Exxon Valdez Oil Spill Restoration Project Annual Report

Montague Island Riparian Rehabilitation

Restoration Project 95139C1
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

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Study History: This project was initiated under Restoration Project 94139. An annual report was issued in 1994 by Schmid, D. et al., under the title Montague Island Chum Salmon Restoration. The project was continued under Restoration Project 95139C1, the purpose of which is to monitor the riparian rehabilitation work completed in 1994. Some additional rehabilitation work was done in 1995 and monitoring will continue in 1996. A final report will be issued after the monitoring is completed in 1996.

Abstract: In 1994 and 1995, riparian restoration work was undertaken in four watersheds on Montague Island where logging had occurred in the 1960's and 70's. Although this work would not deal directly with the habitat oiled by the *Exxon Valdez* oil spill, it was felt that the restoration of these watersheds would improve conditions throughout the stream systems and contribute to the overall restoration of chum and pink salmon in Prince William Sound. The work involved two major parts: building instream structures to reduce erosion, moderate flows, and improve fish habitat; and thinning crowded riparian vegetation to stimulate the growth of Sitka spruce, which was the dominant species before the logging. A total of 32 instream structures were built and 17 acres were thinned. Most of the structures were successful, but some of those in the main branch of the largest stream failed. Variable flows in the smaller tributaries may reduce the benefits of habitat enhancement. Mainstem and whorl growth of trees in thinned areas was significantly greater than growth in untreated areas.

Key Words: *Exxon Valdez*, instream structures, thinning, riparian vegetation, Montague Island.

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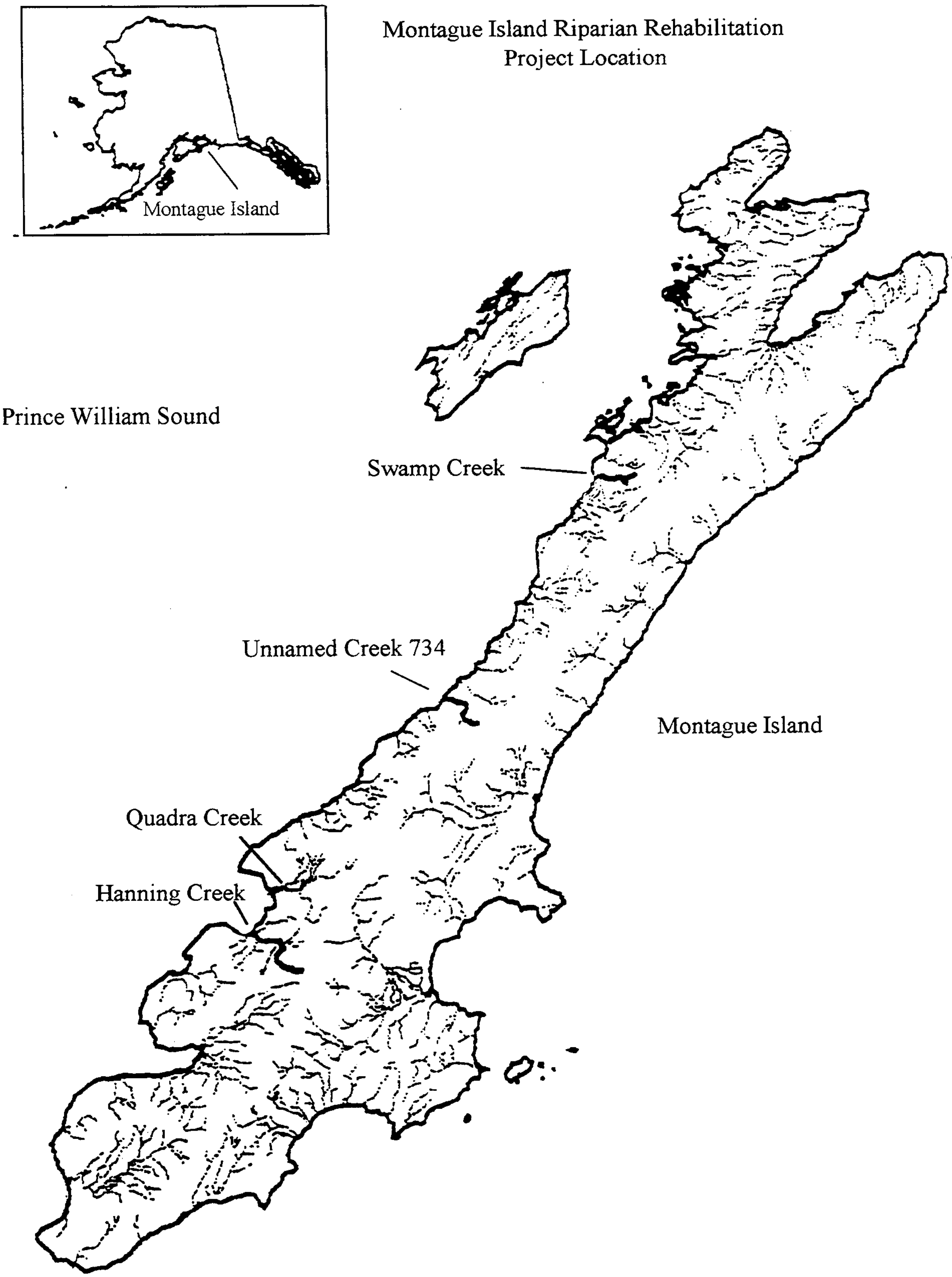

Executive Summary

After the *Exxon Valdez* oil spill it became apparent that not all of the direct effects of the oil spill or the injuries to various species could be undone. There was an opportunity, however, to help restore a number of watersheds on Montague Island where logging had occurred in the 1960's and 70's. Although this work would not deal directly with the habitat oiled by the spill, it was felt that the restoration of these watersheds would improve conditions throughout the stream systems and contribute to the overall restoration of chum salmon (*Oncorhynchus keta*) and pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound.

In most of these watersheds, the timber was harvested without leaving buffer areas around the streams. The logging resulted in diversions of the stream channels, increased erosion, and a loss of large trees which would contribute large woody material to the streams in the future. In addition, woody material was removed from the streams in the belief that it would help fish passage and spawning. Large woody material in streams reduces water velocities, creates pools, provides fish habitat, and stores bedload material. Comparisons of aerial photographs before and after the logging indicate that the streams have widened and gravel bars have increased. This suggests that erosion, stream velocities, and bedload movement have increased. The effects of these conditions are that chum and pink salmon redds in downstream spawning areas are subject to sedimentation, dewatering, or displacement during high flows. Habitat for other fish species is also degraded.

To combat these problems, we developed a two-part project. The first part consists of building instream structures to reduce stream velocities, reduce erosion, recreate lost pool habitat, reduce bedload movement, and create fish habitat. These artificial structures perform the same roles that fallen trees from the old-growth forest would have played if the logging and removal of woody material from the streams had not occurred. By creating more natural flow conditions, the downstream spawning areas should be less prone to disturbances and sedimentation.

In addition, rehabilitation of the riparian areas would help to restore the Sitka spruce (*Picea sitchensis*) forests that existed before the logging. After the clearcutting, crowded stands of Sitka spruce emerged. Thinning these stands will accelerate growth of the remaining trees and restore the mature forest in a shorter amount of time.

In 1994, 32 instream structures were built and 17 acres of riparian vegetation were treated. The structures were monitored in 1995 to determine if they were functioning as intended. The general health of the trees has been assessed by looking for windthrow, sunburn, and new growth. The main stem and top whorl growth were measured for two samples (n=15) of 5-10 ft.

tall trees in treated and untreated areas along Hanning Creek. Both of these parameters were analyzed using a single classification ANOVA.

A more intensive study of the effects of thinning was initiated in 1995 along Quadra Creek. Two one-acre plots were thinned using different spacing patterns: 16-ft. spacing and "diameter plus five." Circular 0.1 acre study plots were established in the center of each treatment area and a 1.0-acre control plot. All of the trees in the study plots were inventoried before and after treatment, with height, diameter, and age data being collected. In addition to the benefits of thinning, these areas will provide long-term study sites for future research.

Although all of the structures survived two bankfull high water events during the summer and fall of 1994, floods associated with the spring runoff destroyed 10 of the 32 structures in the spring of 1995. Eight of these were in the main channel of Hanning Creek where the structures were intended to help moderate flows. Of the four erosion control structures, two were fully successful, one was partially successful, and one failed.

The structures in two smaller tributaries, most of which were intended to provide fish habitat, were more successful. Sixteen of 18 structures held and functioned as intended. These structures created 1,798 sq. ft. of pool habitat and 740 sq. ft. of improved cover area for juvenile fish at normal levels in June. Low flows in August reduced the amount of habitat considerably, however.

The monitoring of the thinned areas showed significantly greater main stem growth and whorl growth in the thinned areas (stem: $F = 9.77$, $P < 0.01$; whorl: $F = 8.07$, $P < 0.01$). There was no apparent windthrow, sunburn, or other negative effects.

Although some of the structures on the main stem of Hanning Creek failed, the monitoring in 1995 shows that they could be repaired using better anchoring techniques in 1996. Similar structures in the smaller streams withstood the high flows, however, and appear to be functioning as intended. Some of the erosion control structures were more effective. Additional structures could be built to increase protection of the streambanks, especially those with stands of young Sitka spruce.

The analysis of tree growth showed significantly greater growth in the thinned area. The sample size was small, however, and included just two sites on Hanning Creek. This monitoring was only a preliminary effort to see if differences would be detectable. Monitoring at all sites will be conducted in 1996.

The full effects of this project will not be apparent for a number of years. In other Forest Service projects involving instream structures, we have found that it takes two or three years for the pools and other habitat features to develop and stabilize. The thinning should result in accelerated growth within a few years, but the desired outcome - the restoration of the mature Sitka spruce forest - will take a number of decades. Both the instream structures and the thinning should help to accelerate the recovery of these watersheds, restore more natural stream conditions, and in turn, provide better habitat conditions for the fish using these systems.

Introduction

Following the Exxon Valdez oil spill it became apparent that not all of the direct effects of the oil spill or the injuries to various species could be undone. Some oiled areas could not be cleaned any further, and the injured species in those areas could not be helped except by the passage of time. We felt it was possible, however, to help injured species such as chum salmon (*Oncorhynchus keta*) and pink salmon (*Oncorhynchus gorbuscha*) by improving habitat conditions in other parts of the Sound. Of particular concern were a number of watersheds on Montague Island which had been logged in the 1960's and 70's. If these areas could be restored, the overall populations of these injured species, and other species as well, could be improved.

In these watersheds the timber was harvested without leaving buffer strips around the streams. This has led to increased bank erosion and, of course, the loss of large trees in the riparian areas. The presence of these trees is important because the trees eventually die and fall into the streams, forming pools, reducing water velocities, and providing fish habitat. This problem was made worse when woody material was removed from the streams in the belief that it would help fish passage and create additional riffle area for spawning.

Without the large woody material and pools to disperse the energy of the water during high flows, the stream velocities, bedload movement, and erosion all increase. Studies by Smith et al. (1993) show that woody material also helps to store excess sediment and bedload material. Comparisons of aerial photographs from before and after the logging show stream widening and the development of larger gravel bars, which suggests increased bank erosion and increased bedload movement. It also appears that erosion and subsequent bedload deposition altered the channel of a tributary in the Hanning Creek watershed so that the creek now flows down a logging road.

These problems can affect chum salmon, pink salmon, and other fish by displacing or crushing eggs in spawning areas during periods of high flows and bedload movement. As flows subside, spawning areas can be affected by siltation from the eroded material. The loss of woody material and pools also limits the amount of juvenile rearing habitat for coho salmon (*Oncorhynchus kisutch*) and other fish species. Juvenile coho prefer low velocity areas such as the pools and backwaters created by woody materials. Logs and other material provide cover from predators, attract aquatic insects and other food sources, and provide shelter from high flows.

This project addressed these problems in several ways. To ensure the availability of woody material for recruitment into the stream in the future, the original Sitka spruce (*Picea sitchensis*) forests need to be restored. Crowded stands of spruce saplings were thinned to accelerate the growth of the remaining trees. Sitka alders (*Alnus sinuata*) and willows (*Salix spp.*) shading the spruce were thinned as well. The benefits from this work will not be realized until the trees mature, but this will accelerate the natural process and return the areas to the condition which existed before the logging.

In the short term, however, the instream structures that were built will play the role that fallen trees and other woody material would perform in a natural system. The structures are designed to recreate pools, increase the complexity of the channels, and lower velocities. The structures and pools will also help to trap gravel and, combined with the reduced velocities, reduce bedload movement. Erosion will be reduced with the lower velocities and with structures specifically designed to protect eroding banks.

The overall goal of this project is to return these clearcut areas to a more natural condition, and in doing so, improve the conditions in the watersheds for fish production. It will take some time before the fish populations respond to these changes, but we feel that by treating the problems of the watersheds, in both the riparian and stream areas, we can improve continued long-term production in the future.

Methods

A series of surveys had been conducted to assess the conditions in the streams that had historically produced chum salmon on Montague Island. In 1991, habitat surveys were performed in all of these streams using the habitat classifications described by Bisson (1982) and the standard Forest Service habitat survey methods developed by Olson and Wenger (1991). It was at this time that the problems in the clearcut areas were identified, particularly the lack of pool habitat and woody material in the streams. In 1992 the clearcut riparian areas were surveyed to determine whether tree planting or thinning were needed. Erosion problems were also identified at this time. In 1993, Forest Service crews identified three streams where restoration work would be most effective: Hanning Creek (Alaska Department of Fish and Game #710), Swamp Creek (#739), and an unnamed creek (#734). Quadra Creek (#711) also had areas that could use thinning. The crews noted the kinds of restoration work that were needed and developed the preliminary work plans. Final structure sites and thinning areas were identified in April 1994.

Instream Structures

The project was started in June 1994. The instream structures were built first to take advantage of the lower flows in the creeks in early summer and to avoid working in the streams when pink salmon were present. After the structures were completed, the thinning work was started.

There were six types of structure designs used: the diagonal log weir, upstream V, wing deflector, log barb, tree top, and log jam (Appendix 1). These structures were made of logs left on site from the logging period and other local material. These structures are designed to perform some or all of the following functions: reduce the energy of the streamflows, reduce bedload movement, reduce erosion, stabilize the channel, create pools, or provide fish habitat. The type of structure built depends on such criteria as the shape of the existing channel, the type of fish habitat available, bank stability, stream flow, and substrate. At each site the effects of the proposed structures were analyzed to ensure that the structure would not cause erosion or other problems at either high or low flows.

The structures were installed with a crew of four or five people using hand tools and small power tools, such as chain saws, gas powered drills, and a gas powered winch. No vehicles or heavy equipment were used. Logs were selected that were close to the site and could be moved without causing damage to the banks or stream. The logs were generally 20 to 30 feet long and 12 to 24 inches in diameter.

The structures were held in place by cabling the logs to stumps at the site, pinning the logs to the streambed with four-foot lengths of rebar, placing the log in trenches dug into the bank, or some combination of these methods. The ends of the structure and the banks were lined with large rocks to prevent erosion.

Riparian vegetation rehabilitation

Another project goal is to restore the original Sitka spruce forest that existed previous to the logging activities. A standard silvicultural practice is to thin crowded stands of trees to promote faster growth and obtain a mature forest in a shorter amount of time.

Small Sitka spruce saplings, Sitka alder, and willow were thinned with chain saws within 100 feet on both sides of the streams, except for a 10-foot buffer of uncut trees along the stream side to prevent new bank erosion. The thinning was not necessary along the entire lengths of the streams, however, since the vegetation is very unevenly distributed.

The spacing between trees was determined using a simple standard formula, where the breast height diameter (in inches) plus three equals the number of feet between trees. The crews also saved the larger, healthier spruce. In areas where small spruce trees were being crowded out or shaded by thick willow and alder, the other species were cut back to give the spruce more room and light. The cut trees were used in erosion control structures or, in some cases, put into brush piles for wildlife cover.

Monitoring Methods

Instream Structures

To evaluate the structures, diagrams of the sites were drawn before and after the structures were built. Depths, substrate composition, channel widths, pools, available fish habitat, and other features were noted. This was repeated in the spring of 1995. Downstream from all of the structures a 300-foot section of Hanning Creek was chosen as a control site to see how the structures affected flows, substrate, and channel morphology. It was hypothesized that if the structures helped moderate flows or reduce bedload movement, there may be changes in the substrate and channel downstream over time.

The control site contains two riffles and a pool. Each area was mapped and channel cross sections were measured. To analyze the substrate, Wolman pebble counts were conducted for each habitat type as described by Harrelson et al. (1994). A pebble count involves the random measurement of 50 pieces of substrate and gives a quantitative measure of the substrate composition for an area.

Riparian vegetation thinning

The effects of thinning done in 1994 were monitored in August 1995. The general health of the remaining trees has been assessed by looking for windthrow, sunburn, and new growth (growth in 1995). To determine the effect on growth, the main stem and top whorl growth were measured for two small samples (n=15) of trees in treated and untreated areas along Hanning Creek. Mainstem growth was measured to the nearest 0.5 inch from the top of the newest whorl to the tip of the tree. Whorl growth was calculated by measuring two of the top whorl stems on opposite sides of the tree and averaging the two measurements. Both of these parameters were analyzed using a single classification ANOVA.

A more intensive study of the effects of thinning was initiated in 1995 along Quadra Creek. Two one-acre plots were thinned using different spacing patterns: 14-ft. spacing and "diameter plus five," in which the average breast height diameter plus five equals the number of feet between trees. Circular 0.1 acre study plots were established in the center of each treatment area and a one-acre control plot. All of the trees in the study plots were inventoried before and after treatment, with height, diameter, and age data being collected. Besides providing the benefits of thinning, this work will serve as a long-term study area. The preliminary report by USFS silviculturist Susan Kesti is presented in Appendix 2.

Results

Although all of the structures survived two bankfull high water events during the summer and fall of 1994, floods associated with the spring runoff destroyed 10 of the 32 structures in the spring of 1995. Eight of these were in the main channel of Hanning Creek where the structures were intended to help moderate flows. Since most of these structures failed, the study of the effects on substrate and channel morphology was not conducted. Of the four erosion control structures, two were successful, one was partially successful, and one failed.

The structures in the two smaller tributaries, most of which were intended to provide fish habitat, were more successful. Sixteen of 18 structures held and functioned as intended. These structures created 1,798 sq. ft. of pool habitat and 740 sq. ft. of improved cover area for juvenile fish at normal flow levels in June. Low flows in late August reduced the amount of habitat considerably, however. On one of the tributaries, large numbers of juvenile Dolly Varden char (*Salvelinus malma*) were observed in two of the pools created by the structures, while the rest of the stream was reduced to a trickle.

The thinning appears to have stimulated the growth of Sitka spruce. Single classification ANOVA tests showed that mainstem growth and growth of the topmost whorl were significantly greater than the growth of trees in an untreated area. Mainstem growth for the 1995 growing season averaged 7.3 inches in the thinned area and 5.0 inches in the untreated area ($F = 9.77$, $P < 0.01$). Whorl growth averaged 5.5 inches in the thinned area and 4.4 inches in the untreated area ($F = 8.07$, $P < 0.01$). There did not appear to be any windthrow, sunburn, or other adverse effects in the thinned areas.

Discussion

Instream Structures

The theory behind the rehabilitation work on Montague Island was based on the results of studies and projects in Alaska, the Pacific Northwest, and the rest of the country. There are, for example, a number of papers describing the successful use of instream structures to improve habitat for salmon and trout (Payne and Copes, 1986; Fuller, 1990; House and Boehne, 1986). It has also been widely documented how large woody material, or instream structures functioning as woody material, serve to reduce flows, store sediment, reduce erosion, and generally improve the hydrologic characteristics of streams for salmonids (Swanston, 1991; Chamberlin et al., 1991; Smith et al., 1993). Thus, given these expectations, it was disappointing that some of the structures on the main branch of Hanning Creek failed.

Admittedly, the effects of the flows were greater than expected. Although the structures survived bankfull events in mid-summer and the fall, the flows during the spring run-off must have been greater. Since there were some structures that held up to the flows, an improved anchoring system would probably solve the problems at the other main branch sites. Almost all of the structures on the smaller streams held, so there does not appear to be a need to rework those.

One other problem was that the flows in the tributaries to Hanning Creek were highly variable. The structures were creating deeper pool areas and other habitat, but during low flows at the end of August, the amount of habitat was substantially decreased. On one tributary, two of the pools created by the structures were packed with juvenile Dolly Varden char when the rest of the stream was reduced to a trickle. It is uncertain whether these flows are an unusual or common occurrence. Although these structures are providing good habitat for much of the year, the benefits may be reduced if the fish are crowded into small areas in late summer or are forced to emigrate. The pools should continue to develop for several years, so there could be additional habitat available in the future.

Spruce Regeneration

The most difficult part of this project to assess will be the response of the spruce to thinning, simply because the full benefits may not be seen for many years to come. Thinning and removal of competing vegetation has been shown to accelerate the growth of Sitka spruce (Fowells, 1965) and has been a standard silvicultural practice for many years (Smith, 1962). Montague Island, however, is at the extreme northern limit of the range for Sitka spruce. The colder temperatures and shorter growing season may result in slower growth rates and a longer recovery period than in other areas. Although it has been 18 to 25 years since the logging on Montague Island, most of the spruce in the crowded stands are less than 15 feet tall.

The monitoring of growth in the thinned and unthinned areas showed that growth was increased in the treated areas. The sample size was small, however, and only two sites were sampled. This monitoring was limited because it was uncertain whether differences in growth would be detectable in the first growing season after thinning and before the growing season was over. Additional monitoring at all of the sites in 1996 will allow us to compare growth rates in different areas and help us to determine that it is indeed the treatment that is responsible for the accelerated growth.

Even though the growth rate may be increased, it will be difficult to predict when the spruce forest (and its value to the aquatic habitat) will be restored. Fowells (1965) developed Sitka spruce production figures based on a rotation age of 80 to 90 years in areas of optimal growth. The thinning should reduce the time it takes for the trees to reach certain size classes. However, it is unknown how many additional years it will take for the mature trees to die and fall into the streams, or otherwise enter the stream to provide the fish habitat and hydraulic benefits.

Plans for FY 1996

The primary need is to repair the structures on the main branch of Hanning Creek. The structures were inspected in 1995, and it appears that an improved anchoring system will keep the structures in place. Once the structures are repaired, the sites and the downstream area will be monitored to determine the effects the structures are having.

The areas thinned in 1994 will be monitored to compare growth rates between treated and untreated areas, and among sites. The monitoring in 1995 showed increased growth in the thinned areas, but it will be important to see if the effect is the same in other watersheds. It will also be important to compare growth rates among sites to determine whether the treatment or the location has the greater effect on growth.

At this point it appears that the thinning is having the desired effect, but the instream structures will require additional work before they are all functioning properly and can be evaluated.

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Appendix I. Types of instream structures built, purpose, and effect.

No.	Type	Purpose	Effect
1.	Tree top	Provide rearing area, cover.	Washed out in high flow.
2.	Tree top	Provide rearing area, cover.	Provides 75 sq. ft. cover.
3.	Log barb	Create backwater pool, rearing.	Created 12 sq. ft. pool.
4.	Deflector	Create backwater pool, rearing,	Created 20 sq. ft. pool.
5.	Tree top	Provide rearing area, cover.	Provides 50 sq. ft. cover
6.	Log jam	Provide rearing area, cover.	Provides 125 sq. ft. cover
7.	Log jam	Provide rearing area, cover.	Provides 490 sq. ft. cover
8.	Deflector	Create backwater pool, rearing, Protect bank.	Created 144 sq. ft. pool. Bank not eroding.
9.	Log barb	Create backwater pool, rearing.	Created 40 sq. ft. pool.
10.	Log V	Create pool, spawning area.	Created 352 sq. ft. pool, 80 sq. ft. spawning area.
11.	Log barb	Create backwater pool, rearing.	Created 100 sq. ft. pool.
12.	Log weir	Create pool, reduce velocity.	Created 462 sq. ft. pool.
13.	Log weir	Create pool, reduce velocity.	Created 24 sq. ft. pool.
14.	Deflector	Protect stream bank.	Bank not eroding. Revegetating.
15.	Log barb	Create backwater pool, rearing.	Washed out.
16.	Log V	Create pool, reduce velocity.	Created 544 sq. ft. pool. Dolly varden present.
17.	Log barb	Create backwater pool, rearing.	Created 40 sq. ft. pool.
18.	Log weir	Create pool, reduce velocity.	Created 60 sq. ft. pool.
19.	Log weir	Create pool, reduce velocity.	Washed out.
20.	Deflector	Protect stream bank.	Washed out.
21.	Bank cover	Reduce bank erosion.	Partially successful. Some erosion.
22.	Log barb	Deflect flow from eroding bank.	Deflected flow.
23.	Bank cover	Reduce bank erosion.	Bank protected.
24.	Log weir	Create pool, reduce velocity.	Washed out.
25.	Log weir	Create pool, reduce velocity.	Created 80 sq. ft. pool.
26.	Log weir	Create pool, reduce velocity.	Washed out.
27.	Log weir	Create pool, reduce velocity.	Washed out.
28.	Log weir	Create pool, reduce velocity.	Log broke in two.
29.	Log weir	Create pool, reduce velocity.	Washed out.
30.	Log weir	Create pool, reduce velocity.	Created 60 sq. ft. pool.
31.	Log weir	Create pool, reduce velocity.	Washed out.
32.	Log weir	Create pool, reduce velocity.	Not monitored yet.

Appendix II. Report on thinning at Quadra Creek by USFS Silviculturist Susan E. Kesti.

Quadra Creek Thinning Prescription

Riparian Management for Future Fish Habitat

Hanning Bay, Montague Island, Alaska

Restoration Project 95139C

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August 1995

RIPARIAN THINNING PRESCRIPTION

Introduction

This silvicultural prescription presents alternative treatments for managing the riparian vegetation along Quadra Creek on Montague Island in Prince William Sound. Quadra Creek runs into Hanning Bay on the southwest side of Montague Island. The area was harvested in 1958-59. The purpose of the treatments is to explore options for promoting development of larger trees to provide a future source of large woody debris to restore fisheries habitat. The treatments will be monitored to gain insight on how the stands respond.

I. Purpose and Need

In 1994, the Forest Service proposed treating the riparian vegetation as well as installing instream structures on Montague Island in the Montague Island Chum Salmon Restoration Project. This project was initiated with oil spill restoration funds to improve habitat for chum salmon, pink salmon, and other species. The purpose of treating the young stand of trees along the streams used by salmon is to provide future large conifers. In natural old-growth forests, a number of the large trees eventually die and fall into the streams, where they create important fish habitat. This prescription will explore ways of treating the dense stands adjacent to fish bearing streams to provide the desired stand structure. Thinning can promote growth on fewer trees and accelerate diameter growth. Permanent plots will be established to monitor effects of treatment.

II. Area Description

A. Location. The project area is located along Quadra Creek in Hanning Bay on Montague Island, in section 25, T. 3 S., R. 10 E., S. M. It is located on National Forest System lands. The 102 acre area was harvested as part of the Hanning Bay 316 timber sale in 1958. Only those acres within 200 feet of the tributary streams of Quadra Creek will be considered for treatment.

B. Climate. Montague Island is in a maritime climatic zone. On the island, mean annual precipitation ranges from 80 to 350 inches; Hanning Bay receives an average of 160 inches. Hanning Bay has a mean annual maximum snowpack depth of between 60 and 80 inches. The mean annual temperature is 40 F. Mean monthly temperature in January is 30.5 F and in July it is 55.1 F.

C. Topography. The project area is about 0 to 75 feet in elevation with a gently rolling topography generally facing south. Treatments will be confined to within 200 feet of the stream course so are generally considered riparian in nature. The forested alluvial plain was subject to the 1964 earthquake and experienced a 25 to 30 foot uplift. Bedrock is generally tertiary in nature and is composed of marine and continental clastic rocks consisting of siltstone, organic shales, sandstone and locally abundant, submarine volcanic rocks.

Soils are generally well drained, siltloam to sandy loam over a coarse soil texture. Gravel and cobble content increase with depth. The 10 to 25 foot high bank along the active channel of Quadra Creek is gradually being eroded causing bank failure and trees to topple in the creek frequently.

D. Wildlife and Fisheries. Sitka blacktailed deer, brown bear, martin, river otter, and voles frequent the area as well as songbirds, bald eagles, water dippers, and kingfishers. Travel corridors are located throughout the project area. Chum, coho, and pink salmon use Quadra Creek for rearing and spawning. Dolly Varden char are also present.

E. Vegetation. The area is a closed needleleaf forest of the Sitka Spruce type. The plant association appears to be Sitka spruce/blueberry - devil's club (PISI/VACCI-OPHO). The stands are densely spaced second growth Sitka spruce (*Picea sitchensis*) originating in 1958 interspersed with mountain hemlock (*Tsuga Mertensiana*), sitka alder (*Alnus crispa sinuata*), and clumps of salmonberry (*Rubus spectabilis*) and devil's club, (*Echinopanax horridum*). Tree diameters range from 0.5 inches to 14.1 inches in diameter with scattered remnant trees over 20" in diameter. Snags range from 6 to 20 inches in diameter. The second growth trees are 12 to 60 feet tall with a density which varies from 740 to 1500 live trees per acre.

Shrubs present in the understory are low in numbers due to the closed canopy conditions (about 90% canopy closure). Besides those species listed above, blueberry (*Vaccinium spp.*) is also present in small amounts. Forbs and ferns present include foamflower (*Tiarella trifoliata*), bunchberry (*Cornus canadensis*), twisted stalk (*Streptopus amplexifolius*), goldthread (*Coptis trifolia*), fiveleaf bramble (*Rubus pedatus*), lady fern (*Athyrium filix-femina*), oak fern (*Gynmocarpium dryopteris*), fragile fern (*Cystopteris fragilis*) and mosses.

No sensitive plants are known to be in the immediate project area. None were observed during treatment area delineations, plot installations, or pretreatment surveys.

F. Insect and Disease. No major insect and diseases are present in this young stand.

III. Management Direction, Goals, and Objectives

A. Management Direction. The Forest Service Manual (FSM) 2632 directs that habitat for fisheries be improved to increase the amount and quality of wildlife and fish habitat to levels or stands specified in the Forest Plan. Section III of the Land and Resource Management Plan for the Chugach National Forest outlines forest-wide direction. Hanning Bay is located in

Management Area 8, Analysis Area 18. Direction specific to the Analysis Area is located on pages III-105 and 106 of the Forest Plan. In summary, the primary management goals are to maintain wildlife habitat, improve fish habitat and enhance marine oriented recreation opportunities. One of the primary management practices is to improve commercial fish habitat.

The area was included as part of the Big Islands Management Area Analysis completed in 1989. The Record of Decision for the Environmental Impact Statement signed July 17, 1989, called for no timber management activities to occur on Montague Island. This included precommercial thinnings. Mitigation measures for class 1 streams included managing alder immediately adjacent to the streams to provide 75% shade on the stream. It also called for leaving as many deciduous trees, conifers less than 12 inches in diameter, snags, and trees with a 10% or greater lean towards the stream as possible within 75 feet of the stream.

Thinning of the trees in the riparian zone was called for in the Montague Island Chum Salmon Restoration Project description. The intent of this restoration project was to improve habitat for chum salmon populations which were adversely affected by the 1989 oil spill. The project was categorically excluded from further documentation. To improve habitat, structure were placed in the stream and thinning of the young densely spaced trees along the streams was proposed to accelerate growth on fewer trees to provide large trees in the future for instream structures.

B. Goals and Objectives. The desired future condition is a stand which can provide large material for instream fish habitat. Large trees either can fall naturally into the stream or be placed artificially. It is desired that the trees be available sooner than the estimated time frame necessary if no thinning were to take place. Since precommercial thinning along riparian areas has not been a common practice in Prince William Sound and has just been started in Southeast Alaska, it was desired to explore options of treating the stands and compare the results of the various treatments. The following goals and objectives were developed to achieve this condition.

1. Provide large diameter trees at an earlier age than if stands were left untreated.

   a. Improve growth on trees in the riparian area.

      Thin stands to concentrate growth on fewer trees and alleviate crowded stand conditions.
      Thin to provide healthy vigorous trees.

   b. Provide adequate number of trees for future instream structures.

      Leave a minimum of 136 TPA within 100 feet of the stream.

2. Provide information for managers on effectiveness of treatments

a. Explore treatment options for meeting desired future conditions and compare results.

Thin stands to a variety of spacings and include control areas for comparison.
Coordinate with riparian thinning effort occurring in Southeast Alaska so results can be compared.

b. Establish monitoring plots to monitor response and change

3. Provide wildlife habitat as described in Forest Plan.

a. Maintain deciduous component in thinned stands to provide canopy diversity and avoid single species stands.

If present in stand, keep 10 - 20% of leave trees as alder and cottonwood. (or use % found in mature riparian stands in area if higher than 10 - 20%.)
Keep wildlife travel corridors free from slash and debris.

IV. Alternatives

A. Alternatives Considered and Effects of Each. To determine thinning regime to follow, spacing options were explored through literature search of thinning studies done in Southeast Alaska. Most of these occurred on upland forests, not in riparian areas. In stands ranging from 16 to 25 years of age (the Hanning Bay stand is about 37 years old) spacing ranged from 12 by 12 feet to 20 by 20 feet. For stands up to 9 inches in diameter, variable spacings based on diameter have been used on the Kenai peninsula to reduce competition and improve vigor in white spruce stands to reduce potential of spruce bark beetle damage.

The spacings selected should provide a range of tree densities all within the guidelines for desired number of trees per acre for large woody debris. The literature on large woody debris, (Sedell et al, 1984, Murphy and Koski, 1989), suggests having a range of 30 to 150 trees over 30 cm in diameter every 100 m along the stream. It is estimated that 99% of the large woody debris originates within 30 m of the stream. By combining this information, the suggested range equal 30 to 150 trees over 11.8 inches in diameter per .22 acres. This translates to 136 to 681 trees per acre as the desired density range for large woody debris input.

Three treatments are proposed to provide a range of thinnings and meet the goals of providing future large trees in sufficient numbers. The "diameter plus 5" spacing will be used since it provides the most trees while reducing the stand to 80 to 120 square feet of basal area (BA). This will reduce stress and competition between trees and improve vigor. This spacing has been found to be enough to improve resistance to bark beetles on the Kenai. If the existing stand has a range of diameters, this thinning regime provides a stand with more variety and interest than a thinning based on a set spacing alone. If the trees average 4 inches in diameter, the diameter plus 5 spacing will leave approximately 538 trees per acre (TPA). The other two treatments will be a 12 by 12 foot spacing thin which will leave approximately 302 TPA and a 16 by 16 ft spacing thin resulting in approximately 170 TPA remaining. A total of 9 acres will be thinned for the study. Three control areas will be designated.

Studies in Southeast Alaska have shown that the remaining trees will respond to thinning; however, it is unclear how the trees will respond in Prince William Sound. Prince William Sound is the upper limits of the Sitka Spruce growing zone and no monitoring of thinned stands in the area has occurred to date. Prince William Sound has a lower species diversity than Southeast Alaska and a lower site index than that predicted from latitude relationships of Farr and Harris (Eck 1984). An example is a Sitka spruce would be predicted to be 113 feet tall at 100 years on a particular site, but instead actual heights are closer to 63 feet. Some reasons for the difference are the heavy snowpack, younger, shallower soils, and relatively cool, short growing season. Understory may or may not respond depending on available seed source, amount of canopy closure, side lighting, and how long the canopy has been closed before thinning takes place. Studies have shown that stands 31-98 years old with closed canopies and little understory before thinning tend to allow existing conifers to fill in, excluding understory shrubs. Response in the understory may be limited to conifers becoming established depending on amount and kind of increased light available. It has been found that increased side lighting is an important factor in how understory shrubs respond to thinning. In Southeast, the effects of thinning on the understory are not expected to last more than 20 years.

The remaining trees should increase in diameter and have improved vigor since more nutrients and sunlight will be available and there will be less competition between trees. It may take a couple of years for trees to respond depending on the severity of the thin.

B. Mitigation Measures. A buffer of ten feet will be left along the stream to minimize streambank erosion. Material will be hand piled and slash height reduce to within 2 feet of the ground. Slash should be cleared from wildlife travel corridors. Trees can be dragged into the stream to provide instream structures. Location of bald eagle nest trees are known and work will be done in a manner to avoid disturbance. No trees will be felled into the stream unless desired for fish habitat.

V. Implementation and Monitoring

A. Proposed Project Design and Guidelines.

The treatments will take place in July 1995. A block design of the three treatments and control will be delineated along Quadra creek. Three replications of each thinning regime and a minimum of three controls will monitored. Each treatment will be 1 acre in size about 200 by 217 feet. The corners of the treatment areas will be designated by painted rebar and boundaries will be flagged.

Trees selected to be left will be based on dominance, vigor, size, as well as spacing regime for treatment area. If one criteria has to be compromised, spacing should be compromised. Attempts will be made to maintain tree spacing within 2 feet of the desired spacing. In extreme cases, a minimum of 8 feet spacing in 12x12 and 16x16 foot spacings will be used as a guideline. This will achieve the main objective of providing a sufficient number of large diameter trees, but may compromise monitoring effects of various thinning regimes. Hopefully trees will be of sufficient vigor and dominance at appropriate spacing. Deciduous trees should make up 10 - 20% of the remaining stand at minimum. If the deciduous component is higher in adjacent unharvested mature stand, then use that percentage.

Fixed plots will be located near the center of each treatment area to reduce influences from outside treatment area. Plots are anticipated to be 1/10th acre circular plots. Monitoring plot centers will be marked by numbered rebar and located by global positioning system (GPS) and referenced with 3 bearing trees if possible.

Plots will be established before treatment and data taken to record stand conditions before treatment. Information will also be collected immediately after treatment. To track response, plots will be revisited 1, 5, 10, 15, and 20 years after treatment and if possible every 10 years after.

Information to be collected will include tree density, heights, ages and conditions using standard stand exam procedures for the 1/10th acre fixed plot data collection. Additional information will be collected on the understory by strata using the Chugach National Forest Plant Association data forms. This information can be used to track changes in the understory for each treatment and control.

The following thinning treatments are proposed on one-acre plots:

1) Control

2) diameter + 5'
(if 4" dia; 9'x9' = 538 TPA)

3) 12' x 12' (302 TPA)

4) 16' x 16' (170 TPA)

Monitoring plot = 1/10th acre in the center of each treatment acre
(circular plot 37.2' radius)

If time allows, it has been suggested to establish 3 other control plots outside treatment area to reduce influences of treatments on control data. It is also suggested to install a plot in an unharvested stand representative of what have occurred on the site before harvest for reference. Since the area experienced a 25 to 30 foot uplift in 1964, a stand further up the drainage may be appropriate if none exist in immediate vicinity. If not done in 1995 due to time limitations, it can take place next year.

B. Actual Project Installation and Preliminary Data Summary.

Stands were very variable along Quadra Creek. Scattered pockets of salmonberry and sitka alder and clumps of trees not harvested in 1958 broke up the second growth to a point where 12 contiguous acres were not available. As a result, the desired number of treatments and controls were not installed. One stretch of second growth did provide an opportunity to install 1 control and 2 treatments, each approximately 1 acre in size, side by side. Due to the density and size of the trees, these 2 treatment areas would be completed before installing any more treatment blocks since it was apparent that each block would have different characteristics.

The two treatments used were the diameter + 5' with all trees over 10 inches in diameter left and an average 14'x14' spacing with all trees over 10 inches in diameter left. Fourteen by fourteen foot spacing was selected since it is recognized that spacings would range from 12 to 16 feet and it was desired to retain the most trees. In both, some trees in the 6 to 9 inch class were girdled to provide future snags instead of being felled. This reduced the amount of material put on the ground at one time. Table 1 summarizes the conditions in each of the treatments and the control before and after treatment. The control plot happened to land in a portion of the control area that has less stocking than the treatment areas. Photos were taken at each plot before and after treatment. Wildlife travel corridors were created in each treatment. Due to the abundance of slash and clearing of paths, slash across the remainder of the area ranges from 2 to 4.5 feet in height. Stems over 3 inches in diameter were cut into 3 to 4 foot lengths to reduce potential for spruce bark beetle and get material closer to the ground to improve decomposition. It is anticipated that winter snows will compact slash further to achieve desired levels. It is recommended to pursue funds to burn some of the slash to further achieve desired results.

Table 1. Quadra Creek Thinning Stand Summaries - Both Pre and Post Treatment

-------- Number of trees in 1/10th acre monitoring plot ----------

	Area 1 - Control		Area 2 - Dia +5				Area 3 - 14x14			
	Live	Dead	Live		Dead		Live		Dead	
Class	Pre		Pre	Post	Pre	Post	Pre	Post	Pre	Post
0 - 2.9" ave. ht. = 12 - 30'										
Spruce	22	9	34	19	105	16	60	0	23	0
Hemlock			2							
3.0 - 4.9" ave. ht. = 25 - 35'										
Spruce	16		45	6	10	0	28	0	1	1
Hemlock		1			2	2				
5.0 - 6.9" ave. ht. = 32 - 40'										
Spruce		12	19	11	1	G=1	9	1	0	0
Hemlock		1								
7 - 8.9" ave. ht. = 40 - 50'										
Spruce	9		20	14	1	G=2	9	5		G=1
Hemlock										
9.0-13.9" ave. ht. = 50 - 60'										
Spruce	14		15	11	1		18	13		
Hemlock	1									
14.0+" average height = 60'+										
Spruce	1		2	2			0			
Hemlock										

Table 1. continued. Quadra Creek Thinning Stand Summaries - Both Pre and Post Treatment

-------- Number of trees in 1/10th acre monitoring plot ----------

	Area 1 - Control		Area 2 - Dia +5				Area 3 - 14x14		
	Live	Dead	Live		Dead		Live		Dead
Class	Pre		Pre	Post	Pre	Post	Pre	Post	
Area Totals									
Spruce	74		134	63			124	19	
Hemlock	3		2	2			0	0	
Live Trees	77		136	65			124	19	
BA (sq. ft.)	200		240	140			220	120	20
Alder	2			4	3		15		
Stumps*	9			7	7		5	5	
Logs	9 @ 14"dia & 20'		8 @ 19"dia & 27'				7 @ 19"dia & 20'long		
Slash	-0-				75%			50%	

Legend: G = Girdled
Slash: % of plot covered by slash.

C. Recommendations for Monitoring.

Either next year or the year after, information on slash amounts and heights should be collected. This is important from an understory perspective since it would appear that it will have the most impact on the changes in the understory. Any windthrow in the stands and effect of girdling should also be noted. We may want to consider moving the control plot to a portion of the control acre that is more similar to stand conditions in treatment blocks (a 1/10 acre that has a stocking level around 1300 trees per acre instead of 740.)

D. Recommendations for Other Stands in the Vicinity.

While searching for a suitable treatment area, the crew looked at stands along Hanning Creek. these stands are younger than those along Quadra Creek (1972 vs 1958). It is recommended that these areas be considered for thinning in 5 to 10 years after the trees have expressed dominance. Currently, the Sitka spruce ranges from 1 to 2.5 inches in diameter, is 3 to 12 feet tall, and is spaced 3 to 5 feet apart. Alder is also present in high numbers; it is 2 to 3.5 " in diameter, 15 to 20' tall and clumps are spaced 3 to 5 feet apart. Five to 8 foot tall salmonberry and devils club prevail.

VI. Consultation

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