Summary of Monitoring Studies of the Effectiveness of Practices under the Alaska Forest Resources and Practices Act 1990-2002

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Introduction

This report is intended to provide a brief overview of effectiveness monitoring studies done with respect to activities under the current Alaska Forest Resources and Practices Act. It is not a review of the broad literature on riparian management, nor does it cover studies done with respect to federal best management practices for national forest land.

Fish: Region I

Studies on the impacts of timber harvest activities (including harvests, buffers, and roads) on fish habitat in Southeast Alaska (Region I) address the following topics:

a. Impacts of timber harvest on:
   a. sedimentation,
   b. bank stability,
   c. debris flows and mass wasting,
   d. blowdown,
   e. changes in LWD supply,
   f. pool size and spacing,
   g. water temperature, and
   h. canopy shading and density.

2. Monitoring the effectiveness of FRPA forest practices (buffers) on controlling the impacts listed above.
3. Reasons for summer fish kills.
4. Investigating research methods.

Impacts of timber harvest

Some creeks in harvested areas have sedimentation levels exceeding those in old growth areas. These harvests, however, were done before 1990 FRPA best management practices and buffers were instituted. Researchers expect that the BMPs would lower sedimentation rates (Pentec 1990).

Bank stability work showed that higher riparian zone forest density increases bank stability and recruitment of LWD. Stabilization by vegetation is most important on unstable channels (Martin 1993).

A study of several debris flows suggested that future management activities on naturally unstable areas may increase the probability of initiating landslides during storm periods. Timber practices may impact the timing of the landslides rather than their rate. Many of the landslides initiated in unmanaged areas (Martin 1995).

Several studies showed that blowdown amounts increased in the few years after harvest along riparian buffers, but the effects are short-lived (Pentec 1996, Martin 1996a). Most of the blowdown occurred in the outer zone (0-10m from the stream) of the riparian buffers (Pentec 1998). One study suggested that where LWD is naturally low, blowdown after harvest benefited fish habitat (Pentec 1998).

Large woody debris supply was influenced by blowdown after harvest. Studies showed that increases in LWD after harvest were not negative influences on fish habitat as long as fish passage could still occur, and there was not so much that it created stagnant water. LWD improves the quantity and quality of salmon habitat by forming pools and retaining gravel (Pentec 1998). Other studies showed that a 66-foot buffer is adequate to maintain 94% of the trees recruitable for LWD to the channel (Martin 1996b). Where stand densities are high, one study indicated that the buffer could be selectively harvested without negatively impacting LWD contributions to the channel. Where density is lower, though, selective harvest should be avoided at some sites (Pentec 1998). One study of regional LWD patterns showed that LWD is lower on the Kenai Peninsula than in Southeast streams. Unstable channels have a greater input of LWD because of greater erosion rates (Martin 2001).

Pool size and spacing was inversely correlated to LWD loading, regardless of harvest history. Channel width also influences pool spacing (Martin 2001). Another study indicated that pool spacing is sensitive to changes in LWD, but pool area is not (Pentec 1998). If the LWD is already high in a channel, it has a low sensitivity to changes in pool spacing when more LWD is added (Martin 2001).

One study suggested that water temperature has increased on channels that were harvested without buffers, but noted that the buffer BMPs would mitigate temperature changes in the future (Pentec 1990). Timber harvest reduces canopy density and shade, which in turn effects temperature. Even with a buffer, one study indicated that there might be reduced shading from blowdown or partial harvest (Martin 1993).

Effectiveness of FRPA best management practices

Several studies compared pre- and post-harvest basins and conditions, and indicated that logging with the new best management practices will not result in significant damage to fish habitat. Studies did show that certain areas (for example, those with low stocking densities) may require different guidelines. A literature review evaluated the importance of buffers on lakes and estuaries (Pentec 1991b).

Summer fish kills

Stream discharge and spawner abundance are primary factors controlling dissolved oxygen concentration during spawner migration. Low dissolved oxygen concentration kills fish (Pentec 1991a).

Research methods

Low-altitude photography was investigated as a method to monitor riparian areas. The study showed that low altitude photography had better accuracy, and would provide multiple and repeat measurements of stream attributes, documentation of stream change, and effects of land management practices (Grotefendt 1996).

Fish: Region II

Two studies addressed the impacts of timber harvest activities on fish habitat in Region II. One examined stream channel morphology, temperature, and spawning substrate in stream reaches affected by timber harvest, and compared them to other areas unaffected by timber harvest. The study found no difference between logged and unlogged streams before and after harvest (Tydinco 1999).

The other study initiated a monitoring program to measure spawning gravel quality in areas in which future timber harvest is planned. That study will provide a baseline for future comparisons (Martin 1996c).

Fish: Region III

Three studies were done on fish habitat in Region III. The Alaska FRPA standards are primarily based on fish, water quality, and hydraulic research in Southeast Alaska. The three studies were done by ADFG to gather more information about fish habitat in Region III, in order to tailor the FRPA standards more effectively to Interior Alaska.

All three studies investigated the Tanana River to determine which fish species used specific types of habitats, and to identify forest practices necessary to protect sensitive habitats. The studies found that groundwater streams and tannic-stained systems had the highest juvenile catches, and were important for spawning and overwintering (Hemming and Morris 1997, Ott et al. 1998, Durst 2001). Fish species and life stages in turbid summer waters seemed less likely to be as sensitive to low-intensity non-point source runoff from timber harvest and road construction activities than life stages tied to clearwater and tannic-stained habitats (Durst 2001).

Water Quality: Region I

Several studies address the impacts of timber harvest activities (including harvests, buffers, and roads) on water quality and streamflow processes in Southeast Alaska (Region I). Other related studies address the following topics:

1. Landslides and sediment supply,
2. LWD supply and recruitment, and
3. Using bioassessment to evaluate the effectiveness of a partial buffer zone.

Timber harvest impacts on water quality

Two literature reviews outline the effects of forest harvest and roads on water quality and streamflow processes in the Pacific Northwest. The first explains how timber harvest can affect water quality in terms of its sediment supply, nutrients, dissolved oxygen, and water temperature, and suggests methods to mitigate negative effects (Schult and McGreer 2001). The second outlines the effects of timber harvest on streamflow processes, specifically quantity and timing of streamflow, low flows, and peak flows. After harvesting, evapotranspiration usually decreases, so discharge increases. Clearcut harvesting causes greater increases in discharge than partial cuts (McGreer 2000).

One study monitored water quality in streams before and after logging (water temperature and turbidity) to determine the effectiveness of partial-cut buffers and other forest practices. The study found no significant turbidity response to timber harvest, indicating that partial cut buffers and BMPs were effective in maintaining turbidity levels. Canopy shading results indicated that some areas are affected by harvest, mainly due to blowdown after harvest. Temperatures did not show a significant change post-harvest, but there was a slight increase in temperatures below harvests compared to above harvests (Martin 1997).

Landslides

Many of the landslides that delivered sediment to streams were from unharvested areas, but some were from harvested areas. Low-gradient channels in basins with high sediment influx showed a definite response to sediment load. Larger channels showed channel migration and braiding, while smaller channels showed canopy opening and bar formation (Perkins 1999).

Large woody debris

Two studies examined LWD supply and recruitment. One was designed to determine the upstream extent of riparian zones for tributaries of anadromous waters. It determined a wood budget for a stream that could help determine how and where to protect LWD sources (Martin and Benda 2002). The other LWD study focused on the effects of buffer treatment on amount of LWD recruited to the stream. The dominant disturbance mechanism contributing LWD to the channel is erosion, rather than blowdown after harvest. Stream size relative to tree size can be an important determinant of which process contributes more LWD, however. For example, small streams are more likely to have their banks stabilized by vegetation, making the LWD contribution by erosion much less likely than along a large river where the vegetation contribution to bank stability is much less. Whichever disturbance mechanism is dominant, logged units do have the potential to temporarily increase LWD recruitment through blowdown (Martin and Grotefendt 2001).

Bioassessment

One study investigated the effectiveness of bioassessment techniques as a way to evaluate effects of harvest using partial buffer strips. Only one measurement showed significant changes, and only a few of those comparisons showed a potential reduction in water quality. Data from above and below bridges showed that road crossings have not changed the benthic communities. The use of bioassessment may be appropriate for future studies (Milner 1996).

Water Quality: Region II

Only one effectiveness monitoring study for water quality has been initiated in Region II. The study asked whether biomonitoring can determine the effectiveness of forest road stream crossing best management practices, by monitoring sedimentation at forest road stream crossings. The study showed that stream reaches downstream of crossings were periodically subjected to greater suspended material than respective upstream reaches, and DEC turbidity standards were exceeded at all sites at some times in the summer, during high flows. Two of the bioassessment tools showed promise for evaluating cumulative impacts of non-point source pollution and BMP effectiveness (Rinella et al. 2002).

Water Quality: Region III

A few studies in Region III have assessed water quality, some of them addressing water quality indirectly. Three of the studies will serve as baseline information for future studies. One study used GIS techniques to map tree dynamics within buffers strips along rivers to study the persistence of riparian buffers and the recruitment of large woody debris into rivers (Ott and

Putman 1999). Another study investigated the entire length of the Tanana River to analyze bank erosion and large woody debris recruitment (Ott et al. 2001). Erosion is controlled primarily by proximity to tributaries of glacial origin entering the river and delivering very large sediment loads, slope, and bank/bed resistance to hydraulic forces. The other baseline-information study was initiated on the Shaw and Providence Creek Watersheds, establishing a series of monitoring stations. Many potential developments may occur in this area, so the baseline data will provide a comparison for future studies conducted after development occurs (Alaska Boreal Forest Council 2002)

Another study relating to water quality in Region III quantified the effects of winter logging roads on floodplains in interior Alaska (Ott 1998). The study analyzed active layer depths and vegetation and ground cover patterns, and found that active layer depths are deeper under roadbeds than under all plant communities, and especially under spruce communities.

EFFECTIVENESS MONITORING STUDIES: SUMMARY OF INDIVIDUAL STUDIES

Fish Habitat

Fish habitat: Region I

Pentech Environmental, Inc. 1990. Inventory of Fish Habitat Conditions on Seven Southeast Alaska Streams Identified by the EPA Section 304(1) Long List.
Note: pre-FRPA/BMPs
Study Site: Seven streams throughout Southeast Alaska on lands owned by Sealaska Corporation: North Fork Steelhead Creek, Steelhead Creek, Election Creek, Deer Creek, North Fork Deer Creek, Humpback Creek, Gunnuck Creek.
Objectives: EPA and DEC prepared a list of streams suspected of being degraded due to timber harvest and other activities. Because no data on water quality existed, streams in SE were placed on EPAs "long list" by the best professional judgment of ADFG and DEC. Sealaska Corp. contracted Pentech to get data on the environmental conditions of seven streams on the "long list" that occur on its corporate lands.
Results:

- One-time survey had to use surrogate parameters for WQ data:
    - cobble embeddedness (sedimentation and turbidity)
    - LWD (channel stability)
    - riparian trees (shading)
- embeddedness (higher sedimentation): some creeks in harvested areas have levels that exceed levels measured in old growth areas. Sediment may be above expected levels. Based on comparison with limited old growth data, and also, embeddedness differs naturally among streams. May not mean that habitat has been degraded.
- Can these levels be reduced and maintained at levels as in old growth? Yes, because of revised 1990 Alaska Forest Practice Act and sediment flushing. Apply to existing harvests and roads, as well as new harvests. New BMPs should lower embeddedness.
- LWD equal or greater than old growth. OK, as long as fish passage OK, and is not so much that it creates stagnant water. FPA mandates a buffer along anadromous streams that will provide future LWD.
- Canopy shade is reduced. Water temp has probably increased. Buffer will address it.

Pentec Environmental, Inc. 1991a. Factors affecting pink salmon pre-spawning mortality in Southeast Alaska. Technical Report 91-01.
Study Site: Historical survey of information on 76 streams in Southeast Alaska, narrowed down to field studies on seven streams in the central portion of Prince of Wales Island in Southeast Alaska.
Objectives: Investigate the cause of summer salmon kills in south Southeast Alaska and to determine if logging affects their occurrence and magnitude.
Results:

- 1949-1989, 76 streams with fish kills.

- USFS draft report: high temps, low dissolved oxygen, low stream flow, many spawners are all potential causal factors.
- Stream discharge and spawner abundance are primary factors controlling DO concentration during spawner migration.
  - Less than 500 fish, DO not affected.
  - During high discharge, DO levels not significantly altered, regardless of numbers of fish.
  - Effects on streams varied.
  - Low stream flow and reduction of DO concentration from fish respiration in holding pools are likely to cause fish kills. Less DO downstream.
  - Lethal DO levels can occur at water temps well below lethal 25 degrees C, if fish are more active and streamflow is low.

Further study recommendations:

- More information must be collected on the environmental factors and basin characteristics that produce lethal conditions and cause pre-spawner mortality.
- ID basin and channel characteristics that cause a stream to be more susceptible, and if and how forest practices may affect susceptibility.

Pentec Environmental, Inc. 1991b. The importance of riparian vegetation to Salmonid habitat in lakes and estuaries.

Study Site: None. Literature review paper.

Objectives: FRPA does not define which components apply to lakes and estuaries; they are different than riparian. What riparian components must be maintained to prevent adverse effects of harvest activities?

Results:

- Direct and indirect effects: shade, stability, LWD, small WD, wildlife habitat for fish predators
- Lakes: holding areas, rearing, spawning.
  - Importance of riparian vegetation in lakes and ponds is indirectly related to the size and depth of the water body.
- Estuaries: adult salmon stage here before moving into rivers. Juveniles feed here, refuge from predators.
  - Removing vegetation along estuaries is likely to have a greater influence on slope stabilization, woody debris, and wildlife habitat than other aspects.

Martin, D.J. Pentec Environmental, Inc. 1993. Fish habitat and channel conditions in nine streams in forested lands of Southeast Alaska and Afognak Island.

Study Site: Nine streams in southeast Alaska and on Afognak Island:

1. Coon, Cabin, Little Afognak, East Fork Little Afognak Creeks: Logged from 1990 to 1992 and prior to passage of revised FRPA, but voluntarily buffered.
2. East Tolstoi, Eagle, East Eagle Creeks: Logging started during 1992 concurrent to this study.
3. Coco, Frosty Creeks: No logging occurred or is planned.

Study Site: Nine streams in southeast Alaska and on Afognak Island. Surveys began at the mouth of each stream and extended upstream to either a barrier for anadromous fish or a reach with poor fish habitat and low habitat utilization.

Objectives: Initiate a monitoring program to evaluate the overall effectiveness of the new forest practices and BMPs. Develop a database of fish habitat and channel conditions in forest land areas that have been recently harvested or are planned to be harvested in the future. Develop a multiyear monitoring program to collect data for before and after timber harvest case studies and for comparative studies between harvested and unharvested basins.

Results:

1992 survey results (one year of data only). Monitoring water quality data to determine if BMPs need to be altered.

- Potential effects of BMPs on habitat- and channel-forming functions:
  - Higher riparian zone forest density increases bank stabilization and recruitment of LWD, therefore encouraging the development of side channel and backwater habitats.
  - Canopy shading affects temperature. Even with a buffer, there might be reduced shading from blowdown or partial harvest.
  - Bank stability provided by roots and stems of trees is most important on floodplain and moderate-gradient mixed control channels. Root strength of riparian vegetation is less important on more stable channels. Unclear if blowdowns make buffer ineffective.
  - LWD management is most important on unstable channels: sensitive to LWD inputs. LWD affects channel morphology (pools), gravels, cover. Blowdown has added significant amounts to channel.
  - Surface erosion on spawning gravel. More fines = lower embryo survival. Question: are high fines in some reaches from management activities or from natural processes? Varying amounts of fines.

Future Study Recommendations:

- Continued monitoring of these basins over time will provide an effective means of assessing the short- and long-term effects of forest BMPs. This information will also indicate where more intensive studies may be needed to evaluate subtle effects on beneficial uses in streams.
- Compare "before" and "after" measurements to analyze BMP effectiveness.
- Additional information on timber density and riparian width relative to the floodplain width would be useful for further evaluation and confirmation of riparian functions along floodplain streams.

Martin, D.J. 1995. An assessment of fish habitat and channel conditions in streams affected by debris flows at Hobart Bay.

Study Site: Two small basins that drain into Laura's Creek and Salt Chuck Creek of Hobart Bay.

Objective: Investigate fish habitat and channel conditions to determine effects of debris flows. Do habitat conditions fall within the natural range of variability?

Background:

- In 1993, several debris flows occurred in basins flowing into Hobart Bay. Three debris flows were triggered by forest practices activities (roads and clearcuts) on steep and unstable slopes. Sediment went into Gypo Creek.
- Two debris avalanches were initiated by natural causes: Nancy Creek and Salt Chuck Creek basins. The avalanches became debris flows passing through clearcuts and depositing sediment.
- 1994, they were on the list of impaired water bodies (EPA 303(d) list).

Results:

- 26 landslides: 13 delivered sediment. 6 originated in harvest areas. Most were in steep inner gorges along channels.
- Thin soils, also evidence of other debris flows pre-harvest.
- Clearcutting creates instability, decreases tree root strength, increases soil saturation by increasing snow pack depth. Forest roads redirect surface and subsurface water.
- Management activities may have altered the timing of the landslides, but can't conclude that they increased the rate. All were in areas that already have landslides.
- Landslide sediment delivery: most landslides were confined to small tributaries, not larger-order channels.
- Fish habitat
  - Channel characteristics described.
  - Barriers to fish migration formed at some locations, but were passable at most locations.
  - Spawning gravel comparison:
    - No significant difference between managed and unmanaged areas.
    - Sedimentation does not appear to be affecting spawning habitat.
  - Rearing habitat:
    - Fewer pools: debris flows caused
    - Less LWD: past harvests without buffers.
    - Extra sedimentation creates channel braiding.
    - Standing timber would have minimized lateral spread of debris flow, then quicker habitat recovery.

Conclusions

- Future management activities on naturally unstable areas may increase the probability of initiating landslides during storm periods.
- Debris flows have had positive and negative effects. Magnitude of effect depends on length of time since last debris flow.

Grotefendt, Richard A. (1996) A pilot study using low-altitude fixed base aerial photography for monitoring riparian and channel habitat conditions.

<u>Study Site</u>: Three miles of Cabin Creek, Prince of Wales Island, Alaska.

<u>Objective</u>: Low altitude photography investigated to see if it can be used to study riparian zones.

<u>Results</u>:

- Low altitude, better accuracy.
- Will provide:
  - Multiple and repeat measurements of stream attributes
  - Documentation of stream change
  - Photos of effects of land management practices
- Vegetation density, orientation, stream size affect visibility.

<u>Further Study Recommendations:</u>

- Costs may be worthwhile for future work.

Pentec Environmental, Inc. 1996. Fish habitat and channel conditions for streams on forested lands of coastal Alaska: An assessment of cumulative effects.

<u>Study Site</u>: Selected timber management areas of Southeast Alaska, the Kenai Peninsula, and Afognak Island.

Objective: Document effects of forest practices on fish habitat. Monitoring program:

- Have fish habitat conditions changed as a result of timber harvest?
- Has habitat quality been affected (degraded or improved) by timber harvest?
- What categories of BMPs (buffers, roads) are not protecting fish habitat?
- Compared habitat conditions in pre- and post-harvest basins

Results:

- All channels showed changes from 1992 to 1994, regardless of whether they were harvested or not. In most cases, the changes in habitat parameters are likely due to natural annual variation in combination with measurement variability. Based on these data, no large changes in habitat conditions are evident in the study streams.
- No definable trends for habitat parameters are evident from the repeated surveys except for the increases of LWD in selected stream reaches.
- Hypothesis that logging under the 1990 FRPA will not result in significant damage to fish habitat in the study streams is not rejected.
- Channel disturbance: some blowdown in few years after harvest; short-lived.
- Channel width and depth: width: need 5-10 measurements, depth: need 40 measurements (not useful)
- LWD: highly variable. Blowdown at most post-harvest basins (increase).
- Bed material: too variable. Particle size increased over the 2 years.
- Pool parameters: very variable. Pool spacing inversely correlated to LWD loading. No differences between pre- and post-harvest streams.
- Riparian canopy density: reduction in canopy over time in post-harvest streams (variation harvests and blowdown).

Further Study Recommendations:

- Additional data and improvements in habitat measurement precision that were made in 1994 will enable a more accurate assessment of deviations in habitat conditions that can be attributed to disturbances from logging versus those from natural processes.
- Additional monitoring will be required to detect and evaluate the significance of changes that may occur over a longer time period and that apply to the region.

Martin, D.J. 1996a. Monitoring the effects of timber harvest activities on fish habitat in streams of coastal Alaska. Project status report.

Study Site: 19 stream basins located in the coastal regions of Southeast Alaska, on the Kenai Peninsula, and on Afognak Island.

Objective: Document potential cumulative effects of forest practices on fish habitat. (see full description in study above).

Results:

- Compared pre- and post-harvest basins and conditions.
- Short-term effectiveness of modern BMPs shown in protecting fish habitat in a variety of streams in coastal Alaska.
- LWD changing more in post-harvest, from blowdown, but new LWD is mostly small compared to total LWD load.
- Blowdown also reduced riparian canopy density.

Further Study Recommendations:

- A large database will be developed over time by the accumulation of data from repeat surveys of the same basins and from the addition of new basins. This database will be used

to develop tools to identify potential impacts, gauge the significance of these changes relative to the natural range of variability, and to identify linkages between impacts and forest practices.
- Continued evaluation of the data will be used to identify monitoring problems, to improve parameter measurements, and to refine the monitoring program.

Martin, D.J. 1996b. Monitoring the effects of timber harvest activities on fish habitat in streams of coastal Alaska. 1997 Status Report, 1992-1997. Same study as above.
Study Site: 32 basins located in the coastal regions in Southeast Alaska, on the Kenai Peninsula, and on Afognak Island.
Objectives: Same as above.
Results:
Buffer zones and mass wasting studies.
- LWD
  - LWD most important pool-forming element in Type A.
  - Boulders and bedrock most important element in Type B.
  - LWD load highly variable.
  - Logging input of LWD from windthrow increase pool habitat if LWD low initially.
  - No negative effects detected from increased windthrow.
  - 66' buffer adequate to maintain 94% of trees recruitable for LWD. 99% of LWD comes from within 66'. More statistics in this study.
- Buffer zones
  - After logging, stand density within 66' about 90% of original.
  - Type A stream needs 500 trees/km to maintain LWD supply.
  - Where tree stocking is naturally low, 66' buffer may not provide adequate LWD supply because of low LWD supply, not because of buffer width.
- Mass Wasting
  - 55% of landslides (in both managed and unmanaged forests) delivered coarse sediment to headwater or larger stream channels.
  - 67% of landslides from unmanaged forests reached stream channels (unstable steep areas).
  - 12% of clearcut/road landslides reached channels.
  - 45% of the landslides originated above timberline.
  - Clearcuts and roads were 11% of landslides, but only 2% of the landslides that reached stream channels.
  - Low gradient channels in basins with high sediment influx responded to sediment load: channel migration, braiding, bar formation.

Further Study Recommendations:
- Future studies will link these results to fish habitat. Further studies will examine relationships between sediment supply, pool development, and spawning gravel conditions.
- Field observations may be required to determine sediment delivery and landslide activity in some areas where aerial photographic evidence is inconclusive.

Pentech Environmental, Inc. 1998. The effectiveness of riparian buffer zones for protection of salmonid habitat in Alaska Coastal Streams.

Study Site: 15 watersheds in the coastal regions of Southeast Alaska and the Kenai Peninsula. Survey reaches located in low- and moderate-gradient channels (Type A and B waters).

Objectives: Determine the effects of buffer zones on the short- and long-term supply of LWD.

Results: Low elevation aerial photos used to delineate potential LWD sources, to determine effects of buffer zones on long- and short-term supply of LWD.

- LWD: improves quantity and quality of salmon habitat by:
  1. Formation of pools (can increase freq of small-med pools)
  2. Contributes to gravel retention (spawning habitat).

Type A waters

- Nearly all of recruitable trees are within 20m of stream. Selective timber harvest in standard buffer zones removed 1-12% of original stand. Did not significantly diminish potential LWD supply.
- Windthrow similar in logged and unlogged riparian zones. Density of recruitable trees unchanged. 0-10m supplied 63%, 10-20m supplied 31%
- 20m buffer zone more effective for providing LWD than a wider buffer, due to increased windthrow. Windthrow losses return to normal a few years after logging.
- Recruitable tree density of 235 trees/km (48 trees/acre) could supply enough LWD to maintain maximum pool development. A bit higher for smaller streams (275 trees/km).
- Where natural stocking levels are high, density is high enough to do some selective harvest. Where lower, though, avoiding selective timber harvest at some sites could have minimized reductions in density.
- Implementation of current buffer regulations should include evaluation of stand composition for buffers on Type A waters (alluvial).
- Where recruitable tree densities >275 trees/km, some trees could be harvested, as long as 65% of the recruitable trees are retained within the first 10m, and the size composition is similar to tree size in pre-harvest stands.

Type B waters

- LWD needs are undefined. Recruitment is not dependent on tree density, but on disturbance frequency. Trees should be distributed in a buffer zone where they are most likely to be recruited (0-10m, unstable or steep slopes, exposed to wind).
- Windthrow may reduce potential long-term supply of LWD in a small % of buffer zones. Stand vulnerability (aspect, location, soil wetness) to large windthrow events should be considered during unit layout, buffer design. Normal windthrow (<15%) is fine.
- Where LWD is naturally low, windthrow could benefit fish habitat.
- 400 pieces of LWD/km is optimal for most streams with alluvial channels: above that, the pools do not increase with additional LWD put into the stream.
- Designing buffers to take advantage of natural disturbances may provide more long-term benefits than the natural conditions (e.g., 20m, not 30m buffer).

Riparian Buffer Zones

- Michael Creek buffers cut more intensely than standard buffers.
- Windthrow higher in buffers and cut areas than unlogged.
- Pool *spacing* is sensitive to changes in LWD, but pool *area* is not, because many small pools can be formed by LWD before a change is detected.

Gravels and Spawning

- Gradient + LWD = spawning habitat.

Management Implications

- Buffers and LWD supply: 20m buffer maintains 94% of potentially recruitable trees in riparian zones of streams.
- Harvest didn't significantly diminish the potential supply of LWD from the 0-10m zone. Windthrow in 20m zone similar to unlogged riparian zone, so recruitable trees unchanged.
- 20m buffer provides more LWD than a wider buffer because of windthrow.
- Habitat: juveniles concentrate in upstream end of pool. Increase in # of pools, rather than size of pools, enlarges usable habitat. New pools formed by LWD increase quantity and quality of rearing habitat.
- Change in LWD most affects pools in alluvial channels.
- Four years of study, no negative impacts on fish habitat observed.
- In areas with LWD loadings below optimal, windthrow following logging increased LWD loadings and in most cases improved the habitat.
- Small streams (<10m wide) were impacted less by windthrow, because trees are suspended over the streams. Rate of biological decay will affect recruitment of LWD. Low recruitment.

Martin, D.J. 2001. Influence of geomorphic factors and geographic region on LWD loading and fish habitat in Alaska coastal streams. North American Journal of Fisheries Management. 21:429-440.

Study Site: Surveys were conducted in 14 streams located in the southern coastal regions of Alaska, extending from the lower Kenai Peninsula to southern Southeast Alaska.

Objectives: This study attempts to show the relationship between LWD, channel features, and habitat. It could help managers define LWD needs quantitatively.

Results:

- Amount and size of LWD
  - LWD lower on Kenai Peninsula than in Southeast streams.
  - LWD lower in contained channels than floodplain or mixed control.
  - Wider channel = larger LWD.
- Influence of LWD on channel
  - Mean number of pools per LWD structure decreased as channel widened; was affected by channel type.
  - Fewer pools formed by LWD in contained channels than in mixed or floodplain channels.
  - LWD-forming gravel bars lower in contained channels.
  - All regions different for percentage of LWD structures that formed gravel bars: Kenai < Northern Southeast < Southern Southeast
- Pool spacing
  - Influenced by LWD abundance, channel width.
  - LWD varies by region, channel type, and possibly width. Kenai timber volume is lower.
  - Input of LWD greater in alluvial channels than in contained channels—more erosion. Also export greater in contained channels—easier transport.
  - LWD influences gravel habitat—sediment traps.
  - LWD increases gravel accumulation—spawning habitat.
  - Decline in pool spacing with increased LWD.
  - Pool formation influences LWD, channel form.

- If LWD already high, low sensitivity to change in pool spacing when more LWD added.

Further Study Recommendations:

- In the present study, channel type seemed to affect the relationship between LWD load and channel width, but this relationship could be masked by differences in LWD loading amongh regions. For example, the lower Kenai Peninsula region had less LWD in all channel types. Therefore, comparisons should be made within similar channel types and among regions with similar timber stands.
- Finding an LWD threshold based on pool spacing could be useful for resource planning and assessment. Could use natural densities of LWD that occur in unlogged forests as indicators of habitat quality. This only shows LWD relative to some natural load, and not the functional effectiveness of the LWD load for forming fish habitat. A regional threshold could provide a benchmark for assessing the pool-forming potential of LWD in alluvial streams.

Fish habitat: Region II

Tydinco, T.A. 1999. The effects of timber harvest practices on fish habitat in Kenai Peninsula Streams.

Study Site: South fork of Deep Creek, Stariski Creek, and Clam Creek, on the lower Kenai Peninsula.

Objective: Examine the effects of timber harvest activities, under FRPA, on the fish habitat that the Act protects. Examined stream channel morphology, temperature, and spawning substrate in stream reaches affected by timber harvest, and compared them to other areas unaffected by timber harvest. Assumed link between habitat and fish population.

Results:

- Found no difference between logged and unlogged, before and after harvest. Sediment transport, LWD, most temps the same.
- Stariski Creek had a higher stream temp. downstream of logging (natural warming downstream could be the reason for warming, not logging).
- Buffers wider than required by FRPA. Concluded: buffers prevented effects on sedimentation, substrate, and LWD. [NOTE: Is that a valid conclusion, to assume that no effects because buffer was wider?]

Further Study Recommendations:

- Several years of data collection would be required to estimate natural variation in sediment inputs and temperature on the lower Kenai Peninsula.
- Temperature records of several years' duration, both before and after logging activities, could be used to account for natural temperature variation between years.
- Changes in stream temperature may be important in term of ecosystem structure and should be recorded in fish habitat studies.

Martin, D.J. 1996c. Spawning gravel quality in selected streams of the Ninilchik area, Kenai Peninsula, Alaska.

Study Site: Spawning gravel samples were collected from 13 stations located within the anadromous zones of the North Fork Ninilchik river, Clam Creek, and Stariski Creek, in the

Ninilchik area of the Kenai Peninsula. The stations were located downstream of timber lands on which harvesting is planned in the near future, and some were located adjacent to existing roads.
Objective: Salmon and steelhead live in the streams in the timberland. Because timber harvest and road construction can cause erosion and sedimentation of streams, a monitoring program was initiated to measure spawning gravel quality in areas in which future timber harvest is planned. This study will provide a baseline for future comparisons.
Results:

- Fines: large variability among streams.
- Spawning Gravel Quality:
    - Fines in Ninilchik streams: quality of spawning gravel is fair to poor. High percentage of fines (glacial outwash area).
    - Compared to the state standard, only Station 6 (Ninilchik River) has levels clearly above the state standard (<30% fines), and several others are close to the limit.
    - There may be a problem with how Alaska regulations interpreted the DEC literature review. It doesn't state 30%.
- Level of detectability and sample size
    - Number of sample sizes needed was calculated.

Further Study Recommendations:

- After logging is completed, compare future conditions with these baseline conditions.
- DEC's report was maybe changed or mistranslated to the 30% by weight standard (see page 17 of Martin's report).

Fish habitat: Region III

Hemming, C.R. & Morris, W.A. 1997. Fish habitat investigations in the Tanana River watershed, 1997. ADFG Technical Report No. 99-1.
Study Site: Two reaches on the Tanana River, Interior Alaska, at Fairbanks and Delta.
Objectives: The FRPA standards are primarily based on fish, water quality, and hydraulic research in Southeast Alaska.

- Investigate selected aquatic habitats in the Tanana during open water season.
- Capture and identify juvenile fish species using specific habitats.
- Identify physical characteristics and water quality of specific habitats used by juvenile fish.

Results:

- 5 water types:
    - glacial, groundwater, tannic-stained (most common)
    - mixed glacial/tannic
    - mixed glacial/groundwater
- Fairbanks
    - Minnow traps: most fish caught in tannic-stained waters. Greatest number of species were caught in groundwater.
    - Catch per unit effort (CPUE): when turbidity is high, juvenile fish catch is low. Highest CPUE in early season (May). Later in summer, most sampling areas had high turbidity (summer flood events).
    - Seine nets: CPUE highest in June. Decreased in turbid waters over summer, except high in June.

    - Number of fish caught didn't differ among substrate types.
- Delta
    - High turbidity means low juvenile fish catch.
    - Tannic stained areas had higher numbers of species and number of fish. [*NOTE: Are they harder to catch when it's high turbidity, or are they not using the areas?]
    - Seine nets: different pattern than Fairbanks. Turbid waters had highest CPUE in June (salmon).

Discussion
- Water quality changed at sites because of change in flow, sediment deposition and transport.
- Juvenile fish use lower turbidity waters most oftn.
- As turbidity increases, fish use and species richness decreases.
- Glacial water habitat with gravel have the most species.
- Clearwater and tannic systems are of primary concern for protection of fish habitat.

Recommendations
- Groundwater stream systems: sensitive.
    - Juvenile coho salmon, also wintering areas for other fish species.
    - They are most sensitive in fall spawning and juvenile out-migration periods (September-June).
    - Winter ice roads with artificial ice-thickening of the river channel crossings could alter groundwater flow.
    - Buffer size to maintain water quality not known.
- Tannic-stained systems (smaller systems)
    - Bank protection recommended for winter road crossings: snow/ice ramps, gravel roads designed to facilitate fish passage, vegetative buffers on small tannic runoff systems recommended to prevent degradation of summer rearing habitat.
- Glacial waters
    - Field review by habitat biologist
    - Bank protection.

<u>Further Study Recommendations</u>:
- This study serves as a base for further study.

Ott, A.G., J.F. Winters, A.H. Townsend. 1998. Juvenile fish use of selected habitats in the Tanana River near Fairbanks (Preliminary Report). ADFG Technical Report 97-1.
<u>Study Site</u>: Tanana River, Clearwater tributaries, tannin-colored sloughs, and connected wetlands between Fairbanks and the mouth of the Wood River.
<u>Objective</u>: Riparian standards are based on Southeast Alaska studies. This study focuses on the Interior. Gathered data on fish species use of various habitat types present in the Tanana River drainage.
<u>Results</u>:
- Habitat types and juvenile fish use
    - Longose suckers and lake chub are most abundant.
    - The highest juvenile catches were in backwater habitats.
    - Backwater habitats are limited on the Tanana.
    - Turbid waters have benthic feeders (slimy sculpin, longnose suckers, lake chub), and clearwater habitats have sight-feeders (grayling, round whitefish).

    - Cohos spawn and overwinter in spring-fed systems. Other species use these areas for feeding in summer.
    - Long-nosed suckers spawn in great numbers in tannin-stained areas.
- Fish species summaries
    - Tanana River provides many habitats used by many fish species for a variety of purposes throughout the year. Some areas are used only seasonally. Main channels are more important in the winter.
    - Hard to assess fish use in the Tanana River because of turbidity, depth, velocity, and ice cover.

Durst, J.D. 2001. Fish habitats and use in the Tanana River floodplain near Big Delta, Alaska: 1999-2000. ADFG Technical Report 01-05.

Study Site: 50km stretch of the Tanana River basin centered near Big Delta (same as 1997 Hemming and Morris study), between the outlet of Clearwater Lake and the lower Richardson Clearwater River.

Objectives: Interior habitat selection poorly understood.
    - Identify fish species and life stages in different habitats in the Tanana River.
    - Determine characteristics associated with specific habitats.
    - Identify forest management practices risking sensitive habitats.
    - Identify practices necessary to protect sensitive habitats.
- Study quantitatively evaluates differential use of 5 water type habitats:
    - Clearwater
    - Mixed clear/glacial
    - Glacial
    - Mixed humic/glacial
    - Humic-stained
- Study measures water temperature, depth, velocity, turbidity, dissolved oxygen, conductance, pH, substrate physical characteristics, and upland vegetation within 30m.

Results:

- Many species use the Tanana River during openwater when turbid. Apparently they use it for rearing as well as travel. Using other means than sight to feed, although sight-feeders.
- Fish density is relatively low in turbid waters, but still a very productive system.

Conclusion

- Fish species and life stages in turbid summer waters seem less likely to be as sensitive to low-intensity non-point source runoff from timber harvest and road construction activities than life stages tied to clearwater and humic habitats.

Water Quality

Water Quality: Region I

Perkins, S.J. 1999. Landslide inventory and sediment response study for monitored Sealaska streams.

Study Site: Twelve streams in Southeast Alaska on islands of the Alexander Archipelago, between the latitudes of Juneau and the US-Canada border.

Objective: Streams monitored, using air photos and topo maps, to:

1. estimate relative sediment supply,
2. determine importance of landslides in sediment supply,
3. history of sediment supply change.

Results:

Six basins had recent timber harvest that could affect landslide rates.

Channel characteristics were recorded from 1970 photos.

- ½ of landslides were below timberline, in undisturbed forest (44%) or in harvested areas and roads (11%).
- > ½ of landslides delivered coarse sediment to 1st order or larger stream channels. Most delivered to steep, small channels.
- 12% of landslides delivered directly to lower-gradient channels accessible to anadromous fish (Types A&B).
- 68% of landslides from unmanaged forests reached stream channels (most of these were unstable gorges near streams).
- 17% of clearcut/road slides are known to have reached channels, but delivery is uncertain for another 22%.
- Most of the sediment delivered was from the unmanaged Coco and Caldera basins. Also Eagle Creek had landslides from unmanaged areas.
- Response reaches are stream reaches that respond to coarse sediment supply (low gradient, unconfined streams, and therefore deposit bedload).
- Influx of sediment to fish-bearing channels depends on landslide rate, landslide size, delivery directness, and chronic episodes.
- Five basins had moderate to high influx ratings, the rest of the 12 had low to none.
- Only a few of the largest response channels had visible changes during the study period.
- Study shows the relative importance of landslides to sediment supply of teach stream, and the influence of forest vs. alpine slides.
- In basins where slides are far up-valley from monitored reaches, year-to-year sediment changes will tend to reflect changes in floodplain storage and flood size, rather than rates of landsliding.
- In basins where landslides deliver relatively directly to main channels, they will respond more directly to inputs of landslide sediment.
- Low-gradient channels in basins with high sediment influx showed definite response to sediment load:
  - Larger channels:
    - Channel migration
    - Braiding
  - Smaller channels:

    - Canopy opening
    - Bar formation

Further Study Recommendations:
Field visits are recommended for some areas to see changes.

Martin, D.J. & Benda, L. 2002. Patterns of wood recruitment and transport in Game Creek.

Study Site: Game Creek drainage, on the northern edge of Chichagof Island, in Southeast Alaska
Objective: Construct a wood budget for Game Creek: LWD recruitment rates and wood transport measured.
Background: Large woody debris is important for sediment storage in steep channels, for transport downstream. The Science and Technical Committee recommended that tributaries to anadromous waters should have a designated riparian area, but did not define upstream extent of riparian zone.
Background:
Wood budget: LWD has inputs, outputs, and residence times. These results used to evaluate the importance of transport and recruitment processes in upstream channels.

- Game Creek: 5% of watershed had commercial timber harvest.
    - Resident and anadromous fish
    - Buffers 20-30m wide along fish-bearing streams

Classification system:

- LWD assigned to categories:
    1. recruited trees: still attached to bank
    2. mobile pieces: in bankfull channel
    3. embedded pieces: partially buried
- Pieces in jams were defined as key pieces or not.
- Recruitment categories:
    1. bank erosion
    2. landslide
    3. mortality
- Decay classes:
    1. green leaves
    2. twigs
    3. secondary branches
    4. primary branches
    5. no branches
    6. moss-covered
    7. saplings growing

Results:

- bank erosion (60%) and mortality (39%) were dominant recruitment mechanisms.
- Most LWD relatively old.
- Recruited wood less stable in larger channels (wider channel = greater stream power)
- Rates of LWD recruitment:
    - Bank erosion and LWD recruitment increases with drainage area (consistent with greater bank erosion downstream).

  - LWD input from mortality is highly variable. No systematic variation with drainage area.
  - Landslide recruitment low.
  - LWD recruitment dominated by mortality in smallest drainages and bank erosion in largest drainages.
- Transport Distance:
  - Inter-jam spacing increased with drainage area.
    - Proportion of trees able to span a channel decreases downstream from increasing channel width.
  - Fluvial transport of LWD increased downstream with increasing drainage area.
  - Estimates of distance traveled by LWD: smallest channel: 50m-300m. largest channel: 300m-2500m.
- LWD Flux
  - Mobile LWD is less than or equal to channel width.
  - Channel width increases downstream, so increasing proportion of recruited pieces will be shorter than the channel width (transportable proportion increases downstream).
  - Model: all recruited LWD is transportable when channel width > 18m, similar to average height of trees (20m).
- Bank Erosion and Forest Mortality
  - Estimate of 0.5%/year from Washington.
  - Bank erosion recruitment of LWD should exceed mortality recruitment where erosion > 8cm/year^{-1}.
- Potential Applications
  - Ecological patterns and habitats.
  - Evaluate importance of stochastic processes in wood recruitment and transport.
  - Could determine how and where to protect LWD sources to streams. Identify probable extent of LWD transport, as well as importance of different recruitmentprocesses on LWD storage.
  - Game Creek: upper extent of LWD recruitment <500m upstream of anadromous fish zone. Tributaries into anadromous zone fall into 3-5m or 5-10m width category. LWD entering channel > 500m upstream has <10% probability of transport downstream to anadromous fish habitat.

Further Study Recommendations:

- The effect of different process rates on the LWD budget in other landscapes should be evaluated on a case-by-case basis.
- Classification System could be developed. Generalized spatial trends of LWD recruitment, transport, and storage could be mapped on drainage networks.
- Patterns of LWD storage and transport could be extended to include morphological consequences on channel morphology and fish habitat.

Martin, D.J. and Grotefendt, R.A. 2001. Buffer Zones and LWD Supply.
Study Site: Buffer zone areas on Prince of Wales Island and Revillagigedo Island in southern Southeast Alaska.
Objectives: Use large-scale aerial photos to:

1. Determine effects of standard buffer treatment on stand density. (primary objective)

2. Determine relative effects of windthrow compared to other stand mortality processes in the buffer zone.
3. Evaluate importance of physical factors (aspect, stand density, channel type) that may cause differences in the response of buffers to the logging treatments.
4. Evaluate effects of buffer treatment on amount of LWD recruited to the stream and on long-term recruitment potential.

Results:

- Stand characteristics.
  - Starting density in 20m wide buffers: 340 trees/ha in logged, 330 in unlogged. (no detectable difference).
  - Stand characteristics varied with distance from stream. 16% denser in inner zone (0-10m) than outer zone (10-20m). Higher % of conifers in outer zone.
  - PCID (Proportional Change in Stand Density) in logged units was significantly greater than unlogged units, in combined 0-20m buffer. The change in stand density (PCID) was not significant in just the inner zone (0-10m). There was an increased mortality (natural and timber harvest) in outer zone (10-20m), compared to the inner zone (0-10m).
  - With only recently down trees, PCID significantly greater at logged units. Stand density in buffers was reduced following logging. Greatest reduction due to increased mortality in outer zone.
- Windthrow
  - Inner zone: logged units 10% greater windthrow than unlogged.
  - Outer zone: logged units 29% greater.
  - Still, bank erosion and other processes were dominant sources of stand mortality.
- Factors affecting changes in density
  - Aspect: none
  - Density: significant (higher initial density = lower change)
  - Logging: significant (logging = higher change)
  - Channel confinement: significant (PCID greater at unconfined channels). Not affected by logging—no difference between buffer types.
  - Geographic area: varied by area.
- LWD Recruitment
  - No significant difference between logged and unlogged.
  - Recruited trees in outer zone of logged units greater than from unlogged units.
  - Logging had a small influence on the probability of LWD recruitment from outer to the buffer zone—no influence on the inner zone.
  - Density, aspect and confinement all had significant influence on proportion of stand recruited to the channel.
  - Southern aspect: greatest recruitment.
  - Unconfined: greater.
  - Low density buffer zones: greater.

Discussion

- Although windthrow increased stand mortality, it was not the dominant process causing stand mortality. Factors controlling bank erosion, mass wasting, and other processes may have a larger influence on stand density and wood recruitment to streams.
- 93% of future LWD supply remains in logged buffer units.
- Logged units have the potential to temporarily increase LWD recruitment.

- Southern aspect buffers exposed to prevailing windstorms in SE Alaska. More LWD recruitment.
- Unconfined channels contribute more recruitment to the channel. Maybe from wet soils that are more vulnerable to windthrow.
- Dense stands are more windfirm than sparse stands.
- Taller trees in low-density stands are more likely to reach the stream.
- Disturbance influences LWD recruitment, depending on stream size, channel confinement, erosion.
- Streams with low LWD could benefit from the increase in LWD after logging.

Schult, D.T. and D.J. McGreer. 2001. Effects of forest harvest and roads on water quality and application to watersheds of SE Alaska.
Study Site: Literature review, primarily from research findings that apply to the cool, wet conditions of the west slopes of the Pacific Northwest, which best represent conditions found in southeast Alaska.
Objective: Examine potential effects on timber harvest and road construction for the general conditions of southeast Alaska.
Results:
Timber harvest can affect water quality:
- Sediment
- Nutrients
- Dissolved oxygen
- Water temperature

Potential effects, based on Pacific Northwest research:
I. Erosion and sediment delivery
- Clearcut logging without buffer strips increases erosion.
- Sedimentation occurs only where soils are disturbed adjacent to unbuffered stream tributaries.
- Effectiveness of modern BMPs: in ½ of analyses, minor amounts of sediment in streams were from ground-based skidding:
    1. Steep slopes near streams
    2. Heavily-disturbed skid trails near streams
    3. Out of compliance.
- Minimize disturbance of forest floor.

II. Sediment from roads.
- Only a portion of the road system delivers sediment.
  1. directly: ditches into streams
  2. indirectly: drainage structures where sediment runs down slopes into streams.
- Limited by erosion control: road surfacing, vegetative cover on slopes, drainage features, sediment trapping effectiveness of forest floor.
- Good erosion control: sediment transport < 200 feet, small amount delivered.

III. Nutrients
- High levels in streams: entrophication. K,N can be toxic to aquatic organisms.
  A. Harvest effects on nutrients:
    - N or K: not long-lasting, not above toxic level.

        - Effects masked by buffers (they remove excess nutrients from runoff) by filtering and plant uptake.

   B. Road effects: usually only 8% of the watershed area is road. Mostly the roads are out of the riparian areas. Roads are unlikely to affect nutrients.

IV. Dissolved Oxygen
   - Low levels are harmful to fish. Can happen if high levels of debris in stream. Alaska FRPA: "slash not likely to enter a stream," so should prevent adverse effects.

V. Water temperature
   - BMPs establish buffers to retain shade.

   A. Harvest effects:
        - Buffer width .4 or .5 times tree height is 80% effective in retaining shade. Buffers of 60-75 feet in Southeast Alaska are effective.
        - Smaller streams: harvest is a negligible contribution to temperature unless 20% of flow or more has been harvested.
        - Cools when shaded downstream.
        - Alaska BMPs direct low-value timber and brush to remain within 25 foot buffer. Appears that AK FRPA will be effective.

   B. Roads: only a short distance. Unlikely to cause temperature change.

McGreer, D.J. 2000. Effects of forest harvesting and roads on streamflow processes and application to watersheds of Southeast Alaska.

Study Site: Literature review, primarily from research findings that apply to the cool, wet conditions of the west slopes of the Pacific Northwest, which best represent conditions found in southeast Alaska.

Objective: Examine potential effects of forest practices (harvesting and roads) on water yield, timing of yield, seasonal low flows, peak flows and floods.

Results:

- Quantity and timing of streamflow: Q = P – ET
  - (discharge = precip – evapotranspiration)
  - After harvesting, ET usually decreases, so Q increases proportionally to amount of cover. Clearcutting makes a greater increase than partial cuts.
  - Wetter areas recover faster.
- Low flows
  - Summer flows increase
  - Persists 15-20 years
- Peak flows and floods
  - Highly variable, hard to pin down.
  - Wetter soils in the fall—decreased ET losses, increased peak flows, usually associated with rain on snow events.
- Roads
  - Surface flowpaths, compacted surfaces.
  - Conflicting results. No consensus on increase in peak flows from roads.
- Summary
  - Clearcut harvesting will cause increases in discharge in all times of the year.
  - Peak flows could potentially increase following extensive clearcut logging.

Milner, A.M. 1996. Data analysis and summary of the use of rapid bioassessment metrics to evaluate the use of a partial buffer zone in timber harvest in a Lake Florence watershed, Admiralty Island. Institute of Arctic Biology, University of Alaska Fairbanks.
Study Site: Michael Creek, Lake Florence watershed, Southeast Alaska.
Objective: The three-year study of macroinvertebrates in Michael Creek was designed to investigate rapid bioassessment as a way to evaluate effects of harvest using partial buffer strips.
Parameters investigated:

1. EPT Genera (Ephemeroptera, Trichoptera, and Plechoptera averaged for the number of replicate samples)
2. EPT/Total Individuals (high number indicates unimpaired site)
3. % Dominant Taxa (community evenness)
4. Family Biotic Index (FBI: abundance of families that tolerate organic pollution)

Study

1. Compare before and after harvest
2. Compare against control (no harvest)

Results

- Of 144 comparisons, 18 showed significant differences, showing potential reduction in water quality. 12 showed an increase in water quality.

Discussion

- Only EPT Genera showed a significant change.
- Multi-metrics permits more balanced approach in detecting possible change. At least 2 metrics would need to be significant to indicate water quality degradation. Only Site 2 showed significant degradation in two categories—but the 2nd metric was FBI, and the value typically indicating unimpaired water quality.
- Logging roads and bridges: usually the greatest sediment source. Data from above and below the bridge show that the road crossing hasn't changed the benthic communities.

Further Study Recommendations:

- The use of bioassessment would be appropriate unless a Type II error had occurred; i.e., there was an effect due to timber harvest on water quality or instream habitat which was undetected by the metrics applied. Other metrics may then need to be used.
  Example: fine sediment inputs that altered substrate characteristics but caused no loss in macroinvertebrate species diversity, only a reduction in their biomass and abundance. However, fine sediments in salmon redds could negatively impact fish eggs worse than the macroinvertebrates.
- In this instance, other techniques than macroinvertebrate bioassessmnet will be necessary for assessing timber harvest effects on stream ecosystems.

Martin, D.J. 1997. A summary of stream water quality monitoring data: South Fork Michael Creek, Admiralty Island, Alaska. Martin Environmental.
Study Site: Michael Creek, Lake Florence watershed, Southeast Alaska.
Objectives:

- Effectiveness study of BMPs for water quality (temperature and turbidity). Monitoring for two years before and two years after logging, also in harvested and unharvested areas.

- Studied partial-cut buffer zones, as well as BMPs on other forest practices (roads, clearcuts, yarding, hauling). Partial-cut buffer zones: 25' wide no-cut zone adjacent to stream, then 41' wide partial cut. 50% of the trees > 12" dbh harvested.

Methods

- Measured stage, turbidity, temperature, canopy density.

Results:

- Missing data.
- High turbidity during storm conditions.
- Canopy density varied widely.
- Turbidity response to harvest
  - No detectable effect. Slight increase in 1996, but not significant.
- Canopy density response
  - Comparisons among treated and untreated zones indicate that some areas are affected by harvest.
  - Some reductions in canopy cover due to blowdown.
- Temperature response
  - Temperatures generally warmer pre-treatment than post-treatment, due to climate variability.
  - Water temps between stations 1 (above harvest) and stations 4&5 (below harvest) shows *slight* increase.

Discussion

- Turbidity
  - Partial cut buffers and BMPs effective in maintaining same turbidity levels.
  - Some blowdown caused sediment input.
  - Sediment runoff from roads and bridges, but only slight increases and not significant.
  - Gentle terrain and BMPs minimized sediment delivery.
- Water temperature
  - Reductions in canopy density from blowdown, so shading is reduced.
  - Responses of temperature minimal, though, possibly because of the cool climate and ground water contributions.

Water Quality: Region II

Rinella, D., A. Prussian, E. Major. 2002. A pilot study using biomonitoring to determine effectiveness of forest road stream crossing best management practices.

Study Site: Southern Kenai Peninsula: Ninilchik River, Deep Creek, Stariski Creek, and Anchor River.

Objective: Determine whether biomonitoring is effective in monitoring sedimentation at forest road stream crossings.

- Could the macroinvertebrate bioassessment already used by DEC be used for this application?
  - Alaska Stream Condition Index
  - Fine Sediment Biotic Index.
  - Water sampling also conducted.

    - Siphon samplers tested.

Methods

- Streams chosen for similarities (bark beetle mortality and salvage harvest)
- Siphon samplers located upstream and downstream of bridges, including a low stage and high stage sampler at each.
- Paired-sample t-tests used to test for differences between upstream and downstream.
    - ASCI (0-100)
    - FSBI (compare)
    - Sediment-sensitive populations

Results

- Sediment
    - Samplers showed increases in suspended inorganic sediment at sites below stream crossings, compared to upstream controls.
    - Turbidity higher below bridges.
    - 2 sites (out of 6) showed increases slightly above water quality standards.
- Macroinvertebrates
    - August ASCI: all sites but 1 assessed as excellent. (SF Ninilchik: good). 73.3 to 85.3 out of 100.
    - October ASCI: All sites excellent or good (52.9-85.3). Stoneflies were found less in the downstream sites (they are intolerant of sediment).
    - August FSBI: Sediment-tolerant assemblage (lower scores) at downstream sites during August, except Stariski Creek. Two taxa designated as sediment-intolerant by the FSBI were significantly lower in abundance below road crossings compared to above crossings.
    - October FSBI: No significant difference. Other population measures, most other taxa known as responsive to sedimentation, showed no significant difference.

Discussion

- Stream reaches downstream of crossings were periodically subjected to greater suspended material than respective upstream reaches.
- Sediment likely was produced as vehicles disturbed existing fine particles and pulverized larger particles.
- August showed sediment increases, but September sampling did not.
- DEC turbidity standards were exceeded at all sites for August 2001 and 2 sites in September.
- Macroinvertebrates:
    - ASCI: established tool for evaluating cumulative impacts of non-point source pollution.
    - FSBI shows promise for using invertebrates to evaluate BMP effectiveness.

<u>Further Study Recommendations</u>:

Continue study using improvements from this pilot study:

- Siphon samplers, methods and protocols for future research.
- Other data collection methods: sediment deposition, rain gages, additional collection sites

Water Quality: Region III

Ott, Robert A. 1998. The impact of winter logging roads on vegetation, ground cover, permafrost, and water movement on the Tanana River floodplain in Interior Alaska.
Study Site: Two sites on winter roads and adjacent undisturbed areas in eight plant communities on the Tanana River floodplain near Nenana in central Alaska.
Objectives: Quantify the effects of winter logging roads on floodplains in interior Alaska, specifically active layer depths and vegetation and ground cover patterns.
Results: Winter logging roads influence the depth of the active layer. Active layers under roadbeds were deeper than under adjacent undisturbed areas in 6 of the 8 plant communities studied.

- Roadbed surfaces were most depressed and active layers deepest, compared to non-roadbed areas, in spruce communities because of the removal of the entire organic mat during roadbed construction.
- Roadbeds were dominated by graminoids (grasses, sedges, or rushes). Moss was also common.
- Exposed soil was not common, and was mainly associated with plowing off the tops of tussocks, or ATV use in snow-free seasons.
- Continued use of winter roads kept them in early seral stages of succession. Annual and herbaceous perennials did better than woody species. Perennial graminoids would continue to dominate as long as roads continue to be used frequently.
- Shading on all sites was removed, and organic mat was removed on some sites, which influences active layer.
- Some thermokarst was already occurring before the road construction. No erosion was apparent.

Ott, Robert and William Putman. 1999. Monitoring riparian buffers along glacial rivers in Interior Alaska: Procedures for data collection and processing: A report accompanying ArcView project "buffer_monitoring.apr."
Study Site: Two riparian buffer monitoring sites at timber sales: one on the Tanana River near Delta, and one on the Tok River.
Objectives: Increase understanding of 1) the persistence of riparian buffers in the absence of erosion, and 2) large woody debris recruitment rates into rivers. The project monitors tree dynamics, specifically growth rates, mortality rates, recruitment rates, and species composition changes within riparian buffer strips.
Results: Mapped tree height, dbh, snags, physical characteristics of trees, regeneration. Created ArcView dataset to show spatial relationships of tree data for both sites.

Ott, R.A., M.A. Lee, W.E. Putman, O.K. Mason, G.T. Worum, D.N. Burns. 2001. Bank erosion and large woody debris recruitment along the Tanana River, Interior Alaska.
Study Site: The entire 824km-long Tanana River corridor in Interior Alaska.
Objective: Quantify baseline conditions of the amount and spatial distribution of bank erosion and associated LWD recruitment on the Tanana River. FRPA regulations are based on Southeast Alaska. This study gives a better understanding of Interior rivers.
Concerns:

1. Harvest along the Tanana River may increase riverbank erosion rates that might degrade spawning/rearing areas (sedimentation or change in channel morphology), AND
2. Timber harvest near the Tanana River would decrease the supply of LWD. The role of LWD in large glacial rivers is poorly understood, but is different than coastal streams.

Methods: studied entire 824km-long river, and land within 0.8km of riverbanks.

Results:

- Riverbank erosion
  - Distribution of erosion highly variable.
  - Five fairly distinct regions of erosion were identified along the length of the river.
  - Variable among vegetation size classes.
  - Most of the erosion was in the vegetation category that contained black spruce forests, seedlings and saplings of all tree species, and recently burned stands.
- LWD
  - Strongly associated with total land eroded.
  - LWD varied among vegetation size classes. Largest volume came from sawlog-sized stands.

Discussion

- This is a baseline dataset for erosion and LWD on the Tanana river. Future studies can be compared against this one.
- Erosion patterns
  - Can be explained primarily by proximity to glacial tributaries carrying a large volume of sediment, slope of the riverbed, and bank/bed resistance to hydraulic forces.
  - Most erosive areas were those where the riverbed slope was the steepest in conjunction with a concentration of silt-laden glacial tributaries entering the Tanana.
  - Tributaries of glacial origin create the largest spikes just downriver from their mouths. They deliver very large sediment loads. The most erosive are those that are closest to their glacial source. Their inputs change the channel pattern of the Tanana from single channel or anastomosing to braided.
  - Resistance to water also explains the patterns. Bedrock: no erosion. Sand dunes are less cohesive than silt.
- LWD
  - Unevenly distributed across vegetation strata.

Management Applications

- Refine riparian standards
- Determine if future activities are in compliance with FRPA.

Further Study Recommendations:

- How does LWD affect channel formation and fish habitat in Interior Alaska?
- What is the residence time of LWD in large glacial rivers?
- To what degree do geomorphic and geologic features control bank erosion?
- How much new land has accreted during the study period?
- Future studies can be compared against this one.

Alaska Boreal Forest Council. 2002. Hydrologic Assessments of Shaw Creek and Providence Creek Watersheds in the Tanana Basin, Alaska.

Study Site: Shaw Creek and Providence Creek watersheds, near Big Delta, Interior Alaska.

Objective: Provide baseline data for the watershed so that anticipated developments might be accommodated while sustaining the values and benefits of the area.

- Establish monitoring stations at the junctions of Gilles-Shaw, Caribou-Shaw, at the Keystone Creek upland site, and at the mouth of Shaw Creek.
- Survey Shaw Creek.
- Assemble GIS database.
- Collect data on water temperature, streambed temperature, soil temperature profiles, air temperature, atmospheric relative humidity, wind speed and direction, net radiation, precipitation, stream stage and water conductivity.
- Organize a citizen-based water quality data collection group.
- Conduct interviews to capture local-community knowledge of Shaw Creek.
- Survey fish habitat of Shaw Creek.
- Analyze and interpret the hydrologic data.

Background: Developments that may occur include new access roads and rights-of-way assocated with the Pogo Mine; timber sales; prescribed burns to improve moose habitat; a new gas line, and/or railroad right-of-way. Climate change could also impact the area.

Results: Analysis of the data has not yet been completed.

Further Study Recommendations:
Compare this baseline data on current conditions with future conditions after development has occurred.