
Temperature (°C)	Stowaway	0.1	0 to 15	97 to 103 @ 15°C	5%	95%

Parameter	Method	Resolution/ Limit*	Expected Range	Accuracy% *	Precision	Completeness
Discharge	Measure	1	15 to 40	N/A	10%	95%

* Method Detection Limit for Laboratory Analyses

Quality Assurance Definitions

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures.

$$Accuracy = \frac{MeasuredValue}{TrueValue} \times 100$$

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of methods. Precision is expressed in terms of the relative percent difference between two measurements (A and B).

$$\Pr ecision = \frac{(A - B)}{((A + B)/2)} \times 100$$

Representativeness

Representativeness is the extent to which measurements actually represent the true condition. Measurements that represent the environmental conditions are related to sample frequency and location relative to spatial and temporal variability of the condition one wishes to describe.

Comparability

Comparability is the degree to which data can be compared directly to similar studies. Standardized sampling and analytical methods and units of reporting with comparable sensitivity will be used to ensure comparability.

Completeness

Completeness is the comparison between the amounts of usable data collected versus the amounts of data called for.

Quality Assurance for Measurement Parameters

Accuracy

The percent accuracy for the acceptance of data is shown for each parameter in Table 2. Accuracy will be determined for those measurements where actual values are known. For pH, conductivity, turbidity, and dissolved oxygen, measurements of commercially purchased standards within the range of expected values will be used. For dissolved oxygen, 100% saturated air will be used as a standard. Measurement accuracy will be determined for each sampling event. Contract laboratories will provide the results of accuracy measures along with chemical analytical reports. Accuracy for Stowaway temperature loggers has been calculated to be 0.40°C by the manufacturer, which at 15°C is 97% to 103%. Accuracy will not be determined where true values are unknown: substratum, macroinvertebrates, and discharge. However, for discharge, the velocity meter will be spin tested as per manufacturer's recommendation prior to each use. Accuracy of discharge rating curves will be determined by comparing measured value (as actual) with calculated value.

Precision

Table 2 shows the precision value for the acceptance of data. Precision will be determined for all chemical measures by processing a duplicate for every 8 samples. A discharge measure will be repeated at one site on one occasion to determine measurement precision. Precision of stowaway meters will be determined by placing all meters in one location for 24 hours. Precision for substratum size distribution will be determined by repeating the pebble count at one location and comparing the number of stones within each size class.

Representativeness

The monitoring design site locations, sampling frequency, and timing will ensure that the measurement parameters adequately describe and represent actual stream conditions for the sampling period. Chemical measures should represent two distinct periods within the single annual period, spring runoff and baseflow conditions. Single year data should not be interpreted to be representative of conditions over longer temporal scales. Repeated measures over multiple years are necessary to describe the variability among years.

Comparability and Completeness

The use of standard collection and analytical methods will allow for data comparisons with previous or future studies and data from other locations. We expect to collect all of the samples, ensure proper handling, and ensure that they arrive at the laboratory and that analyses are conducted. Our objective is to achieve 100% completeness for all measures. Sample collection will be repeated if problems arise such as equipment malfunction or lost samples. For spring runoff samples, due to laboratory turnaround time, repeating sample collection may need to occur the following year.

Data Management

Field data will be entered into rite-in-the-rain books. The Quality Assurance Officer will copy the field books and review the data to ensure that it is complete and check for any errors. Field and laboratory data sheets will be given to the project manager. The project manager will enter data into Excel spreadsheets. The Quality Assurance Officer will compare approximately 10% of the field and laboratory data sheets with the Excel files. If any errors are found they will be corrected and the Project Manager will check all of the field and laboratory data sheets with the Excel files. The Quality Assurance Officer will then verify correct entry by comparing another 10% of the sheets. This process will be repeated until all errors are eliminated. The Project Manager will then summarize and compare the data and submit it to a statistician for review or analyses. Results will be compared to state water quality standards 18 AAC 70. The statistical approach outlined previously (see Study Design page 13) will be used to test stated hypotheses. The Quality Control officer will review any statistical or other comparisons made. The Project Manager will write the final report, which will be proofed by the Quality Assurance Officer and at least three other peer reviewers. The Quality Assurance Officer will check the results in the report and associated statistical error (i.e. standard deviation and confidence interval) against those calculated with computer programs. Any errors found will be corrected by the Project Manager. Any errors will be corrected.

Additionally, water quality data will be provided to ADEC in a modernized STORET compatible format or other specified format as described at the following ADEC web site.

https://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm

Reporting Requirements

Sampling Event Reports

Following each sampling event ARRI will send a report to the ADEC Project Manager. The report will include: date, time, and location samples were collected, time samples delivered to laboratory, any collection problems or sampling recommendations, the results of field measures, and any laboratory results.

Draft Final Report

ARRI will submit a pre-draft report providing analytical results and a draft final report to the ADEC project manager. The report will describe the objectives of the project and the methods used to meet project objectives. Monitoring data will be summarized and evaluated for any trends and differences among sites. Data will be compared to previously published data for other similar stream systems. Potential causes of variability in the data will be discussed relative to any potential historic or current causes.

Final Report

ARRI will provide the ADEC project manager with the final report of first season data collection. The final report will be modified to incorporate any editorial, content, or formatting comments to the draft report as requested by the ADEC project manager.

Project photographs will be submitted as CD-stored JPEGs.

Citations

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