United States
Department of
Agriculture

Forest Service

Alaska Region

April 2006

Cobble Area Aquatic Watershed Restoration Prioritization and Rehabilitation Plan

Thorne Bay Ranger District, Tongass National Forest

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Introduction and Background

This plan provides a rationale and means to prioritize the allocation of resources for the restoration of watershed in the Cobble Area. While the extraction and development of natural resources has been and continues to be important to the economies of the nearby communities of Thorne Bay and Coffman Cove, many watersheds now require some level of rehabilitation to restore ecosystem function. The 2004 Cobble Landscape Assessment recommended a series of projects designed to meet the desired future condition objectives of the Forest Plan. The Cobbler Area Aquatic Watershed Restoration Prioritization and Rehabilitation Plan (1) assesses the conditions or health of 18 watersheds within the Cobble Area, (2) identifies watersheds with high quality functioning habitat, (3) prioritizes watersheds for restoration, (4) recommends actions to accelerate the recovery of watershed patterns and processes, and (5) provides schedules and cost estimates for implementation and monitoring.

Location

The Cobble Area; located along the central eastern shoreline of Prince of Wales Island, north of Thorne Bay, Alaska; is bordered to the east by Clarence Strait; to the west by an alpine ridge separating it from drainages of the North Fork of the Thorne River; and to the north by a low pass dividing the Ratz Creek drainage from the Luck Lake drainage (Figure 1). The 18 watersheds within the Cobble Area boundary were modified from the original U.S. Geological Survey 5th field hydrologic unit code (HUC) watersheds (USDA Forest Service 2004) (Figure 2). About 94 percent of the 45,989-acre planning area is administered by the U.S. Forest Service; non-Forest Service lands are not included in this project.

Climate

The region typically receives between 90 to 150 inches of precipitation annually, mostly during the fall and winter, which typically causes high stream flows. Typical annual average high and low temperatures are 51°F and 37°F, respectively; monthly average high temperatures of 66°F usually occur in July, and a low of 27°F occurs in January (data provided by Alaska State Climate Center, University of Alaska, for Hollis, Alaska).

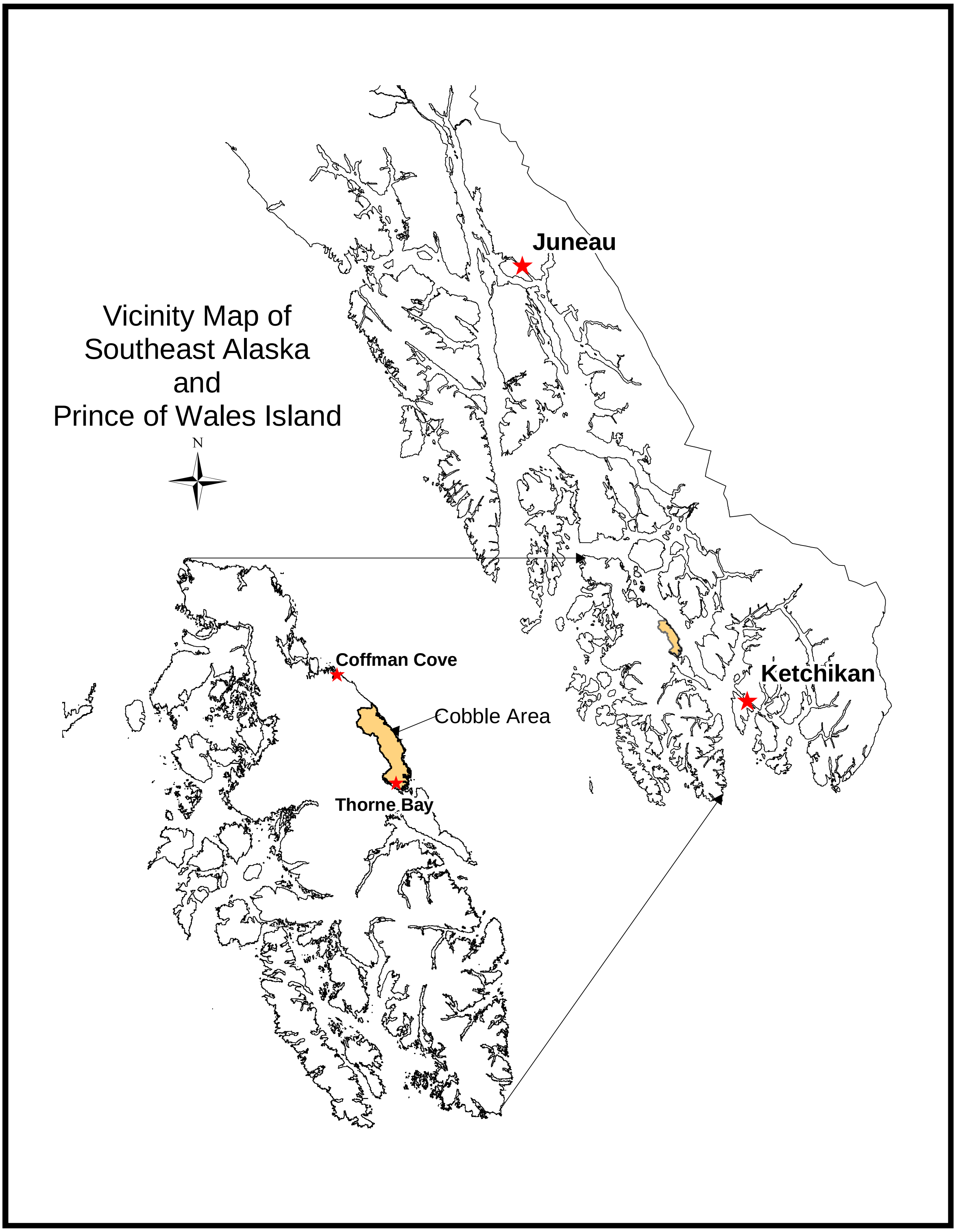

Figure 1. Location of the Cobble Area, Thorne Bay Ranger District, Tongass National Forest, Prince of Wales Island, Alaska.

Figure 2. Map of the Cobble Area Watersheds, Thorne Bay Ranger District, Tongass National Forest, Prince of Wales Island, Alaska.

Geology

The landscape of the Cobble Area is dominated by numerous small, steep dissected valleys surrounded by shallow volcanic mountains largely underlain by heavily weathered granitic bedrock. Glacial tills soils are dominant at the low elevations, while shallow less productive organic soils are dominant at the higher elevations (Nowacki et al. 2001). Glacial tills overlying granite can be found at higher elevations (Baichtal, J., 2006, personal communication). Much of the lower elevation landscape is composed of a heavily forested structure shaped by aspect, elevation, soil composition, and wind. Wetland complexes dominate the upper elevations. As a result, landslides and wind are the dominant landscape-structuring components, creating small, homogenous patches of young trees among a relatively heterogeneous forest (USDA Forest Service 2004).

Purpose and Need

Wide-scale logging operations beginning in the mid-1950s harvested much of the suitable and accessible timber volume, converting large areas of diverse forest to single-age, dense stands of second-growth spruce and alder. Fisheries habitat and watershed patterns and processes have been impaired in several watersheds due to timber harvest in riparian areas, the conversion from conifer-dominated riparian areas to red alder-dominated riparian areas, road construction over and along stream channels, unmaintained roads and culverts, and limited accessibility to fisheries spawning and rearing habitat by the improper construction and maintenance of culverts and bridges.

Subsistence, commercial, and sport fishing are vital to the culture, sustenance, and economy of Prince of Wales Island. The Cobble Area provides the communities of southeast Alaska with stocks of salmon and trout for commercial, subsistence, and recreational fishing. Tourism in the area has been increasing in recent years, mainly due to the influx of sport anglers, and a new ferry system in Coffman Cove will further increase tourism. Rehabilitation/restoration projects prioritized by this plan will accelerate recovery of watershed processes and improve sustainable fisheries use.

The aquatic environment in the Cobble Area has changed dramatically in the last 50 years. The majority of productive, fish-bearing streams in the Cobble Area are recovering from pre-1997 Tongass Land Management Plan (TLMP) forest practices that included road building on flood plains, alluvial fans, and steep unstable hillsides; timber harvest within riparian areas and flood plains; and the removal of instream large woody debris. The resultant increase in landslide activity, loss of streambank stability, inadequate maintenance and/or improper closure of roads, and installation of a fish pass, have all contributed to the alteration of historic aquatic conditions and a legacy of degraded salmonid habitat in the Cobble Area (USDA Forest Service 2004).

Although there is a lack of systematic data available on pre- and post-logging salmonid populations in Alaska, Bryant and Everest (1998) predicted that logged watersheds would be less resilient to environmental stresses than intact watersheds, and salmonid populations would therefore be more vulnerable to environmental disturbances such as decreased marine survival, drought, landslides, and flooding. They also note studies on the contribution of large trees to stream channels that have shown that stream habitat deterioration may not be apparent for decades after logging, and habitat quality is unlikely to recover for more than 100 years after logging ceases.

Most drainages in the Cobble Area contained some or all of the aquatic species observed today including cutthroat (*Oncorhynchus clarkii*) and steelhead trout (*Oncorhynchus mykiss*); Dolly Varden (*Salvelinus malma*) and coho salmon (*Oncorhynchus kisutch*); chum salmon (*Oncorhynchus keta*); pink salmon (*Oncorhynchus gorbuscha*); and sockeye salmon (*Oncorhynchus nerka*); plus sculpin (*Cottus* spp.) and threespine stickleback (*Gasterosteus aculeatus*) (Table 1). Fish populations within the planning area, specifically juvenile steelhead trout and coho salmon, have declined in recent years (USDA Forest Service 2004). Aquatic habitat conditions impacted by past management within these watersheds are believed to be reducing egg-fry survival, limiting winter and summer habitat for juvenile steelhead trout and coho salmon.

Table 1. Known fish distribution (in river miles) by watershed within the Cobble Area

Watershed	Steelhead Trout	Cutthroat Trout	Chinook Salmon	Coho Salmon	Sockeye Salmon	Chum Salmon	Pink Salmon	Dolly Varden
Barren Creek	0	0	0	0	0	0	2	5
Big Ratz Creek	15	25	0	15	15	5	15	25
Cobble Creek	0	0	0	4	0	4	4	5
Deer Creek	0	0	0	0	0	0	2	0
Doughnut Creek	0	8	0	4	0	0	4	0
Little Ratz Creek	3	8	0	3	0	3	3	8
No Name Creek	0	0	0	0	0	0	0	0
North Creek	0	0	0	2	0	2	2	6
North Sal Creek	0	0	0	0	0	0	0	0
Pin Creek	0	0	0	3	0	0	3	6
Ratz Harbor Creek	0	0	0	0	0	1	1	3
Sal Creek	6	9	0	6	6	4	6	9
Salamander Creek	0	0	0	3	0	0	3	6
Slide Creek	0	23	0	10	0	5	10	23
Thorne River	0	7	0	3	0	0	3	7
Tiny Creek	0	0	0	0	0	0	0	0
Torrent Creek	0	0	0	0	0	0	2	4

Source: ADFG GIS data and Thorne Bay Ranger District fish distribution.

Landslides

Erosion and sediment transport are natural processes that provide streams with a continual source of substrate and nutrients essential to biota. Sediment is naturally delivered to streams by a variety of mechanisms such as landslides and bank erosion. Aquatic organisms evolved to rely on a natural sediment load and regime, or quantity, quality and timing, of material transported through streams (McNeil and Ahnell 1964; Phillips et al. 1975). When streams or watersheds show evidence of disturbance (i.e., fire, logging, or road construction), excess sediment can be delivered to the stream, altering both the quantity and composition of the substrate. This shift in the sediment composition can directly and indirectly affect aquatic organisms by altering water quality, incubation, larval development, and juvenile rearing habitat.

Research from Alaska, Utah, California, Oregon, Japan, and other areas, documented that clearcutting on slopes increased the frequency of mass soil movement events (landslides, earthflows, slips, etc.). The loss of forest cover was believed to affect slope stability in two principal ways:

1) Mechanical root support due to interconnected root systems was lost after logging. Research in Alaska, for example, indicated a time lag after clearcutting before landslide activity increased and a lack of landslide correlation with rainfall intensity (Johnson et al. 2000). The authors believe this was due to the increased deterioration of root systems with time. Other studies similarly showed that with increasing age and maturity, the effectiveness of forest cover in preventing landslides increased.
2) A denuded slope was likely to reach critical soil saturation earlier than a forested slope (since no transpiration from trees can occur). Therefore, during a large storm, it was predicted that these soils would reach a critical failure condition earlier than would a forested slope.

By accelerating erosion rates, logging increased sedimentation rates of streams. In the steep and high-rainfall forests of Oregon, Washington, British Columbia, and Alaska, for example, mass movements of soil were the dominant erosional process. Many of these mass movements originated on open areas after logging, with increases in frequency ranging from 2 to 31 times (Chamberlin et al. 1991).

Sediment Generated from Roads

Roads accelerate soil erosion rates due to chronic surface erosion through rills and gullies, and mass soil movements in the form of slumps and earthflows. This may increase stream sedimentation (Kahklen 2001). In southwestern Washington for example, soil erosion rates were up to 300 times higher on forests with roads than undisturbed forest, and average sediment levels in runoff from forest roads ranged from 500 to 20,000 milligrams per liter during storm events (Gray 1970).

Sedimentation of streams can also lead to declines in spawning habitat (Meehan and Swanston 1977) and rearing habitat necessary for fish survival (Cederholm and Reid 1987). Macroinvertebrates, the primary food source of juvenile fish, may also decline when large amounts of fine sediment are present (Furniss et al. 1991).

Altered Hydrology (Stream Flow and Discharge)

Streamflow rates and volumes can also be altered by roads and timber harvest. Timber harvest may increase runoff rates through reducing both forest canopy interception of rain and snowfall, and evapotranspiration. Roads can reduce stream density by either intentionally channeling several streams though fewer culverts, or unintentionally through lack of maintenance when culverts become blocked. Soil compaction can also change infiltration rates leading to increased runoff and erosion rates (Everest et al. 2004).

Riparian Areas, Stream Channels, and Fish Habitat

Historically, the riparian areas of streams within the Cobble Area were dominated with western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), western red cedar (*Thuja plicata*), and red alder (*Alnus rubra*). Currently, many of the riparian areas are dominated by red alder and low densities of small-diameter Sitka spruce.

The quantity and species composition of floodplain and instream large woody debris (LWD) within most harvested streams have also been significantly altered compared to un-harvested streams. LWD on streams helps stabilize stream banks and channels, stores sediment, maintains side channels, dissipates stream energy and alteration of flows (Bryant 1983; Everest and Meehan 1981; Harmon et al. 1986). Log jams and LWD can alter the longitudinal profile of stream channels by creating steps and pools, can modify channel sinuosity and side channels in low gradient channels, and can create extensive secondary channels and off-channel sloughs and marshes critical to fisheries populations (Murphy and Meehan 1991; Nakamura and Swanson 1993). Woody debris also stores sediment and alters substrate composition (Smith et al. 1993), and retention of organic materials (Bilby and Likens 1980).

Logging can decrease instream LWD, and subsequently, increase sediment transport (Hedin et al. 1988). Experimental removal of LWD in southeastern Alaska increased bedload transport (Smith et al. 1995). In contrast, experimental installation of LWD trapped and reduced bedload (Wallace et al. 1995).

Increased bedload and deposition of fine sediment can acutely affect survival of salmonids. Increasing proportions of fine sediment in substrates have been associated with reduced survival of cutthroat trout (Irving and Bjornn 1984), steelhead (Tappel and Bjornn 1983), pink salmon (McNeill and Ahnell 1964), and coho salmon and steelhead fry (Phillips et al. 1975).

Woody debris has also been shown to play a key role in salmonid survival and abundance, by providing cover from predators and refuge from high flows, and acting as sinks for nutrients and other food sources (Wallace et al. 1995). Bustard and Hawthorne (1975) showed that juvenile coho and steelhead occupied microhabitats within 1 meter of in-stream LWD during winter months, and Bryant (1983) and Dolloff (1986) showed that the abundance of age 1 coho salmon and Dolly Varden declined after LWD removal from southeastern Alaska streams.

Changes to LWD and stream channels were measured in a study of four logged streams on Prince of Wales Island (Maybeso, Harris River, Indian Creek and Twelvemile Creek) (Wright and Bryant 2000). The authors found that alder dominated instream wood and adjacent riparian vegetation, and total LWD density was lower than in non-harvested streams and the majority of legacy LWD was located on abandoned channels and meanders. The authors of this study concluded that, "…as large pieces are replaced by small diameter and different species, i.e., alder, the result will be a less stable environment and greater loss of fish habitat…".

Riparian timber harvest has also been shown to alter stream temperatures, raising them in some cases, but lowering winter stream temperatures in more northern regions. Stream temperature was shown to affect the time required for salmonid eggs to develop and hatch.

Strategic Elements, Indicators and Model

The objectives of modeling are to prioritize watersheds for rehabilitation and to develop a strategic restoration plan. This model is based on the best available data derived from the Thorne Bay Ranger District and Alaska Department of Fish and Game GIS databases. The strategic elements of this watershed rehabilitation prioritization and aquatic restoration plan are based on the fisheries production potential, watershed condition, and future management within each watershed.

Fisheries Production Potential

Fisheries production potential is weighted as the most important category in the model and ranks watersheds by the number of fish species and estimated area of streams and lakes they occupy. The percentage of floodplain and palustrian stream channels within each watershed was used to weight this category because they typically provide high quality spawning and rearing habitat for fish. In addition, *fisheries richness index,* which accounts for the number of species and miles of stream they occupy, was also used to weight the category. Anadromous fish were also emphasized due to their ecological importance in supplying nutrients to the watershed, and economic and cultural benefits provided by sport, subsistence, and commercial fisheries. Watersheds are ranked from the highest estimated production potential to lowest in Table 2. The fisheries production model includes:

Fisheries Production Potential Ranking = Total Fish Habitat Area [(length of fish bearing stream × average stream channel width) + (lake area)] × (% Palustrian Stream Channels + % Flood Plain Stream Channels) × Fisheries Richness Index [(2X steelhead river miles) + cutthroat river miles + (2X Chinook river miles) + (2X coho river miles) + (2X sockeye river miles) + (2X chum river miles) + (2X pink river miles) + Dolly Varden river miles + sculpin river miles + whitefish river miles + stickleback river miles]

Table 2. Watershed fisheries production potential ranking for the Cobble Area

Rank	Watershed	Production Potential Value
1	Big Ratz Creek	25358781
2	Slide Creek	15756658
3	Sal Creek	646933
4	Pin Creek	615839
5	Little Ratz Creek	290922
6	Doughnut Creek	232552
7	Thorne River	219135
8	Deer Creek	168798
9	Salamander Creek	164193
10	North Creek	160665
11	Cobble Creek	97311
12	Torrent Creek	14784
13	Barren Creek	1064
14	Ratz Harbor Creek	441
15	No Name Creek	426
16	North Sal Creek	0
17	Tiny Creek	0

Hydrology Condition

The *hydrology condition* category ranks watersheds on the potential for altered peak and low flow discharge. Since the majority of watersheds within the Cobble Area have transient snow zones and are vulnerable to rain on snow events, timber harvest and road building can negatively affect the timing, duration, and magnitude of peak and low flow events. Increased peak flows or alteration of the timing of discharge can adversely affect stream channels, and fisheries habitat and survival. The hydrologic condition model includes:

Hydrology Condition Ranking = % of the Watershed Harvested × (road density × road-stream crossing density).

Watersheds were ranked from the lowest risk of altered hydrology to the highest in Table 3.

Table 3. Ranked risk for altered hydrology within the Cobble Area watersheds

Rank	Watershed	Hydrology Condition Value
1	Doughnut Creek	0.63
2	Thorne River	0.85
3	Pin Creek	0.88
4	Barren Creek	5.23
5	North Creek	6.52
6	Big Ratz Creek	6.55
7	Sal Creek	7.72
8	Little Ratz Creek	8.26
9	North Sal Creek	8.73
10	Cobble Creek	9.26
11	Slide Creek	9.48
12	Ratz Harbor Creek	10.90
13	Torrent Creek	11.12
14	Salamander Creek	11.96
15	No Name Creek	12.25
16	Deer Creek	13.59
17	Tiny Creek	14.88

Sediment Impacts

The *sediment impact* category ranks watersheds on the potential for landslides and road network to negatively affect water quality, stream channels, fish habitat, insect production and fish egg-to-fry survival. This category was computed with the following formula:

> *Sediment Impact Ranking* = % of Alluvial Fan Stream Channels + Road Density + Road-Stream Crossing Density + [(Area of Landslides Impacting Streams/Area of Streams) $\times$ 10] +(% of Watershed area in Landslides $\times$ 5)

Watersheds were ranked from the lowest risk of sediment impacts to the highest in Table 4.

Table 4. Ranking for potential sediment impacts to aquatic resources within the Cobble Area watersheds

Rank	Watershed	Sediment Impact Value
1	Doughnut Creek	0.4
2	Pin Creek	0.7
3	Thorne River	1.9
4	Barren Creek	23.2
5	North Creek	25.7
6	North Sal Creek	32.7
7	Tiny Creek	38.1
8	Cobble Creek	39.2
9	Sal Creek	39.5
10	Little Ratz Creek	41.8
11	Salamander Creek	42.8
12	Torrent Creek	45.9
13	Ratz Harbor Creek	46.3
14	Slide Creek	47.1
15	Deer Creek	48.3
16	No Name Creek	58.9
17	Big Ratz Creek	66.5

Riparian and Stream Channel Conditions

The *riparian and stream channel conditions* category ranks watersheds on the condition of riparian areas and the potential impacts to stream channels. The percentage of palustrian and floodplain stream channels were used to weight this category due to their sensitivity to disturbance. This category was computed with the following formula:

Riparian and Stream Channel Condition Ranking = % Riparian Area Harvested + % Palustrine Stream Channels + % Flood Plain Stream Channels

Watersheds were ranked from the best riparian conditions to the poorest in Table 5.

Table 5. Riparian and stream channel condition ranking for the Cobble Area watersheds

Rank	Watershed	Riparian Condition Values
1	North Sal Creek	2.20
2	Doughnut Creek	6.58
3	No Name Creek	14.20
4	Thorne River	14.22
5	Barren Creek	17.20
6	Pin Creek	20.98
7	Ratz Harbor Creek	21.20
8	Tiny Creek	24.20
9	North Creek	33.18
10	Big Ratz Creek	36.71
11	Sal Creek	37.72
12	Little Ratz Creek	47.91
13	Cobble Creek	51.46
14	Salamander Creek	59.88
15	Torrent Creek	62.74
16	Slide Creek	70.75
17	Deer Creek	81.70

Watershed Condition

The *watershed condition* category represents the existing watershed conditions under past and current management regimes. The higher the watershed condition value infers the potential for detectable response in resources of concern (fish populations, water quality, etc.). It is intended to rank watersheds from the lowest amount of disturbance to the highest. This category ranking was computed by adding the ranked values of the above indicators; *hydrology condition*, *sediment impacts*, and *riparian and stream channel condition* ranking. The watersheds with the lowest values have the least amount of disturbance and were, therefore, categorized as being in the best condition. Conversely, watersheds which produced the highest values are expected to be in the worst condition. Table 6 provides watersheds in order of best to worst condition.

Table 6. Watershed condition ranking for the Cobble Area

Rank	Watershed	Watershed Condition Value
1	Doughnut Creek	4
2	Pin Creek	9
3	Thorne River	10
4	Barren Creek	13
5	North Sal Creek	14
6	North Creek	19
7	No Name Creek	27
8	Tiny Creek	28
9	Sal Creek	29
10	Cobble Creek	31
11	Little Ratz Creek	32
12	Ratz Harbor Creek	33
13	Big Ratz Creek	34
14	Salamander Creek	39
15	Torrent Creek	43
16	Slide Creek	45
17	Deer Creek	49

Refuge Ranking

For this analysis *refuge* is defined as the watersheds which have the highest fish production potential, are in the best ecological condition, and have the highest percentage of non-consumptive land use designations (i.e., wilderness, old growth preserves, etc.). These watersheds are a priority for protection and any necessary restoration treatment because it would be easier, less expensive, and ultimately more successful to maintain high quality habitats than to attempt to recreate or restore degraded habitats (Beechie et al. 2003; Bilby et al. 2003; Roni et al. 2002). Such refugia are critical for the maintenance and recovery of populations because they provide reserves or source areas for recolonization and meta population maintenance. Intact watersheds of southeast Alaska such as these are critical to maintain sustainable salmon stocks. The protection of these functioning habitats is an important goal, and should work in concert with improvement actions. *Note:* However, this document focuses on identifying watershed improvement project priorities and not habitat protection actions. *Refuge ranking* was calculated with the following formula:

> [(Fisheries Production Potential Ranking) + (Watershed Condition Ranking) + (Ranked % of Watershed Precluded from Management)]

Table 7 shows watershed refuge ranking.

Table 7. Fisheries watershed refuge ranking for the Cobble Area

Rank	Watershed	Refuge Value
1	Pin Creek	8
2	Doughnut Creek	10
3	Thorne River	11
4	North Creek	20
5	Sal Creek	21
6	Big Ratz Creek	26
7	Barren Creek	28
8	Salamander Creek	28
9	Little Ratz Creek	29
10	No Name Creek	30
11	North Sal Creek	31
12	Slide Creek	32
13	Torrent Creek	33
14	Deer Creek	34
15	Cobble Creek	36
16	Tiny Creek	42
17	Ratz Harbor Creek	43

Watershed Restoration Prioritization

The *watershed restoration prioritization* category measures the degree of human impact on the watersheds with the highest fish production potential. This category is a measure of potential to affect significant change in resource conditions through restoration work. Watersheds were prioritized for restoration with the following formula:

[(2 × Fisheries Production Potential Ranking) + (Ranked % of Watershed Precluded from Management) + (Watershed Condition Ranking)]

Table 8 shows watershed restoration prioritization.

Table 8. Watershed restoration prioritization for the Cobble Area

Rank	Watershed	Prioritization Value
1	Big Ratz Creek	19
2	Slide Creek	20
3	Sal Creek	23
4	Deer Creek	25
5	Pin Creek	26
6	Salamander Creek	27
7	Little Ratz Creek	29
8	Thorne River	31
9	Doughnut Creek	32
10	Torrent Creek	33
11	North Creek	36
12	Cobble Creek	44
13	No Name Creek	48
14	Barren Creek	51
15	Ratz Harbor Creek	54
16	North Sal Creek	55
17	Tiny Creek	61

The top five watersheds ranked for restoration are Big Ratz, Slide, Sal, Deer and Pin Creek. Table 9 presents the existing watershed conditions and watershed characteristics.

Table 9. Existing watershed conditions and characteristics for Big Ratz, Slide, Sal, Deer and Pin Creek Watersheds

	Watershed				
	Big Ratz Creek	**Slide Creek**	**Sal Creek**	**Deer Creek**	**Pin Creek**
Watershed Area (Mi^2)	16	10	7	5	1.5
Total Stream Miles	57.6	37.3	35.4	21.5	8.2
Miles of Fish Bearing Stream	25.3	22.8	9	12	6.3
Miles of Anadromous Stream	15	9.6	5.7	1.9	3.1
Acres of Anadromous Lakes	322	70	0	29	37
Acres of Resident Fish Lakes	0	0	0	3	0
Flood Plain Channels (Mi)	1.7	3.3	2	0	0.8
Palustrine Channels (Mi)	1.6	1.9	0	2.7	0.1
% of Watershed Harvested	30%	57%	33%	69%	11%
% of Riparian Area Harvested	31%	57%	32%	69%	10%
Road Density (Mi/Mi^2)	1.9	3.7	2.1	3.9	0
Road/Stream Crossing Density	3.8	5.1	5	9.2	0
Acres of Landslides Impacting Streams	1239	72	165	2	1
% of Watershed in Reserves	9%	3%	26%	33%	95%

Objectives, Goals, and Proposed Projects

The goal of these rehabilitation projects is to accelerate the natural recovery of watershed processes within stream channels and riparian areas to restore and maximize production potential of stream-rearing salmonids; coho and sockeye salmon, steelhead and cutthroat trout, and Dolly Varden. Cumulative impacts from historic road building and timber harvest, before current protections were required in headwater areas and floodplains, can negatively affect watershed processes that otherwise maintain spawning and rearing habitats for salmonids. The rehabilitation approach outlined in this document addresses those specific impacts such as increased sediment load from roads and landslides, impassable culverts for fish, and riparian degradation from historic timber harvest, in the context of current riparian and channel conditions.

Quantitative objectives to meet these goals have been developed to guide rehabilitation of these watersheds and will be used in part as the basis for evaluation monitoring. The three objectives are discussed as follows.

Objective #1

Reduce risk of sedimentation to streams from undersized, wooden, or blocked culverts, or from landslides originating from roads on unstable soils or steep hillsides. Forest roads that are not maintained and are undrivable may have culverts or bridge structures in place and present a risk of chronic sedimentation to streams. Collectively, these roads can cause long lasting effects to streams by increasing fine sediment deposition in fisheries spawning areas, filling in rearing pools, funneling many streams into a single channel causing erosion and sediment deposition downstream, and increasing risk of landslides by increasing soil instability on already unstable slopes.

These objectives will be accomplished by removing at least 525 culverts along 5 miles of temporary road and up to 40 miles of USFS classified, non-drivable road to restore natural stream networks and decrease risk of sedimentation.

Big Ratz Creek

In the Ratz Creek Watershed, 13.6 miles of road are proposed to be decommissioned, and 17.7 miles of road would be rehabilitated or restored (Table 10). Over 1 mile of road has already been resurfaced, and culverts replaced to accommodate fish passage (Forest Road [FR] 3000302). An additional 9.5 miles is scheduled for decommissioning and maintenance in 2006 that will remove an estimated 268 culverts, including one log bridge over a primary Class I spawning stream.

Table 10. Road rehabilitation and fish passage restoration projects by watershed for the Cobble Area

Road Number	Length (miles)	Recommendation	Mileposts and Comments	Status
Big Ratz Watershed				
Proposed Projects				
3026000 3026100	5.2	Decommission from MP 1.4-5.9 Construct or leave trail tred	FR 3026000 and 100 Road in northern Big Ratz Watershed was built on unstable soils in the depositional zone of several landslides. This has resulted in plugged culverts and ditches, causing redirection of stream channels and erosion.	Classified and open
3023500	2.02	Rehabilitate from MP 0-3.0	The 3023500 (from MP 0-3.0) road was also built on unstable soils and the depositional zone of several landslides. This has resulted in plugged culverts and ditches, causing redirection of stream channels and erosion.	Classified and open
3023500	3	Remove crossings and decommission	18 culverts (6 plastic), 1 log bridge, 10 wooden culverts, 20 missing structures from MP 3.0-4.75. No RCS data from 3.803 to end. Multiple landslides on roads. Requires crossing Class I stream to access.	Classified and non-passable, road closed 2006-2007
3023520	1.4	Decommission Recontour stream at beginning of road	At least 7 locations eroding road, one wooden culvert blocking fish passage. Erosion potential into Class I stream is high. Culvert from 3025500 at junction is eroding intersection, creating sediment erosion and deposition immediately into Class I stream.	Classified and non-passable, road closed 2006–2007
3023521	0.5	Remove crossings and decommission	No RCS data available. Multiple wooden culverts, potentially blocking fish passage into Class I Ratz Creek. Parallels Big Ratz.	Classified and non-passable, closed 2006–2007
3023525	0.97	Remove crossings and decommission	Multiple blocked wooden culverts and filled ditches. Erosion of road into streams and nearby Big Ratz Creek. Classified road 0.7 miles, temporary road 0.27 miles.	Classified and non-passable, closed 2006–2007
3023530	2.44	Removal crossings and decommission	Road closed to traffic. Requires additional 13 drainage waterbars on both classified (1.67 mi) and temporary roads (3023530_0.90L, 0.77 mi). Might require crossing waterbars to access. Culvert at 0.294 blocking Class I stream. Beaver dam diverting water.	Classified and non-passable, closed 2006–2007
3023535	1.14	Remove crossings and decommission	Stream is eroding entire road prism. Excessive sediment production, leading to sediment deposition in Class I stream. 13 removed structures currently, 20 additional erosion areas and require waterbars.	Classified and non-passable, closed 2006–2007
Completed Projects				
3000302	1.1	Replace culverts blocking fish passage, resurface and reduce erosion	Perched culvert blocking fish passage at MP 1.01. Additional culverts partially blocking passage at MP 0.59 and 0.72. Chronic erosion into Big Lake from inadequate culverts along this road.	Classified and open, culverts replaced 2006
Slide Creek Watershed				
Proposed Projects				
3018000	2.73	Decommission from MP 8.96-9.916; Construct or leave trail tred	This road segment has been built on MMI3 soils with landslide concerns in the northern portion of Slide Creek. Several landslides present and 9 log culverts to remove.	Classified and non-passable
3018000	4.39	Decommission from MP 3.30-7.69 to improve drainage Remove up to 25 structures Replace fish crossing at MP 7.01	Several areas of surface from MP 3.30-5.42, including road damage and sediment inputs to Class II streams. Fish crossing replacement needed at MP 7.01.	Classified and non-passable section
3018200	2.5	Complete decommissioning Remove 54 crossings from MP	Bridge is removed at beginning of road (MP 2.7). Culverts at MP 3.65, 3.73, and 3.83 are plugged or missing. 49 culverts, and approximately 5 missing structures should be removed.	Classified, bridge removed

Road Number	Length (miles)	Recommendation	Mileposts and Comments	Status
		2.7-5.19 Prevent or harden initial access point at Slide Creek		
3018250, 3018255	3.3	Complete decommissioning Remove blocked fish passage culvert at MP 0.08	Blocked fish passage at MP 0.08. 63 culverts along mid-slope road to be removed also.	Classified and bridge removed
3018300	0.1	Remove crossings and decommission	Erosion and watershed damage. Closed to vehicle traffic.	Classified and non-passable
3018300_0.40L	0.24	Remove crossings and decommission	Several blocked or non-functioning wooden culverts near Class I stream.	Temporary and non-passable
3018300_0.60R	0.25	Remove crossings and decommission	Several blocked or non-functioning wooden culverts near Class I stream.	Temporary and non-passable
3018400	0.76	Remove crossings and decommission	0.535 classified, 0.222 temporary road miles. 1 known wooden culvert, 3 surface erosion. Near Class I stream, producing sediment to downstream fisheries streams.	Classified and non-passable
3018450	0.58	Remove crossings and decommission	Road parallels Class I stream, blocking drainage and adding sediment to stream. Remove approximately 4 wooden culverts, and add approximately 3 waterbars. Must cross Class I stream to access.	Classified and non-passable
3018490	0.91	Remove erosion potential from Class I and II streams, decommission	Many beaver dams over road, surface erosion, high potential for sediment to Golden Pond, or Class I streams.	Classified and non-passable
3018220+spur	2.91	Remove crossings and decommission	1.496 classified, 1.41 temporary. 5 known wooden culverts, at least 5 locations with surface erosion, at least 1 fill slope erosion. Located adjacent to Class II stream, producing sediment.	Classified/ temporary and non-passable
Completed Projects				
3018200_0.84R	0.8	Remove crossings and decommission	11 wooden culverts and missing structures to be removed.	Temporary and non-passable
Sal Creek Watershed				
Proposed Projects				
3020000	1.05	Decommission from MP 3.56-4.66	The final 1.05-mile of the 3020000-road in Sal Creek is built on MMI4 soils with past landslides. Future landslides will likely occur in this area, affecting this road.	Classified and open
3020000	NA	Replace culvert at MP 0.53 with larger, or drivable waterbar Replace red culverts with appropriate size and design	Culvert at MP 0.53 100% plugged, upstream landslide producing sediment to ditch, eroding road. Culverts not passing fish (red) at MP 0.62, 0.73, 0.74, 1.65, 1.72.	Classified and open
3020000_2.40L	0.59	Finish closure, additional crossings to be removed	At least 5 stream crossings continue to erode road, producing sediment to Class I streams, and blocking fish passage at MP 0.009, 0.104.	Temporary and non-passable
3020000_0.5L	0.5	Partly obliterate	Several fisheries streams are blocked by this temporary, abandoned road. It is non-drivable and should be removed as much as possible to restore flood plain function and fish passage.	Classified and non-passable
Completed Projects				
3020000_0.88L	1.05	Remove crossings	Temporary road parallels Class I stream. 19 wooden culverts and missing structures. Producing sediment to Class I stream, blocking fish passage at MP 0.081, 0.664, 0.716.	Temporary and non-passable, completed 2006
Deer Creek Watershed				
Proposed Projects				
3018100	2.8	Remove crossings	At least 3 wooden culverts, 16 culverts, and multiple	Classified and

Road Number	Length (miles)	Recommendation	Mileposts and Comments	Status
		and decommission	surface erosion location along road. Closed by locked gate, several wooden culverts remain and cause extensive erosion into Class II streams.	non-passable, survey and design complete for trail
3018110	2.5	Remove crossings and decommission	Very extensive surface erosion, at least 2 wooden culverts and 8 culverts in place. Many of the structures are buried by debris or beaver dams, creating excessive erosion into Class II Deer Creek drainage. Road closed by gate at 3018100. Existing waterbars begin at MP 1.58. 1.6 miles of Classified, 1 mile of Temporary road.	Classified and non-passable, survey and design complete for trail

Slide Creek

In the Slide Creek Watershed, 18.7 miles of road are proposed to be decommissioned, and 194 culverts removed, including two culverts that will restore fish passage (Table 10). The highest priority for this drainage are FRs 3018200, 3018250, and 3018255, which contain a total of 117 culverts beyond removed bridges and cannot be maintained properly. In addition, many of these culverts are within the transition area between steep headwater transport streams and lower gradient depositional streams will continue to become blocked, leading to downstream erosion and sedimentation of Slide Creek.

Sal Creek

In the Sal Creek Watershed, 4 miles of road are proposed to be decommissioned, 1 culvert replaced to reduce erosion, and 34 culverts removed (Table 10). In addition, four culverts should be replaced to restore fish passage in the Sal Creek.

Deer Creek

In the Deer Creek Watershed, 5.3 miles of road are proposed to be decommissioned and 29 culverts removed (Table 10).

Objective #2

Restore unimpeded fish passage at 48 stream crossings in the Cobble Area. Of the known stream-crossing structures that block fish migration in the Cobble Area, 22 are located in the Big Ratz, Ratz Harbor, and North Watersheds. All of these watersheds flow into Ratz Harbor, and therefore, considered for this analysis. Fourteen are located on FR 3000000, locally known as the Sandy Beach Road, which has been nominated as a Forest Service and Federal Scenic Byway. These culverts should be replaced with suitable crossings when FR 3000000 is upgraded.

In the priority watersheds, Big Ratz has an additional four culverts that block fish passage. Culverts at milepost 0.294 of FR 3023530 and milepost 0.081 of FR 3023520 are on non-drivable sections of roads and will be removed during 2006 as part of a 2006 Integrated Resource Project. The remaining culverts at mileposts 0.40 and 0.67 on FR 3023500 blocks passage to about 150 meters of Class II habitat.

Slide Creek has three documented culverts that do not pass fish. One 36-inch culvert at milepost 0.08 of on FR 3018250 limits access to 684 meters of Class II habitat due to steep gradient and a perched outlet, and should be removed when the remaining 62 culverts are removed (see Table 11). FR 3000170 contains two log culverts on high gradient streams at milepost 0.802 and 0.93 that are 50 and 90 percent blocked, respectively. These culverts limit the migration of Dolly Varden, and possibly other resident species.

FR 3018000 has several undocumented crossing structures between milepost 5.4 and 7.6, including a failing bridge that blocks fish passage to an estimated 2 miles of high quality Class I habitat. This bridge structure also continues to undermine water quality within the mainstem of Slide Creek by continually adding fine sediment from the road surface as water crests the road.

The Sal Creek Watershed has four crossings that block fish migration along FR 3020000. These crossings limit upstream migration to at least 580 meters of suitable spawning or rearing habitat. The Sal Creek Watershed has limited rearing habitat for juvenile salmonids, especially during the winter months, and restoring these crossings would benefit fish that utilize side channels and tributaries during winter, including coho salmon and steelhead trout. Steelhead use tributary streams extensively in the winter months, therefore restoring these crossings will initiate the process of restoring runs of steelhead to Sal Creek. However, FR 3020000 is recognized to be closed and maintained for all-terrain vehicle (ATV) access only, in which case these culverts should be removed and these stream crossings be designed to adequately handle ATV crossings without further damage to the streams.

The Deer Creek drainage contains eight crossings that block passage to Class II fish habitat: two are located on FR 3018000, one on FR 3018050, one on FR 3018100, two on FR 3018110, and two on FR 3000000. Not including FR 300000, these crossings limit access to over 2,800 meters of Class II habitat, including at least 10 acres of high-quality lake habitat.

Another five high priority crossings are all located on FR 3000000 within the Salamander Creek Watershed and will be upgraded in the future via the Sandy Beach Reconstruction Project (see the Sandy Beach EA 2001). Two additional crossings in the Little Ratz Watershed impede Class II fish passage near the end of FR 3023200. These crossings were removed, but continue to block fish passage due to beaver activity. Upstream habitat is steep and limited and their replacement is low priority.

Table 11. Mile post and location of culverts to be replaced or removed for fish passage restoration in the Cobble Area

Watershed	Road	Culvert Milepost
Big Ratz	3000000	38.47, 39.38, 40.78 & 40.85
Big Ratz (completed)	3000302	0.59, 0.72 & 1.01
Big Ratz	3023500	0.40, 0.67
Big Ratz (completed)	3023530	0.29 & 1.08
Ratz Harbor	3000000	33.21, 33.94, 34.47, 35.72 & 35.81
Slide	3018250	0.08
Slide	3000170	0.93, 0.802
Sal	3020000	0.62, 0.73, 1.65 & 1.77
Deer	3000000	19.6
Deer	3018050	0.39
Deer	3000140	0.27
Deer	3018000	0.27, 0.71
Deer	3018100	0.89
Deer	3018110	0.47 & 0.55
Salamander	3000000	20.41, 21.37, 21.5, 22.23, 22.34
Little Ratz	3023200	0.59 & 0.66
Torrent	3000000	17.17
North	3000000	36.56, 36.89 & 36.91
North	3025520	0.82
Cobble	3000200	0.37, 0.42, 0.45 & 2.1
Cobble	3000230	0.05
Barren	3000000	23.49, 23.5 & 24.82

Objective #3

Restore riparian vegetation to historic structure and composition in floodplain and upland areas. Sitka spruce (*Picea sitchensis*) are typically the dominant overstory species and make up approximately 30 to 80 percent of the overstory species composition in flood plain ecosystems of southeast Alaska (USFS Forest Plant Association Management Guide 1992). Western hemlock (*Tsuga heterophylla*) can comprise from 10 to 30 percent of overstory species composition, and is more prevalent in slightly elevated microsites above flooded areas. Red alder (*Alnus rubra*) can comprise up to 30 percent of the riparian overstory composition along regularly flooded or disturbed areas.

After clearcut timber harvesting in these floodplain areas, species composition can change dramatically depending on age of the harvest and yarding technique. In southeast Alaska, alder has been shown to be as high as 90 percent, and as low as 33 percent of the overstory composition, with Sitka spruce comprising as much as 62 percent, and as little as 6 percent of the composition 45 years after harvest (Deal 1997). Few studies have investigated the influence of alder on conifer regeneration in lowland floodplains after clearcut harvesting in southeast Alaska. Deal et al. (2004) found that in some sites on Prince of Wales Island , Sitka spruce trees reach the maximum alder height within 30 years after harvest. Mixed red alder-conifer stands are also more structurally complex and contain multiple canopy layers compared to pure conifer stands that regenerate after clearcut harvest, and appear to mitigate some of the negative impacts that single-aged timber harvest might have on an ecosystem (Deal et al. 2004; Wipfli et al. 2003). Conifer height and basal diameter also tend to be highly variable within these mixed alder-conifer stands, and in general, the largest conifer trees tend to be smaller and shorter in stands containing greater alder density 45 years after harvest (Deal 1997).

Many watersheds in the Cobble Area provide good examples of 40+ year old mixed red alder-conifer stands. In Sal Creek for instance, a wide lowland floodplain harvested in 1966, alder comprises between up to 90 percent of the overstory canopy. Conifer sizes are highly variable ranging from 1 to 30 meters in height, and range from 0.05 to 0.18 meters in diameter at breast height (dbh). Attempts to reduce alder density through girdling have proven largely unsuccessful, and to date, no monitoring of subsequent conifer growth has been accomplished. Various other thinning treatments have focused on reducing conifer density, alder density, or overall tree spacing, to improve conifer growth and understory condition, but only recently have these treatments incorporated other ecosystem components such as wildlife, soil and stream chemistry, or leaf litter, as proposed in the literature described earlier.

To improve conifer growth rates in these densely stocked mixed alder-conifer stands and accelerate the recovery of riparian areas, non-standard silvicultural thinning treatments and monitoring plans may be required. Treatments should target the desired future species and age class distribution to ensure an adequate supply of wood to the stream over many years. As an example, treatments along beach fringe areas may require more red alder within the stand to maximize winter-time wildlife forage, while less red alder is required along floodplain streams where wildlife forage is regularly scarce.

For 45-year-old harvested mixed-red alder-spruce stands in lowland floodplain areas with poorly drained soils (the Spruce-Alder plant association described in the 1991 Forest Plant Association Management Guide), spruce should comprise at least 50 percent of the total basal area and 35 to 45 percent of the overstory species composition. Stands should also contain a wide range of diameters for conifer species. These objectives will be accomplished by a combination of releasing existing sapling/pole-aged conifers within the riparian area. The first phase of riparian rehabilitation will be single tree release of existing conifers. Overstory canopy will be reduced to allow a minimum of 40 percent full sunlight (Chan et al.1996, 1997). Each conifer should be individually selected and the surrounding alders thinned to a spacing of at least 20 feet (Emmingham and Maas 1994; Minore and Weatherly 1994; Maas and Emmingham 1995; Chan et al. 1996; Hibbs and Giordano 1996; Newton et al. 1996; Chan et al. 1997).

Within alluvial terraces elevated slightly above the annual floodplain, Sitka spruce and hemlock stocking should be more equal, with red alder comprising much less of the total basal area. At 45 years after harvest, 30 percent of the spruce should be greater than 25 inches dbh, 50 percent should be 12 to 25 inches dbh, and 20 percent should be less than 12 inches dbh. Spruce and other conifer should comprise at least 70 percent of the species composition and greater than one-half of the total basal area. If red alder comprises greater than 30 percent of the composition or more than one-half of the total basal area, or continues to comprise the majority of the overstory canopy, then thinning around individual conifer trees might be required.

Overstory reduction will stimulate the growth of the understory (salmonberry), and therefore, each released tree will need to have brush manually cut (6 to 10 feet) around the tree annually in June or July (Emmingham et al. 2000). Understory management should continue until 30 percent of the released conifer crown exceeds the height of salmonberry (8 feet).

The Cobble Landscape Assessment recommended treatment of approximately 470 riparian acres within Slide, Big Ratz, and Sal Creek watersheds (see Table 12 and Figure 3), based on the 1997 Tongass Land Management Plan 100-foot-buffer for some streams. These estimates will likely increase by at least twofold upon field verification of each area. However, a rapid, but formal, assessment of the riparian stand composition should be done to estimate treatment types and costs (Table 13). At the time of printing, a substantial amount of this riparian area had been thinned as part of ongoing projects, with the exception of part of Sal Creek, and all of Slide Creek.

Table 12. Length of stream and area of proposed riparian thinning along Class I and II streams in the Cobble Area

Watershed	Project Area	Longitudinal Stream Length (feet)	Estimated Acreage
Big Ratz	North Ratz	7,000	64
Big Ratz	Trumpeter Lake Inlet	2,000	18
Big Ratz	Upper Big Lake	10,000	92
Big Ratz	Big Lake Alluvial Fan	2,000	18
Slide	Middle Slide	12,000	110
Slide	Lower Slide	3,000	27
Sal	Upper Sal	5,000	46
Sal	Lower Sal	10,000	92
Total		51,000	469

Table 13. Watersheds and length of Class I and II streams proposed for riparian stand condition assessments within the Cobble Area

Watershed	River Mile
Slide	0-22
Deer Creek	0-12
Pin Creek	0-6
Salamander Creek	0-6
Little Ratz Creek	0-8
Thorne River	0-7

Degraded fisheries habitat, stream structure, and function, caused by declining levels of large woody debris and increased levels of sedimentation, would be improved. Many riparian areas along anadromous and resident streams in the Cobble Area were harvested during the initiation of long-term timber contracts in the 1950s and 60s, and yarding was oftentimes facilitated by removing existing wood from within the stream itself. These areas typically held the highest, and most accessible, volumes of wood because of their frequently flooded and well-drained mineral soils and low topographic relief. They also contributed all of the woody debris critical to the maintenance of certain physical properties of these streams, which were largely responsible for producing large populations of salmon.

Since then many of these streams have undergone dramatic physical and biological changes as instream wood decays and leaves the system, and as roads and landslides add sediment to the stream. Many riparian areas still contain trees too small to protect stream banks or provide the beneficial effects of larger trees. Furthermore, it may be 50 to 100 years until streamside trees are large enough to provide those positive effects when they fall into streams.

To replace lost or decaying key LWD (that which influences channel processes and morphology) densities of logs will be increased within disturbed reaches to historic reference conditions of 190 to 335 pieces/river mile. Sal Creek, Ratz Creek, and Slide Creek have had significant portions of their riparian floodplain harvested: Stream surveys in Sal Creek and parts of Ratz Creek have shown much reduced densities of LWD, declines in pool volume and density, and spawning habitat.

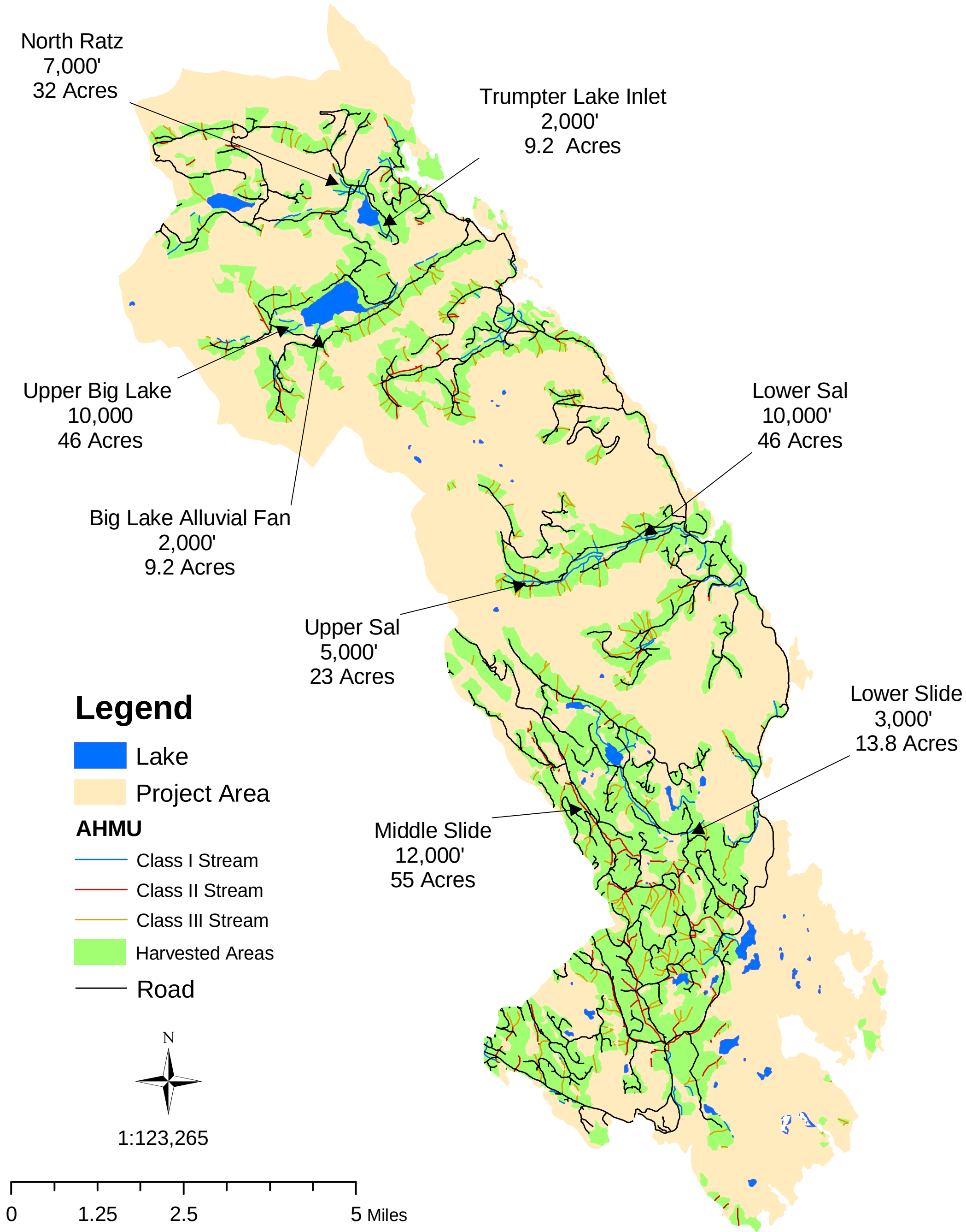

Figure 3. Proposed riparian thinning locations along Class I and II streams in the Cobble Area.

Both Sal Creek and a tributary to Big Lake in the Ratz Watershed were recently surveyed using USDA Forest Service Tier II and III methods. The floodplain of Sal Creek was harvested in 1966, and the mainstem channel now contains an average of 37 percent fewer key pieces (>30 inches in diameter, >50 feet in length) of LWD per river mile and 313 percent more pieces of smaller LWD (4 to 29 inches, >6 foot in length) per river mile than undisturbed stream channels in southeast Alaska (based on average number of pieces of LWD/mile in unharvested floodplain streams from Bryant et al. [2004]). The majority of the smaller diameter LWD is comprised of rapidly decaying red alder. In addition, 70 percent of the historic stream channel has been abandoned resulting in a significant loss of off-channel fish habitat.

Similar changes to LWD and stream channels were measured in a study of four other logged streams on Prince of Wales Island (Maybeso, Harris River, Indian Creek and Twelvemile Creek) (Wright and Bryant 2000). Alder dominated instream wood and riparian vegetation and was lower in volume than non-harvested streams. The majority of LWD remaining in the study sites was located on abandoned channels and meanders, i.e., the stream had moved away from the previous channel which is precisely what has occurred in Sal Creek. The authors of this study concluded that: "as large pieces are replaced by small diameter and different species, i.e., alder, the result will be a less stable environment and greater loss of fish habitat". The young under-stocked riparian conifers will not contribute to floodplain or in-stream LWD levels within Sal Creek for decades. In-stream and floodplain LWD within Sal Creek is dominated with red alder which decays at a much higher rate and provides less channel stability then key coniferous pieces of LWD. Therefore, channel stability, aquatic habitat, and fish production are expected to continue to decline.

Much of the watershed restoration in the Cobble Area can be accomplished through objectives 1, 2, and 3. However, to maintain channel processes and fish habitat until riparian areas recover, LWD and stream rehabilitation projects in select drainages should be initiated to (1) restore unobstructed water flow and reduce erosion from roads, (2) ensure year-round access by fish to habitat, and (3) restore riparian areas and eliminate further degradation to stream channels from future developments. Stream channel rehabilitation and LWD introductions should be site specific and strategically designed to meet the following objectives:

1) appropriately store and route sediment;
2) scour pools and provide protection and cover for juvenile fishes;
3) reduce bank erosion and reconnect floodplains during high flow;
4) reduce width/depth ratios during base flow and bankfull flows;
5) restore certain patterns and process of stream ecosystems, such as biodiversity, nutrient retention, and primary production; and
6) protect and restore early succession riparian vegetation.

Sal Creek was chosen as the highest priority for watershed rehabilitation because of its accessibility, less-complicated channel geometry and floodplain, amount and type of historic physical and biological information, and potential for successful watershed restoration.

Stream surveys, aerial photographs interpretation hydraulic analysis, fisheries habitat surveys, and biological data were used to evaluate hydraulic geometry and habitat conditions of Sal Creek. The analysis found that 70 percent of Sal Creeks historic habitat was disconnected from its historic flood plains. In addition, much of the existing LWD are remnant pieces from before harvest occurred in 1966, although 10 percent of the pieces are parallel to the stream or on gravel bars and do not directly influence channel morphology. This legacy wood probably prevented the mainstem channel from becoming wider and more braided and has maintained the existing fisheries habitat and stream processes. However, the existing key pieces will decline before riparian areas are able to replace the quantity and quality of in-stream wood, leading to further degradation of habitat and fish productivity into the foreseeable future.

A significant commitment of resources is required to replicate the historic channel and habitat conditions to fully restore fish productivity and stream processes, and large quantities of LWD would need to be strategically placed from valley wall to valley wall and along the entire length of the stream. In addition, the existing bed load within the system could complicate full channel and floodplain restoration. Currently, there are no financial resources nor commitment for an effort of this scale; however, a cooperative project has been designed to utilize the existing resources to arrest and rehabilitate degrading habitat and preserve the remaining functioning habitat. This intervention will retard further degradation, accelerate recovery by decades, and increase fish production to the maximum extent practicable.

In 2005, funds were secured to rehabilitate over 1 mile of the Sal Creek mainstem and restore water flow through 1 mile of closed logging road. Eleven individual reaches were chosen for LWD additions and riparian improvements to be completed by August 15, 2006. Eighteen additional reaches and riparian areas were also evaluated, and funding opportunities explored, for potential restoration. Project-level surveys and designs have been proposed for these reaches in 2006, and monitoring and evaluation plans will be part of each design (see the Sal Creek Watershed Rehabilitation Plan, USFS Thorne Bay Ranger District, 2006).

In the Ratz Watershed, tributaries to Big Lake serve as the critical spawning and rearing area for juvenile sockeye, kokanee, and coho salmon, and steelhead trout. The floodplain surrounding these tributaries was entirely harvested in 1960 and numerous landslides have since deposited large amounts of gravel into the mainstem stream. Six different reaches of Upper Big Ratz Creek totaling 1.0 miles were also surveyed using USDA Forest Service Tier II methods in 2003 to quantify overall in-stream physical condition. An average of 155 percent more LWD, and 60 percent less key LWD exists in the main tributary compared to similar southeast Alaska streams in Bryant et al. (2004). The survey results also reflect that the overall condition of this area has been extensively impacted by landslides through two of the larger tributaries. The quantity and the characteristics of sediment being routed into Upper Ratz Creek and Big Lake poses a chronic threat to fisheries spawning habitat, while the remnants of FRs 3023500, 530, and 535 continue to erode and deposit sediment directly into spawning channels. This system has formed large, braided, unstable depositional areas that continue to erode new channels during high flows.

Upper Big Ratz would benefit by projects outlined earlier, including riparian thinning and road removal. The addition of key LWD to this area, and design of multiple, stable, overflow channels to accommodate high flows while efficiently transporting and or storing bedload and reducing further erosion of the nearby road, would also help reduce the impacts to spawning habitat. Tier III surveys and retrospective project-level surveys are recommended for the Upper Ratz Creek system.

Additionally, USFS Tier II and Tier III stream surveys are recommended for Slide, Deer, Pin, Salamander, Little Ratz, Thorne, Doughnut, Torrent, and North Creek streams (Tables 14 and 15). These surveys will be used to evaluate stream channel and habitat conditions, fish passage, and identify out-year project reaches. These surveys will also be used to refine objectives and facilitate the development of conceptual designs by analysis of characteristics of the mainstem stream. These surveys also offer comparative information from streams that have had relatively little impact from logging or road building, specifically Pin, Salamander, and Doughnut creeks. Tables 16 and 17 present recommended projects by watershed.

Table 14. Watersheds and length of fish bearing streams proposed for Tier II and III stream surveys within the Cobble Area

Priority	Watershed	River Mile
1	Slide	0-22
2	Deer Creek	0-12
3	Pin Creek	0-6
4	Salamander Creek	0-6
5	Little Ratz Creek	0-8
6	Thorne Creek	0-7
7	Doughnut Creek	0-8
8	Torrent Creek	0-3
9	North Creek	0-6

Table 15. Reaches of stream proposed for project level surveys within the Cobble Area

Priority	Watershed	River Mile
1	Lower Sal Creek	0-22
2	Upper Sal Creek	0-12
3	Big Ratz Creek	0-8

Table 16. Proposed stream and watershed projects for the Big Ratz Creek Watershed

	Project Type	Quantity	Unit
Proposed Projects			
3026000 Road Condition Survey	Survey	14.1	Miles
Upper Ratz Rehabilitation Survey and Analysis	Survey & Analysis	2	Miles
Upper Ratz Flood Plain & Fan Rehabilitation	Flood Plain Rehabilitation	2	Miles
North Ratz & Trumpeter Lake Inlet Channel Survey and Analysis	Survey & Analysis	1	Miles
Lower Big Ratz Teir II Stream Survey	Survey	8	Miles
Completed Projects [1]			
North Ratz Riparian Rehabilitation	Riparian Rehabilitation	64	Acres
Trumpeter Lake Inlet Riparian Rehabilitation	Riparian Rehabilitation	18	Acres
Upper Big Lake Riparian Rehabilitation	Riparian Rehabilitation	92	Acres

[1] Completed projects are listed to show those projects that were implemented as funds became available since completion of this document.

Table 17. Identified watershed rehabilitation projects proposed for the Thorne Bay Ranger District

Proposed Projects	Project Type	Quantity	Item
Slide Creek Watershed			
Slide Creek Teir II Stream Survey	Survey	8	Miles
Slide Creek Teir III Stream Survey	Survey	2	Miles
Slide Creek Fish Distribution Surveys	Survey	8	Miles
Slide Creek Rehabilitation Analysis	Analysis	1	Analysis
Middle Slide Riparian Rehabilitation	Riparian Rehabilitation	110	Acres
Lower Slide Riparian Rehabilitation	Riparian Rehabilitation	27	Acres
Lower Slide Creek Stream Rehabilitation and Enhancement from river mile 1.4-2.5	Stream Restoration	1	Miles
Upper Slide Creek Stream Rehabilitation from river mile 3.7-3.9, and 4.5-5.3	Stream Restoration	1	Miles
Golden Pond Fish Population Assessment	Analysis	1	Lake
Golden Pond Restoration and Fishing Enhancement	Lake Restoration and Fishing Access	100	Acres
Sal Creek Watershed			
Sal Creek Stream Channel & Flood Plain Rehabilitation	Stream & Flood Plain Rehabilitation	5	Miles
Project Level Survey	Survey	5	Miles
Design/Contract Prep.	Design/Contract	5	Miles
Upper Sal Flood Plain Riparian Rehabilitation	Riparian Rehabilitation	46	Acres
Lower Sal Riparian Flood Plain Rehabilitation	Riparian Rehabilitation	92	Acres
Deer Creek Watershed			
Deer Creek Teir II Stream Survey	Survey	2	Miles
Deer Creek Teir III Stream Survey	Survey	1	Miles
Deer Creek Fish Distribution Survey	Survey	2	Miles
Deer Creek Rehabilitation Analysis	Analysis	1	Analysis
Deer Creek Riparian Stand Assessment	Riparian Survey	2,400	Acres
Pin Creek Watershed			
PinCreek Teir II Stream Survey	Survey	6	Miles
Pin Creek Teir III Stream Survey	Survey	2	Miles
Pin Creek Fish Distribution Surveys	Survey	6	Miles
Pin Creek Riparian Stand Assessment	Riparian Survey	1,200	Acres
Pin Creek Rehabilitation Analysis	Analysis	1	Analysis
Salamander Creek Watershed			
Salamander Creek Teir II Stream Survey	Survey	6	Miles
Salamander Creek Teir III Stream Survey	Survey	3	Miles
Salamander Creek Fish Distribution Surveys	Survey	6	Miles
Salamander Creek Riparian Stand Assessment	Riparian Survey	1,200	Acres
Salamander Creek Rehabilitation Analysis	Analysis	1	Analysis
Little Ratz Creek Watershed			
Little Ratz Creek Teir II Stream Survey	Survey	8	Miles

Proposed Projects	Project Type	Quantity	Item
Little Ratz Creek Teir III Stream Survey	Survey	2	Miles
Little Ratz Fish Distribution Surveys	Survey	8	Miles
Little Ratz Creek Riparian Stand Assessment	Riparian Survey	1,600	Acres
Little Ratz Creek Rehabilitation Analysis	Analysis	1	Analysis
Little Ratz Creek Rehabilitation	Stream Rehabilitation	2	Miles
Little Ratz Estuary Survey and Rehabilitation	Estuary Rehabilitation	10	Acres
Thorne Creek Watershed			
Thorne Creek Teir II Stream Survey	Survey	7	Miles
Thorne Creek Teir III Stream Survey	Survey	3	Miles
Thorne Creek Fish Distribution Survey	Survey	7	Miles
Thorne Creek Riparian Stand Assessment	Riparian Survey	1,450	Acres
Thorne Creek Rehabilitation Analysis	Analysis	1	Analysis
Doughnut Creek Watershed			
Doughnut Creek Teir II Stream Survey	Survey	8	Miles
Doughnut Creek Teir III Stream Survey	Survey	4	Miles
Doughnut Creek Fish Distribution Survey	Survey	8	Miles
Torrent Creek Watershed			
Torrent Creek Teir II Stream Survey	Survey	4	Miles
Torrent Creek Teir III Stream Survey	Survey	2	Miles
Torrent Creek Fish Distribution Survey	Survey	4	Miles
North Creek Watershed			
North Creek Teir II Stream Survey	Survey	6	Miles
North Creek Teir III Stream Survey	Survey	2	Miles
North Creek Fish Distribution Survey	Survey	6	Miles
Cobble Creek Watershed			
Cobble Creek Teir II Stream Survey	Survey	5	Miles
Cobble Creek Teir III Stream Survey	Survey	2	Miles
Cobble Creek Fish Distribution Survey	Survey	5	Miles
Barren Creek Watershed			
Barren Creek Teir II Stream Survey	Survey	5	Miles
Barren Creek Teir III Stream Survey	Survey	2	Miles
Barren Creek Fish Distribution Survey	Survey	5	Miles
Ratz Harbor Creek Watershed			
Ratz Harbor Teir II Stream Survey	Survey	3	Miles
Ratz Harbor Teir III Stream Survey	Survey	1	Miles
Ratz Harbor Fish Distribution Survey	Survey	3	Miles

Project Prioritization and Cost Estimates

Project prioritization, sequencing and implementation logistics are critical to efficient and cost effective watershed restoration. Rehabilitation of roads and up-slope conditions are the highest priority projects for watershed rehabilitation within the Cobble Area. However, it is imperative that road decommissioning and road storage projects be coordinated with other restoration actions that may require access into an area.

Cost estimates developed for this analysis are intended to assist in efficient and timely allocations of limited and competitive resources for watershed restoration; however, they must be refined after project planning has been initiated and as material or labor costs change. Cost estimates were generated from the average cost of similar completed or contracted projects on Prince of Wales Island, Washington, and Oregon, between 1992 and 2005, and the National Marine Fisheries Service Cost Estimation Guide (2001). Project cost estimates generated from Washington and Oregon were adjusted by 4 percent per year plus a 20 percent cost of operation increase for Alaska.

Table 18 provides the prioritized project sequence, cost estimates, and yearly implementation schedule for the Cobble Area. Table 19 lists rehabilitation projects proposed for 2010.

Table 18. Prioritized 2006–2009 rehabilitation projects and cost estimates for the Cobble Area

Proposed Projects	Project Type	Quantity	Unit	Price/Unit	Cost
2006 Projects					
All Watersheds					
Sandy Beach (FR 3000000 MP 17.17-40.85) culvert prioritization, design, and permitting	Design/Contract Preparation	27	Culvert	$5,000	$135,000
Sal Creek Watershed					
Lower Sal Riparian Rehabilitation	Riparian Rehabilitation	92	Acres	$400	$36,800
Middle Sal Creek Stream/Riparian Rehabilitation	Channel & Flood Plain Rehabilitation	1.2	River miles	$80,000	$96,000
Upper & Lower Sal Stream Channel/Floodplain Survey & Analysis	Survey & Design	4.5	River miles	$7,170	$32,265
Lower Sal Creek Channel and Flood Plain Rehabilitation Design/Contract Prep.	Channel & Flood Plain Rehabilitation Design	3.1	River miles	$6,780	$21,018
Upper Sal Creek Riparian and Channel Rehabilitation Design and Contract Preparation	Channel & Flood Plain Rehabilitation Design	0.6	River miles	$6,780	$4,068
Big Ratz Watershed					
Upper Ratz Rehabilitation Topographic Survey and Analysis	Survey & Design	2	River miles	$18,810	$37,620
North Ratz & Trumpeter Lake Inlet Survey & Analysis	Survey & Design	1	River miles	$7,170	$7,170
Upper Ratz Road and Hydrologic Rehabilitation Survey and Contract Prep	Design/Contract Preparation	13.67	miles	$1,371	$18,742
3023500/520/521/525/530/535 Road and Hydrologic Rehabilitation	Road Rehabilitation	13.67	miles	$5,000	$68,350
Upper Big Lake Riparian Rehabilitation	Riparian Rehabilitation	55	Acres	$400	$22,000
North Ratz Riparian Rehabilitation	Riparian Rehabilitation	64	Acres	$400	$25,600
Trumpeter Lake Inlet Riparian Rehabilitation	Riparian Rehabilitation	18	Acres	$400	$7,200
Slide Creek Watershed					
Slide Creek Teir II Stream Survey	Stream Survey	8	River miles	$1,372	$10,976
Slide Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Slide Creek Fish Distribution Surveys	Fisheries Survey	8	River miles	$1,372	$10,976
Slide Creek Rehabilitation Analysis	Data Analysis	22	River miles	$104	$2,288
Slide Creek Riparian Restoration Contract Preparation	Design/Contract Preparation	170	Acres	$2	$340
Lower Slide Riparian Rehabilitation	Riparian Rehabilitation	27	Acres	$400	$10,800
Middle Slide Riparian Rehabilitation	Riparian Rehabilitation	110	Acres	$400	$44,000

Proposed Projects	Project Type	Quantity	Unit	Price/Unit	Cost
Deer Creek Watershed					
Deer Creek Teir II Stream Survey	Stream Survey	2	River miles	$1,372	$2,744
Deer Creek Teir III Stream Survey	Stream Survey	1	River miles	$2,744	$2,744
Pin Creek Watershed					
Pin Creek Teir II Stream Survey	Stream Survey	6	River miles	$1,372	$8,232
Pin Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Sal Creek Watershed					
Lower Sal Channel Rehabilitation	Channel & Flood Plain Rehabilitation	3.1	River miles	$80,000	$248,000
				Total	**$863,909**
2007 Projects					
Slide Creek Watershed					
Slide Creek Road and Hydrologic Restoration Design and Contract Preparation	Design/Contract Preparation	13.3	Road miles	$1,371	$18,234
Big Ratz Watershed					
Upper Ratz Flood Plain and Channel Design and Contract Preparation	Channel & Flood Plain Rehabilitation Design	2	River miles	$6,780	$13,560
Lower Big Ratz Teir II Stream Survey	Stream Survey	8	River miles	$1,372	$10,976
Sal Creek Watershed					
3020000 Fish Passage Restoration Design and Contract Preparation	Design/Contract Preparation	4	Culvert	$15,000	$60,000
3020000 Road Rehabilitation Design and Contract Preparation	Design/Contract Preparation	1.05	Road miles	$1,371	$1,440
Upper Sal Channel Rehabilitation	Channel & Flood Plain Rehabilitation	0.6	River miles	$80,000	$48,000
Upper Sal Riparian Rehabilitation	Riparian Rehabilitation	46	Acres	$400	$18,400
Deer Creek Watershed					
Deer Creek Watershed Road Rehabilitation Design and Contract Preparation	Design/Contract Preparation	5.9	Road miles	$1,371	$8,089
Big Ratz Watershed					
3026000/100 Road Condition Survey	Road Condition Survey	5.2	Road miles	$721	$3,749
Slide Creek Watershed					
Upper and Lower Slide Creek In-Stream Restoration Design and Contract Preparation	Channel & Flood Plain Rehabilitation Design	1	River miles	$6,780	$6,780
Deer Creek Watershed					
Deer Creek Fish Distribution Survey	Fisheries Survey	2	River miles	$1,372	$2,744

Proposed Projects	Project Type	Quantity	Unit	Price/Unit	Cost
Deer Creek Riparian Stand Assessment	Riparian Assesment	2,400	Acres	$2	$5,472
Deer Creek Rehabilitation Analysis	Data Analysis	10	River miles	$104	$1,040
Pin Creek Watershed					
Pin Creek Fish Distribution Surveys	Fisheries Survey	6	River miles	$1,372	$8,232
Pin Creek Riparian Stand Assessment	Riparian Assesment	1,200	Acres	$2	$2,736
Pin Creek Rehabilitation Analysis	Data Analysis	5	River miles	$104	$520
Salamander Creek Watershed					
Salamander Creek Teir II Stream Survey	Stream Survey	6	River miles	$1,372	$8,232
Salamander Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Salamander Creek Fish Distribution Surveys	Fisheries Survey	3	River miles	$1,372	$4,116
Salamander Creek Riparian Stand Assessment	Riparian Assesment	1,200	Acres	$2	$2,736
Salamander Creek Rehabilitation Analysis	Data Analysis	3	River miles	$104	$312
Barren Creek Watershed					
Barren Creek Teir II Stream Survey	Stream Survey	5	River miles	$1,372	$6,860
Barren Creek Teir III Stream Survey	Stream Survey	2	River Miles	$2,744	$5,488
Barren Creek Fish Distribution Survey	Fisheries Survey	5	River miles	$1,372	$6,860
Ratz Harbor Watershed					
Ratz Harbor Teir II Stream Survey	Stream Survey	3	River miles	$1,372	$4,116
Ratz Harbor Teir III Stream Survey	Stream Survey	1	River miles	$2,744	$2,744
Ratz Harbor Fish Distribution Survey	Fisheries Survey	3	River miles	$104	$312
				Total	**$257,236**
2008 Projects					
All Watersheds					
Sandy Beach (FR 3000000, MP 17.17-40.85) Fish Passage Restoration	Fish Passage Restoration	27	Culvert	$30,000	$810,000
Sal Creek Watershed					
3020000 Road and Hydrologic Rehabilitation from MP 3.56 to 4.66	Road Rehabilitation	1.05	Road miles	$5,000	$5,250
3020000-0.62-1.77 Fish Passage Restoration	Fish Passage Restoration	4	Culvert	$30,000	$120,000
Big Ratz Watershed					
Upper Ratz Fan & Flood Plain Rehabilitation	Channel & Flood Plain Rehabilitation	2	River miles	$80,000	$160,000
Slide Creek Watershed					

Proposed Projects	Project Type	Quantity	Unit	Price/Unit	Cost
3018200, 250, 255, 300, 400, 450, and 490, Road and Hydrologic Rehabilitation	Road Rehabilitation	13.3	Road miles	$5,000	$66,500
3018000 Road and Hydrologic Restoration and Golden Pond Access Analysis	Road Rehabilitation	7.2	Road miles	$5,000	$36,000
Golden Pond Recreation and Fish Population Analysis	Recreational Fishing Analysis	10	Acres	$1,372	$13,720
Big Ratz Watershed					
3026000/100 Road Rehabilitation Design and Contract Preparation	Design/Contract Preparation	5.2	Road miles	$1,371	$7,129
3026000/100 Road Storage and Decommissioning	Road Rehabilitation	5.2	Road miles	$5,000	$26,000
Slide Creek Watershed					
3000170 Culvert Removal for Fish Passage Restoration (MP 0.802 & 0.93)	Fish Passage Restoration	2	Culvert	$5,000	$10,000
Upper Slide Channel Rehabilitation and Enhancement	Channel & Flood Plain Rehabilitation	1	River miles	$80,000	$80,000
Little Ratz Watershed					
Little Ratz Creek Teir II Stream Survey	Stream Survey	8	River miles	$1,372	$10,976
Little Ratz Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Little Ratz Fish Distribution Surveys	Fisheries Survey	8	River miles	$1,372	$10,976
Little Ratz Creek Riparian Stand Assessment	Riparian Assessment	1,600	Acres	$2	$3,648
Little Ratz Creek Rehabilitation Analysis	Data Analysis	3	River miles	$104	$312
Thorne Creek Watershed					
Thorne Creek Teir II Stream Survey	Stream Survey	7	River miles	$1,372	$9,604
Thorne Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Thorne Creek Fish Distribution Survey	Fisheries Survey	7	River miles	$1,372	$9,604
Thorne Creek Riparian Stand Assessment	Riparian Assessment	1,450	Acres	$2	$3,306
Thorne Creek Rehabilitation Analysis	Data Analysis	3	River miles	$104	$312
Doughnut Creek Watershed					
Doughnut Creek Teir II Stream Survey	Stream Survey	8	River miles	$1,372	$10,976
Doughnut Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Doughnut Creek Fish Distribution Survey	Fisheries Survey	8	River miles	$1,372	$10,976
				Total	**$1,421,753**
2009 Projects					
Slide Creek Watershed					
3018000 Road and Hydrologic Rehabilitation	Road Rehabilitation	7.2	Road miles	$5,000	$36,000

Proposed Projects	Project Type	Quantity	Unit	Price/Unit	Cost
Lower Slide Channel Rehabilitation and Enhancement	Channel & Flood Plain Rehabilitation	1	River miles	$80,000	$80,000
Deer Creek Watershed					
3018050-0.39 Fish Passage Restoration	Fish Passage Restoration	1	Culvert	$30,000	$30,000
3018000 Fish Passage Restoration MP 0.27 & 0.71	Fish Passage Restoration	2	Culvert	$30,000	$60,000
3000140-0.27 Fish Passage Restoration	Fish Passage Restoration	1	Culvert	$30,000	$30,000
3018100-0.89 Fish Passage Restoration	Fish Passage Restoration	1	Culvert	$30,000	$30,000
3018110-0.47, 0.55 Fish Passage Restoration	Fish Passage Restoration	2	Culvert	$30,000	$60,000
Little Ratz Watershed					
3023200-0.59 & 0.66 Fish Passage Restoration	Fish Passage Restoration	2	Culvert	$30,000	$60,000
Torrent Creek Watershed					
Torrent Creek Teir II Stream Survey	Stream Survey	4	River miles	$1,372	$5,488
Torrent Creek Teir III Stream Survey	Stream Survey	1	River miles	$2,744	$2,744
Torrent Creek Fish Distribution Survey	Fisheries Survey	4	River miles	$1,372	$5,488
North Creek Watershed					
North Creek Teir II Stream Survey	Stream Survey	6	River miles	$1,372	$8,232
North Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
North Creek Fish Distribution Survey	Fisheries Survey	6	River miles	$1,372	$8,232
Cobble Creek Waterhsed					
Cobble Creek Teir II Stream Survey	Stream Survey	5	River miles	$1,372	$6,860
Cobble Creek Teir III Stream Survey	Stream Survey	2	River miles	$2,744	$5,488
Cobble Creek Fish Distribution Survey	Fisheries Survey	5	River miles	$1,372	$6,860
				Total	**$440,880**

Table 19. Proposed 2010 rehabilitation projects for the Cobble Area

Proposed Projects	Project Type	Quantity	Unit	Price/Unit	Cost
North Watershed					
3025520-0.82	Fish Passage Restoration	1	Culvert	$30,000	$30,000
Cobble Creek Watershed					
3000200-0.37,0.42, 0.45 & 2.1	Fish Passage Restoration	4	Culvert	$30,000	$120,000
3000230-0.05	Fish Passage Restoration	1	Culvert	$30,000	$30,000
				Total	**$180,000**

Monitoring, Evaluation, and Assessment

Evaluation and monitoring of restoration projects is essential to improving and documenting changes in biological productivity, technical designs, and cost effectiveness of projects; and should be considered an “up-front” expense when planning restoration projects (Bryant 1995; Frissell and Ralph 1998). However, the cost of monitoring is usually the first to be removed from project budgets when funding is limited or highly competitive (Ralph and Poole 2003). Additionally, when monitoring is incorporated into project plans, the perceived “success” of many restoration projects is often ambiguous due to insufficient monitoring designs or data collection (House 1996; Frissell and Ralph 1998). While evaluating ecological restoration often requires additional funds, a well-planned, scientifically-defensible monitoring strategy should be a necessary component of any ecological restoration program (see Roni [2005]).

Recently, monitoring ecological restoration has been the subject of increasing study and scrutiny as restoration science attempts to incorporate landscape-scale processes and patterns. Several evaluation methods have recently been discussed in the literature and many may afford adequate data collection with minimal budgetary requirements (see Roni et al. [2005] for discussions). After a project’s goals and objectives have been established, a monitoring strategy designed for the appropriate temporal and spatial scales should be developed (Kershner 1997; Roni et al. 2005; Frissell and Ralph 1998). While only a few designs truly detect change in both time and space, a well-planned, peer-reviewed strategy has the advantage of adding scientific and public credibility to meeting project objectives.

To monitor and evaluate watershed restoration in the Cobble Area, the ideals of two existing models were incorporated to develop a long-term monitoring strategy. The first developed by Bryant (1995), called a “pulsed method”, varies monitoring intensity (what is measured) and frequency (how often it is measured) to maximize efficiency and cost benefits. Briefly, this method utilizes “…a series of short term (3-5 years), high intensity studies, separated by longer periods (10-15 years) of low-density date collection…” to ensure a reasonable degree of success.

The other, developed by Walters (1988), called the “staircase” method, addresses watershed restoration in a larger context and requires the sequential treatment of several reaches or watersheds over time, with untreated reaches or watersheds serving as controls until their subsequent treatment (Figure 4). This design has the advantage of replicating treatments in time and space, especially in watersheds not connected by a single stream, and is designed to overcome climatic or other confounding factors because of its ability to study multiple sites over several years (see Roni et al. [2005] for further discussion). Obviously this method involves a long term commitment, but has the advantage of collecting data as projects are completed and comparing them to yet-to-be-treated sites over the course of the program. The Cobble Area fits the criteria of the staircase method well since none of its streams are connected and each watershed is proposed for sequential treatments through the year 2010.

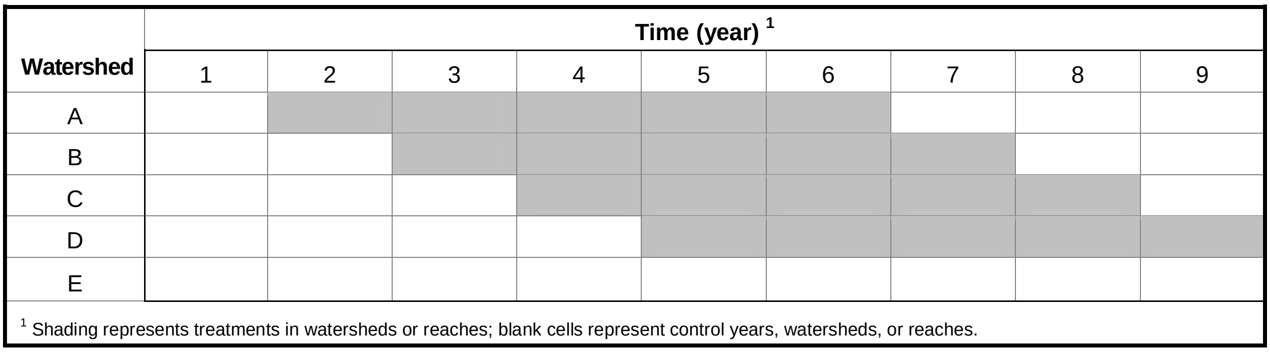

Figure 4. Example of a modified staircase design for watershed restoration projects (from Walters et al.1988).

Watershed restoration projects also involve the expertise of many disciplines, and may include experts in fisheries, wildlife, silviculture, hydrology, geomorphology, and structural engineering, all of which should be represented in a monitoring strategy. Since a successful monitoring program is a function of duration and intensity, input from some or all may be required at different monitoring times. For instance, to gather data on the effects of restoration on fish populations, fisheries biologists may be required initially and for several years thereafter, whereas fish passage restoration projects might require initial data collection and analysis by an engineer to ensure that passage designs were effectively constructed. These projects may also require the expertise of a hydrologist to ensure that certain properties of water flow and sediment transport are included into an engineers design, and that the design is meets the biologists requirements for habitat. All three specialists may then be required at some later date to ensure the design met their objectives and to determine if design improvements are warranted.

To monitor the restoration projects in the Cobble Area, two forms of monitoring were incorporated into this broad pulsed-staircase context: referred to as “routine” and “effectiveness” monitoring (Koning et al. 1998). These forms of monitoring have separate goals and objectives and can occur simultaneously, but typically for different lengths of time.

Routine monitoring is a low intensity, subjective assessment and occurs over several years to determine how a specific project or design is functioning. It begins prior to project initiation to collect background data, and should continue at regular intervals for several years thereafter. This form of monitoring can include annual photo-monitoring from a benchmark, rapid measurements of microhabitat parameters such as pool depth, or measuring forest understory biodiversity. The goals of this form of monitoring are to document trends or changes in specific structures or processes over time, identify reasons for success or failure, and provide recommendations to assist with future projects.

Project effectiveness monitoring is higher intensity and is performed for a longer duration, at greater time intervals, on a subset of projects or sites. This type of monitoring is adaptive and focuses on a select set of abiotic (i.e., longitudinal stream surveys, LWD density) and biotic (i.e., fisheries population, riparian vegetation composition and density) parameters for each project type. For example, an in-stream habitat improvement project might monitor smolt production for 2 to 3 years using a juvenile screw trap and inexpensive methods such as a depletion survey, then continue every 3 to 5 years thereafter using only the depletion survey method. At the same time, a riparian thinning project might establish long-term monitoring plots and collect forest data both before and immediately after, then re-measure the same plots every 5 to 10 years thereafter. In this form of monitoring, a before-after-control-impact (BACI) method is useful in order to compare restored sites to unrestored, and pre-completion to post-completion.

Fish Population Monitoring

Fisheries populations are a valuable commodity to commercial and sport anglers, but have ecological benefits for wildlife populations, riparian vegetation growth and species diversity, primary production and nutrient availability in streams, and even juvenile salmonid growth. Stream and watershed restoration projects are increasing throughout the Pacific Northwest and Alaska, attempting to improve declining salmonid populations in impaired watersheds. The response of fish populations to these projects has regional benefits to all of southeast Alaska, as more watershed restoration programs are initiated on Federal, State, and private lands. Long-term fisheries population data is one way to determine the success of rehabilitation projects within the Cobble Area, and these methods have shown promise in other regions of the northern Pacific coast (Keeley and Walters 1994).

We propose to establish a link between smolt production and habitat restoration by estimating annual smolt production, parr and fry density, mortality rate of juvenile steelhead and coho from fry-to-smolt, and instream habitat characteristics. Smolt output has been used as a key measure of fish species response to habitat rehabilitation (Keeley and Walters 1994), and instream wood placement has been shown to increase juvenile coho production (Roni and Quinn 2001). Measuring both smolt production and parr density may also provide an estimate of parr-to-smolt survival when measured for multiple years. In addition, smolt and parr data collected simultaneously via these two methods can be used to estimate smolt production in the future by measuring parr density and establishing a statistical relationship through a regression analyses.

A long-term fisheries monitoring effort should be established on Sal, Ratz, Slide, Pin, and Salamander Creeks. These watersheds provide a continuum of restoration treatments, from most treated (Sal Creek) to least treated (Slide Creek), so responses can be evaluated in terms of overall amount of treatment. Sal Creek will receive the largest monetary commitment for in-stream and riparian rehabilitation, and erosion and sediment reduction projects. Ratz Creek will receive a moderate amount of instream habitat restoration, with additional road decommissioning and fish passage and riparian improvements. The Ratz drainage also contains a diversity of anadromous and resident fish species, has extensive existing habitat data, and has a significant investment in a fish pass. Slide Creek will receive more road decommissioning for sediment and hydrologic rehabilitation than the other watersheds, but will receive the least instream habitat improvement and a moderate amount of riparian restoration. Pin and Salamander Creeks serve as control watersheds because they are relatively undisturbed and contain a diversity of fish species and aquatic habitats.

To quantify smolt production, a smolt trap or weir should be installed at the mouth of Sal Creek in 2007 following the initial in-stream rehabilitation in 2006, then continue after in-stream work is complete for at least 1 year in 2009. In Slide Creek, the same should be done beginning 1 year prior to treatment, and continue for at least 1 year following treatment. Parr and fry density also should be estimated using traditional depletion or mark-recapture methods and adult steelhead and coho escapement should be estimated by snorkel or other visual method during the same time. Coho and sockeye salmon and steelhead trout should be the focus of the monitoring efforts due to their extended freshwater life history phases and their perceived declines in recent years. Finally, steelhead and coho redd surveys should be done to estimate fry production using standard egg-to-fry survival rates from the literature. By estimating production and survival at all life stages we will be able to determine if a bottleneck occurs at one life stage and limits population capacity (i.e., if many redds are present in one year and few fry are found in the next year, overwinter survival at that life stage might be low due to predation, poor habitat, or climatic factors). Additionally, Dolly Varden and cutthroat trout monitoring should be included in at least the snorkel surveys efforts to determine if treatments have an effect on those species, and if their density might affect salmon and steelhead populations through competitive interactions or predation.

Stream Monitoring

Evaluating fisheries habitat and the stream channel should be done at various intensities for different periods of time. Any changes would be determined by routine annual monitoring or after any major storm flow event. Determining any positive or negative effects of such changes on meeting overall project objectives would require more intensive project effectiveness monitoring, which would be done less frequently and on fewer treatments.

Establishing permanent photopoints and collecting basic stream channel, habitat, substrate, and LWD data within the treated reaches will complete the annual routine monitoring. Photographs will be taken at each permanent cross-section, and photos will be assigned a unique identifier and logged in a sequential, organized manner. Photos will include taking high quality photos from the stream center upstream and downstream and toward each bank, from each bank toward the opposite bank and upstream and downstream along the bank.

The deepest point of each pool and the pool tail crest formed by each designed LWD structure will be measured at each treated site and given specific identifying codes for future comparison.

Channel cross-section measurements will be taken at permanent locations within each treated reach and will be surveyed with the longitudinal profile discussed below. At each cross section, the elevation and distance from a permanent pin for the top of each bank, bottom of each bank, bankfull, water edge, and thalweg will be noted. Evaluation of each LWD structure will follow Koning et al. (1998), and will include biological and physical performance, structural condition, structural stability, and maintenance recommendations.

Finally, stream substrate will be measured within a reach that will extend 50 meters upstream and 50 meters downstream of each permanent cross section. One hundred random numbers will be generated and rounded up to the nearest 10 to represent a percentage across the stream from the downstream right bank. At each 1 meter increment along the 100 meter sample reach, a stone will be randomly chosen by first placing a stick or measuring stick into the substrate and picking the first stone touched by the stick. The stone will then be removed from the water and measured along its b-axis to the nearest millimeter.

Project effectiveness monitoring will occur on a subset of treatment sites with the specific objective of determining if a particular type of action met its objectives. To determine if changes to stream channels or fisheries habitat actually met their a priori objectives, a few reaches within Sal Creek, Slide Creek, and Ratz Creek should be measured using USDA Region 10 Aquatic Habitat Tier III protocols. These methods are detailed enough to quantify changes in LWD as well as the stream channel. In years where Tier III measurements are taken, all routine measurements can be taken concurrently. For instance, the Tier III method for quantifying pool size and density can be substituted for the routine pool monitoring since they are the same, as long as the unique pool identification is recorded. Tier III surveys should be measured every 2 to 3 years in a subset of treated reaches, with beginning and end permanently benchmarked at each site.

In addition, a longitudinal survey of the treatment reach should be measured at regular intervals, and should include surveying each permanent cross section. In this case, each cross section can be measured simultaneously with the longitudinal survey. The longitudinal survey should occur every 3 to 5 years.

Water quality monitoring consists of leaf retention, nutrient availability, macroinvertebrates, and temperature. Leaf retention is a measure of transport rates for leaves that serve as a substrate for bacterial and fungal growth and used by higher trophic organisms. Leaf retention can be measured by depositing a known amount of leaves, or leaf surrogates, at a point in the stream and measuring their transport distance over some known time, or by passively measuring drifting leaves using drift nets. Nitrogen and phosphorus should be taken four times per year, once during each season, by taking a grab sample of water and sending it to an appropriate processing facility. Macroinvertebrates should be measured semi-annually for density and diversity, as a measure of lower trophic level response. These can be measured passively using drift nets. Samples should be sent to an appropriate processing facility for analysis. Finally, in-situ water temperature should be measured hourly with remote temperature data loggers.

Water Volume and discharge

Water volume and flow will be measured regularly using automated discharge meters or crest meters to evaluate how structures are affected by high flows and to determine what flows the structures are subjected to. Flow meters will be placed toward the furthest downstream point in the stream, and should be placed in the midway between treatment sites in the case of Sal and Slide Creeks.

Riparian Vegetation

Within riparian areas, monitoring should follow the protocols established by the U.S. Forest Service and modified by the Tongass National Forest (Krosse, P., personal communication; modified by Prussian, A., 2005). Adequately sized control areas should be established to provide comparisons of treated versus untreated vegetation. Briefly, these protocols should include establishing permanent plot centers and measuring overstory, understory, herb, and forb species density, cover, and tree diameter and height. Ideally, trees will be tagged with a unique number to track growth through time after treatment. Plots should be of adequate size to encompass the riparian vegetation, yet not be too large to be unmanageable (the largest plot ring is typically 1/8th of an acre, the smallest ring being 1/100th of an acre).

Fish Passage

Monitoring and evaluating fish passage should include three forms of monitoring: (1) implementation monitoring (Was the project design constructed correctly?), (2) long term design monitoring (Did the site maintain its design for its predetermined life span?), and (3) effectiveness monitoring (Does it meet passage requirements and objectives for that site?).

Implementation and long-term design monitoring will require the expertise of hydrologists and engineers to determine if the prescribed design was adequately constructed and if the design was maintained for some predetermined period of time. For instance, if a crossing was designed to sustain repeated 50-year flow events and maintain its functionality for at least 20 years, then monitoring should occur at regular intervals, perhaps every 3 to 5 years, or after large storm events.

Effectiveness monitoring should occur at longer intervals and should include an assessment of fish passage at various times of the year (i.e., are fish able to pass during both summer and fall flows). This form of monitoring should be done less routinely than implementation and design monitoring, but should occur when changes in the functionality of the site are found. The goals of these monitoring types should be to recognize changes in the functionality of the site, choose an appropriate course of action (replace the site if it no longer works or leave it alone), and provide feedback for future design programs by understanding why a particular design may have either failed or been successful.

Erosion and Sedimentation

Evaluating and quantifying erosion rate, sediment yield, and sediment delivery is inherently difficult and many methods have been proposed and adopted by watershed restoration projects, each with their own advantages and disadvantages. The goal of this part of the watershed restoration program is to reduce the risk from both chronic and potentially chronic sediment sources mainly from forest roads and hillside streams. Reducing these risks can be accomplished by removing crossing structures that no long pass water; removing or replacing crossing structures at risk of not passing water in the future; or reducing sedimentation from hillside streams that may have increased rates of erosion caused by LWD removal or decay through logging, or inadequate crossing structures that funnel many streams into a single channel.

Monitoring Schedule

As discussed earlier, monitoring stream and watershed restoration projects is often a neglected and underfunded part restoration programs (Bash and Ryan 2002; Ralph and Poole 2003; Frissell and Ralph 1998). As an example, the Bonneville Environmental Foundation recently undertook a study to examine whether their conventional 1 to 2 year watershed restoration grants promoted accountable and scientific watershed-scale restoration in the Pacific Northwest

(Reeve et al. 2006). As a result, they found that these funding programs promoted site-specific monitoring that limited the effectiveness of watershed recovery efforts, and have since begun to implement more long-term funding.

The goal of this monitoring schedule is to follow the modified staircase design presented by Walters et al. (1988), where treated units are monitored for some period of time and then discontinued, while another treatment unit is monitored the following year for some period of time then discontinued, followed by a third treatment unit, and so on (see Figure 4).

The monitoring schedule presented here is multidisciplinary, designed to maximize understanding of watershed patterns and processes in response to restoration efforts at minimal cost and time (Appendix B). For instance, in 2006, 28 different parameters are proposed to be measured. They include juvenile fisheries populations surveys of Sal and Pin Creeks, and adult snorkel and redd surveys of Sal, Ratz, and Salamander Creeks. Juvenile population surveys at three to four reaches per stream require about 2 days each for a crew of four; adult surveys should be limited to 3 to 4 days per year for both steelhead and coho (8 days total), and include at least three people; and redd surveys can generally be done at the same time as the snorkel surveys.

Also in 2006, a suite of stream measurements that include photos at permanent locations, measurement of erosion pins, and automated discharge measurements should be taken in Sal and Pin Creeks, all of which should take about a day. A USDA Region 10 Tier III survey (project effectiveness-level) should also be done at at least three 100 to 300 meter reaches, including treatment areas, of Sal and Pin Creeks; about 3 days time for a crew of two (three Tier III reaches were established on Sal Creek in 2004). A longitudinal survey should also be done on Pin Creek for stream channel comparisons between systems (2 days for a crew of two). Finally, nutrient availability in the form of nitrogen and phosphorus, leaf retention and macroinvertebrate density and diversity should be measured, and temperature data loggers should be present at three locations (lower, middle, and upper reaches) in Sal and Pin Creeks (1 day). Riparian monitoring would occur on a subset of sites prior to treatment, as well as on control sites. In summary, 15 to 20 days are required to fulfill this monitoring plan with a crew of two to four in 2006 for approximately $64,750, nearly all of which is personnel time.

In 2007, fish population surveys would occur again on Sal, Ratz, and Salamander Creeks, along with a smolt trap on Sal Creek, and adult and redd surveys on Sal, Ratz, Slide, and Pin Creeks. The full suite of routine stream monitoring would then occur on Sal Creek, while the Tier III survey would occur on Ratz and Salamander Creeks. Post implementation water quality sampling would occur on Sal Creek while pre-implementation water quality sampling occurs on Ratz Creek, as well as on the control sites in Pin and Salamander Creeks. Pretreatment riparian monitoring would occur on a separate subset of sites that were not monitored in 2006. The total cost of this monitoring is $111,500, most of which comes from personnel costs to run a smolt weir.

Finally, this schedule is proposed to continue through 2017, though monitoring tapers off steadily after 2014. Costs include personnel time, materials, as well as analysis and reporting time. Though the goals of this restoration program incorporate many characteristics of each watershed, this program focuses on fisheries, stream, and water quality, and does not include measures of sedimentation, primary production, or other potentially significant factors resulting from restoration treatments. Many parameters were dropped because of cost, difficulty in acquiring accurate results, or relevance to the program. For instance, measuring sedimentation and transport might be useful in determining if removing culverts reduced erosion and sedimentation. However, methods to estimate erosion from roads and culverts are often inaccurate, and processing samples is time-consuming and requires specialized equipment. The parameters listed in Appendix B were determined to have the greatest relevance to this restoration program and provide the most accurate data and require the least time and money to determine if these treatments result in both local and watershed scale restoration.

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Appendix A

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Appendix B. Monitoring

Table B1. Pre-treatment (**) and Post-treatment (*) Monitoring in the Cobble Area

Monitoring Type	Year												
	Costs	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Fish Population Surveys													
Smolt survey	$25,000												
Sal			**		*								
Slide					**		*						
Population surveys	$5,000												
Sal		**	**	*	*	*	*	*	*	*			
Ratz			**	**	*		*		*				
Slide				**	*	*	*	*		*			
Pin		**		**		**		**		**			
Salamander			**		**		**		**		**		
Adult redd surveys and snorkeling	$6,000												
Sal		**	**	*	*	*	*						
Ratz		**	**	**	*	*	*	*					
Slide			**	**	**	*	*	*	*				
Pin			**		**		**		**				
Salamander		**		**		**		**					
Cost of fish population surveys		$28,000	$64,000	$44,000	$94,000	$39,000	$69,000	$33,000	$27,000	$15,000	$5,000	$0	$0
Stream Monitoring													
Sal Creek													
Routine	$1,000												
pool survey			*		*		*						
LWD survey			*		*		*						
channel transects			*		*		*						
substrate			*		*		*						
photopoints		**	*	*	*	*	*						
discharge		**	*	*	*	*	*						
streambank erosion		**	*	*	*	*	*						
Project effectiveness													
Tier III	$1,500	**		*		*		*					
Longitudinal Survey	$1,000			*			*			*			
Water Quality	$1,000												
Leaf retention (annually)		**		*		*		*		*			
Nitrogen (seasonally)		**	*	*	*		*		*		*		

Monitoring Type	Year												
	Costs	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Phosphorus (seasonally)		**	*	*	*		*		*		*		
Macroinvertebrates (annually)			*		*		*		*		*		
Temperature (hourly)		**	*	*	*	*	*	*	*	*	*	*	
Ratz Creek													
Routine	$1,000												
pool survey				*		*		*					
LWD survey				*		*		*					
channel transects				*		*		*					
substrate				*		*		*					
photopoints			**	*	*	*	*	*	*				
discharge			**	*	*	*	*	*	*				
streambank erosion			**	*	*	*	*	*	*				
Project effectiveness													
Tier III	$1,500		**		*		*		*		*		
Longitudinal Survey	$1,000				*			*			*		
Water Quality	$1,000												
Leaf retention			**		*		*		*		*		
Nitrogen			**	*	*	*		*		*		*	
Phosphorus			**	*	*	*		*		*		*	
Macroinvertebrates				*		*		*		*		*	
Temperature			**	*	*	*	*	*	*	*	*	*	*
Slide Creek													
Routine	$1,000												
pool survey					*		*		*		*		
LWD survey					*		*		*		*		
channel transects					*		*		*		*		
substrate					*		*		*		*		
photopoints				**	*	*	*	*	*	*	*		
discharge				**	*	*		*		*			
streambank erosion				**	*	*		*		*			
Project effectiveness													
Tier III	$1,500			**			*			*			
Longitudinal Survey	$1,000			**		*			*				
Water Quality	$1,000												
Leaf retention				**		*		*		*		*	
Nitrogen				**	*	*	*		*		*		*

Monitoring Type	**Year**												
	Costs	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Phosphorus				**	*	*	*		*		*		*
Macroinvertebrates					*		*		*		*		*
Temperature				**	*	*	*	*	*	*	*	*	*
Pin Creek													
Routine	$1,000												
pool survey				**		**				**			
LWD survey				**		**				**			
channel transects				**		**				**			
substrate				**		**				**			
photopoints		**		**		**		**		**			
discharge		**		**		**		**		**			
streambank erosion		**		**		**		**		**			
Project effectiveness													
Tier III	$1,500	**			**			**			**		
Longitudinal Survey	$1,000	**											
Water Quality	$1,000												
Leaf retention		**		**		**		**		**			
Nitrogen		**	**	**	**		**		**		**		
Phosphorus		**	**	**	**		**		**		**		
Macroinvertebrates			**		**		**		**		**		
Temperature		**	**	**	**	**	**	**	**	**	**	**	
Salamander Creek													
Routine	$1,000												
pool survey					**		**				**		
LWD survey					**		**				**		
channel transects					**		**				**		
substrate			**		**		**		**		**		
photopoints			**		**		**		**		**		
discharge			**		**		**		**		**		
streambank erosion			**		**		**		**		**		
Project effectiveness													
Tier III	$1,500		**			**			**			**	
Longitudinal Survey	$1,000		**										
Water Quality	$1,000												
Leaf retention			**		**		**		**		**		
Nitrogen			**	**	**	**		**		**		**	
Phosphorus			**	**	**	**		**		**		**	

Monitoring Type	Costs	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
						Year							
Macroinvertebrates				**		**		**		**		**	
Temperature			**	**	**	**	**	**	**	**	**	**	**
Cost of Stream Monitoring		$18,000	$32,500	$45,000	$49,000	$38,500	$42,000	$32,000	$30,500	$26,500	$33,000	$12,000	$6,000
Riparian Monitoring	$3,750												
Sal (Control)		**				**				**			
Sal (Upper)			**				*				*		
Sal (Lower)		**				*				*			
Ratz (Control)			**				**				**		
Ratz (Upper Big Lake)		**				*				*			
Ratz (Trumpeter Lake Inlet)		**				*				*			
Slide (Control)				**				**				**	
Slide (Upper)			**			*				*			
Slide (Lower)			**	*		*				*			
Pin		**					**					**	
Cost of Riparian Monitoring		$18,750	$15,000	$7,500	$0	$22,500	$11,250	$3,750	$0	$22,500	$7,500	$7,500	$0
Fish Passage Monitoring	At least every third year following implementation												
Analysis and Reporting	$2,500	*	*	*	*	*	*	*	*	*	*	*	*
Cost of Analysis and Reporting		$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500
Total Cost of Monitoring Projects		$64,750	$111,500	$96,500	$143,000	$100,000	$122,250	$68,750	$57,500	$64,000	$45,500	$19,500	$6,000