Fish Habitat

Goal: Maintain or restore the natural range and frequency of aquatic habitat conditions on the Tongass National Forest to maintain the abundance and diversity of resident and anadromous fish.

Objective: Determine if our best management practices (BMPs) and 1997 Tongass Land and Resource Management Plan (Forest Plan) Standards and Guidelines have been implemented and, if they are effective in protecting fish habitat and fish populations. Monitor key stream channel characteristics and representative fish populations to determine if trends attributable to forest management are evident.

Background: Fish and aquatic resources on the Tongass National Forest provide major subsistence, commercial, and sport fisheries. Abundant rainfall and watersheds with high stream densities provide a high number and diversity of freshwater fish habitats. The Tongass National Forest provides spawning and rearing habitats for the majority of fish produced in Southeast Alaska. Maintenance of this habitat and high water quality is of concern to the public, State and Federal natural resource agencies, and Native organizations.

In FY 2006, major emphasis was placed on monitoring resident fish populations, fish passage conditions at road culverts, BMP implementation, and stream habitats. A synthesized approach was used for all aspects of fish habitat monitoring. The Pacific Northwest Forest Experiment Station progressed on development of a plan for monitoring juvenile coho salmon.

Fish Habitat Question 1: Are population trends for Management Indicator Species (MIS) and their relationship to habitat changes consistent with expectations?

The Forest Plan identified Dolly Varden char, cutthroat trout, coho salmon and pink salmon as MIS. An annual monitoring program for resident Dolly Varden and cutthroat and their habitat was established in 1999. In 2006, fish abundance and stream habitat surveys were completed for 24 previously identified monitoring streams.

The protocol incorporates a design that requires monitoring of streams before and after timber harvest. Initial timber harvest is complete in the watersheds of two streams (Tunehean and Salty creeks) and harvest or road construction began in two additional watersheds (Vial and Gunsight creeks) in 2006. Predicting the year of future timber harvest is difficult and is controlled by many variables including appeals and litigation of National Environmental Policy Act (NEPA) documents, the market value for timber, and changes in laws and policy affecting timber harvest in Southeast Alaska.

Alaska Department of Fish and Game (ADF&G) commercial harvest and escapement data are reported for coho and pink salmon for 1997 through 2006. A project will be completed in 2007 to develop and evaluate a protocol for monitoring juvenile coho. For pink salmon, a project to determine the sensitivity of historical escapement (number of adults returning to spawn) to previous timber harvest has stalled.

Monitoring Results for Dolly Varden Char and Resident Cutthroat Trout

Fiscal year 2006 was the eighth consecutive year for resident Dolly Varden and cutthroat monitoring. Monitoring streams are located throughout the Forest in watersheds with anticipated future timber harvest (Map Fish–1).

Power analysis has suggested 16 treatment streams will be necessary for an 80 percent chance of detecting a decline in fish populations of 0.80 of the standard deviation of the samples (the effect size). Existing long-term data sets for resident cutthroat in Oregon and for Dolly Varden in Southeast Alaska indicate that a decline of approximately 20 percent of the mean annual population could be detected.

Even though the power analysis indicated 16 streams would be sufficient for the minimum monitoring program, 20 streams have been selected. We will continue identifying and adding streams for a more robust program. Doing so will compensate for fall-down in the planned timber harvest that reduces the sample of streams. A new stream on Etolin Island was identified and field verified this year and monitoring will begin in 2007.

In addition to the 20 treatment streams, four control streams are being monitored (Table Fish-1). As of July 2005, timber harvest for eight of the treatment streams has been substantially delayed or dropped. Timber harvest has occurred or is now likely for 13 treatment streams (including the new stream on Etolin Island to be added in 2007) within the next 8 years.

Control streams were added to the design following a recommendation from the Interagency Monitoring and Evaluation Group. Control streams are not required for the planned paired-t test, but will help to explain changes in the fish abundance that might not be related to timber harvest.

Site selection criteria for treatment streams include:

- Populations of resident cutthroat trout and/or Dolly Varden char;
- Migration barriers to prevent interaction with anadromous fish;
- FP3, MM1, or closely related channel types;
- No previous logging, but with planned future logging; and
- Not connected to lakes.

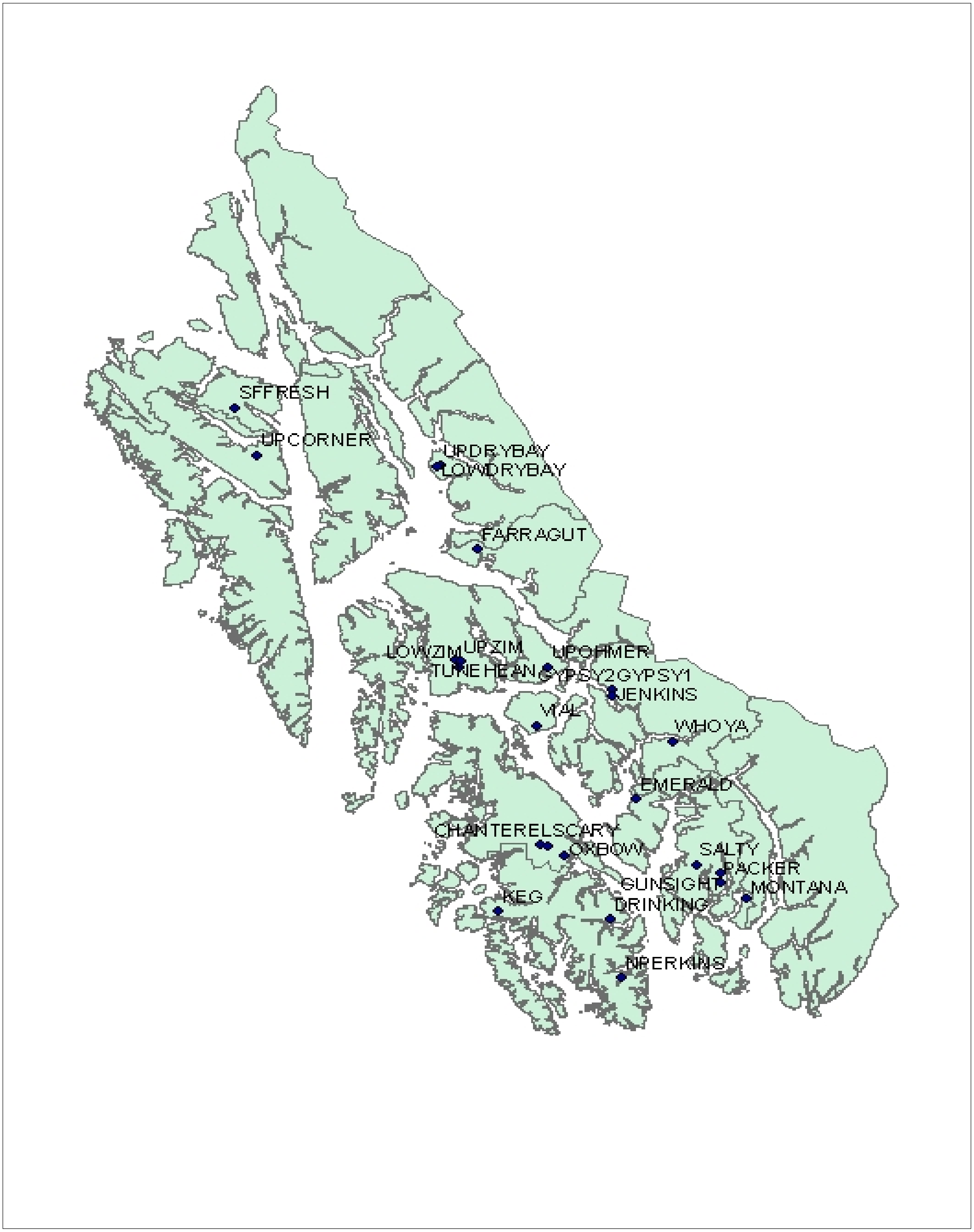
Control streams meet the same criteria except there is no planned future logging.

Two of the monitoring streams are located in case-study watersheds. One is a control stream (Chanterelle Creek) and the other is Scary Creek, a previously harvested watershed. Scary Creek data cannot be used for the resident fish MIS project, as the watershed does not meet the site selection criteria. Both data sets will be valuable to help interpret the wide range of monitoring data being collected from the case-study watersheds.

Table Fish 1. Summary of Stream Reaches for Resident Fish Monitoring in 2006

Ranger District	Stream Name	Year of Timber Harvest	Channel Type	Fish Species	Population Estimate	Habitat Survey
Craig	Drinking Water Cr	2007	MM1	Cut, DV	Yes	Yes
	N Perkins Cr	2010	MM1	Cut, DV	Yes	Yes
	Keg Cr	Control	FP4	DV	Yes	Yes
Hoonah	S Fork Freshwater Cr	2010	MM1	Cut, DV	Yes	Yes
Juneau	Dry Bay Upper	Dropped	FP3	DV	Yes	Yes
	Dry Bay Lower	Dropped	FP3	DV	Yes	Yes
Ketchikan-Misty	Montana Cr	2007	MM1	Cut	Yes	Yes
	Packer Cr	2007	MM1	Cut, DV	Yes	Yes
	Gun Sight Cr	2006	MM1	DV	Yes	Yes
	Salty Cr	2001	MM1	Cut	Yes	Yes
	Emerald Cr	2007	FP3	Cut	Yes	Yes
Petersburg	Farragut Cr	Deferred	FP3	Cut, DV	Yes	Yes
	Tunehean Cr	2002	MM1	Cut, DV	Yes	Yes
	Lower Zim Cr	2014	MM1	Cut, DV	Yes	Yes
	Upper Zim Cr	2014	FP3	Cut, DV	Yes	Yes
	Upper Ohmer	Control	FP3	DV	Yes	Yes
Sitka	Corner Bay Tributary	Dropped	MM1	Cut	Yes	No
Thorne Bay	Oxbow Cr	Control	MM1	Cut, DV	Yes	Yes
	Chanterelle Cr	Control	MM1	DV	Yes	Yes
Wrangell	Gypsy Mainstem	Deferred	MM1	Cut	Yes	Yes
	Gypsy Tributary	Deferred	MC1	Cut	Yes	Yes
	West Fork Hoya Cr	Deferred	FP3	DV	Yes	Yes
	Vial Cr	2006	MM1	DV	Yes	Yes
	Jenkins Cr	Deferred	MM1	Cut	Yes	Yes

Map Fish–1. Location of monitoring streams



In 2006, density of cutthroat and Dolly Varden varied widely among the sampled streams (Appendix A, Fish-1). Densities generally ranged from five to 15 fish per 100 m^2 for streams with only Dolly Varden. Streams with only cutthroat had densities ranging from seven to 22 per 100 m^2. In streams with both species, the total fish density ranged from four to almost 34 per 100 m^2. Of the 24 monitoring streams, eight have only Dolly Varden, four only cutthroat, and 12 have both species. Estimated abundance of Dolly Varden and cutthroat in the monitoring reaches generally tracks the density and in 2006 ranged from 30 to 183 fish (Appendix A, Fish-2).

We also annually monitored stream habitat in the same reaches where we estimate fish abundance. Measured stream habitat includes number of pieces of large woody debris, pool area, number of pools, average residual pool depth, length of undercut banks, and the D50 substrate size (Appendix A, Fish-3). Differences in the amount of these habitat components are apparent between streams. For example in 2006, large woody debris counts ranged from 12 in Oxbow Creek to 151 in Gypsy Main Stem. For pool area, the range was less than 62 m^2 for South Fork Freshwater to 665 m^2 for Upper Ohmer Creek. Complete data on reach lengths and additional descriptions of large woody debris, pools, and substrates are in the project files.

A crew of two or three people completed the monitoring for each stream. A Supervisor's Office employee traveled to many of the districts and worked with district representatives. This approach provided training for the often-newer district employees. Experienced Ketchikan and Thorne Bay Ranger District employees monitored the streams on their districts. Both approaches helped ensure consistency and will be used next year. The Sitka, Wrangell, and Petersburg districts are completing more of the monitoring on their units.

Evaluation of Results

Annual variation in estimated fish abundance is evident for all monitored streams (Figures Fish-1 and Fish-2). This variation will affect our ability to detect change in the mean abundance of fish following timber harvest. The preliminary sample size of 16 streams was based on annual variations for fish populations found in the literature. We now have multiple years of Dolly Varden and cutthroat abundance data from our own streams. Based on the annual variation calculated for streams with 8 years of data, we will likely be able to detect a change in mean abundance of 12 to 38 percent if the stream has 40 or more fish and approximately 25 to 50 percent if the populations are less than 40 fish. Annual abundance estimates are more variable for streams with fewer fish.

Annual variation for pool area (Figure Fish-3) and large woody debris (Figure Fish-4) appear to be less than the variation for fish. Calculated standard deviations for most of the habitat variables confirm this visual observation.

Figure Fish - 1. Dolly Varden char abundance estimates for streams with 8 years of data.

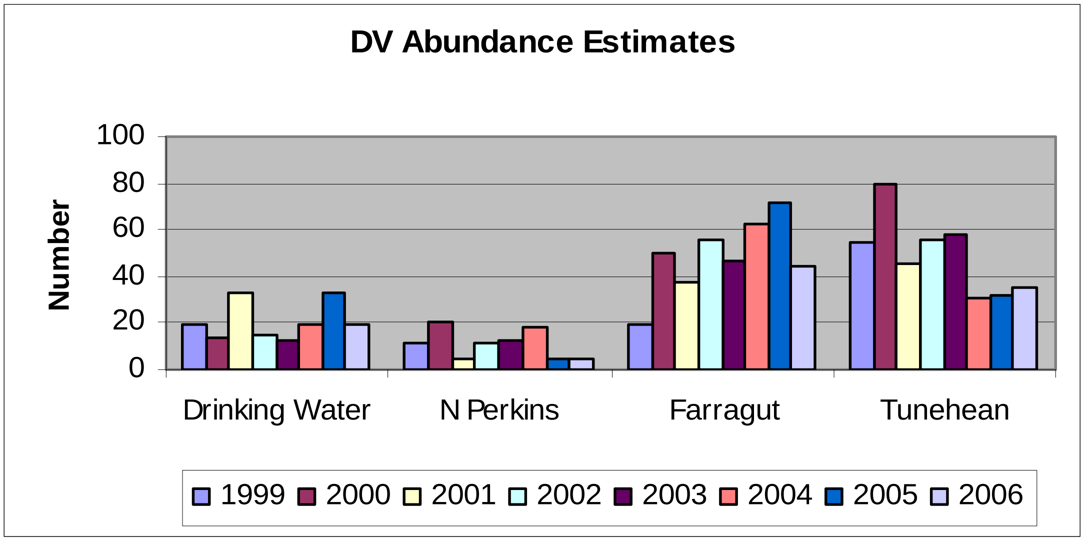


Photo Fish-1. Cutthroat Trout

Photo Fish-2. Dolly Varden on Measuring Board

Figure Fish - 2. Cutthroat trout abundance estimates for streams with 8 years of data.

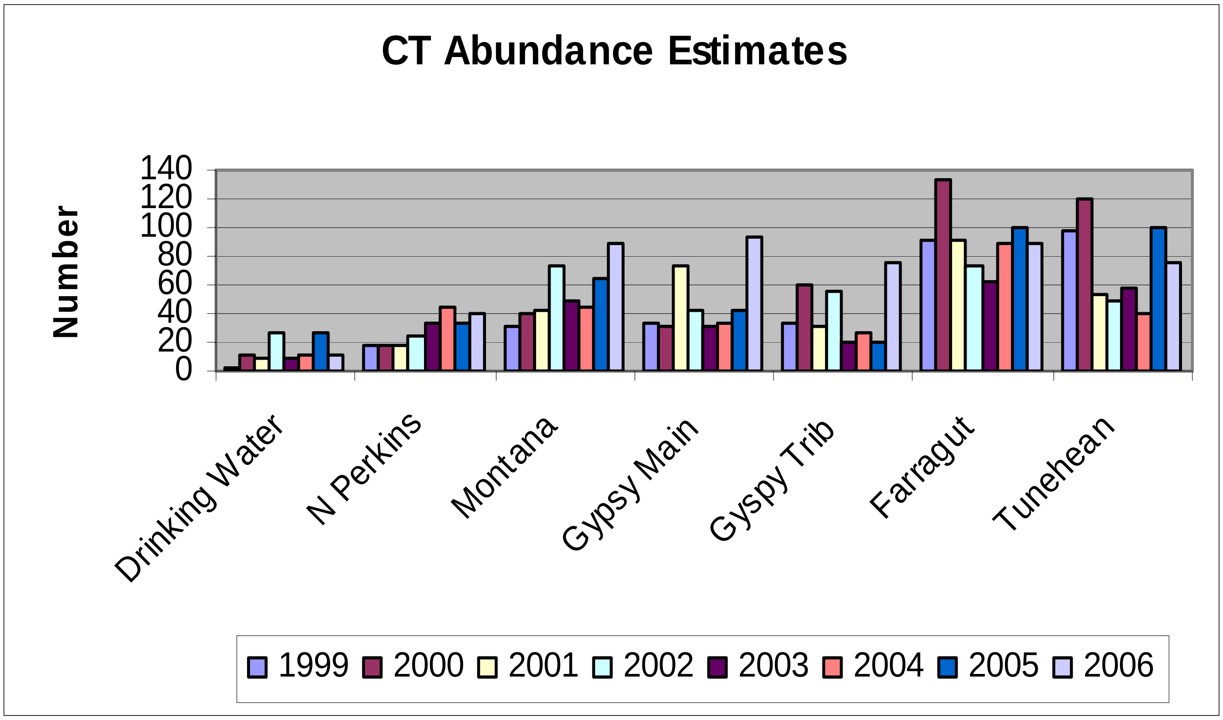


Figure Fish - 3. Measured pool area for the streams with 7 or 8 years of data

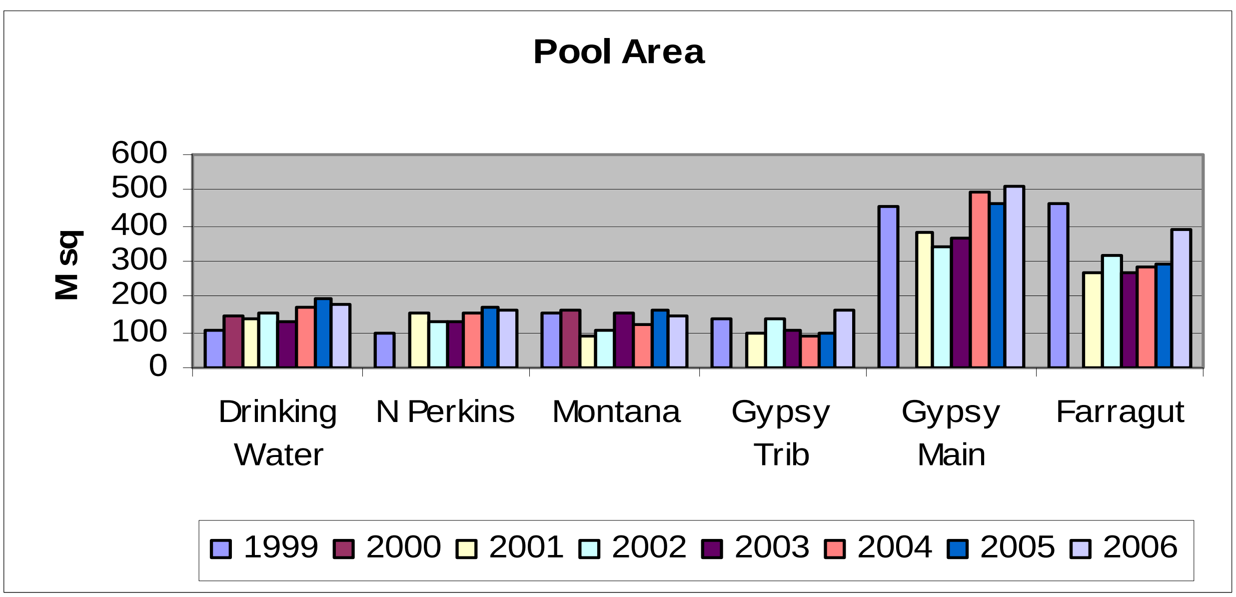
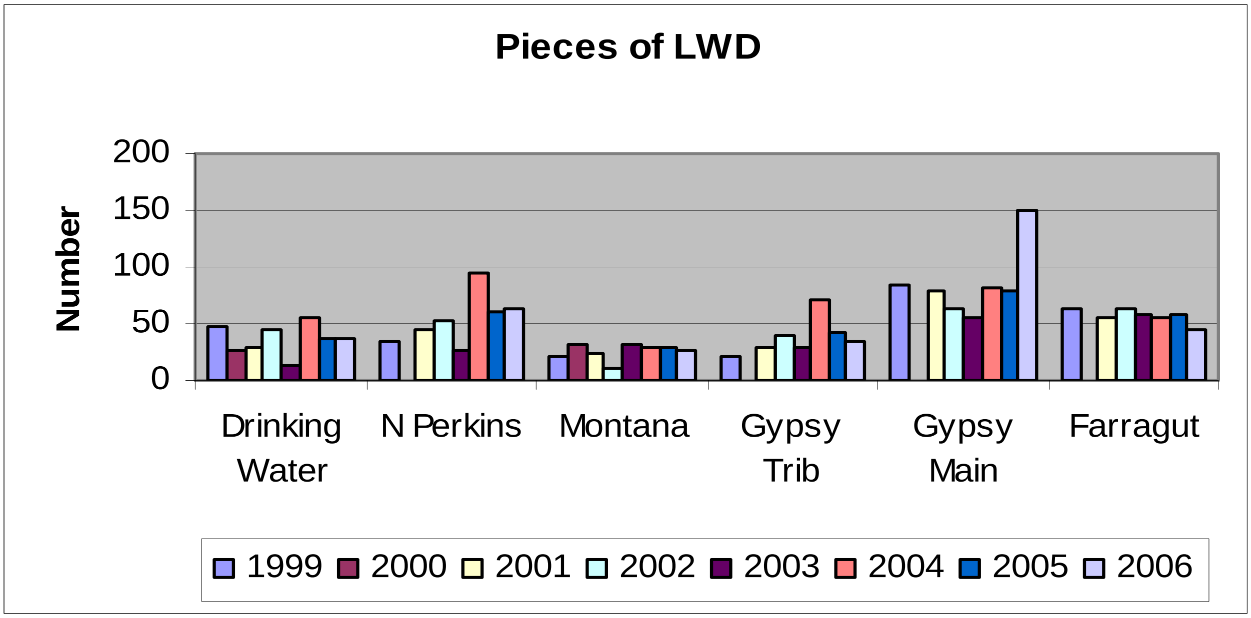


Figure Fish - 4. Pieces of wood for the streams with 7 or 8 years of data



No consistent trends are evident in the annual fish abundance data (Figures Fish–1 and Fish–2). Dolly Varden abundance in Farragut appeared to be increasing through 2005, but the trend reversed with a reduction in 2006. Dolly Varden abundance in Tunehean appeared to be decreasing from 2000 through 2006, but 2000 was a peak year following a relatively low estimate in 1999. Fish abundance in many streams demonstrates no apparent trend and short term-trends for individual streams often reverse as monitoring continues.

The mean density of both Dolly Varden and cutthroat for 15 streams from the Petersburg, Wrangell, and Ketchikan/Misty ranger districts consistently declined in 2005 from previous levels and again increased in 2006. Region-wide trends may be an indication of weather patterns, for example a dry summer with low stream flow in 2004 may have increased fish mortality and we measured the result in 2005. In future years, we will be alert for further evidence of region-wide synchronization of abundance.

Timber harvest began in the Tunehean Creek watershed in 2002. A large culvert was being installed just upstream from the monitoring site during the 2002 abundance estimate and timber had been fallen in upstream units. The Dolly Varden populations were reduced in 2004, 2005, and 2006 and we wondered if this was an effect of forest management. It is possible, but it is also likely the decline is natural variation caused by multiple factors currently not fully understood. Additionally, cutthroat in Tunehean declined through 2004, but rebounded markedly in 2005 and 2006. It is too early to speculate on the effects of forest management until sixteen treatment streams are harvested and the statistical tests are completed.

There are no consistent trends in the habitat data. For example, the area of pools appears to be relatively uniform for streams with 7or 8 ears of habitat data (Figure Fish-3). An increasing trend of wood was apparent for North Perkins and Gypsy Tributary through

2004, but the number of pieces declined sharply in both streams in 2005 and 2006 (Figure Fish-4).

We are curious if annual variation for fish abundance in a specific stream was related to measured changes in habitat for that stream. Montana Creek was chosen for an initial analysis because we have eight continuous years of data and only cutthroat reside in the stream eliminating potential effects of species interaction. The product moment correlation coefficient for cutthroat density and pool area, number of pieces of large woody debris, average residual pool depth, and length of undercut banks are not significant at the 0.05 level so it appears that short-term fluctuations of fish abundance are not related to stream habitat in Montana Creek.

In addition, a sharp three-year decline of Dolly Varden density in Gunsight Creek does not appear to be related to habitat changes in the monitoring reach. Formal analysis is not warranted due to the small number of observations, but visual inspection revealed no obvious relationships.

The difference in abundance and density of fish between streams is intriguing. It was anticipated that there would be more fish in FP3 channels compared to the slightly steeper MM1 channels. Four of the streams had high fish density in 2006 of more than 25 per 100. Three of the four streams with dense populations are MM1 channels (Appendix Fish-1). The differences in abundance and density of fish between streams are likely caused by multiple factors including watershed geology, elevation, stream productivity, and physical habitat. However, we have to remember that the number of fish in individual streams is not as important as the eventual comparison of the number of fish in each stream before and after timber harvest.

Actions Recommended for FY07

Continue annual fish abundance and stream habitat monitoring in FY07. The monitoring program will be complete when at least 16 treatment streams have been logged and the number of years of the post-logging data is approximately equal to the number of years of pre-logging data. This suggests the resident-fish monitoring project will continue for more than 10 years.

Add new treatment streams as opportunities arise. It now appears that timber harvest will only occur for 12 of our treatment streams, and power analysis has indicated the need for a minimum of 16. New treatment streams should be associated with timber sales likely to be sold and harvested within the next several years.

Consult a statistician to evaluate progress in the monitoring project. Ask if the data collected to date will be suitable for answering the monitoring question. Additionally, consult with a statistician to further evaluate relationships between measured stream habitat and fish abundance in the existing data.

Continue to monitoring resident fish populations in the case-study watersheds.

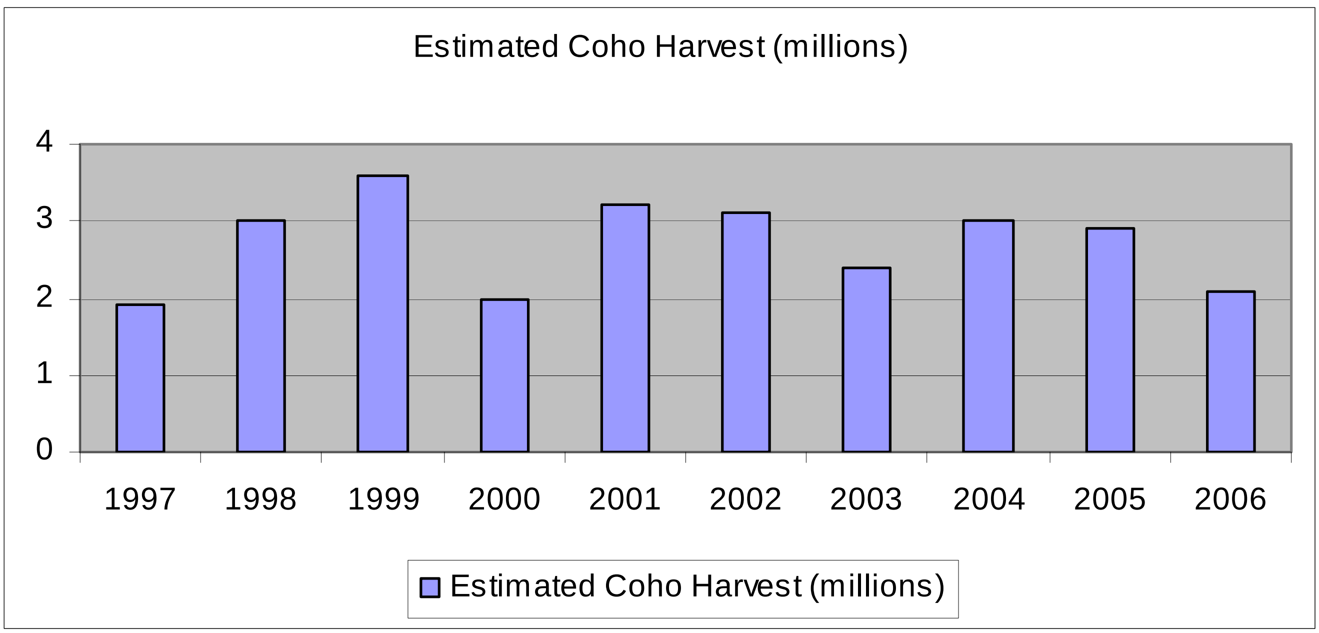
Amend the Forest Plan to specify monitoring the abundance and habitat of resident Dolly Varden and cutthroat. The Forest Plan currently states we will monitor Dolly Varden char and cutthroat by annually evaluating the ADF&G’s harvest statistics and completing population surveys on a sample basis, if necessary. We have found the harvest statistics are only available for popular sport fishing streams. Many of these streams are anadromous and do not have planned future logging.

Monitoring Results for Coho Salmon

Annual commercial harvest of coho salmon is reported by the ADF&G, and the Forest Service evaluates these estimates for trends (Figure Fish-5). No trends are evident. After reviewing ADF&G's entire data set that extends back to 1960, it was interesting to note that the commercial harvest of coho salmon has been above the long-term average for eight of the last 10 years.

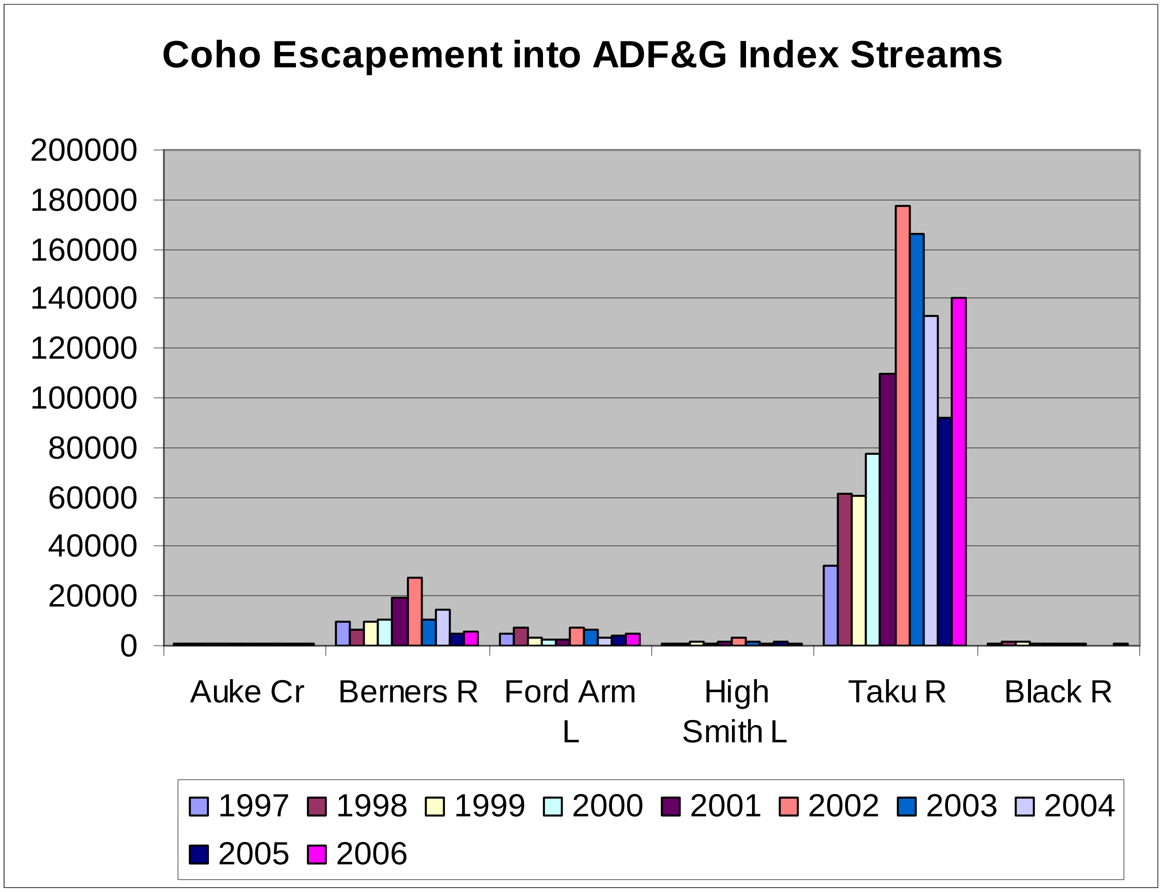
An ADF&G coho research biologist reports that the mean wild coho abundance in SE Alaska from 1982 through 1997 was 3.68 million, and the mean from 1998 through 2006 was 3.65 million. This indicates there are no major differences in wild coho abundance following completion of the Forest Plan in 1997. The ADF&G is becoming concerned that glacial rebound is causing dewatering of many small rearing streams that may result in a long-term decline for wild coho around Yakutat.

Figure Fish - 5. Annual commercial harvest of coho salmon in Southeast Alaska from 1997 through 2006, Data provided by ADF&G



Coho escapements are difficult to estimate since the adults enter spawning streams during the fall when flows are often high. The ADF&G has selected a small number of representative streams across Southeast Alaska to carefully (and expensively) count or estimate escapement. Data from these streams and rivers are the best available for the Forest Service to review for trends (Figure Fish-6).

Figure Fish - 6. Annual escapement of coho salmon in six index streams from 1997 through 2006, Data provided by ADF&G.



No consistent trends for coho escapement to index streams are evident from 1997 through 2005. High escapement occurred for Berners and the Taku rivers in 2002. ADF&G attributes this to reduced commercial fishing effort and harvest due to low selling prices for wild salmon. Compared to 2002, escapements in 2003, 2004, 2005, and 2006 are reduced for all index streams.

Evaluation of Results

The region-wide commercial harvest estimates and escapement data from index streams are indicators of the annual abundance and potential trends of adult coho returning to Southeast Alaska. Since juvenile coho normally spend one or two years rearing in freshwater, juvenile survival is likely affected by changes in the quality of stream habitat. Research in the Pacific Northwest and in Southeast Alaska has shown that forest management affects coho salmon on a stream-by-stream basis. Coho are also affected by the severity of winter weather and the cyclical productivity of the marine environment. Monitoring the abundance of juvenile coho in freshwater may be a more direct indicator of potential effects of timber harvest as sources of annual variation from marine survival and commercial and sport harvest are largely excluded.

Development of Monitoring Protocols Using Juvenile Coho Salmon

The Forest Sciences Laboratory is developing and testing a protocol to use juvenile coho abundance in tributary streams as an indicator of potential effects of forest management. A review draft of the monitoring protocol was completed in November 2006. Copies were sent to the Alaska Department of Fish and Game and U.S. Forest Service, Region 6, Monitoring and evaluation group for review. A copy was also submitted to the PNW statistician for statistical review. When these reviews are received, the final revision will be completed. Supporting work from the University of Washington (Wissmar 2006) and Western Ecosystems (McDonald et al. 2006a; McDonald et al. 2006b) are incorporated into the draft monitoring protocol.

The protocol provides quantitative methods to measure trends of juvenile coho in small streams that are located in watersheds managed in accordance with standards and guidelines in the Forest Plan. The field methods and analysis are based on a three-year pilot study that was completed in 2005 (Bryant and others 2005). Results from the pilot study were used to estimate sample sizes in the monitoring protocol for specified levels of statistical power (i.e. the ability to detect trends in population size.) To detect a decrease in population abundance of juvenile coho of 5 % per year, a sample size of 12 streams per treatment (TLMP and old growth) are required at $\alpha = 0.10$ and $\beta = 0.20$ over a ten-year monitoring period.

The protocol provides a description of a sampling strategy, a detailed sampling methodology to obtain quantitative estimates of fish population numbers and habitat, and statistical analysis to measure population trends. The primary analysis of trends in salmon abundance is a mixed-effects linear regression model that adjusts treatment effects for both correlation among years and values of habitat covariates. Inclusion of significant covariates accounts for differences among streams that may be external to management effects. Examples of potential landscape covariates are watershed relief and drainage density identified by Wissmar and Timm (2006). Significance differences among locations (north to south) were observed for coho salmon fry in the pilot study (McDonald et al. 2006b). Significant covariates for the protocol were identified from existing SE Alaska data collected over a ten-year period using a stepwise regression methodology. The details for conducting the protocol, sampling fish and habitat, and analysis are provided in a set of appendices in the protocol.

Actions Recommended for FY07

Continue to evaluate ADF&G’s commercial harvest and escapement statistics. There is a concern that the region-wide coho databases are insensitive to National Forest management, but should be evaluated until a more sensitive protocol is implemented.

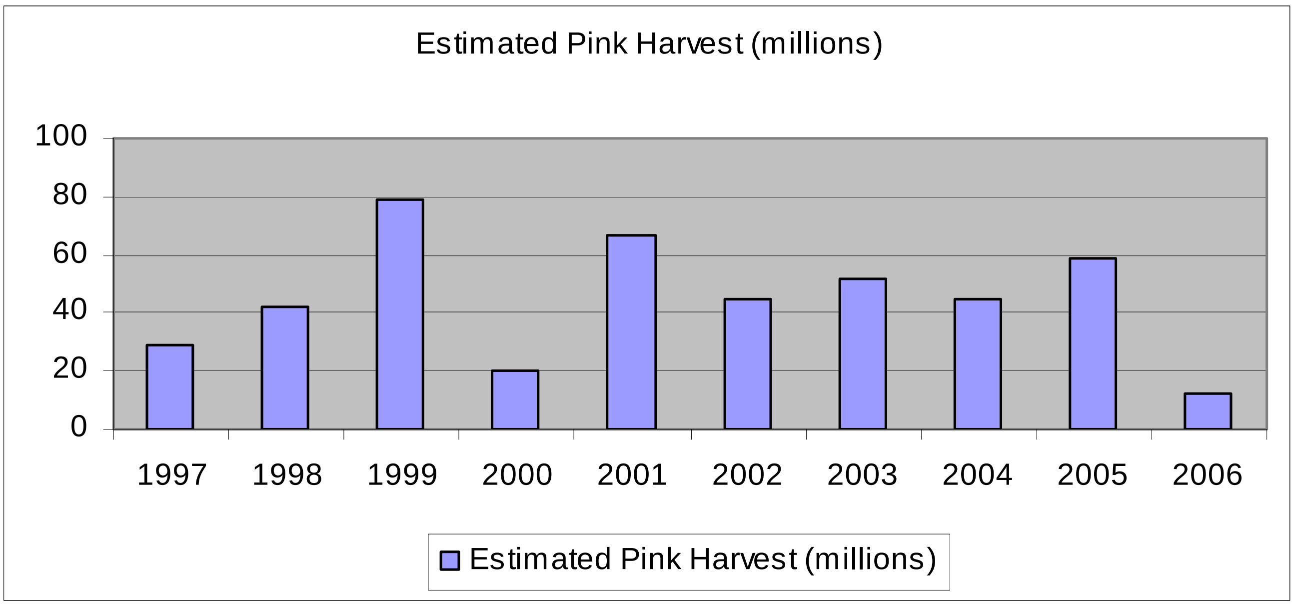
The Forestry Sciences Laboratory should complete the final report describing a protocol to monitor juvenile coho in small streams. The Forest should review the protocol and consider if the recommended monitoring is sufficiently sensitive to forest management and is affordable. If both are affirmative, the Forest should request funding for implementation beginning in FY08.

No changes in the Forest Plan are recommended at this time. Future recommendations may be developed following completion and acceptance of the protocol to monitor juvenile coho in streams.

Monitoring Results for Pink Salmon

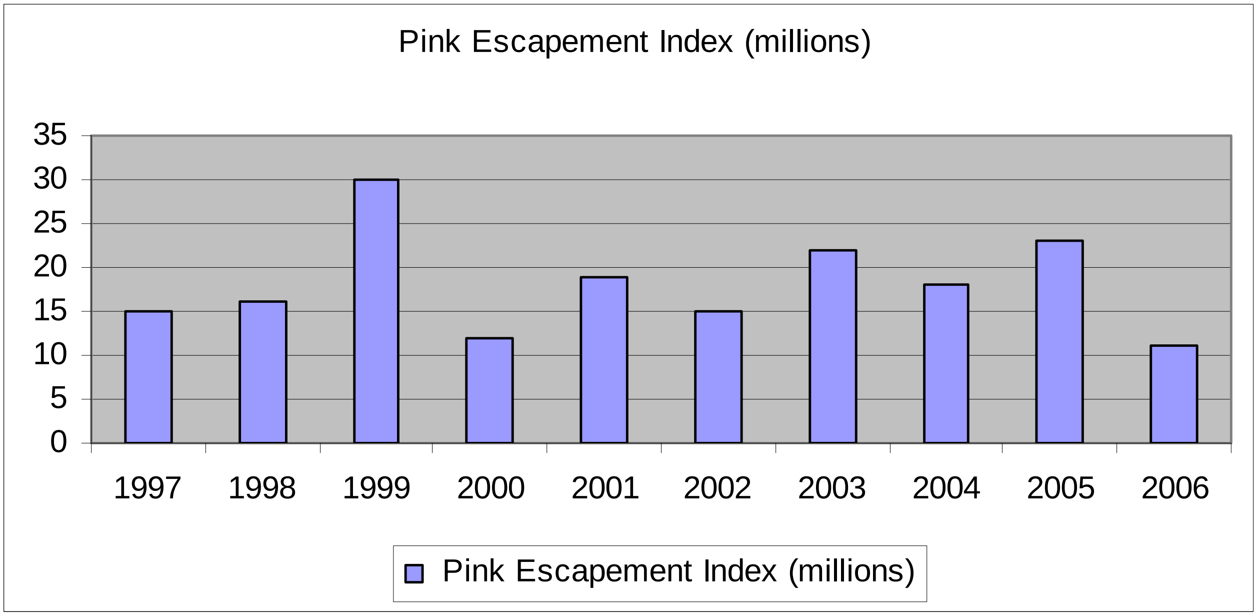
Annual commercial harvest of pink salmon is reported by the Alaska Department of Fish and Game. The Forest evaluated these estimates to see if trends are evident following completion of the Forest Plan in 1997. Annual commercial harvest is an indicator of population abundance. Harvest data from 1997 through 2006 are presented in Figure Fish-7.

Figure Fish - 7. Annual commercial harvest of pink salmon in Southeast Alaska from 1997 through 2006. Data provided by ADF&G



Another indicator of pink salmon abundance is the number of adult fish returning to spawn. ADF&G biologists fly over the spawning streams and count pink salmon concentrated on broad spawning riffles. ADF&G annually reports this spawning-survey data (commonly and hereafter called "escapement" data) for a series of index streams across SE Alaska. The reported data is the sum of the peak escapement counts for approximately 850 index streams across Southeast Alaska (Figure Fish-8).

Figure Fish - 8. Annual escapement of pink salmon in Southeast Alaska from 1997 through 2006. Data provided by ADF&G



No trends are apparent in the harvest and escapement data from 1997 through 2006. After reviewing the entire data set for commercial harvest of pink salmon, it is interesting to note that the harvests in 1999 and 2001 were the highest and second highest recorded. The estimated harvest of 12 million pink salmon in 2006 is well below the average long-term harvest since 1960. The reduced 2006 return was surprising to fishermen and fisheries managers, and commercial harvest was curtailed to allow for escapement into spawning streams. In 2004, region-wide cold weather and stream freezing when the eggs and fry were incubating in the spawning streams have been offered as a likely explanation of the reduced 2006 return of pink salmon.

Evaluation of Results

The combination of annual harvest and escapement is a good indicator of the annual abundance and potential trends for the pink salmon returning to Southeast Alaska. It is generally believed, that pink salmon abundance is controlled by several factors including stream freezing and the cyclical productivity of the marine environment. Quality of the freshwater habitat, mainly the percentage of fine sediment in the spawning gravel, is also important and may be affected by forest management, but is likely overshadowed by the influence of winter freezing and ocean productivity.

Commercial harvest of both pink and coho salmon was high in 1999. The synchrony of high commercial harvest of both species suggests a strong influence of ocean productivity on the abundance of these species.

A study to determine the sensitivity of pink salmon escapement to previous forest management has been in the design stage since 2000. The plan is to review approximately 30 years of spawning escapement data that have been collected in over 800 watersheds and relate escapement trends to timber harvest for the same watersheds.

Kuiu Island was selected for a pilot study. Eighty-one streams were identified on Kuiu with long-term escapement records, and a strategy was developed to quantify the logging history for each watershed. Information was gathered on the percent of watersheds harvested each year, harvested on slopes greater than 72 percent, and harvested in riparian areas; the road density; the amount of road on slopes greater than 5 percent; and the amount of road within riparian areas and on wetlands. Adjacent logged and unlogged streams were paired to compare trends in escapement. The project slowed in 2002 when concerns surfaced that the pink salmon escapement data was not suitable for this project. In 2006, ADF&G determined the data is not suitable and the project has terminated.

Actions Recommended for FY07

Annually review the ADF&G pink salmon harvest and escapement data for trends.

Consider developing a new approach for monitoring pink salmon. One potential is to monitor fine sediment in pink salmon spawning gravel for selected streams with planned future timber harvest and road construction. Both field and laboratory studies have established a relationship between increased fine sediment and reduced survival of salmon eggs. Previous field studies have generally identified a need for large numbers of samples to detect change in fine sediment in spawning gravel. As stated in Chapter 6 of the Forest Plan, request that the Pacific Northwest Experiment Station help design a project to monitor fine sediment, or another approach, to monitor for trends in pink salmon populations and habitat changes resulting from forest management.

No changes in the Forest Plan are recommended at this time.

Photo Fish-3. Oxbow MIS monitoring reach

Fish Habitat Question 2: Are Fish and Riparian standards and guidelines being implemented?

Best Management Practices (BMPs) described in the Soil and Water Conservation Handbook (Forest Service Handbook 2509.22, October 1996) define practices that provide protection for soil and water resources. The Fish Riparian standards and guidelines define site-specific measures to protect the resources. These standards and guidelines were monitored following a methodology described in the Tongass Monitoring Strategy. The strategy was developed to provide direction for Forest Plan implementation monitoring. Refer to the *Tongass Best Management Practice Implementation Monitoring Report: Fiscal Year 2006* in the appendix for details on how the monitoring was conducted. A summary of the findings for the fish and riparian resources relative to BMP implementation follows.

The BMP implementation monitoring included two distinct efforts: (1) 100 percent monitoring of the units closed out and roads completed and (2) Interdisciplinary Team (IDT) monitoring. The 100 percent monitoring was primarily conducted by Forest Service sale administrators and engineering representatives with assistance from resource specialists in a few circumstances. An interdisciplinary team of Forest Service employees and other Federal and State agency representatives conducted the IDT monitoring. Included were sale administrators, engineers, foresters, planners, and resource specialists from soils, water and fisheries. The IDT monitoring was conducted on a stratified random sample the units and roads completed by the date of the IDT review of the units and roads monitored during the 100 percent monitoring effort.

Monitoring Context

Planning for some of the roads and units was completed before the Soil and Water Conservation Handbook was revised in October 1996, and new Forest Plan Standards and Guidelines were approved in May 1997. Both documents included many improvements for protecting soil and water resources. Several important changes in the 1996 Soil and Water Conservation Handbook included improving wetlands management direction, considering stream buffer windthrow, and generally making Forest Service BMPs consistent with State Forest Practices Regulations. A few of the significant changes included in the 1997 Forest Plan Final Environmental Impact Statement and the Forest Plan Standards and Guidelines resulted in new stream class definitions and stream protection measures required for each stream class and channel type. Buffer protection of Class III streams was entirely new. A number of the units monitored were planned, laid out, and harvested under pre-1997 Forest Plan Standards and Guidelines. The concepts of the new standards and guidelines were incorporated into most of these timber sales. Implementation of the new standards and guides occurred in most of the units, although Class III stream buffers were not implemented in all cases.

Monitoring Overview

The data summarized in the table and discussed below reflect results from the total units and roads monitored in the 100 percent and IDT monitoring efforts. Details of the Best Management Practices monitoring can be found in the Tongass report and IDT trip reports in the appendix.

Review of the timber sales and respective environmental documents associated with the monitoring this fiscal year, showed that some of the units were harvested under contracts that were included in environmental impact statements (EISs) or environmental analyzes (EAs) signed after the 1997 Forest Plan as well as a few before the 1997 Forest Plan. The units and roads in the FY2006 monitoring pool are listed below with their respective environmental document or contracts. The small sales and public works contracts were all implemented under the 1997 Forest Plan Standards and Guidelines.

Table Fish 2. Units Monitored in FY 2006 through BMP Implementation Monitoring Process

Units	Timber Sale; EIS/ EA (decision year)
679-433, 679-409, 679-414	Fusion TS; (Dumpy) Polk EIS (1995)
594-412, 594-420	Kogish Shinaku; Control Lake EIS (1998)
581-417, 581-423, 581-448, 581-449, 581-452	Luck Lac TS; Luck Lake EIS (2000)
8*, 10*, 19, 29, 34, 51, 67	Licking Creek; Licking Creek EIS (2003)
551-001	Thorne Island TS; Lab bay EIS (1996)
60A & B	South Lindenberg TS; South Lindenberg EIS (1996)
Red Carpet unit	Red Carpet Small Sale; Roadside EA (2003)
118,122, 67*,145*, 147, 128, 127, 125, 108, 64, 124	Finger Point TS; South Lindenberg EIS (1996)

*Monitored by IDT and 100% monitoring groups

Table Fish 3. Roads Constructed/ Reconstructed and Monitored in FY 2006 through BMP Implementation Monitoring Process

Roads	Road Contract/ Timber Sale
6350	South Lindenberg TS; South Lindenberg EIS (1996)
6590, 6260, 6296, 6270, 6267, 6585, 6265	Zarembo Reconstruction
43500-1	Lindenberg TS Public Works
6594*, 52033*, 520331, 520332, 5203321, 520333, 520334, 520335, 520336	Skipping Cow TS Roads Contract, Skipping Cow EIS (2000)
8446150*, 8446140*, 8400470	Licking Creek Reconstruction

*Monitored by IDT and 100% monitoring groups

Table Fish 4. Roads with Culverts replaced for Fish Passage Improvement and Monitored in FY 2006 through BMP Implementation Monitoring Process

Roads	Road Contract/ Timber Sale
6256 MP 2.801, 3.144, 3.242*, 3.443*, 3.543*, 4.091, 4.496*, 5.524	Thomas Bay Fish Passage Structures
2160000 MP 7.715, 4.975	Polk Fish Passage Improvements

*Monitored by IDT and 100% monitoring groups

Monitoring Results

A total of 31 units and 25 roads/road segments (8 culvert replacement sites) were monitored this year through the 100 percent implementation monitoring process. The IDT monitored 4 units, 6 road construction segments including 4 fish pass improvement culvert replacements (located on 1 road) and 2 log transfer facilities. The 10% quality control threshold was exceeded through the IDT monitoring in 2006. Of the 957.39 acres of harvested units; 133.91 acres were monitored by the IDT during the review. The tables presented below reflect results from the total units and roads monitored in the 100 percent and IDT monitoring efforts. Summary of this effort are included in Soil and Water Question 3 and additional details are included in *Tongass Best Management Practice Implementation Monitoring Report: Fiscal Year 2006.*

BMPs Applicable to Fish and Riparian Management that were included in the monitoring suite for FY 2006 include:

BMP 12.6 Riparian Area Designation and Protection
BMP 12.6a Buffer Design and Layout (TTRA and other buffers)
BMP 13.16 Stream Channel Protection
BMP 14.6 Timing Restrictions for Construction Activities
BMP 14.14/ 14.17 Bridge and Culvert Design and Installation (fish passage, etc.)
BMP 14.15 Diversion of Flows Around Construction

As part of the Best Management Practices implementation monitoring, information is collected on the streams monitored in the harvest units. The following tables show the number of linear feet of stream channel protected and the approximate stream buffer acres retained in the areas in and adjacent to harvest units monitored. Since some of the units monitored were planned, laid out, and harvested under pre-1997 Forest Plan Standards and Guidelines, some Class III streams were not buffered and some Class IV streams were not designated as “Class IV streams” but designated live streams.

Significant lengths of stream channels were reported as protected during unit harvest in the implementation monitoring effort in FY 2006 as shown in the table below. These stream lengths and associated buffer areas show that the stream protection measures are being implemented. Comparison of the stream data collected during the IDT monitoring effort and the total implementation monitoring effort illustrated on tables that follow shows that a number of the protected streams were checked during the IDT quality control monitoring process. In the quality control monitoring, roughly 19 percent of the streams lengths protected were reviewed by the IDT.

Table Fish 5. Linear Feet/ Acres of Stream Channel Protected and Lakes/ Wetlands Effected in FY 2006 monitored through implementation monitoring effort

Stream Class	**100 % Monitoring Effort**		**IDT Monitoring Effort**	
	Linear feet of Stream Channel Protected/ Acres of Wetland Effected	**Approximate Acres Retained as Streamside/ Beach/ Wetlands/ Buffer**	**Linear feet of Stream Channel Protected/ Acres of Wetland Effected**	**Approximate Acres Retained as Streamside/ Beach/ Wetlands Buffer**
Class I	1,695 feet	6.03 acres		
Class II	13,688 feet	48.93 acres	5,620 feet	13.2 acres
Class III buffered	29,152 feet	59.27 acres	5,536 feet	4.3 acres
Class III un-buffered*	3,425 feet			
Class VI	27,214 feet	8.6 acres	3,055 feet	
Class I Lake	0 feet			
Beach buffer		18 acres		
Wetlands		48.86 acres		16.86 acres

* Un-buffered Class III streams in units planned, laid out, and harvested under pre-1997 TLMP Standards and Guidelines

The BMP implementation monitored relative to road construction and reconstruction related primarily to culvert replacement sites in FY 2006, although some culverts and bridges were installed on roads constructed for transportation (public works and specified roads) and timber harvest (specified and non-specified roads). Culvert installation included sites at 3 Class I streams, 1 Class II streams, 13 Class III streams and 23 Class IV streams. These sites included bridges constructed to cross 3 Class I streams, 1 arch on a Class I stream, 8 Class II streams, 5 Class III streams and 1 Class IV stream. The IDT monitored 3 Class I culverts, 0 Class II culverts, 7 Class III streams and 14 Class IV streams as well as 4 bridges that spans 1 Class I stream, 2 Class II stream, 1 Class III stream and 1 Class IV stream crossings respectively.

Comparison of the number of times the IDT applied the BMP relative to the 100% monitoring effort shows that the IDT monitoring was conducted on a high percentage of the sites where BMPs relative to riparian areas were applied. Best Management Practice 12.6/12.6a Riparian Area Designation & Protection/Buffer Zone Design and Layout and BMP 13.16 Stream Channel Protection were applied in timber unit harvest. BMPs 14.6 Timing Restrictions for Construction Activities/Fisheries Prescription and 14.14/14.17 Design & Installation of Bridges and Culverts were applied in road construction/reconstruction.

The corrective actions on the Best Management Practices relative to riparian areas, streams and buffers are shown in the table below. These corrective actions were implemented to achieve BMP standards. The table also shows no departures noted relative to full BMP implementation were designated on the monitoring forms.

Table Fish 6. BMPs Relative to Riparian Areas, Streams, and Buffers Implemented as Tracked through Implementation Monitoring Effort

BMPs Applied	Number of Times the BMP was Appropriate for Use	Number of Times Corrective Action Implemented	Number of Times Departure from Full BMP Implementation
BMP 12.6 Riparian Area Designation and Protection/ BMP 12.6a Buffer Design and Layout (TTRA and other buffers)	15	1	0
BMP 13.16 Stream Channel Protection	27	0	0
BMP 14.6 Timing Restrictions for Construction Activities	6	0	0
BMP 14.14/ 14.17 Bridge and Culvert Design and Installation (fish passage, etc.)	25	0	0
Totals	73	1	0

Corrective actions associated with riparian areas, streams and buffers were reported during implementation in FY 2006. Relative to BMP 12.6 Riparian Area Designation and Protection/ BMP 12.6a Buffer Design and Layout (TTRA and other buffers) relating to one incident on the Licking Creek timber sale where there was a discrepancy between the flagging shown on the ground and the sale area map. The sale area map showed a Class III stream and the stream was flagged as a Class II on part of the stream reach. The sale administrator requested a fisheries biologist review the stream and the biologist determined the stream was a Class III stream. A Class III buffer was prescribed and implemented on this stream.

A few actions were noted on the Finger Point Timber sale relative to changes in the stream designation and flagging in retrofitting the timber sale to the Riparian Standards and Guidelines. The unit configuration was changed between layout and harvest to drop acreage where numerous braided channels bisected the slopes to provide stream protection.

There was one case where a few trees were felled within a Class II stream buffer due to safety concerns associated with yarding on the Licking Creek Timber sale. The stream corridor was still protected by some timber and the stream course was not damaged. During the course of administering the timber sale contract and ensuring the stream protection measures are implemented, the sale administrators have made conscientious efforts to work diligently with the hydrologists and fish biologists to resolve any questions that arise related to riparian areas and buffers.

The culverts were installed per design and concurrence for the timing of the installations on fish streams were made by ADNR. Turbidity measurements were taken at some of the culverts larger than 48 inch diameter. There were some cases where fish simulation techniques were used to design structures although no upstream habitat surveys and no verification of fish presence had been completed.

Evaluation of Results

Best Management Practices are being successfully implemented on the Tongass National Forest. The high quality work of the individuals involved with preliminary site investigations, layout, unit and road design, environmental assessment, contract preparation, and contract administration has been reflected in the successful identification of streams and implementation of protective measures in units and effective culvert installations. Emphasis needs to continue on correcting any improperly identified or missed streams. Specific focus should be placed on correctly identifying streams during the early stages of planning, site investigation, and layout.

The effective work of the engineers has contributed to the successful implementation of the Best Management Practices associated with culverts and bridges. Significant emphasis needs to be focused on reviewing the designs relative to the specific sites and minimizing turbidity. Emphasis needs to continue on site-specific designs for construction and evaluation of the designs after the initial high flows of the fall.

Action Plans

Recommendations include modification of the monitoring process to transition away from a 100% monitoring of the implementation of the Best Management Practices to a review of a selected set of a random generated subset of units and roads by an IDT team. Focus on an improved understanding of the guidelines on how to fill out the forms is necessary to improve the consistency of the ratings. Recommendations also follow to modify the Forest Service Handbook to better address the fish passage culvert sites. Modification of the form to include only applicable BMPs for culvert replacement sites is also recommended. A pilot form has been developed for culvert replacement site tracking and monitoring. Further detail on the recommended action is included in the interdisciplinary team reports in the appendix.

Fish Habitat Question 3: Are Fish and Riparian Standards and Guidelines effective in maintaining or improving fish habitat?

Fish Passage

Upstream Passage of Juvenile Fish at Road Crossings

Applicable Forest Plan Standard and Guidelines:

FISH112 IV.G, Class I: Maintain, restore or improve the opportunities for fish migration.

FISH112 IV.G, Class II: Maintain, restore or improve the opportunities for the natural fish migration of resident fish where feasible.

Upstream migration is essential for many fish species in the Tongass National Forest. Anadromous fish (fish that migrate from the ocean to freshwater to spawn) require access to spawning habitat. Juvenile anadromous fish migrate during their freshwater life stage, seeking seasonal habitats. Resident fish (fish that spend their entire life in freshwater) also may migrate seasonally in response to food, shelter and spawning needs.

Providing for fish passage at stream and road intersections to ensure fish migration is an important consideration when constructing or reconstructing forest roads. Improperly located, installed or maintained stream crossing structures can restrict these migrations, thereby adversely affecting fish populations. These structures can present a variety of potential obstacles to fish migration. The most common obstacles are excessive vertical barriers, debris blockages, and extreme water velocities that can inhibit fish passage, especially smaller or juvenile fish.

The Tongass National Forest strives to incorporate an adaptive management process to achieve the desired management goals and objectives for the fish passage at road crossings program. The adaptive management approach includes a continuous process of using, or developing, state-of-the-art assessment and restoration techniques followed by monitoring and adjustment of the techniques accordingly.

Designing the crossing structure to fit the stream is the key for attaining fish passage objectives and avoiding many unintended and undesirable impacts. Culverts that constrict the stream channel may cause excessive water velocity, excessive bedload deposition or rapid change in water surface profile at the inlet. Culverts installed at a gradient significantly different than the natural stream grade can induce stream head cutting upstream or excessive deposition of bedload at the culvert inlet. Culverts that do not retain adequately sized bedload may lead to excessive water velocities within the culvert. Culverts with excessive water velocities may release energy by eroding the outlet control, leaving the outlet perched.

Commonly used techniques to provide fish passage across roads include:

1) Maintaining the natural streambed using bridges and bottomless arch culverts;
2) Installing culverts that mimic and retain the natural stream characteristics of stream width, gradient, substrate and pool depth and spacing;
3) Installing culverts that are countersunk and at a flat gradient. This technique has limited application and is only effective where the natural stream grade is also flat and the water is pooled and backwatered, as is found in palustrine, estuarine and occasionally floodplain channels
4) Installing culverts equipped with a system of weirs or baffles. The complex hydraulics and poor bedload transport associated with baffled culverts require very careful design considerations if fish passage is to be retained over time.
5) Removing culverts and restoring the natural stream channel.

Juvenile Fish Passage Evaluation Criteria

Forest Plan standards stipulate that juvenile fish will have unrestricted upstream passage within a defined range of stream flows. The stream flow at the upper end of this range is the stream flow that exists two days before and two days after a peak flow. The peak flow that is used is the mean annual flood, the flow that statistically recurs about once every two years. This upper limit stream flow, or "fish passage design flow," is unique for each stream since it is based upon the specific hydrologic characteristics of that stream. It has been estimated that streams in Southeast Alaska have flows at or below this design flow approximately 98% percent of any given year. Therefore, in effect current fish passage standards stipulate that juvenile fish be able to swim successfully through culverts approximately 98% of the year.

The basic challenge of evaluating fish passage capability at culverts is to determine and compare fish swimming performance against culvert hydraulic conditions across a range of stream flows. Analytical software, entitled "FishXing", has been developed by the Forest Service to assist with these calculations. This software is designed to allow the user to input various criteria important to fish passage and estimate the effects on the fish's ability to move through the culvert at different stream flows. Some of the input variables are fish swimming ability, culvert dimensions, roughness within the culvert and various streambed and culvert elevations.

To improve assessment efficiency, a Juvenile Fish Passage Evaluation Criteria Matrix was developed by a group of interagency, interdisciplinary professionals. The matrix increases assessment efficiency by creating a coarse sieve that quickly separates out the culverts that have conditions that can be assumed to meet standards from those that do not. It is then only necessary to do the more time intensive FishXing analysis on the culverts with less obvious fish passage conditions. The evaluation matrix stratifies culverts by type and establishes criteria thresholds for culvert gradient, stream constriction, debris blockage, and vertical barrier at the culvert outlet (perch) specific to each culvert type. Each culvert is placed into one of the three juvenile fish-passage capability categories.

> GREEN Category: conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows.
>
> RED Category: conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows.
>
> GRAY Category: conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability. This additional analysis includes use of the FishXing analytical software (Table Fish-7).

Table Fish 7. Juvenile fish passage evaluation criteria matrix.

Structure Group #	Structure Group	GREEN CRITERIA	GRAY CRITERIA	RED CRITERIA
1	Bottomless pipe arch OR embedded[1] pipe arch OR embedded CMP.	Culvert span to bed width ratio >= 0.75 AND no blockage OR backwatered [3] AND no blockage.	Culvert span to bed width ratio of 0.5 to 0.75 OR blockage >0% but ≤10%.	Culvert span to bed width ratio <0.5 OR blockage >10%
2	Non-embedded pipe arches AND culvert span ≤ 144” OR non-embedded CMP AND culvert span > 48” AND ≤144”.	Culvert gradient <0.5% AND no perch [2] AND no blockage AND culvert span to bed width ratio > 0.75 OR backwatered AND no blockage.	Culvert gradient between 0.5% - 2.0% OR perch >0.0’ but ≤4” OR blockage >0% but ≤10% OR culvert span to bed width ratio between 0.5 to 0.75.	Culvert gradient >2.0% OR >4” perch OR blockage >10% OR culvert span to bed width ratio <0.5.
3	Non-embedded CMP AND ≤ 48” span.	Culvert gradient <0.5% AND no perch AND no blockage AND culvert span to bed width ratio > 0.75 OR backwatered AND no blockage	Culvert gradient between 0.5% - 1.0% OR perch >0.0’ but ≤4” OR blockage >0% but ≤10% OR culvert span to bed width ratio between 0.5 to 0.75.	Culvert gradient >1.0% OR >4” perch OR blockage >10% OR culvert span to bed width ratio <0.5.
4	Non-embedded culvert AND culvert span >144”	Culvert gradient <1.0% AND no perch AND no blockage AND culvert span to bank full ratio > 0.75 OR backwatered AND no blockage.	Culvert gradient between 1.0% - 2.0% OR perch >0.0’ but ≤4” OR blockage >0% but ≤10% OR culvert span to bed width ratio between 0.5 to 0.75.	Culvert gradient >2.0% OR >4” perch OR blockage >10% OR culvert span to bed width ratio <0.5.
5	Baffled Culverts	Backwatered AND no blockage OR newly installed baffled culverts with current design criteria.	All baffled culverts that do not meet Green OR Red criteria	Baffled culverts AND blockage >10%
6 & 7	Bridges OR fords OR removed structures	No road fill caused blockage	Not Applicable	Road fill causing blockage. Water piping through road fill
8	Multiple drainage structures in same channel	Multiple structures are assessed as other similar structures with the exception that constriction is calculated by dividing the stream bedwidth by the sum of all the structure widths. The structure with the best passage performance is used to determine the passage capability of the entire array.		

Note: These criteria are not design criteria, but rather indicate whether the structure is likely to provide for juvenile salmonid passage.

[1/]Embedded: 100% bedload cover and average substrate depth >=20% of culvert rise

[2/]Perch: Perch is calculated as a flow dependent value. Perch is defined as the difference in height between the downstream invert of the culvert (or top of bedload at downstream end of culvert if bedload is present) and top-of-water at the downstream control.

[3/]Backwatered: The culvert is considered backwatered if the elevation of the top-of-water at the downstream control is greater than the elevation of the upstream invert of the culvert. Culvert gradient, constriction, and perch criteria are not considered in the assessment of fish passage in backwatered culverts.

Monitoring Results

During 2006, twenty-nine culverts that were installed since the inception of the current Forest Plan (1997) were evaluated for their ability to provide juvenile fish passage. Criteria defined in the Juvenile Fish Passage Evaluation Criteria Matrix were used to evaluate the culverts. The culverts evaluated were not randomly selected but were selected for the following reasons: 1) information on their passage status was required for other project objectives; or 2) they were considered to have a higher probability of not meeting passage standards; or 3) they were in the vicinity of the culverts considered to have a higher probability of not meeting passage standards.

The evaluated culverts were installed from 1999 to 2005 and are located on the Hoonah and Craig Ranger Districts. Twenty–five of the culverts are round corrugated metal pipes and four of them are corrugated metal arch pipes. The stream gradients in which the culverts were installed varied from 1 to 11 percent.

Twenty-five (86%) of the culverts evaluated had conditions that were considered adequate to meet juvenile fish passage standards (Green), while 2 (7%) of the culverts had conditions assumed not adequate to fully meet juvenile passage standards (Red) and 2 (7%) culverts require further more detailed analysis with the use of FishXing analytical software.

The two culverts classified as Red culverts were assumed not to meet juvenile fish passage standards because they were installed at too steep of a gradient without enough bedload material retained within them. One of them was installed at a gradient of 7.1% with no bedload retention while the other was installed at a gradient of 2.2% and although it had bedload throughout its length the depth of bedload was insufficient.

Only one of the assessed culverts had an outlet perch and all but two of the culverts were embedded and contained bedload substrate throughout their length (Table Fish-8).

Photo Fish-4. Culvert installation in fish stream. Road 8513 milepost 1.463

Table Fish 8. Culverts assessed for juvenile fish passage capability.

Road	Milepost	Year Installed	Culvert Dimensions and Type	Average Stream Gradient	Culvert Gradient	Outlet Perch (ft)	Outlet Embedded	Stream Bedwidth to Culvert Width Ratio	Bedload in Culvert	Back watered	Passage Evaluation
2100000	0.230	2005	72” cmp	5%	4.4%	none	43%	2.00	100%	No	Green
2100000	5.190	2005	75”x112” cmpa	5%	6.1%	none	31%	1.87	100%	No	Green
2120000	0.830	2005	75”x112” cmpa	5%	6.4%	none	29%	1.04	100%	No	Green
2150000	8.870	2005	90” cmp	1%	1.7%	none	41%	1.29	100%	No	Green
2150000	8.920	2005	72” cmp	2%	1.5%	none	27%	1.50	100%	No	Green
8508	11.353	2000	60” cmp	3%	0.3%	none	24%	0.91	100%	Yes	Green
8508	11.539	2000	60” cmp	2%	0.2%	none	30%	1.04	100%	Yes	Green
8508	11.954	2000	96” cmp	4%	0.0%	none	10%	0.75	100%	No	Green
8508	12.193	2000	72” cmp	3%	-0.1%	none	32%	1.02	100%	No	Green
8508	12.584	2000	72” cmp	7%	0.1%	none	42%	1.00	100%	No	Green
8508	12.754	2000	72” cmp	8%	-0.8%	none	52%	1.50	100%	No	Green
8508	13.547	2000	72” cmp	6%	-0.2%	none	40%	1.33	100%	No	Green
8508	14.016	2000	72” cmp	5%	2.2%	none	12%	1.00	100%	Yes	Green
8513	0.273	1999	60” cmp	7%	7.1%	none	0%	1.30	0%	No	Red
8513	0.795	1999	60” cmp	7%	0.2%	none	18%	0.83	100%	No	Green
8513	0.954	1999	72” cmp	9%	0.2%	none	10%	0.88	100%	No	Green
8513	1.463	1999	72” cmp	8%	0.2%	none	22%	0.77	100%	No	Green
8513	1.922	1999	59”x81” cmpa	4%	1.0%	none	4%	0.79	100%	Yes	Green

Road	Milepost	Year Installed	Culvert Dimensions and Type	Average Stream Gradient	Culvert Gradient	Outlet Perch (ft)	Outlet Embedded	Stream Bedwidth to Culvert Width Ratio	Bedload in Culvert	Back watered	Passage Evaluation
8513	2.446	1999	72” cmp	6%	0%	none	8%	1.13	100%	No	Green
8530	10.912	1999	60” cmp	4%	1.1%	none	38%	0.85	100%	No	Green
8530	13.092	1999	72” cmp	8%	0.1%	none	43%	1.50	100%	No	Green
8530	13.886	1999	72” cmp	6%	1.6%	none	0%	1.13	0%	No	Gray
8530	16.394	2004	91”x142” cmpa	4%	4%	none	22%	0.98	100%	No	Green
8534	1.554	2000	60” cmp	7%	2.2%	none	6%	1.02	100%	No	Red
8534	1.895	2000	72” cmp	4%	-0.9%	none	15%	1.00	100%	No	Green
8534	1.973	2000	72” cmp	11%	0.4%	none	28%	1.20	100%	No	Green
8534	3.051	2000	60” cmp	11%	0.7%	0.2’	0%	0.94	95%	No	Gray
8576	1.119	2004	84” cmpa	5%	2.0%	none	43%	2.00	100%	No	Green
8576	5.096	1999	72” cmp	6%	-0.5%	none	22%	1.05	100%	No	Green

Evaluation of Results

The culverts assessed were not randomly selected and cannot be used to represent the fish passage capability of the approximately 220 other culverts installed in fish streams since 1997. The results do provide conditions of a select group of culverts at which, with future monitoring, trends can be assessed.

All of the evaluated culverts that were installed in 1999 or 2000 did not at the time of installation have bedload substrate placed in them yet almost all of them had accumulated natural stream bedload. The presence of bedload within a culvert is desirable because it provides roughness that reduces water velocity and in turn more desirable fish passage conditions. This result was achieved by installing the culverts at a very low gradient regardless of the natural stream gradient. This approach is not desirable and can occasionally cause the channel to respond with severe upstream head cutting and substantial bedload deposition at the culvert inlet or within the culvert. Several of the culverts evaluated had responded in this manner. Future monitoring will determine if the bedload accumulation becomes excessive at these culverts.

More recently installed culverts, such as the evaluated culverts that were installed in 2004 and 2005, strive to align better with natural stream processes. In recent years, a set of interim culvert design criteria have been developed, which better ensure that juvenile fish passage will not be impaired. These design criteria better recognize the importance of designing a drainage structure to fit the characteristics of the stream. More recently, a greater emphasis has been placed on using stream simulation concepts in culvert design. Stream simulation includes embedding a culvert at natural stream grade, sizing it to the streams bank full width and backfilling it with streambed and riprap material to mimic stream characteristics. An advantage of stream simulation designs is that these designs are not dependent on the validity of assumptions pertaining to fish performance, stream hydrology and culvert hydraulics, as are hydraulic designs. Successful stream simulation provides the assurance that all aquatic species and life stages present are able to pass through the culvert with the same level of difficulty as that found in the natural stream channel.

It is important to emphasize that fish are assumed able to pass through most of the crossings identified in the Red and Gray categories most of the year. Results from a Tongass National Forest survey which evaluated habitat conditions and fish presence upstream of approximately 1,200 Red culverts indicated that 84% of these crossings do have fish located upstream of them. Through more intensive sampling, fish may eventually be found upstream of more of the crossings. Also, it is possible that some of the stream sections upstream of the identified Red and Gray crossings never supported fish and is not actually fish habitat. The determination of fish habitat upstream of the culverts currently without fish was based on stream characteristics. Specialists are mostly concerned that passage may not be possible for juvenile fish during periods of high stream flow. The results presented are for juvenile fish passage, and it is likely that stronger swimming adult fish are not restricted in many of the structures.

Fish Passage at Road Crossings Recommendations

The Tongass National Forest strives for an adaptive management approach to achieve the goals and objectives of the fish passage at road crossings program. Adaptive management is essential to assure that the assumptions that are prevalent in the assessment and restoration of the crossings are correct and that our actions are functional. The knowledge and tools to assess fish passage capability at road crossings and the design of crossing structures are evolving. The fish-passage-analysis-model currently is based upon assumptions on stream hydrology, culvert hydraulics, fish swimming abilities, and fish migration needs. Work on testing these assumptions and reexamining Forest Plan fish passage evaluation criteria is required and in progress. In an effort to learn additional information about Dolly Varden char and cutthroat trout movement patterns in higher gradient headwater streams, a Tongass National Forest administrative study was initiated in fiscal year 2001. This study is anticipated to be completed in 2007 and will provide a better understanding of the stream flow conditions and season that these fish naturally move. Although this study is not complete, some preliminary results are emerging. Spring and fall are the periods when most upstream movement occurred and most fish appeared to move less then 100 meters with more of the fish moving downstream than upstream. Analysis of fish movement as related to stream flow discharge is preliminary but data suggests that almost all upstream fish movement occurred at stream flows substantially less than that of current fish passage design flow standards. Upon completion of this study, the fish- passage-analysis-model and additional field trials, modification of the design flow standards for culverts to provide unimpeded passage for these species may be required. This information will eventually allow culverts to be evaluated and designed appropriately.

Recommendations follow that monitoring of the hydraulic and structural conditions continue at culverts recently installed (i.e., designed and installed under the direction of the Forest Plan) in fish bearing streams. This monitoring effort will assess the fish passage and will assist in the evaluation of the success of design, maintenance and other management actions. Monitoring the structural and hydraulic conditions of new culverts installed in fish bearing streams is especially important as the Forest applies innovative design concepts and criteria in its aggressive program to restore and improve fish passage.

Proposals include:

1) Refining effectiveness monitoring objectives and protocol,

2) Providing better integration of fish passage implementation and effectiveness monitoring,

3) Improving the process for the identification and reporting of drainage structures installed or reinstalled in fish streams on an annual basis so effectiveness monitoring sample populations can be better defined, and

4) Continue to use contract as-built measurements to record baseline conditions to provide for improved follow-up effectiveness monitoring.

Fish Habitat Objectives and Case Study Watersheds

The Forest Plan directs us to use fish habitat objectives to evaluate aquatic habitat health. These objectives were developed from physical stream attributes (channel morphology, pools, wood, substrate, etc.) measured in harvested and unharvested watersheds (USDA Forest Service 1995). The attributes are stratified by stream channel process group (Paustian et al 1992) and displayed as percentiles to reflect the natural variability of habitat features. Table Fish 9 displays the current Tongass National Forest fish habitat objectives for Floodplain (FP) and Moderate Gradient Mixed Control (MM) streams.

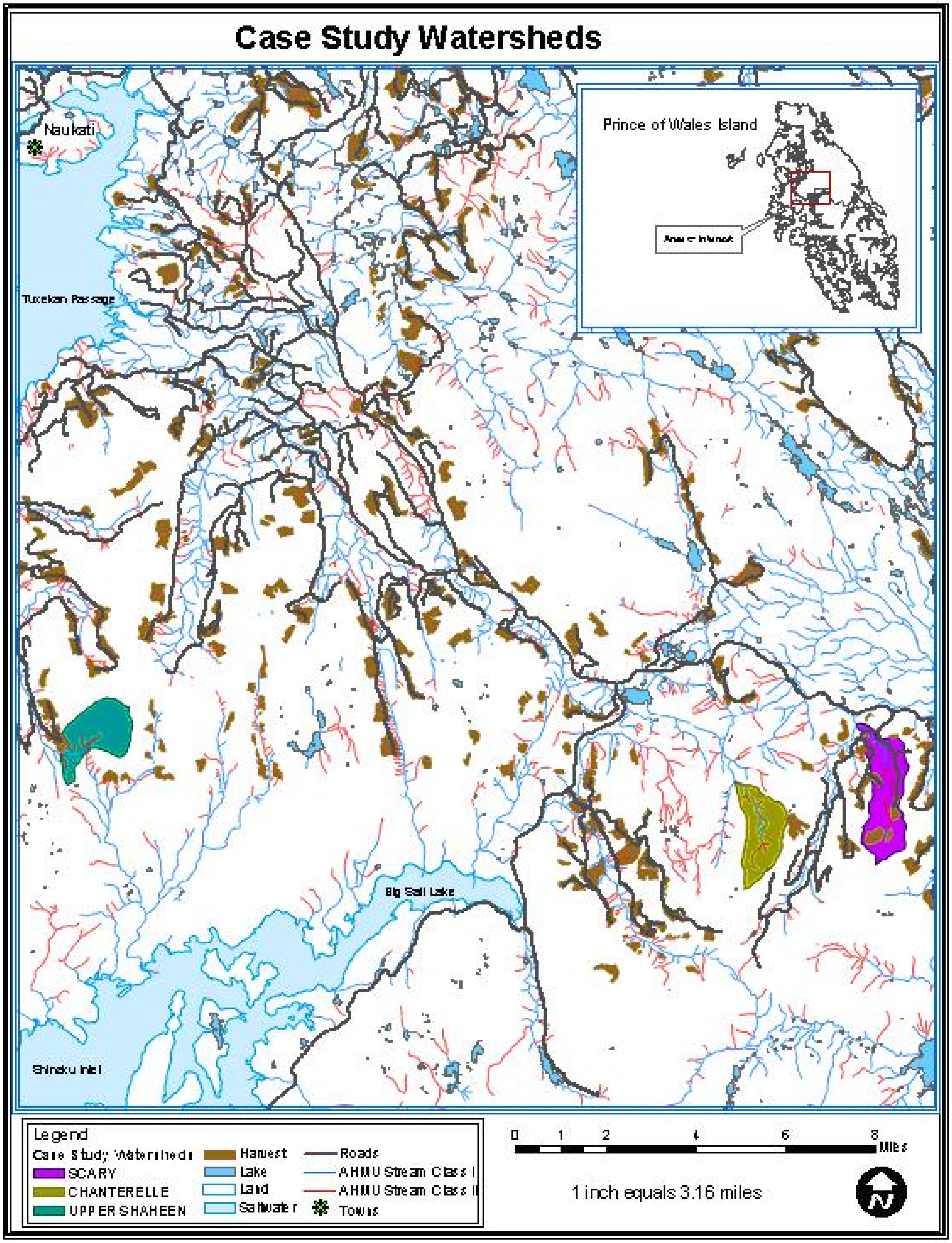
Table Fish 9. Tongass National Forest Fish Habitat Objectives (Bryant et al 2004)

Habitat Attribute (units in meters unless otherwise specified)	Percentiles	Process Group=FP		Process Group=MM	
		Harvested		Harvested	
		NO	YES	NO	YES
Channel bankfull width/depth ratio	25	18.0	18.6	5.8	13.9
	50	23.5	23.8	10.7	18.4
	75	33.6	38.4	16.1	23.7
Total large wood pieces / stream length surveyed	25	.23	.16	.21	.19
	50	.33	.25	.30	.25
	75	.47	.49	.47	.29
Total key pieces large wood / stream length surveyed	25	.04	.07	.04	NA
	50	.09	.10	.10	NA
	75	.19	.13	.12	NA
Number of pools / stream length surveyed (kilometers)	25	24.6	21.4	41.7	24.5
	50	41.0	28.3	51.0	34.9
	75	52.7	36.2	68.4	44.9
Pool spacing (stream length surveyed / channel bed width) / total number of pools	25	.46	.22	.20	.45
	50	1.84	.57	.37	.62
	75	5.49	4.52	.71	2.22
Average residual pool depth / average channel bed width	25	.039	.035	.066	.048
	50	.045	.042	.075	.056
	75	.060	.046	.098	.076
Median particle size (D50) (millimeters)	25	20	20	25	32
	50	29	30	49	43
	75	50	51	83	143
Total pool length / stream length surveyed	25	.32	.32	.17	.35
	50	.48	.50	.29	.38
	75	.56	.66	.37	.55

An analysis of channel condition assessment reaches across the forest concluded that very large sample sizes and/or long term data would be necessary to achieve sufficient statistical power to successfully discriminate habitat measurements in unharvested watersheds from those with management practices consistent with the current Forest Plan (Woodsmith et al 2005). This finding supports the case study approach, where stream, riparian, and upland data are intensively evaluated in a few carefully selected locations over the long term in order to provide a watershed context to interpret fish habitat responses to Forest Plan implementation.

A set of three case study watersheds has been established as part of the Forest Plan aquatic monitoring synthesis (see Figure Fish 9 Case Study Watersheds). The goal of the Aquatic Synthesis is to evaluate the effectiveness of Forest Plan standards and guidelines in protecting aquatic resources such as fish habitat at the watershed scale. The Aquatic Synthesis includes objectives for stream biota and habitat, water quality, stream flow, soils, wetlands, and riparian and upland vegetation (Thompson 2004).

Figure Fish - 9. Case Study Watersheds



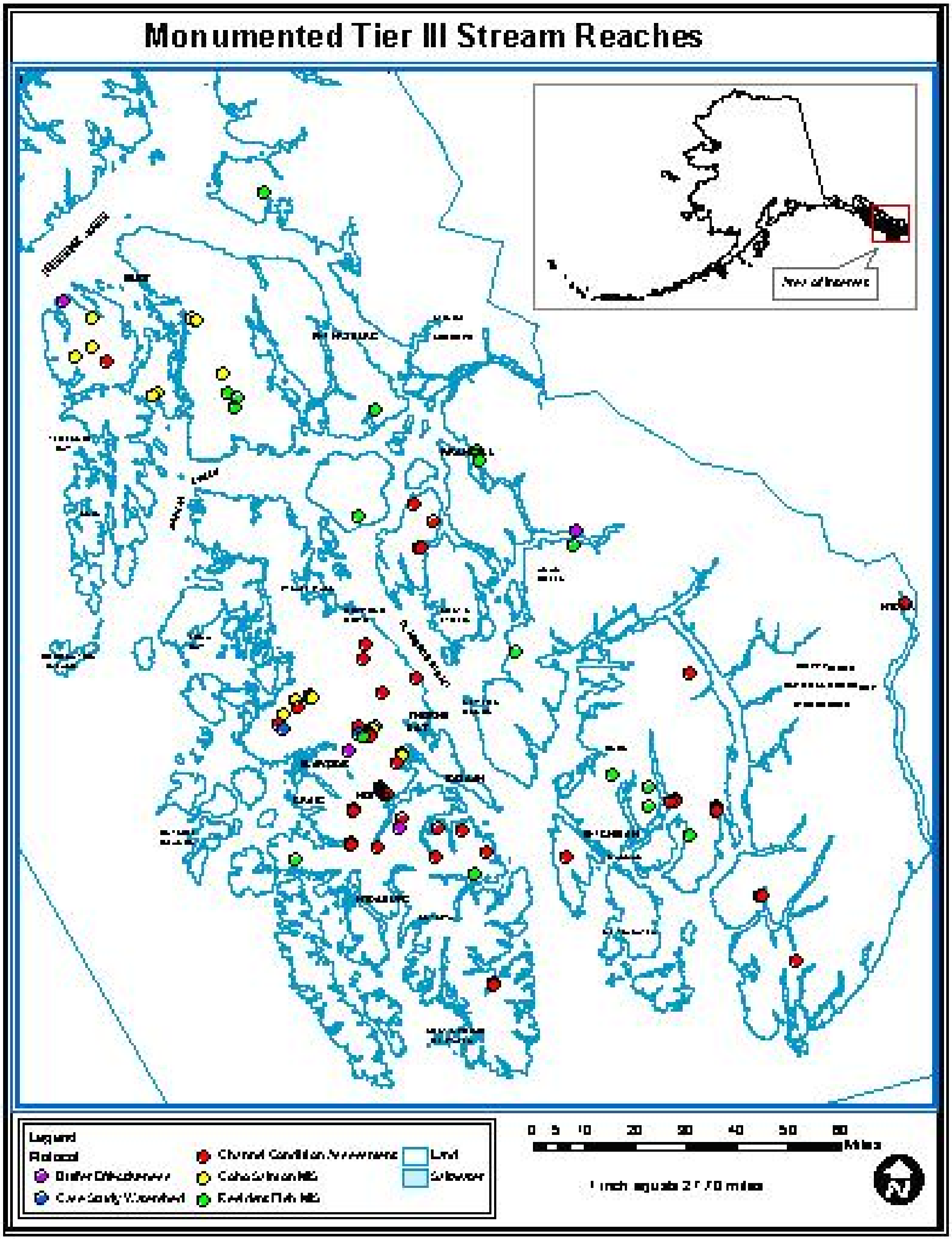
The case study watersheds are small third-order watersheds, about 1000 acres each, within the Central Prince of Wales Volcanics Ecological Subsection (Nowacki et al 2001). Chanterelle Creek serves as a long term reference with no roads or timber harvest. Scary Creek is a cumulative effects treatment with existing timber harvest and road system. Upper Shaheen Creek reflects pre- and post-treatment conditions as roads and timber harvest progress according to the Forest Plan.

We established permanent stream habitat monitoring reaches in the case study watersheds. Habitat data from these reaches will be integrated with other watershed data, providing reference conditions to calibrate habitat data from a forest-wide network of over 250 stream reaches. We will examine storm events, windthrow, and new landslides in the case study watersheds and evaluate responses to these disturbances. Stream channels will naturally respond to watershed disturbance. The types and magnitude of these responses must be considered during evaluation of monitoring results.

Forest-wide fish habitat surveys[1] will proceed according to results of ongoing statistical analysis of data from a network of over 250 stream reaches across the Tongass National Forest (see Figure Fish 10). These data include physical stream attributes measured during stream buffer effectiveness, channel condition assessment, and coho salmon, resident cutthroat and Dolly Varden char MIS monitoring efforts and other habitat surveys. Measurements are compatible with Tier II and Tier III procedures described in the Forest Service's Alaska Region Stream Survey (USDA Forest Service 2001). In 2005 and 2006 these data were compiled into a single database that is compatible with the Natural Resources Information Systems (NRIS) water module. The objectives of the analysis in progress include 1) characterizing forest-wide variability in fish habitat attributes, 2) updating the fish habitat objectives in Table Fish 11, and 3) evaluating the utility of the habitat data for effectiveness monitoring, or as a tool for assessing aquatic habitat health and overall watershed condition.

[1] In 2006 we re-measured five channel condition assessment reaches established on the Ketchikan Misty Ranger District.

Figure Fish - 10. Stream Monitoring Reaches



Analysis of a subset of these data (the channel condition assessment reaches) successfully discriminated between unharvested and heavily harvested watersheds, implying that these data could be used to quantify cumulative watershed effects and focus watershed restoration planning efforts (Woodsmith et al 2005). We are developing a decision support model that will eventually integrate reach-level habitat data with watershed scale data (landslides, road erosion, etc) to assess watershed condition across the Tongass National Forest. The Aquatic and Riparian Effectiveness Monitoring Plan (AREMP) for the Northwest Forest Plan uses a similar approach (Reeves et al 2004). Crew training, experience, and standard protocols for these surveys are critically important to minimize variability associated with measurement error (Woodsmith et al 2005).

We recommend no changes to Forest Plan standards and guidelines for protecting fish habitat at this time. The following specific actions are recommended for 2006:

Actions Recommended for 2007

1. Continue measurement of established Tier III stream habitat reaches associated with resident fish MIS efforts and locations with pre- and post-treatment monitoring objectives, including case study watersheds.

2. Complete statistical analysis of compatible fish habitat data, update fish habitat objectives and develop sampling design for effectiveness monitoring and/or watershed condition assessment.

3. Complete baseline landslide inventory and analysis upstream of all resident fish MIS reaches, and any other long term Tier III stream monitoring reaches.

4. Maintain case study watershed data collection and analysis.

5. Continue emphasis on crew training and quality assurance procedures.

Stream Buffer Stability

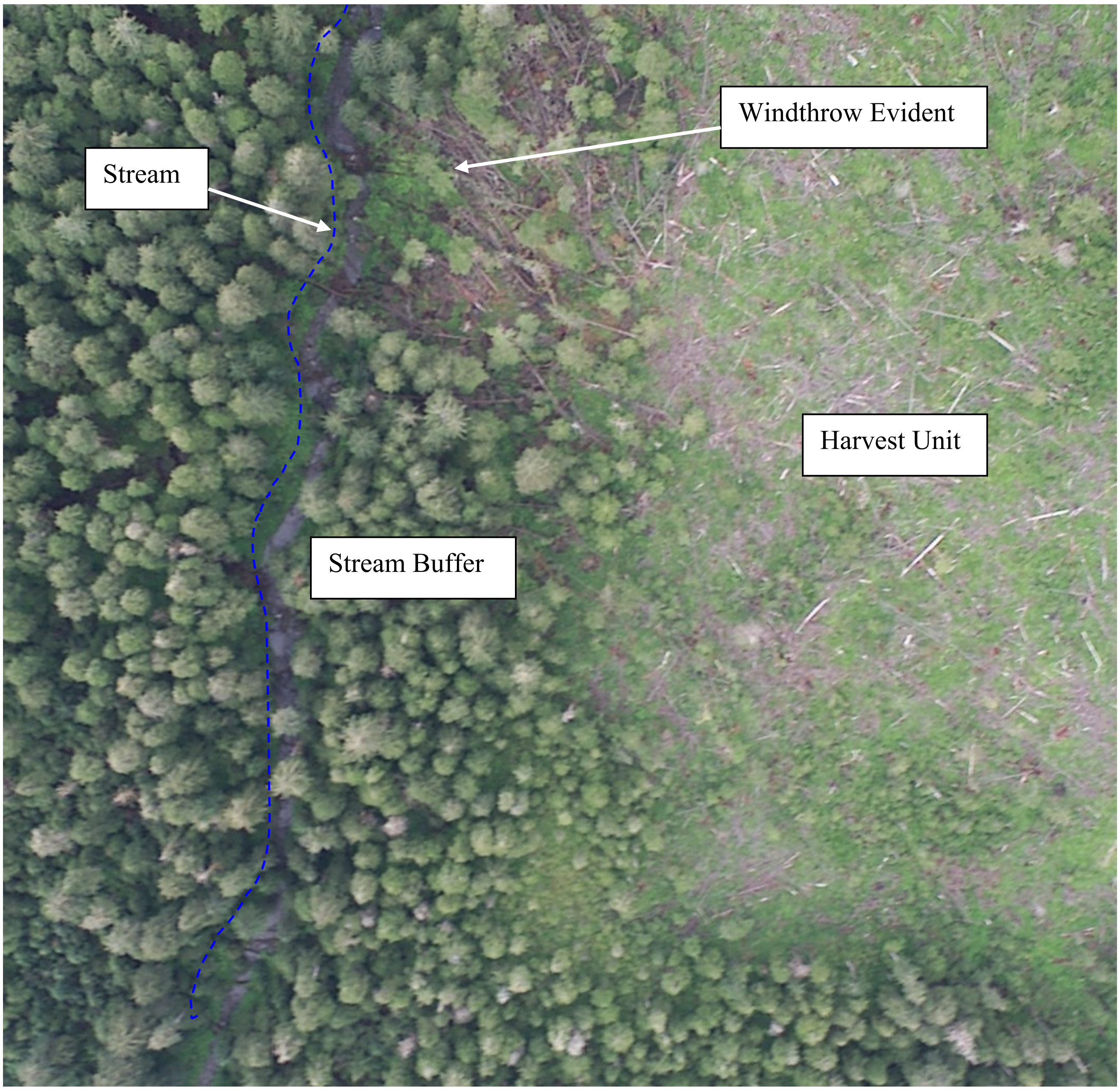
The Occurrence of Windthrow in Stream Buffers

The vegetation inherent in riparian areas is recognized as an important controlling factor and component in maintaining the natural range and frequency of aquatic habitat conditions. The Forest Plan contains several Riparian Standards and Guidelines that are intended to retain the integrity of riparian management areas. These standards specifically intend to: 1) maintain natural and beneficial quantities of large woody debris over the short and long term, 2) maintain stream banks and stream channel processes, 3) provide for the beneficial uses of riparian areas by maintaining water quality, and 4) maintain optimum salmon stream temperatures. By retaining riparian vegetation in a condition found within the range of natural variability, it is anticipated that these Riparian Standards and Guidelines can largely be achieved.

Windthrow is a natural and important phenomenon of Southeast Alaska. It recycles forest stands, and maintains and renews the forest ecosystem. However, timber harvest has the potential to exacerbate the rate of windthrow in adjacent forest stands, including riparian management areas, beyond that found within the natural range of variability. Monitoring the incidence of windthrow in riparian management areas and comparing that to windthrow found in control riparian areas will assess whether the buffers are retained in a condition found within the natural range of variability.

The incidence and characteristics of windthrow is monitored in all riparian buffers of Class I, II and III streams on the Tongass National Forest that are associated with timber sales consistent with the Forest Plan. Windthrow is monitored in both Riparian Management Areas (RMAs) and within adjacent areas where trees are retained to provide a reasonable assurance of windfirmness (RAW zone) in the RMA. The amount of windthrow is measured as the number of windthrown trees compared to the total number of originally standing trees in the buffer. The number of trees felled due to windthrow is documented and measured using low-altitude digital still aerial photographs (Figure Fish-11). First, pre-windthrow baseline conditions are obtained after harvest of a unit but before the windthrow prone months of the year, which are typically the winter months, beginning in October. Repeated measurements of tree loss due to windthrow are then obtained annually for the first five years after harvest and then again 10 and 15 years after harvest.

Figure Fish - 11. Low Altitude Aerial Digital Image of Riparian Buffer



Monitoring Results

2006 was the seventh consecutive year that windthrow within stream buffers was monitored. There are currently 237 RMAs monitored and they are located on 5 Ranger Districts and are associated with 37 timber sales and 106 harvest units. The orientation of buffers is well represented and varies from 13 buffers with northwest exposure aspects to 40 with an east exposure aspect. Approximately 32 percent of the buffers are associated with streams that have buffers on both sides of the stream while 68 percent of the buffers are associated with streams that only have a buffer on one side of the stream. Approximately 61 percent of the buffers are adjacent to Class III streams (non-fish bearing, water quality concern streams). The remaining 39 percent of the buffers are adjacent to Class I or II streams (anadromous and resident fish bearing streams). Characteristics of the buffers in the sample population are shown in Table Fish-10.

Table Fish 10. Characteristics of Monitored Buffers.

Characteristics	Number of Buffers
Year of Harvest	
2000	28
2001	27
2002	11
2003	29
2004	6
2005	89
2006	47
Buffer Exposure Aspect	
north	33
northeast	28
east	40
southeast	24
south	33
southwest	28
west	38
northwest	13
Buffer Location	
Buffers on one side of stream	162
Buffers on both sides of stream	75
Stream Class	
Class I or II (fish streams)	93
Class III	144
Total	**237**

Monitoring results have shown that post harvest windthrow is present in 45 (25%) of the 183 buffers associated with harvest units harvested during the 6 years from 2000 through 2005. The average amount of windthrow in the buffers is 2.3 percent. The amount of windthrow is expressed as the cumulative number of trees windthrown divided by the original number standing trees in a buffer. The cumulative amount of windthrow in the buffers is highly variable and ranges from 0 to 73 percent (Table Fish-11).

Table Fish 11. Table Fish-2 Stream Buffers Monitored for Windthrow

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
Petersburg	Dakota	DK138A	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		DK138B	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
	Crane	CR46A	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		CR47A	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		CR48aA	2000	III	132	0(0%)	31(23%)	6(28%)	0(28%)	0(28%)	0(28%)	no data
		CR48bA	2000	III	102	0(0%)	4(4%)	0(4%)	0(4%)	0(4%)	0(4%)	no data
		CR49bA	2000	III	87	0(0%)	0(%)	0(%)	6(7%)	0(7%)	4(12%)	no data
		CR49bB	2000	I/II	380	0(0%)	11(3%)	8(5%)	3(6%)	0(6%)	0(6%)	no data
		CR51aA	2000	III	76	0(0%)	26(34%)	7(43%)	6(51%)	0(51%)	8(62%)	no data
		CR51aB	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		CR51bA	2000	III	232	0(0%)	6(3%)	0(3%)	4(3%)	0(3%)	7(7%)	no data
		CR51bB	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
	Twin Creek	TC41A	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		TC41B	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		TC41C	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		TC41D	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		TC41E	2001	III	102	n/a	0(0%)	0(0%)	0(0%)	0(0%)	1(1%)	0(1%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		TC41F	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		TC41G	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
	East Fork	EF3aA	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		EF1aA	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		EF1A	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		EF1B	2001	II	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
	South Pass	SP148A	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		SP148B	2002	III	193	n/a	n/a	0(0%)	0(0%)	0(0%)	76(39%)	0(39%)
	South Saddle	SS60A	2002	III	400	n/a	n/a	0(0%)	0(0%)	0(0%)	7(2%)	0(2%)
		SS60B	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		SS60AA	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
	Last Twin	LT74aA	2003	III	134	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	7(5%)
		LT74aB	2003	III	47	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	6(13%)
		LT74bA	2003	III	108	n/a	n/a	n/a	0(0%)	0(0%)	9(8%)	2(10%)
	Lindenberg	LD31A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD31B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD34A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD34B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		LD34C	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD34D	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD36aA	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD36aB	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD36bA	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD36bB	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD43aA	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD43aB	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD69A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD69B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD111A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD111B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD142A	2006	I	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LD60aB	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
	Finger Point	FP66A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		FP66B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		FP68A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		FP68B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		FP125A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		FP125B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
Wrangell	Nemo	NL9aA	2000	III	233	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	1(0.4%)	no data
		NL9aB	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		NL9aC	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		NL9bA	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		NL9bB	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		NL13A	2000	III	26	0(0%)	14(54%)	0(54%)	5(73%)	0(73%)	0(73%)	no data
		NL13B	2000	III	33	0(0%)	11(33%)	0(33%)	5(48%)	3(58%)	0(58%)	no data
	Turn	TN2A	2000	II	26	0(0%)	2(8%)	3(19%)	0(19%)	0(19%)	0(19%)	no data
		TN3B	2000	III	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
	Kuakan	KK31A	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK31B	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK31C	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK31D	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK31E	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK32A	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK32B	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		KK32C	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK32D	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK33A	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK33B	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK33C	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK35A	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK35B	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
		KK35C	2001	III	no count	n/a	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
	Shady	SH26A	2006	I	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		SH27aA	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		SH27bA	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
Thorne Bay	North Thorne	CL401A	2000	I	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		CL401B	2000	I	387	0(0%)	110 (28%)	0 (28%)	0 (28%)	0 (28%)	0(28%)	no data
		CL404aA	2000	I	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		CL404aB	2000	I	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
		CL404bA	2000	I	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data
	Lower Rio Beaver	CL417A	2000	I	no count	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	no data

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
	Alder	AL202A	2003	I	261	n/a	n/a	n/a	0(0%)	0(0%)	16(6%)	0(6%)
	Abandon	AB204A	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		AB204B	2003	I	222	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	6(3%)
	Ridge	RD249A	2003	II	107	n/a	n/a	n/a	0(0%)	0(0%)	2(2%)	0(2%)
	Pepper	PP403A	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP403B	2003	III	163	n/a	n/a	n/a	0(0%)	0(0%)	5(3%)	0(3%)
		PP403C	2003	I	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP405A	2003	II	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP405B	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP405D	2003	I	211	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	2(1%)
		PP406A	2003	I	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP406B	2003	II	74	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	7(10%)
		PP412A	2003	II	280	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	8(3%)
		PP412B	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP413A	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP413B	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		PP414A	2003	II	87	n/a	n/a	n/a	0(0%)	0(0%)	2(2%)	5(6%)
		PP414B	2003	II	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
	Rio Beaver	CL416A	2004	I	no count	n/a	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)
		CL416A	2004	III	no count	n/a	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)
		CL418A	2004	II	291	n/a	n/a	n/a	n/a	0(0%)	0(0%)	2(1%)
	Change	LB206A	2004	I	111	n/a	n/a	n/a	n/a	0(0%)	0(0%)	4(4%)
		LB222A	2004	I	no count	n/a	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)
		LB222B	2004	I	no count	n/a	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)
	Lucky Duck	LU435A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
	Fusion	CL420-4A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-5A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-11A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-11B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-12A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-12B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-13A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420-13B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL421A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL421B	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL421C	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		CL421D	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL47MA	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL60eA	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL60wA	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL28eA	2005	III	372	n/a	n/a	n/a	n/a	n/a	0(0%)	65(18%)
		CL28wA	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL435A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL435B	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL437A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	27(8%)
		CL438A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL438B	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
	Kogish	CL405A	2005	I	175	n/a	n/a	n/a	n/a	n/a	0(0%)	3(2%)
		CL411A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL411B	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL411C	2005	III	89	n/a	n/a	n/a	n/a	n/a	0(0%)	2(2%)
		CL412A	2005	I	91	n/a	n/a	n/a	n/a	n/a	0(0%)	3(3%)
		CL412B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL413A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		CL419A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL419C	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL420C	2005	III	106	n/a	n/a	n/a	n/a	n/a	0(0%)	1(1%)
		CL420D	2005	III	361	n/a	n/a	n/a	n/a	n/a	0(0%)	60(17%)
		CL420E	2005	III	145	n/a	n/a	n/a	n/a	n/a	0(0%)	10(7%)
		CL420F	2005	III	149	n/a	n/a	n/a	n/a	n/a	0(0%)	12(8%)
		CL420G	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
	Shinaku	CL409A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL409B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL415A	2005	I	851	n/a	n/a	n/a	n/a	n/a	0(0%)	7(1%)
		CL416A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
	Angel	CL430A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		CL430B	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
	LuckLacII	LL449A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LL449B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LL449C	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		LL452A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LL452B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LL417A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
	Prime Special	PS1A	2006	II	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
	Thorne Island	TI1-56A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		TI175A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		TI183A	2006	I	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		TI184A	2006	I	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
Craig	Fork 2	FKA	2002	II	74	n/a	n/a	0(0%)	0(0%)	1(1%)	0(1%)	no data
	Rolling Rock	RRA	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	no data
	South Arm	SA265A	2003	II	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		SA265B	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		SA301A	2003	III	31	n/a	n/a	n/a	0(0%)	0(0%)	4(13%)	0(13%)
		SA303A	2003	I	117	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	1(1%)
		SA303B	2003	I	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		SA312A	2003	II	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
		SA316A	2003	III	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)
	Gnu	GN	2003	I	no count	n/a	n/a	n/a	0(0%)	0(0%)	0(0%)	no data

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
	Dumpy ATC	DP467A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP470A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP447A	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP447B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP446A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP446B	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP441A	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP433A	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP433B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP433C	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497B	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497C	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497D	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497E	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497F	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497Ea	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497Eb	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		DP497Ec	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497Ed	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497Ee	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497Ef	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP497Eg	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP437WA	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		DP414A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
Ketchikan	Upper Carroll	UC8A	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	no data
		UC8B	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	no data
		UC17A	2002	III	94	n/a	n/a	0(0%)	0(0%)	7(7%)	0(7%)	no data
		UC17B	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	no data
		UC18A	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	no data
		UC9A	2002	III	no count	n/a	n/a	0(0%)	0(0%)	0(0%)	0(0%)	no data
	Licking Creek	LC65A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	no data
		LC67A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC67B	2005	III	53	n/a	n/a	n/a	n/a	n/a	0(0%)	15(28%)
		LC68A	2005	II	872	n/a	n/a	n/a	n/a	n/a	0(0%)	1(0.1%)
		LC68B	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)

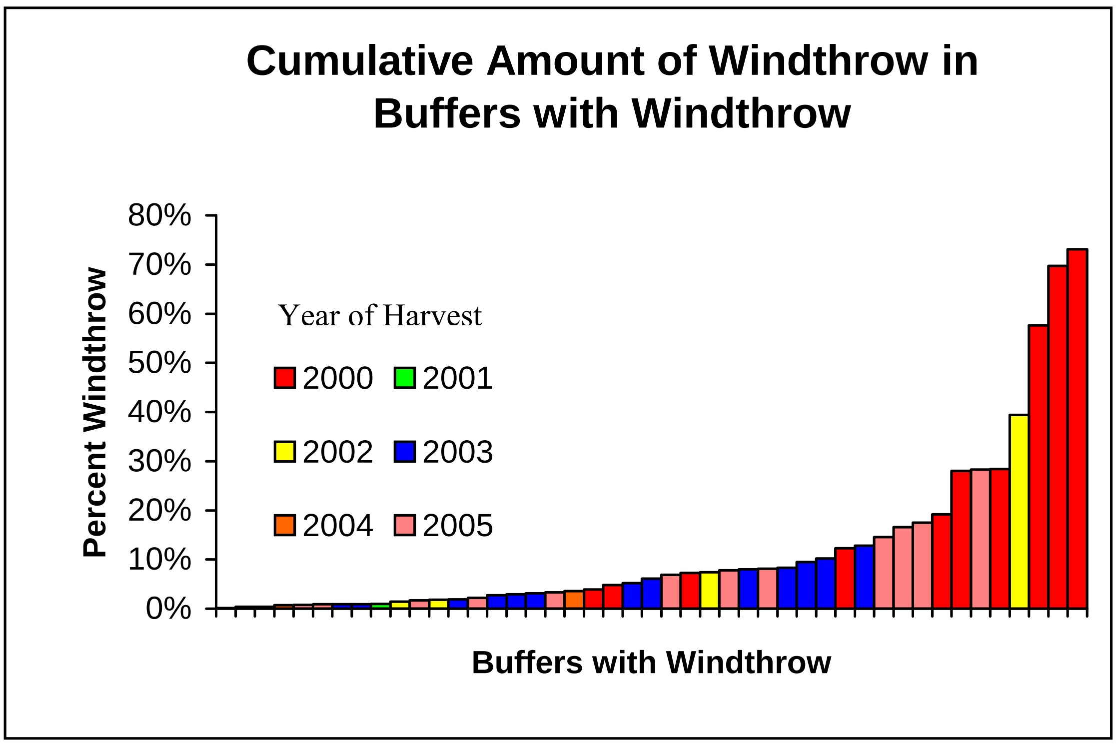
District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		LC68C	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC50A	2005	I	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC8A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC10A	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC10B	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC10C	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC10D	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC42aA	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC42bA	2005	III	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC44A	2005	I	224	n/a	n/a	n/a	n/a	n/a	0(0%)	1(0.4%)
		LC19aA	2006	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		LC29A	2006	II	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LC29B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LC31A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LC31B	2006	II	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LC31C	2006	II	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LC31D	2006	II	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
		LC34A	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)

District	Timber Sale	Riparian Management Area (RMA)	Harvest Year	Stream Class	Initial Number of Trees in Buffer	Incidence of Windthrow (Number of annual windthrow trees and cumulative windthrow % of initial number of trees within stream buffer)						
						2000	2001	2002	2003	2004	2005	2006
		LC43B	2006	III	no count	n/a	n/a	n/a	n/a	n/a	n/a	0(0%)
	Mop Point	MP23A	2005	II	137	n/a	n/a	n/a	n/a	n/a	0(0%)	20(14%)
		MP23C	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		MP26A	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)
		MP26B	2005	II	no count	n/a	n/a	n/a	n/a	n/a	0(0%)	0(0%)

The following results assess windthrow in buffers that are associated with harvest units that have been harvested one or more years ago. Low altitude aerial images were obtained for buffers associated with 2006 harvest units and those will be assessed after they have been re-sampled in 2007.

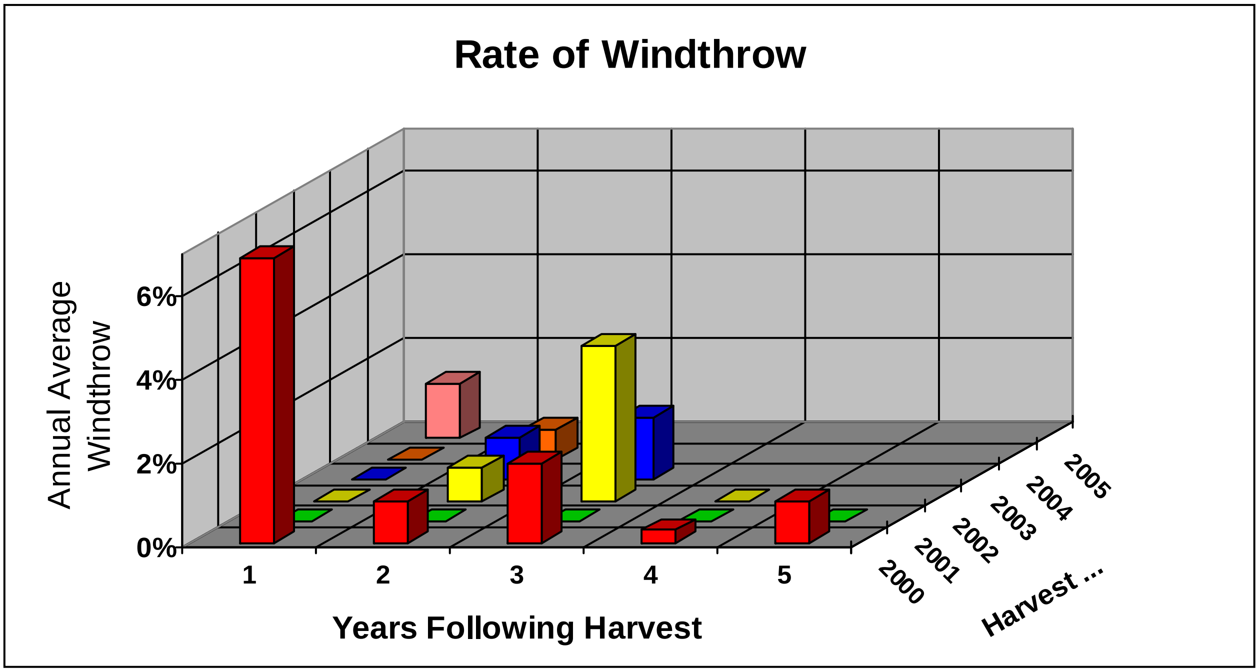
The cumulative amount of windthrow (i.e., cumulative number of windthrown trees compared to the original number of standing trees in a buffer), within the 45 buffers that have had some windthrow occurrence, ranges from less than 1 percent to 73 percent. In 14 buffers windthrow exceeded 10 percent. Seven buffers had windthrow exceeding 20 percent. Three buffers had windthrow in excess of 50 percent. The average amount of windthrow within these buffers is 12 percent, the median is 6 percent and a total of 704 trees were windthrown (Figure Fish-12).

Figure Fish - 12. Percent of initial number of standing trees windthrown in the 45 buffers with windthrow by harvest year from 2000 through 2005



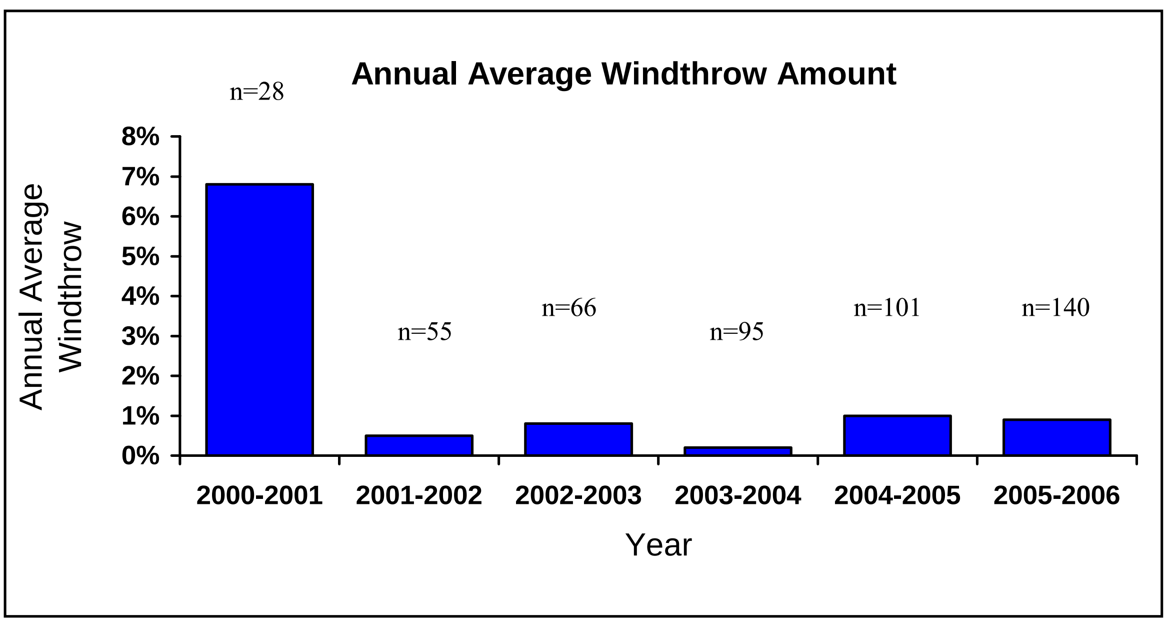
The amount of windthrow varies inconsistently when compared to time elapsed since harvest. The greatest average percent of windthrow (1.6%, n=183) occurred during the first year following harvest but only buffers associated with 2000 and 2005 harvest units had windthrow during the first year. The average percent of windthrow during the second year following harvest was 0.7 percent, (n=101); after the third year windthrow averaged 1.4 percent, (n=95); after the fourth year the average was 0.2 percent, (n=59); and after the fifth year following harvest the average was 0.6 percent (n=48) (Figure Fish-13).

Figure Fish - 13. The average rate of windthrow within all monitored buffers by harvest year 2000 through 2005.



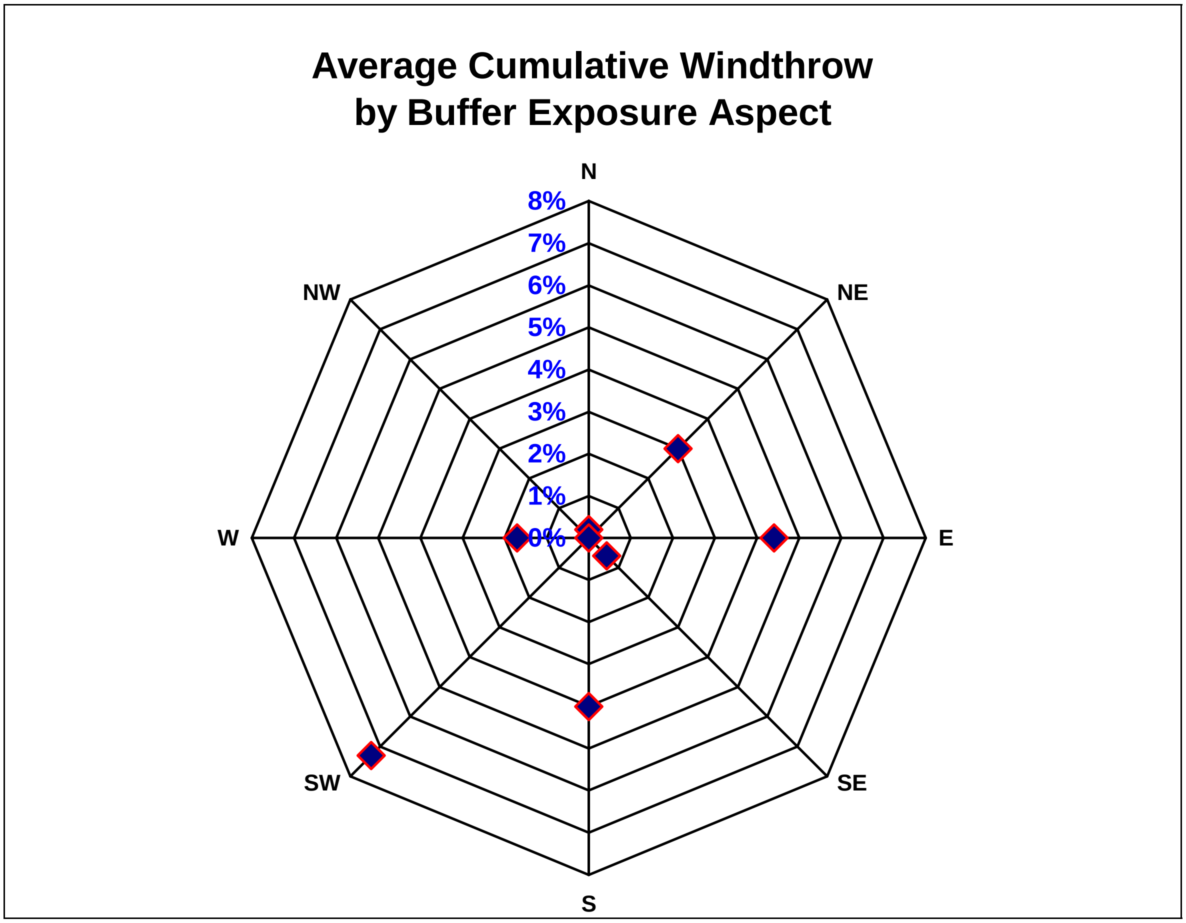
The annual average amount of windthrow in the buffers varies from 6.8 percent in 2000 to 0.2 percent during 2003. All years, with the exception of 2000, include windthrow amounts from multiple harvest years (Figure Fish-14).

Figure Fish - 14. Figure Fish-14. Annual average amount of windthrow in buffers from years 2000 to 2006. Windthrow amounts are from generally one summer to the next.



A comparison of average cumulative windthrow to the orientation of the face of the buffer indicates that buffers with a north to west orientation tend to experience less windthrow. The greatest percentage of windthrow was measured in buffers facing and exposed toward the southwest with an average cumulative windthrow of 7% while buffers facing northwest had no windthrow (Figure Fish-15).

Figure Fish - 15. Average cumulative windthrow by buffer exposure aspect. Exposure aspect is the direction that the face of the buffer is exposed to.



The average percent of windthrow in the buffers adjacent to Stream Class I or II channels was 1.9 percent while the average amount in the buffers adjacent to Class III channels was 3.5 percent.

Evaluation of Results

Monitoring results indicate that the average amount of windthrow in the stream buffers is 2.3 percent and that 25 percent of the 183 buffers associated with recent timber sales had some degree of windthrow. Seven (4%) of the monitored buffers had windthrow exceeding 20 percent and three (2%) of the buffers had windthrow in excess of 50 percent. A comparison of this windthrow amount to that found naturally within riparian areas adjacent to un-harvested forest stands has yet to be completed. Upon completion this comparison will help determine if windthrow has been exacerbated beyond that found within the natural range of variability. Cursory observations of control stream sections located upstream and downstream of buffers adjacent to harvest units suggest that significantly less windthrow is present within them. Therefore, current windthrow abatement practices may not be 100% effective.

By retaining riparian vegetation in a condition found within the range of natural variability it is anticipated that Forest Plan riparian objectives can be achieved. If windthrow is exacerbated beyond the range of natural variability, its effect will need to be understood to assess if natural channel processes are maintained in a natural condition as aspired to in the Forest Plan Riparian Standards and Guidelines.

2006 was the 7th consecutive year of data collection of windthrow occurrence in riparian areas. In addition to the need to monitor windthrow over an extended period it is also important to represent the many other interacting factors that can affect the occurrence of windthrow. These other factors include both abiotic and biotic factors. The abiotic factors include soil conditions, wind direction and speed, which can potentially be affected by topography and harvest unit size. Biotic factors include the age, health, size, and species composition of the stand. This monitoring effort attempts to encompass the widest range of these factors by ideally monitoring all and not just a sub-sample of the RMAs intended to be consistent with the Forest Plan. For the most part, this has been achieved but with exceptions. To date, the sample population does not include several potential and eligible RMAs. These RMAs were not included most often due to: 1) poor weather; 2) timing of the harvest; 3) the RMA were not distinguishable on the low elevation digital image due to the streams narrow width, slight incision depth and large percent of tree retention within the harvest unit; 4) simply not aware of the RMAs existence during harvest year.

A better understanding of the complex relationship between temporal, spatial and structural variables and riparian windthrow is expected through the continuation of this monitoring effort. This better understanding will provide more effective windthrow abatement prescriptions and management will move closer toward assuring desired riparian conditions.

Actions Recommended for 2007

- Continue to monitor the occurrence of windthrow in previously sampled buffers to assess the rate of windthrow.
- Continue to add additional buffers to the sample population to assure that the widest range of the interacting factors controlling windthrow be represented.
- Continue to georeference the low altitude digital aerial images of buffers to establish scale for differentiation of RMAs from RAW zones and to assist in detecting change in windthrow from one year to the next.
- Create a GIS geodatabase containing polygons feature classes of RMAs, RAW zones and the harvest unit; a line feature class of the stream, and a point feature class of standing and fallen trees.
- Distinguish the amount of windthrow within RMAs from that in adjacent RAW zones.
- Determine how RAW zone width affects the amount of windthrow within a RMA.

- Determine percentage of windthrow entering stream channel.
- Assess the occurrence of windthrow in control RMAs, which are adjacent to un-harvested stands, for comparison to the RMAs associated with harvested stands.
- Establish harvest unit tree retention classes and assess for effects on windthrow amount.

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