Duffield Peninsula:

Duffield Creek & Adams Creek Watersheds

HYDROLOGIC CONDITION ASSESSMENT
&
WATERSHED RESTORATION PLAN

USDA FOREST SERVICE
TONGASS NATIONAL FOREST
SITKA RANGER DISTRICT

September 29, 2006

Introduction

The Sitka Ranger District initiated this Duffield Peninsula Watershed Restoration Plan to collect, summarize and analyze both existing and new data in order to describe the existing condition of this watershed. This information will also be used to compare existing conditions to the desired future condition (DFC), as outlined in the Tongass Forest Plan (USDA Forest Service 1997), and to provide a detailed management strategy to accelerate movement toward DFCs. Restoration activities will incorporate the biodiversity, landscape, ecological/ geological characterization, forest vegetation, old-growth diversity, wildlife habitat, riparian and aquatic habitat, and human use of the area. The information is organized and summarized to provide guidance for project planners and the public.

The Duffield Peninsula Hydrologic Condition Assessment and Watershed Restoration Plan were designed to be a tool to help managers improve watershed and stream channel conditions. The HCA-WRP process serves to:

- Identify major watershed concerns and issues
- Summarize existing watershed and channel conditions and relevant physical/biologic processes contributing to the conditions
- Set measurable goals and objectives for watershed and channel condition improvement
- Summarize existing watershed restoration projects/efforts and their effectiveness
- Recommend management actions to improve watershed/channel condition

I. Executive Summary

Duffield Creek watershed (HUC 190102031003) and Adams Creek watershed (HUC 190102031005) are located on Duffield Peninsula on the northern end of Baranof Island. The peninsula is defined by Peril Strait on the north and west, Rodman Bay on the east, and Adams Creek watershed to the south. The Duffield Creek watershed is made up of 10,655 acres, while the Adams Creek watershed is 5,021 acres. The Duffield Peninsula Analysis Area is located about 29 air miles north of Sitka, 27 air miles west of Angoon, 17 air miles south of Tenakee, and 40 air miles south of Hoonah. Figure 1 shows the location of the Analysis Area. The Analysis Area is administered by the Sitka Ranger District of the Tongass National Forest.

Historically it was used primarily for subsistence purposes prior to European settlement. The majority of both Duffield and Adams watersheds are managed for Timber Management and Old Growth Land Use Designation as directed by the Tongass Forest Plan (1997). See Figure 2 for spatial locations.

Over 2300 acres of clearcut timber harvest and 17 miles associated road construction occurred within the Analysis Area under management by the USDA Forest Service between 1961 and 1965 (see figures for locations). Many of the stream channel types in the Analysis Area are sensitive to disturbances and are dependant on large woody debris for proper functioning. Fisheries habitat and aquatic ecosystem function has been impaired along the watershed due to riparian harvest and the conversion from conifer-dominated riparian areas to red alder-dominated riparian areas. Roads in riparian management areas (RMAs) or stream crossing structures such as log stringer bridges and culverts have modified stream flow regimes, diverted water from natural stream courses, and routed sediment to streams.

Clearcut harvest converted conifer-dominated old growth habitat to red alder-dominated forest or young growth conifer stands. These stands contain an understory component of conifers but these trees continue to be shaded by red alder overstory, slowing growth of conifers and reducing vegetation on the forest floor. Harvest activities and stand conversion also reduced wildlife habitat quantity, quality and connectivity in the Analysis Area for Management Indicator Species (MIS) such as Sitka black-tailed deer, marten and goshawk which were identified in the Tongass Forest Plan (USDA Forest Service 1997) as dependant on old growth habitat.

A project is currently underway to remove log culverts and stringer bridges in the Duffield watershed using explosives. Some riparian thinning activities have been implemented in the Duffield and Adams watersheds. Additional thinning (commercial or non-commercial) to reduce red alder dominated stands and thinning of conifers in some areas would improve growth rates of conifers to accelerate stand succession toward old growth characteristics, promote growth of shrubs and other understory vegetation providing better habitat for wildlife, supply future sources of large wood (LW) for stream channels and accelerate stand succession. Placement of LW in some stream channels would improve aquatic habitat, increasing the quality and quantity of fish habitat and benefiting local fish populations. Additional riparian and stream surveys are planned for site specific recommendations and National Environmental Policy Act (NEPA) documentation.

II. Condition Assessment and Problem Description

Watershed Assessment Area Description

The Analysis Area is located in the northwest corner of Baranof Island in Southeast Alaska (Figure 1). Baranof Island is the third largest island in the Alexander Archipelago. Although most analysis is confined to the two named watersheds, linkages to the rest of the island are recognized, particularly with respect to wildlife issues.

This Analysis Area covers approximately 15,676 acres and contains two 6th field hydrologic unit code (HUC) watersheds within the Northwest Baranof 5th field HUC watershed. The Duffield peninsula in which the these two watersheds reside is defined by Peril Straits on the north, Deadman's Reach on the west and Rodman bay to the east. It is located about 29 air miles north of Sitka, 27 air miles west of Angoon, and 17 air miles south of Tenakee Springs (Figure 1). The Analysis Area is administered by the Sitka Ranger District of the Tongass National Forest.

Land Use Designation

Land Use Designations are categorized into two broad categories: development and non-development LUDs. Development LUDs are those that "permit commercial timber harvest (Timber Production, Modified Landscape, and Scenic Viewshed) and convert some of the old-growth forest to early-to-mid-successional, regulated forests" (USDA FS 1997, p. 7-9). Non-development LUDs are "land use designations that do not permit commercial timber harvest and generally maintain the integrity of the existing old-growth ecosystem" (USDA FS 1997, p. 7-25).

The Analysis Area contains land allocated to one each of the development and non-development LUDs (Table 1 and Figure 2).

Table 1. Land Use Designations within the Analysis Area.

LUD	Development Status	Acres[1]	Percent of Assessment Area
Timber Production	Intensive Development	12,188	78
Old-growth Habitat	Mostly Natural	3,388	22

Source: Sitka Ranger District 2006 GIS Coverage.
[1] Acres do not equal total Analysis Area acreage due to portions of the watershed boundaries falling within saltwater.

The goals of each of these two LUDs present in the Analysis Area are located in Appendix A. Chapter 3 of the Forest Plan contains a detailed description of each land use designation (USDA FS 1997).

Table 2 lists the five Value Comparison Units (VCUs) located within the Analysis Area. VCUs are parcels of land that generally encompass a drainage basin or watershed containing one or more large stream systems. VCU boundaries usually follow easily recognizable watershed divides. These units delineate areas for resource inventory and interpretation. For the purpose of this analysis, VCUs were not uses and are referenced only for future landscape level assessments purposes; all analyses were based instead on watershed area. VCUs in the Assessment Area are delineated in Figure 2.

Land ownership within the Assessment Area is not complex, with the entire Area in federal ownership and managed by the USDA Forest Service.

Table 2. VCUs within the Analysis Area.

VCU Number	VCU Name
2880	Range Creek
2890	Nixon Shoal
2900	Cozian Reef
2910	**Peschani Point**
2920	**Rodman Bay**

Source: Sitka Ranger District 2006 GIS Coverage.
Note: **Bold** text indicates the major VCUs of the Analysis Area. Others have only portions of slivers of Analysis Area lands within their boundaries.

Figure 1. Duffield and Adams Watersheds—Vicinity Map

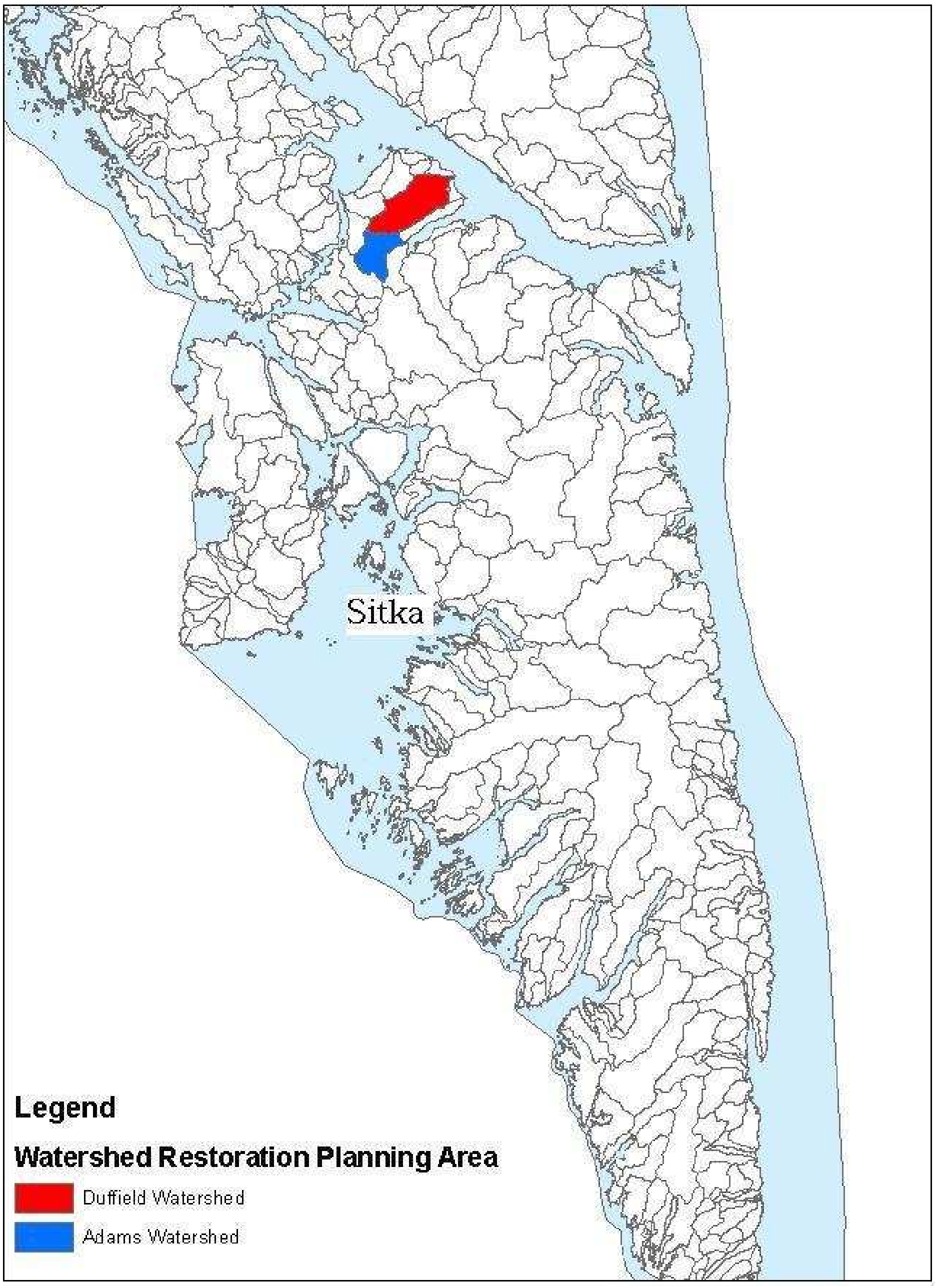
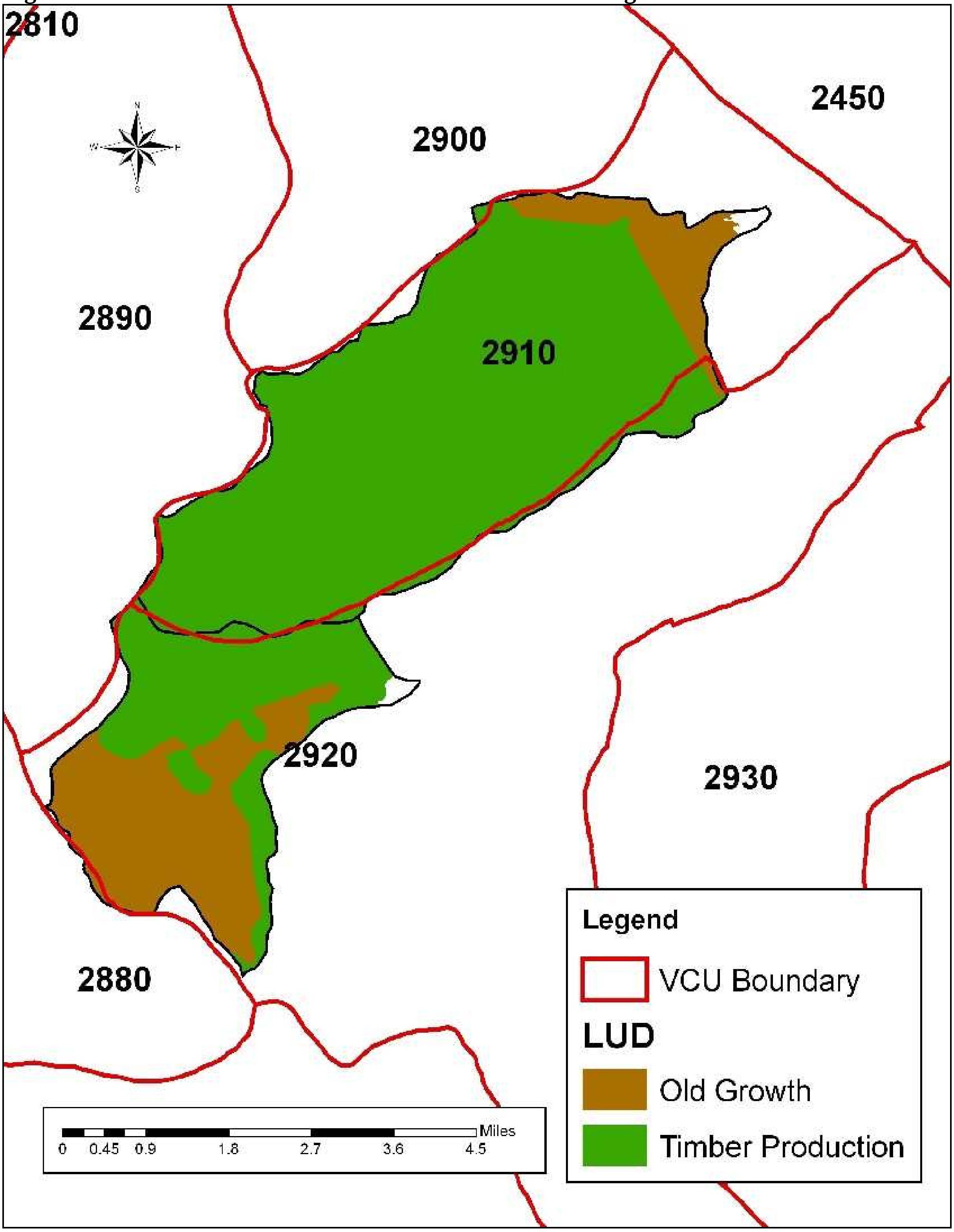


Figure 2. Duffield and Adams Watersheds – Land Use Designation and VCUs.



Climate

The Analysis Area has a maritime climate that has affected the physical and biological characteristics and the human uses of the area. Temperatures are moderated by the Alaska Current, which circulates counterclockwise up the coast (Johnson and Hartman 1969). The climate is predominantly cloudy, cool, and wet throughout the year. Precipitation occurs throughout the year, with typically June being the driest month and October the wettest. The actual climate data within the various Analysis Area watersheds is likely to be much colder and wetter at higher elevations and further from saltwater.

The nearest climatic station is at Tenakee Springs (Latitude 57°47', Longitude 135°12') 17 miles north of the Analysis Area (Table 3). Data from this station indicates only 28 °F (15.5°C) difference between the mean average temperatures of the warmest and coldest months. The climate is predominantly cloudy, cool, and wet throughout the year. The normal storm track aims frequent "Gulf Lows" at Southeast Alaska (Curtis 1993). Short-term measurements in the Kadashan River watershed indicate that it receives approximately 66 in. (1670 mm) of precipitation a year (Stednick 1981). A climate station on the outer coast of Chichagof Island receives 113 in. (2870 mm) of precipitation, while Angoon on the west coast of Admiralty Island receives an average of 39 in. (991 mm) of precipitation (Farr and Hard 1987). All of these measuring stations are very close to saltwater and are less than 50 ft. (15 m) in elevation. Precipitation at higher elevations further inland varies considerably (Farr and Hard 1987).

Table 3. Climatology Information for Tenakee Springs, Alaska: 1941-1951.

Weather Extreme	Metric	English
Mean annual temperature	5.7 °C	42.3 °F
Mean temp. May-Sept.	11.7 °C	53.1 °F
Mean temp. June-Aug.	12.9 °C	55.3 °F
Mean temp. warmest month (Aug)	13.5 °C	56.3 °F
Mean temp. Nov.-Feb.	-0.6 °C	30.8 °F
Mean temp. coldest month (January)	-3 °C	28.6 °F
Mean number of days of frost	210	210
Mean frost-free period (days)	146	146
Mean number of months with mean monthly temp. greater than 10 °C (50 °F)	4	4
Mean number of months with mean monthly temp. below 0 °C (32 °F)	3	3
Mean total precipitation	1605 mm	63.2 in.
Driest month: June Mean total ppt. June	64 mm	2.5 in.
Wettest month: October Mean total ppt. October	286 mm	11.3 in.
Mean number of days with measurable ppt.	152	152
Mean annual potential evapotranspiration (Thornthwaite method) Patric and Black 1968	533 mm	21.0 in.

Source: Farr and Hard 1987.

Wind

Wind data for the Analysis Area is not available; however two stations to the north and south do have partial data. Hoonah is located 40 miles north of the Analysis Area on the eastern shore of Fredrick Sound. The Sitka Airport is located 29 miles south-southeast of the Analysis Area along the eastern shore of Sitka Sound. Both Stations have mountains and/or hillslopes within a short distance to their east. Mean daily annual wind speeds average roughly six to eight mph, with annual prevailing wind directions from the east southeast in Sitka (Table 4). December is the windiest month in Sitka, with average wind speeds of 10.2 mph. January is the windiest month in Hoonah, with average wind speeds of 7.2 mph (Table 4).

Table 4. Mean Wind Speed (mph) and Prevailing Direction, 1996-2002

LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
HOONAH	7.2	6.5	6.8	5.4	5.8	4.9	4.3	4.5	4.8	5.3	5.9	6	5.6
SITKA Airport	9.8	8.8	8.5	7.8	7.5	6.3	6	6.3	7.1	9.3	9.4	10.2	8.1
SITKA Airport	ESE	ESE	ESE	ESE	ESE	SW	SW	ESE	E	ESE	ESE	E	ESE

Source: http://climate.gi.alaska.edu/Climate/Wind/mean_wind.html

Note: Prevailing wind is the direction of highest percent frequency. Stations may have close secondary maximum owing to noticeable differences from month to month.

Ecological Classification

The Assessment Area is comprised of only one ecological subsection according to Nowacki and others (2001). Ecological subsections, which help to define the ecosystems of Southeast Alaska, are based upon physiography, lithology, and surficial geology due to their interactions in processing water.

The ecological subsection in the Assessment Area is labeled as the North Baranof Complex and is described as:

> This northern portion of Baranof Island facing Peril Strait consists primarily of low-grade metamorphic rocks such as greenschist, greenstone, and phyllites. Although steep and rugged, the area is considerably lower and less precipitous than the Central Baranof Metasediments to its south. It has a few permanent snowfields, but lacks glaciers and icefields. Glacial till deposits are more abundant here than within any other subsection on Baranof Island. Hemlock-spruce forests cover a large portion of this subsection from shorelines to mid-slope positions. Stunted "*krummholz*" forests change to open subalpine and alpine communities with increasing elevation. Brushy landslide and avalanche chutes frequently dissect mountain slopes. Wetlands, predominantly forested, cover about 25 percent of the area. The mixed alpine and coastal forest habitats support brown bear, Sitka black-tailed deer, mountain goat (introduced), marten (introduced), common shrew, Keen's mouse, and tundra vole (Nowacki and others 2001, p. 102).

Geology / Soils

Tectonics and bedrock geology have shaped this region of the State. Southeast Alaska is composed of several bands of rock called terranes which originated far from North America in the Pacific Ocean (Brew 1990). Each band is composed of different materials and measures hundreds of kilometers long by tens of kilometers wide. These bands or terranes, separated by faults, have moved both vertically and horizontally. The primary terrane of the region is the Wrangellia (a thin piece of northern Baranof Island and inland along the west coast of Chichagof Island) (Brew 1990).

The topography of this part of Baranof Island is the result of folding and faulting of thick sequences of sediments and the upwelling of magma which formed granite when it cooled.

Soils on mountain and hill slopes are formed of decomposed bedrock and colluvial material (deposited by gravity). Bedrock soils are generally shallow, while colluvial soils are deeper and better drained. In addition, soils formed of glacial till occur in patches plastered along mountain and hill slopes to elevations of about 1,000 feet. In the valley bottoms, soils have formed of river deposits, colluvial material, and marine sediments.

The cool, wet climate in the Assessment Area causes organic matter to decompose slowly, creating soils characterized by organic surface layers. Where drainage is restricted by topography or an impermeable layer, such as bedrock or glacial till, peatlands composed of organic matter are common. In coarse alluvium (gravels and cobbles) the soils are well drained and support forests. Where the alluvium is finer and restricts drainage, nonforested vegetation communities such as fens and bogs form. Tree root depth is shallow, primarily in the nutrient-rich organic layers and the first few inches of the mineral layers. Typically the root zone is moist, acidic, and contains most of the nutrients available for plant growth (Heilman and Gass 1972).

Soil Stability

Swanston (1969) counted more than 3,800 landslides, which occurred in the last 150 years in Southeast Alaska. Most slides occur on steep slopes and when heavy rainfall has saturated the soil. In addition, wind associated with these storms can blow down trees, which may help trigger slope failure.

Landslides typically begin on open slopes and are a mixture of rock, soil, and vegetation. Swanston and Marion (1991), in their study of landslides within Southeast Alaska, observed that only about 3 percent of all landslides reached fish streams. No in-depth landslide inventory was completed for this analysis, however existing gis inventories indicate there are 7 mapped landslides within the two watersheds; six in Duffield and one in Adams (Figures 3 & 4). Only one of the slides occurred within a managed stand (Duffield). Aerial reconnaissance in 2006, observed that there were no recent landslide in the Duffield or Adams Creek watersheds.

Soil type also influences landslide occurrence. The soils in the Assessment Area are mapped and described in the Chatham Area Integrated Resource Inventory (USDA 1986). In order to describe their relative instability, soils are grouped into mass movement hazard categories: MMHAZ 1 (low hazard), MMHAZ 2 (moderate hazard), MMHAZ 3 (high hazard), and MMHAZ 4 (extreme hazard). These categories are based on a number of factors that influence landslides, including slope, landform, parent material, and drainage. Twenty-eight percent of the total Assessment Area is rated as either MMHAZ 3 or 4.

Figures 3 and 4 shows the distribution of MMHAZ 3 and 4 soils and management activities within them throughout the Analysis Area. Table 5 lists the Analysis Area watersheds with MMHAZ 3 and 4 soils and the extent of management activities that has occurred in them. The Adams watersheds has the highest percentage of high hazard soils of the two watersheds, however this percentage is relatively low compared to other watersheds within Sitka Ranger District which are considered high risk to have the potential to produce and transport sediment to streams. Although these watersheds have a moderate to low overall percentages (27 & 32 %) of their acreage in MM-HAZ soils, neither has had substantial overall harvest within these soils. Harvest acreages of these soils however, are sizable and any harvest of these areas has the potential to contribute sediment and debris to stream channels. To date there has been no documented soil instabilities as a result of management impacts on these soil types.

Table 5. High Hazard Soils within the Analysis Area.

Watershed	Total Watershed Area (acres)	Total MM-HAZ 3&4 (acres)	MM-HAZ 3&4 within Previous Harvest (acres)	MM-Haz 3&4 within RMA[1] (acres)	MM-Haz 3&4 RMA Harvested (acres)	Percent of Total Watershed in MM-Haz 3&4	Percent of Total MM-Haz 3&4 Harvested	Percent of Total RMA[1] in MM-Haz 3&4
Duffield	10,655	2,843	218	199	14	26.7	7.7	9.7
Adams	5,021	1,580	176	86	9	31.5	11.1	12..5
Total	**15,676**	**4,423**	**394**	**285**	**23**	**28.2**	**8.9**	**10.4**

Source: 2006 Sitka Ranger District GIS Coverage

[1] RMA refers to a Riparian Management Area.

Figure 3. High Hazard Soils within the Duffield Watershed

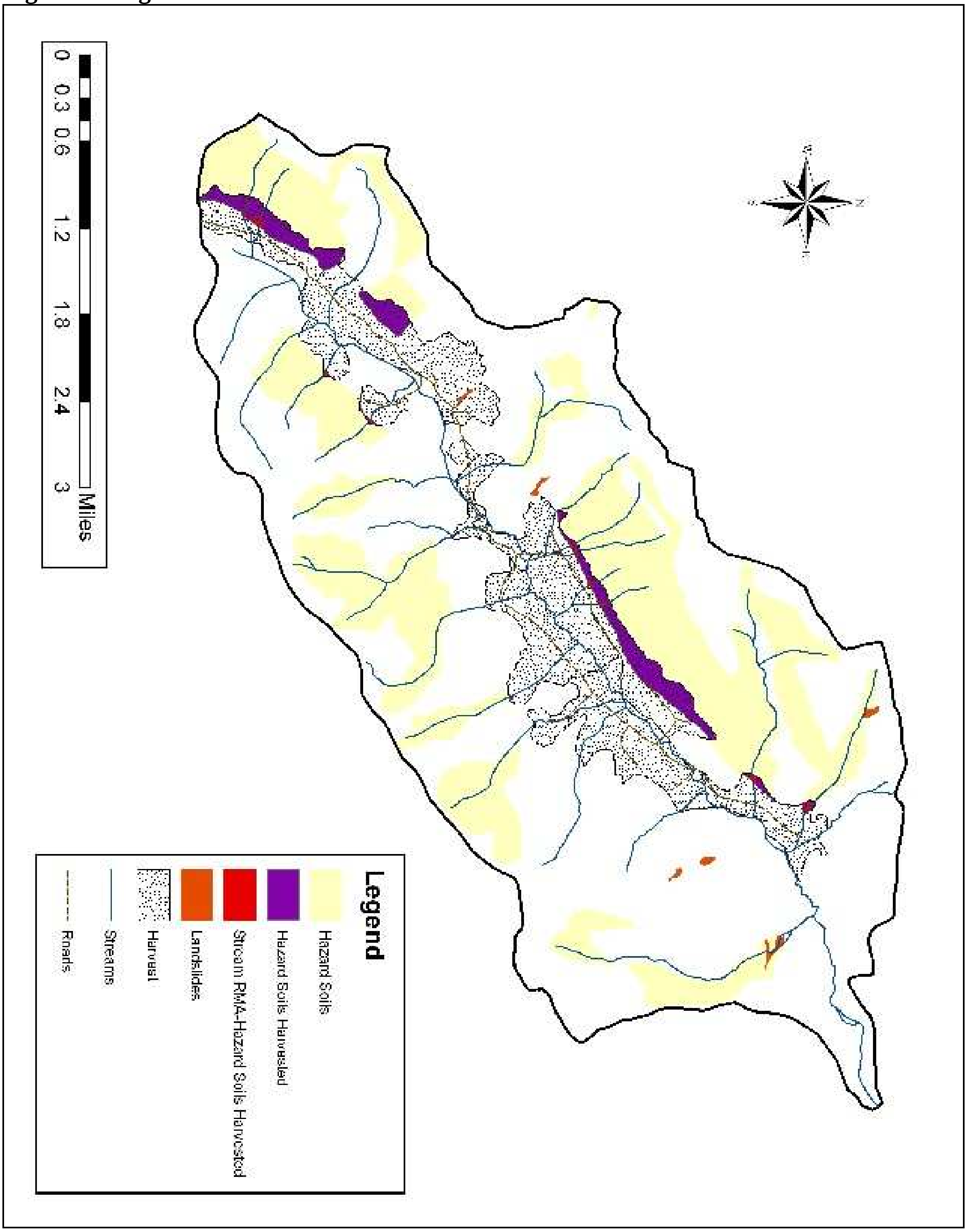
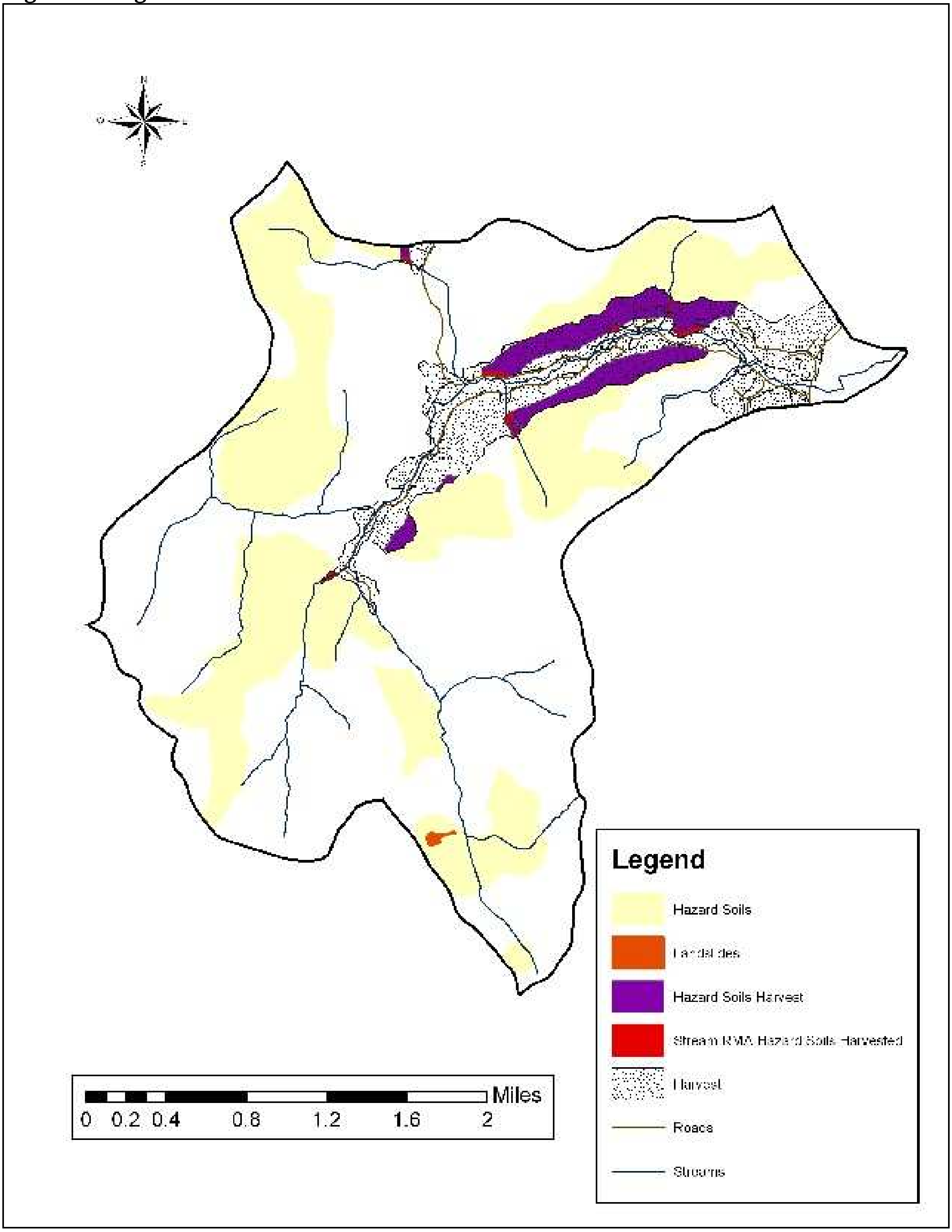


Figure 4. High Hazard Soils within the Adams Watershed

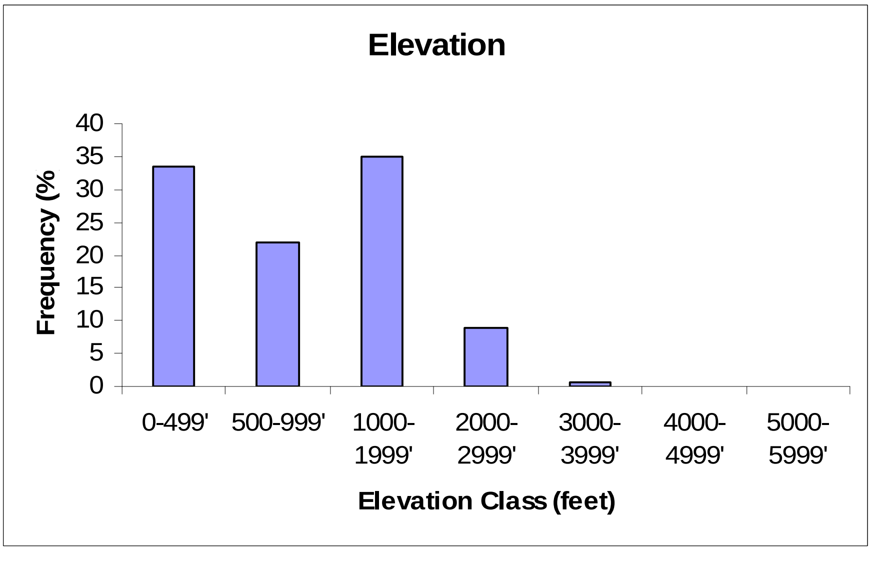


Drainage Basin Morphology

The Analysis Area ranges in elevation from sea level to a maximum of 2,275 feet. Drainage patterns of the Duffield Creek watershed runs generally south to north and Adams Creek runs generally west to east. Both watersheds empty into saltwater. Figures 5 and 6 below display the slope class and elevation distribution throughout these watersheds. These figures show that the majority of the slopes (>75%) are less than 55% and below 2,000 feet.

Figure 5. Slope Class Distribution within the Analysis Area.

Figure 6. Elevation Distribution within the Analysis Area



Steam density, also referred to as drainage density, is a measure of stream length per square mile of watershed. This measurement is useful in determining a stream's potential for runoff and sediment transport. The same factors that influence channel type, geology, landform, climate, and vegetation also influence drainage density. Drainage density within the Analysis Area averages 2.4 miles per square mile (mi/mi^2) and ranges from 2.32 mi/mi^2 in Duffield Creek to 2.44 mi/mi^2 in Adams Creek (Table 6).

Table 6. Stream Miles and Drainage Densities for the Analysis Area.

Watershed	Area (mi^2)	Total Stream Miles	Drainage Density (mi/mi^2)
Duffield Creek	16.7	38.7	2.32
Adams Creek	7.8	19.0	2.44
Total	**24.5**	**57.7**	**2.36**

Source: 2006 Sitka Ranger District GIS Coverage.
Note: Total stream miles denote only mapped class I-III stream channels. Unmapped stream channels including Class IV channels would significantly increase total stream miles and basin drainage densities.

Surface Water and Stream Habitats

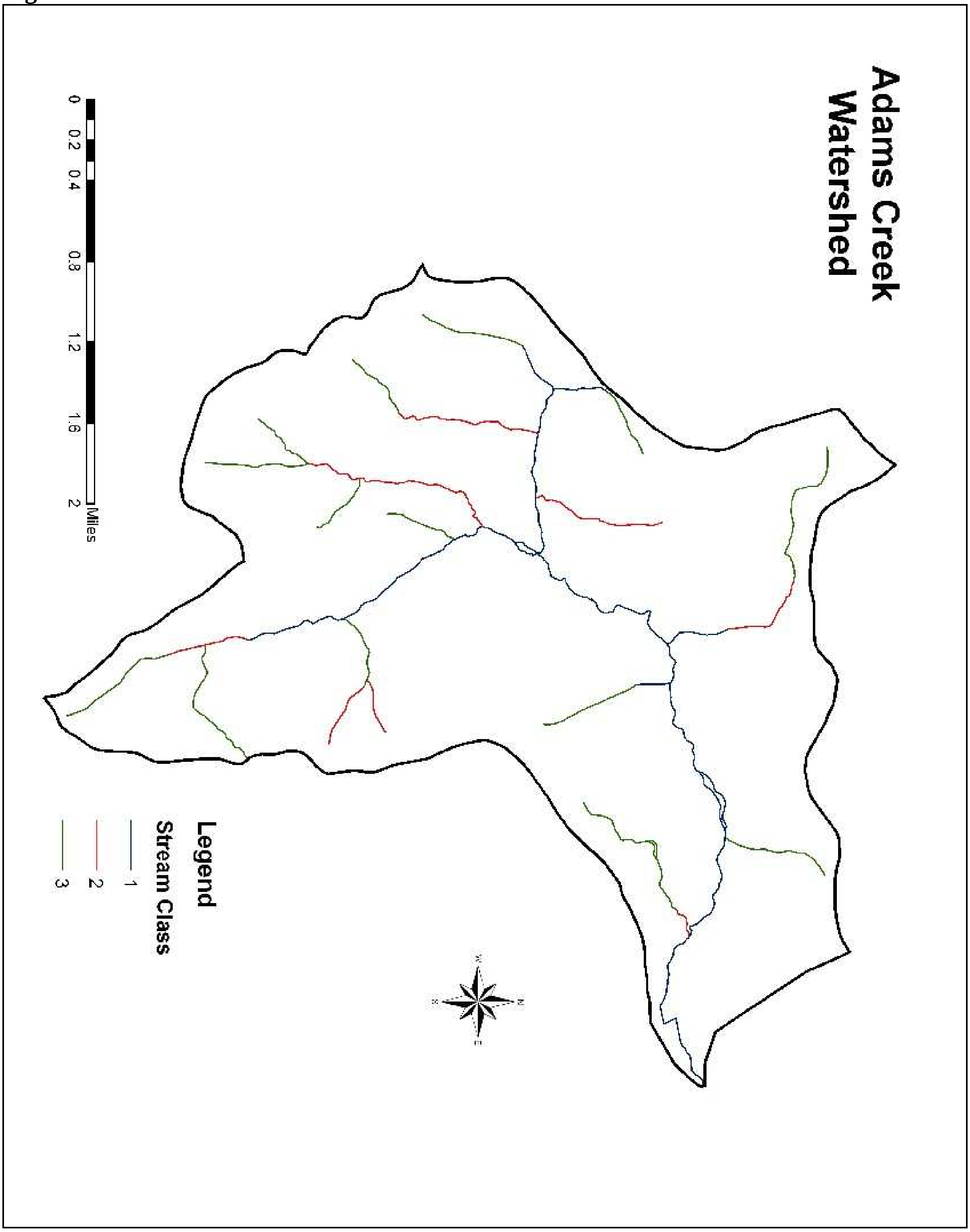
Hydrology

The Analysis Area is divided into two watersheds (Figure 7 & 8). Watershed delineations enable land managers to evaluate the effects of various management activities on fish habitat and an aquatic system's capability to produce fish. In all, there are two HUC 6 watersheds in the Analysis Area (Figure 7 & 8). Both of these watersheds have moderately well-developed flood plains that support or, prior to valley bottom timber harvest activities, supported stands of large Sitka Spruce. Transport and transitional channels drain the moderate to higher gradient reaches of the watershed and transport sediment and organic debris downstream to the valley bottom depositional streams. In addition to providing much of the available fish habitat, these flood plain stream channels provide short- and long-term storage for sediment and are sensitive depositional reaches.

The Adams Creek watershed is generally steeper and has a relatively smaller floodplain. Both watersheds have a quick response to storm runoff, and are efficient in routing runoff to the mainstem channel and out of the watershed to saltwater.

Figure 7. Duffield Creek Watershed Streams.

Figure 8. Adams Creek Watershed Streams.



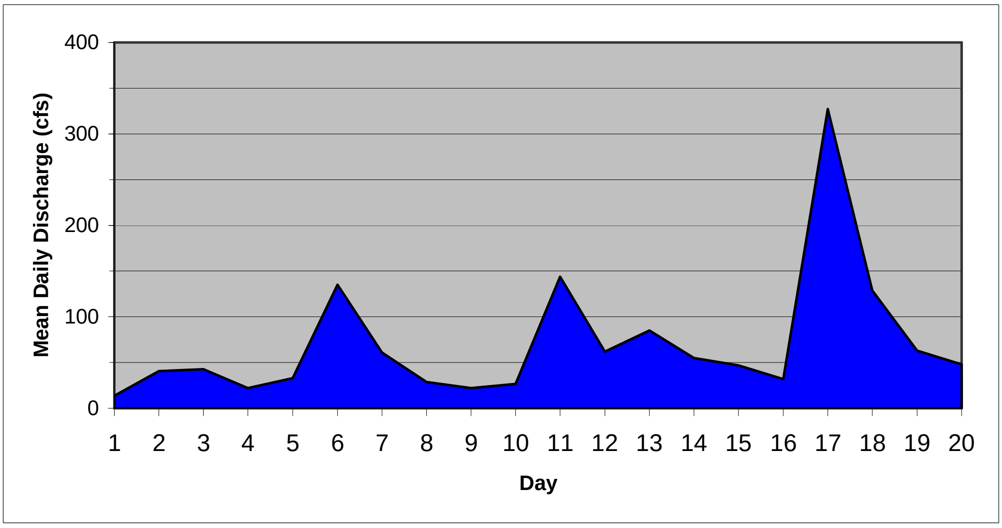
Stream Flow

Stream flows for the Analysis Area watersheds are typical of island watersheds in Southeast Alaska. Steep slopes along with well-drained, shallow soils and high drainage densities characterize watersheds in the Analysis Area. Most watersheds in the area respond rapidly to rainstorms, which can cause large daily fluctuations in stream flow. Stream flow is highly variable during the year. River discharge generally peaks in September or October, with a maximum stream discharge of 12 cfs/mi^2 and gradually declines throughout winter and early spring. Snowmelt at high elevations results in moderate flow increases in May and June and results in a second discharge peak. Infrequent winter storm freshets may result from warm rain-on-snow events. Low flows of 3 cfs/mi^2 generally occur between June and August although low flows can also occur during prolonged winter cold periods.

Overland flow is seldom observed in Southeast Alaskan coastal forests, except from compacted sites such as roads and landings, rock outcrops and ice fields. Nearly all runoff occurs by soil infiltration and subsurface routing to streams. Stream networks expand during storms, especially storms continuing for several days to weeks. As the soil becomes saturated, live flow reappears in low-order intermittent channels.

The majority of precipitation entering Analysis Area watersheds exits through runoff. The remaining percentage is lost to soil recharge, transpiration, and evaporation. Steep slopes and stream gradients, combined with low groundwater storage capacity, cause quick hydrographic response and flashy flow after the onset of rain. Stream hydrographs for an individual storm event underscore this short lag-time with a steep rising curve and rapid recession. Though no stream flow data exists for these individual watersheds, this flow response from runoff can be seen in data from the nearby gaging station at Kadashan River (Figure 9).

Figure 9. Typical Storm Event Hydrograph (Kadashan River, Aug. 12-31, 1999).



Other factors which influence water flow and conditions in the Analysis Area include groundwater recharge from fens, bogs or 'muskegs', and shallow aquifers and seeps. Shallow aquifers and seeps associated with valley floor wetlands and alluvium help sustain summer and winter base flow in main stream channels.

All significant stream segments in the Analysis Area were mapped and classified using the Alaska Region Channel Type Classification System (USDA FS 1992). The area contains roughly 58 miles of significant streams with an average stream density of 2.4 miles per square mile (Table 6). For this report, stream class (a measure of fish habitat) and channel type (a measure of sediment transport) were analyzed. There are no lakes within the Analysis Area.

Management Effects on Stream flow. In large basins where timber harvest activities are dispersed in space and over time, relatively small changes in stream flow can be expected (Duncan 1986). Studies in Oregon showed increased magnitude of small and moderate peak flows associated with logging (Harr 1986). Salmon have adapted to average flow regimes for all stages of their freshwater life history. Seasonal low flows and peak flows can affect migration, channel conditions, water quality and egg survival (Hicks et al. 1991).

Reduced low flows in watersheds that have been converted from old-growth forest to second-growth forest is a relatively new issue. This reduction in summer and winter flows is from increased canopy interception of precipitation and increased evapotranspiration rates. Myren and Ellis (1984) speculated that converting old-growth watersheds to second-growth forests may significantly reduce summer low flows in Southeast Alaska streams and impair summer rearing and spawning for salmonids. This decrease would be evident in the intermediate stages of forest succession. However, streamflow analysis for Staney Creek, a large watershed on Prince of Wales Island near Ketchikan, indicated an increase in summer low flows after 35% of the watershed was harvested. Low flow changes are most likely to occur where a significant portion of the stream riparian area has been harvested (Hicks et al. 1991).

Peak flow increases from timber harvesting in rain-dominated runoff regimes will be minor, assuming minimal soil compaction and low road density in a watershed. However, clearcut harvest practices have the potential to increase the magnitude of peak flows under a rain-on-snow runoff regime (Harr 1986).

The sustained baseflow and thermal cover found in palustrine channel types are important to winter survival of juvenile fish. Low streamflow during extreme cold weather may freeze gravel riffles and incubating eggs. Low flows in the summer and winter can adversely affect adult spawners, rearing juveniles, and egg incubation. Low summer flows may shrink and occasionally dry up rearing pools used by juveniles; this most often affects young-of-the-year coho, steelhead, cutthroat and Dolly Varden and occurs in the smaller tributaries and side channels of the main stem stream.

Changes in the magnitude and duration of winter peak flow can adversely affect rearing salmonids and the integrity of spawning beds. Flooding reshapes and redistributes gravel bars and large woody debris, causing eggs to be washed away, buried, or crushed. Annual peak streamflows and rain-on-snow storm flows consistently occur during egg incubation. Debris flows, landslides, alluvial fan and flood plain channel migration and stream crossing failures usually occur during peak streamflows. All of these processes have the potential to dramatically affect egg survival and alter habitat features.

There are no current or historic gage sites within this Analysis Area. Lack of stream gauging information for the Analysis Area streams precluded us from doing a quantitative analysis of streamflow condition and trends in these watersheds. Kadashan River is the only drainage near the Analysis Area with adequate stream gauging information to track annual flow levels. However, little timber harvest has occurred and it is essentially an unmanaged watershed. Eight years of stream gauging data were collected for the upper Indian River (Tenakee) for the Indian River Watershed Analysis (IRWA) (USDA-FS 1996), these two sets of data were compared to evaluate trends over time and possible changes to the Indian River hydrology associated with timber harvest practices. The following results can be extrapolated to some degree for Analysis Area watersheds with similar harvest levels (<16%).

Peak Flows. As mentioned, rain-on-snow peak flow events are the most susceptible to change as the result of timber harvest in Southeast Alaska watersheds. Areas with shallow winter snowpack and large canopy openings such as clearcut units are the most important source zones for rain-on-snow floods (Harr 1986). For the IRWA, maximum daily flows from November through February for the period prior to and following timber harvest (at Indian River) were compared. An analysis of the two regression lines indicated no significant difference (P=.95) between pre- and post-timber harvest winter peak flows. The IRWA concluded that it was unlikely that 10% harvesting of the transient snow zone resulted in measurable changes in Indian River peak flows. This same conclusion should also hold true for this Analysis Area as harvest levels in all watersheds is less than 10%, harvest occurred below this transient snow level, and subsequent regeneration of harvest has is beyond that of the Indian River harvests.

Low Flows. The month of August is considered to be a critical period for summer low flows in the Analysis Area. August typically has warm temperatures and periods of one to two weeks with no or little precipitation. Alpine snowpack runoff contributions to base stream flow are minimal. Adult salmon are also migrating and spawning during this time. Similar to peak flows, the IRWA team analyzed summer low flow conditions and trends for Indian River. Mean monthly flows and minimum daily flows in August for Upper Kadashan were compared to flows for the Indian River. They concluded there was a consistent relationship between Kadashan and Indian River over most of the period that both stream gauges were operated and they discounted the possibility of measurable changes to low flow levels in Indian River resulting from timber harvest. Again, this same conclusion should also hold true for this Analysis Area as harvest levels in both watersheds is less than 10%, harvest occurred below this transient snow level, and subsequent regeneration of harvest has is beyond that of the Indian River harvests.

Stream Channel Types

Stream channel types are determined by their size, location in the watershed, adjacent landforms, gradient, hydraulic control, and riparian vegetation. Channel type and stream class are influenced by geology, landform, climate, and vegetation. Table 7 displays the stream miles by channel type and stream class within the Analysis Area. Table 8 summarizes these stream miles into individual channel process groups.

Table 7. Streams in Duffield & Adams Watersheds by Stream Class and Channel Type

Channel Type	Duffield				Adams			
	Stream Miles By Class							
	I	II	III	Total	I	II	III	Total
AF1	3.6			3.6	0.4			0.4
AF2		2.4		2.4		0.7		0.7
ES2	0.2			0.2				
ES4					0.1			0.1
FP3	3.8			3.8	0.7			0.7
FP4	3.3			3.3	1.9			1.9
HC2							0.1	0.1
HC3		2.3		2.3		0.4		0.4
HC4		0.6		0.6		2.0		2.0
HC6			17.9	17.9			7.2	7.2
LC1	2.5			2.5	1.2			1.2
LC2					0.4			0.4
MC1					0.3			0.3
MC2	0.5	0.1		0.6				
MC3		0.5		0.5		1.0		1.0
MM1	0.3			0.3	1.0			1.0
MM2		0.7		0.7	1.6			1.6
Total	**14.2**	**6.6**	**17.9**	**38.7**	**7.6**	**4.1**	**7.3**	**19.0**

Source: 2006 Sitka Ranger District GIS Coverage.

Table 8. Stream Miles by Process Group for the Analysis Area Watersheds.

Watershed	AF	ES	FP	HC	LC	MC	MM	Grand Total
Duffield Creek	6.0	0.2	7.1	20.8	2.5	1.1	1.0	**38.7**
Adams Creek	1.1	0.1	2.6	9.7	1.6	1.3	2.6	**19.0**
Grand Total	**7.1**	**0.3**	**9.7**	**30.5**	**4.1**	**2.4**	**3.6**	**57.7**

Source: Sitka Ranger District 2006 GIS Coverage.

Stream channels can also be classified into three main types: transport, transitional, and depositional channels (Table 9). Transport channels have low sediment retention and include high gradient contained (HC), moderate-gradient contained (MC), and low gradient contained (LC) channels. HC channels are located on steep headwater slopes and are the primary sediment conduit to the low-gradient valley bottom and footslope streams. Transitional channels, in contrast, have moderate sediment retention and include moderate-gradient mixed control (MM), estuarine (ES3), glacial (GO5), and some alluvial fan (AF2) channels. Finally, depositional channels have high sediment retention and include the valley bottom flood plain (FP), palustrine (PA), estuarine (ES2 and ES4), and some alluvial fan (AF1) channels. As mentioned above, the Assessment Area contains 57.7 miles of mapped streams: 37.1 miles (64 percent) are transport channels, 6.9 miles (12 percent) are transitional channels, and 13.7 miles (24 percent) are depositional channels. Depositional channels which contain the flood plain and palustrine streams process group generally have the most anadromous (Class I) fish spawning and rearing habitat.

Table 9. Analysis Area Transport, Transitional and Depositional Stream Miles.

Watershed Name	Transport		Transitional		Depositional		Total Miles
	Miles	% of WS	Miles	% of WS	Miles	% of WS	
Duffield Creek	24.4	63	3.6	9	10.7	28	**38.7**
Adams Creek	12.7	67	3.3	17	3.0	16	**19.0**
Total	**37.1**	**64**	**6.9**	**12**	**13.7**	**24**	**57.7**

Source: Sitka Ranger District 2006 GIS Coverage.

Stream Habitat

The Alaska Department of Fish and Game Anadromous Fish Catalog lists steelhead, coho, pink, and chum salmon, steelhead, sculpin and Dolly Varden char for streams in the Analysis Area. Four stream designations are used on the Tongass National Forest to classify stream channels (USDA-FS1997).

- Class I streams and lakes have anadromous or adfluvial (resident migration) fish habitat.
- Class II streams and lakes have only resident fish populations.
- Class III streams do not have fish populations but have the potential to influence the water quality of downstream aquatic habitat.
- Class IV streams are small, intermittent and/or perennial channels with insufficient flow or transport capabilities to have an immediate influence on the water quality of downstream fish habitat.

Class IV streams have not been analyzed for this report because of a lack of data. However, Class IV streams are analyzed during project-level planning and implementation. The watersheds in the Assessment Area contain a total of 21.8 miles of Class I streams (37 percent of all stream miles), 10.7 miles of Class II streams (19 percent of all stream miles), and 25.2 miles of Class III streams (44 percent of all stream miles) (Table 10 and Figures 7 & 8).

Table 10. Stream by Class within the Assessment Area.

Watershed Name	Class I		Class II		Class III		Total
	Total	% of WS	Total	% of WS	Total	% of WS	
Duffield Creek	14.2	37	6.6	17	17.9	46	38.7
Adams Creek	7.6	40	4.1	22	7.3	38	19.0
Total	**21.8**	**37**	**10.7**	**19**	**25.2**	**44**	**57.7**

Source: Sitka Ranger District 2006 GIS Coverage.

Management Effects by Stream Class. As mentioned before, timber harvest was not evenly distributed throughout the watersheds, with harvest occurring primarily in valley bottoms and lowlands. Consequently, the vast majority of streams affected are Class I and II fish channels. Table 11 displays the miles of stream by class within harvest units. This data shows that roughly 71% of the stream channels impacted by harvest contain fish habitat, with the majority of that (59%) occurring along anadromous fish habitat.

Table 11. Stream Miles by Class within Harvest Units.

Watershed	Stream Class			Grand Total
	I	II	III	
Duffield Creek	7.4	1.9	0.9	**10.2**
Adams Creek	4.2	0.4	4.8	**9.4**
Grand Total	**11.6**	**2.3**	**5.7**	**19.6**

Source: Sitka Ranger District 2005 GIS Coverage.

In 2006 Tier II stream surveys were conducted along selected stream segments that had been previously harvested in the Duffield Creek watershed. Table 12 below displays the results of these surveys. Appendix B displays the Tongass Habitat Variables rankings by process group.

When compared to the Tongass Habitat variables (see Appendix B), survey data indicates that for the floodplain process group, pools are generally fewer in number, shorter in length and spaced farther apart than average streams of the same process group within the Tongass.

Table 12. Channel Habitat and Morphology Variables for the Analysis Area.

Watershed	Reach Number	Channel Type	Pools / km	Total Key LW/km	Pool Spacing	RPD / CBW	Pool Length / m
Duffield (Main)	39874	FP4	21.33	0.06	2.93	0.20	0.46
Duffield (Trib 1)	39798	AF1	84.31	0.16	2.58	0.09	0.40
Duffield (Trib 2)	39823	MM1	96.24	0.19	1.98	0.07	0.32

Note: Only Key LW data collected for these reaches.

Large wood (LW) is naturally introduced into stream channels during storms by flooding (bank erosion) or windthrow events. Trees enter the stream singly or in small groupings from these sorts of disturbance events. These pieces, if small enough to be transported downstream by current velocities, most often then accumulate into debris jams downstream. These debris jams, as well as the largest LW pieces, called 'key' pieces, dissipate stream energy. This dissipation is primarily through channel scour, which creates pools, which are an important component of fish habitat. Additionally, energy dissipation through pools helps routing and distribution of substrates, stabilizing them and maintaining channel dimensions, patterns and profiles. Beside pool habitat for fish, wood in streams provides cover from predation and serves as a primary production source of food for fish. A study in Southeast Alaska found lower fish population densities in streams where smaller LW pieces were selectively removed (Dolloff 1986).

The key LW data collected from the mainstem Duffield creek indicates that these streams have lower numbers of key LW than similar streams in the rest of the Tongass National Forest (Table 12). Key LW in the two tributary channels surveyed however, were higher values than those of other southeast streams.

Water Quality Concerns and Status

There are no state-listed water quality-impaired water bodies in the Analysis Area. Propagation of fish and other aquatic species is the primary beneficial use of water in this Analysis Area. Temperature, dissolved oxygen, pH, turbidity, and total dissolved solids are the main parameters adopted by the State of Alaska as standards for assessing surface water quality. As with streamflow, the only quantitative water quality data are available primarily for the Kadashan River watershed.

Stream Chemistry. There are no indications of historic or future sources of chemical contamination in the Analysis Area watersheds. Atmospheric sources of chemical pollutants are not a major factor influencing water quality in the region. Due to the lapse of time since and low-to-moderate intensity of past management activities, it is unlikely that stream chemistry will be out of the natural range of variability.

Stream Temperature. The proportion of clearcut harvest within the stream riparian management area (RMA) in the Analysis Area can be used as a relative index of cumulative sunlight and temperature changes associated with second-growth riparian stand development. Miles of clearcut harvest by stream class and riparian acres by watershed for the Analysis Area were summarized previously in Tables 11 and later on in the Vegetation section in Table 15. This index of past riparian harvest identifies watersheds most likely to have experienced stream temperature changes and to experience future temperature changes. Consequently, because of the lapse of time since past harvest and subsequent regrowth of trees along impacted reaches, it is presumable that stream temperatures will be within state standards and will not be out of the natural range of variability.

Vegetation

The Analysis Area is a diverse and dynamic landscape with considerable topographic relief. It contains a mosaic of young and old forests, muskegs, forested muskegs, and alpine areas. Forest vegetation structure, composition, and distribution are largely determined by site productivity and soil drainage, as well as natural and human-caused disturbance. The dominant tree species in the Analysis Area is western hemlock.

Varying amounts of Sitka spruce and Alaska yellow cedar are also found within the area. The most productive forests are associated with deep, well-drained soils, many of which are found in the alluvial fan and flood plain landforms. Sitka spruce favors these more nutrient-rich and well-drained sites. Western hemlock dominates the less productive sites with Mountain hemlock at higher elevations. Yellow cedar is often absent on the more productive sites, but does occur in scattered pockets. Cedar can be relatively common on many open and less productive sites or forested muskeg stands and occasionally dominates these areas. Mixed conifer stands dominated by small to medium-sized mountain and western hemlock and yellow cedar are typical of wet, sparsely forested muskeg areas and low productivity sites. Much of the upland area surrounding Fish Bay is comprised of this forest type. Shore pine, a variety of lodgepole pine, is also common in these mixed conifer stands and open muskeg areas. Alder tends to grow on exposed and disturbed soil sites such as old roads.

The distribution and abundance of understory plants is highly variable and dependent on soil drainage, the distribution of large organic debris as a rooting substrate, the amount of light reaching the forest floor, and the type and amount of natural or human-caused disturbance. Vaccinium (blueberry, huckleberry) tends to be the most prevalent understory shrub. It is typically found with Menziesia, copperbush, and devil's club. Salmonberry is common on disturbed sites, and skunk cabbage occurs throughout the area on wet micro-sites. The dominant forbs are typically five-leaf bramble and bunchberry. Various species of ferns, lichens, and moss are also numerous. The dominant plant associations[1] are western hemlock/blueberry and western hemlock/blueberry/devil's club.

The plants in estuaries and along the beach fringe include red alder, Sitka alder, crabapple, and various sedges and grasses.

[1] Plant association refers to the climax forest plant community type representing the end point of succession.

Muskeg vegetation is a mixture of sedges, deer cabbage, sphagnum mosses, and low growing herbs such as Labrador tea and bog laurel. Muskegs typically contain numerous small ponds. Stunted, slow-growing shore pines grow on the less saturated areas.

Forest Vegetation Structure

Forest stand structures in the Assessment Area vary from single-storied, even-aged forests to complex, multi-layered, uneven-aged forests.

Even-Aged Forest

Stand replacing disturbances such as clearcut timber harvest and/or windthrow are responsible for most of the even-aged stands within the Analysis Area. These stands are generally classified as young-growth. The Analysis Area contains 2,316 acres of management induced young-growth forest. These stands follow a clearly defined pattern of development beginning with rapid establishment of conifer seedlings, shrubs, and herbaceous plants (i.e., stand initiation) and followed by canopy closure after about 25 to 35 years. These developing young forests are extremely dense, containing thousands of trees per acre. They are also characterized by relatively uniform tree height and diameter distributions that result in intense competition preventing new tree regeneration (i.e., stem exclusion). During the stem exclusion stage, light is unable to reach the forest floor. The absence of light prevents the growth of understory shrubs and herbs. The stem exclusion stage can persist for 50 to 100 years before understory vegetation is reestablished and new tree cohorts emerge (i.e., understory reinitiation). Understory reinitiation occurs as wind disturbance, insects, and diseases create gaps in the forest canopy (Deal 2001, p. 2).

Intermediate silvicultural treatments such as thinning can potentially reduce the duration of the stem exclusion stage, encourage more rapid growth among a smaller number of trees, and maintain or enhance understory vegetation. The majority of harvest generated young-growth in the Analysis Area is currently in the early to middle stage of stem exclusion. Precommercial thinning activities favoring the growth of Sitka spruce are responsible for the dominance of this species in young-growth stands. The majority of young-growth forest in the Analysis Area is located in the valley bottoms of the Duffield and Adams Creek drainages.

Uneven-aged Forest

Uneven-aged stands are characterized by a patchy, multi-layer canopy; trees that represent many age classes; larger trees that dominate the overstory; large standing dead trees (snags) or decadent trees; and higher accumulations of large down woody material (USDA 1997 [Forest Plan], p. 7-31). These multi-aged stands, which produce at least 20 cubic feet of wood fiber per acre per year or have greater than 8,000 board feet per acre, are classified as productive old-growth forest.

The remaining forested acres of NFS Lands in the Analysis Area are characterized by non-productive forest. Non-productive forest is associated with muskeg land types including lowlands, fens, riparian areas, broken mountain slopes, plateaus, glacial outwash zones, and other unproductive land types (e.g., steep, narrow canyons associated with areas other than muskegs). Non-productive forest is characterized by very low timber volume, mixed species, and old, defective, and stunted trees. Table 13 provides a summary of harvest within the Analysis Area.

Table 13. Acres of Harvest by Watershed within the Analysis Area.

Watershed	Watershed Area (acres)	Total Harvest (acres)	Total Watershed Harvested (%)
Duffield Creek	10,655	1,716	16.1
Adams Creek	5,021	616	12.2
Total	**15,676**	**2,332**	**14.9**

Source: Sitka Ranger District 2006 GIS Coverage.

Yellow Cedar Decline

Many yellow cedars are in a state of decline and experiencing high rates of mortality in the Assessment Area and across the Tongass National Forest. The cause of this decline is not entirely understood. Ongoing research suggests that mortality is naturally occurring and is caused by some form of environmental stress such as soil toxins or freezing. The decay resistant properties of yellow cedar make salvage desirable; the strength of the wood does not deteriorate, and the trees retain their value for decades after they die. Yellow cedar currently has the highest commercial value of any tree species on the Tongass National Forest.

Harvest History and Regeneration

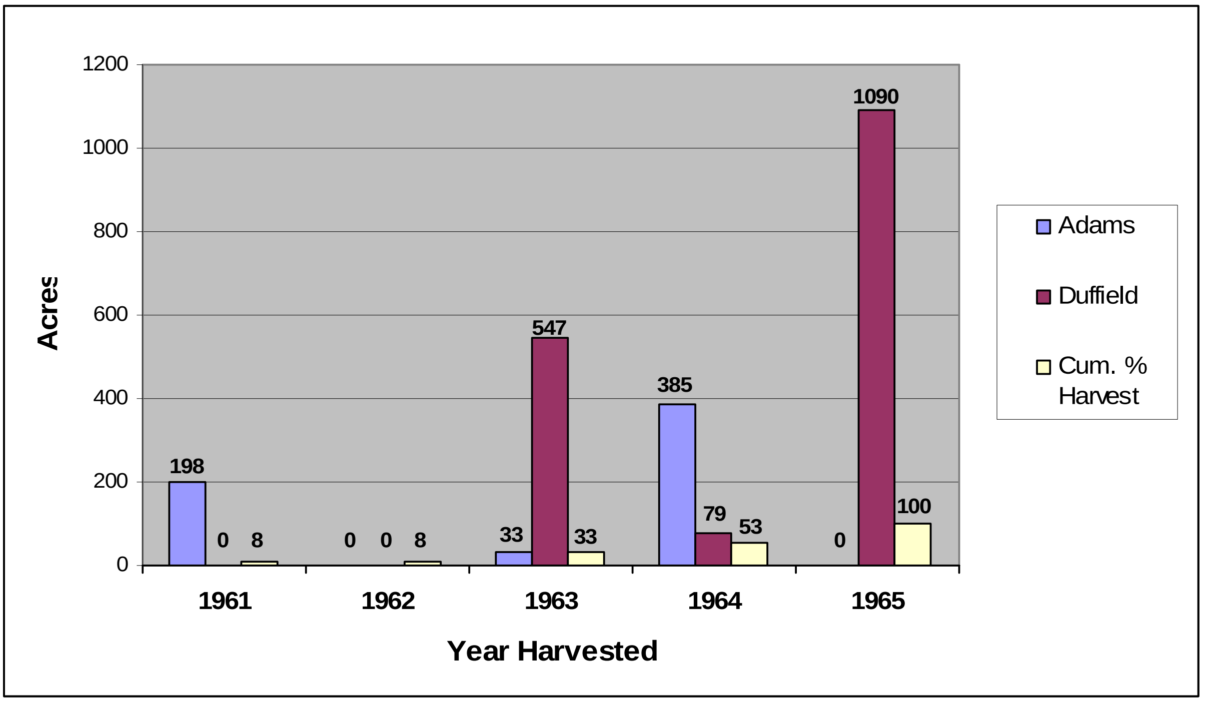
Approximately 2,316 acres have been harvested within the Analysis Area. This represents an estimated 15 percent of the total land area. Clearcut regeneration harvest method was the primary means of harvesting timber within the area and most harvest occurred between 1961-1965 (Table 14). Table 14 also provides a harvest summary by year for the Analysis Area. Figure 10 depicts the harvest acreage by year and Figures 11 and 12 display the locations of harvest units with the Analysis Area.

Table 14. Harvest History within the Vegetation Analysis Area.

Watershed Name	1961	1962	1963	1964	1965	Grand Total
Duffield Creek	0	0	547	79	1090	**1716**
Adams Creek	198	0	33	385	0	**616**
Total (acres)	**198**	**0**	**580**	**464**	**1090**	**2332**
Percent of Total Harvest	**8**	**8**	**25**	**20**	**47**	
Cumulative Total (acres)	**198**	**198**	**778**	**1242**	**2332**	
Cumulative Percent	**8**	**8**	**33**	**53**	**100**	

Source: Sitka Ranger District 2006 GIS Coverage.

Figure 10. Harvest History within the Analysis Area.



Source: Sitka Ranger District 2006 GIS Coverage.

Figure 11. Previous Harvest within the Duffield Creek Watershed

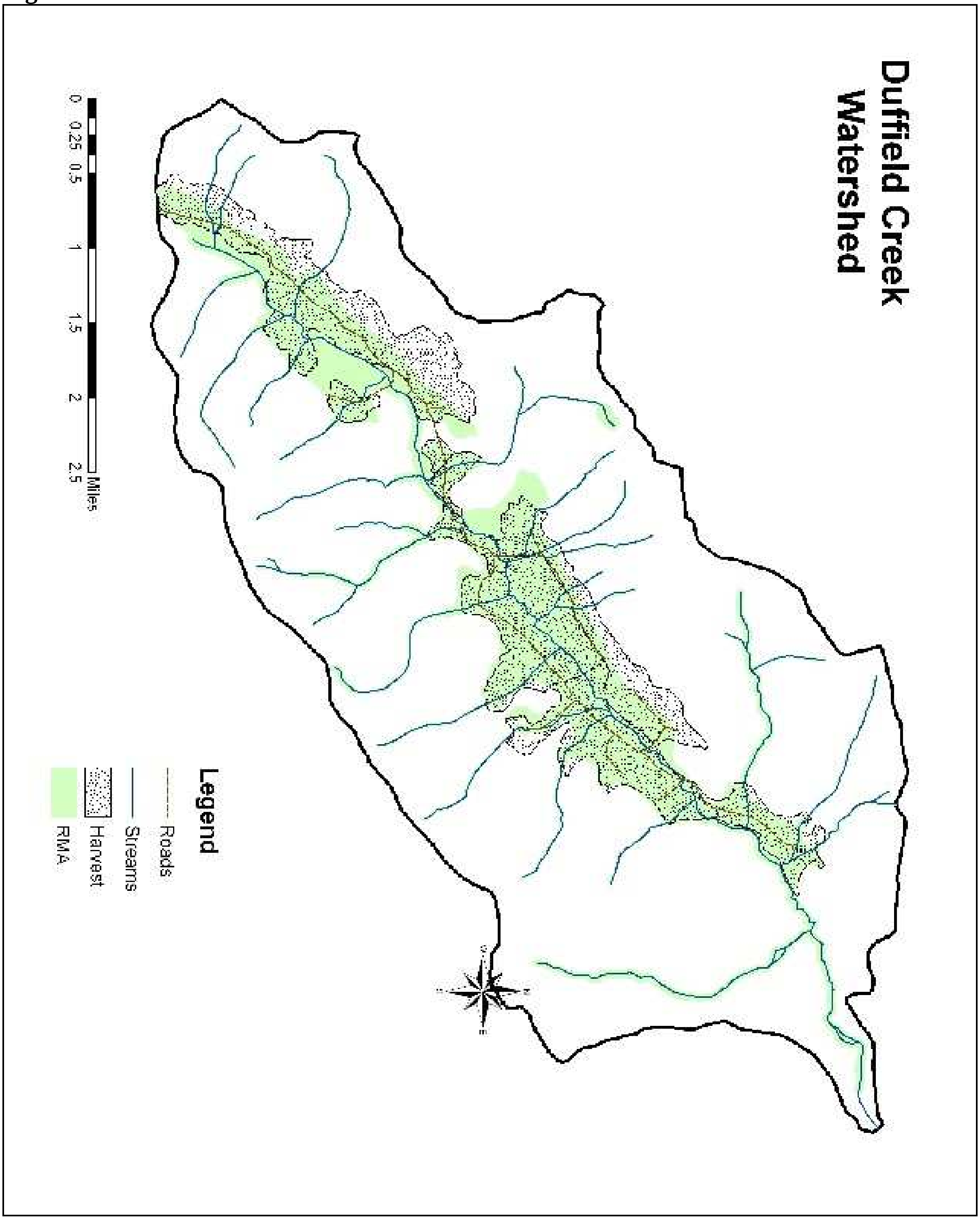
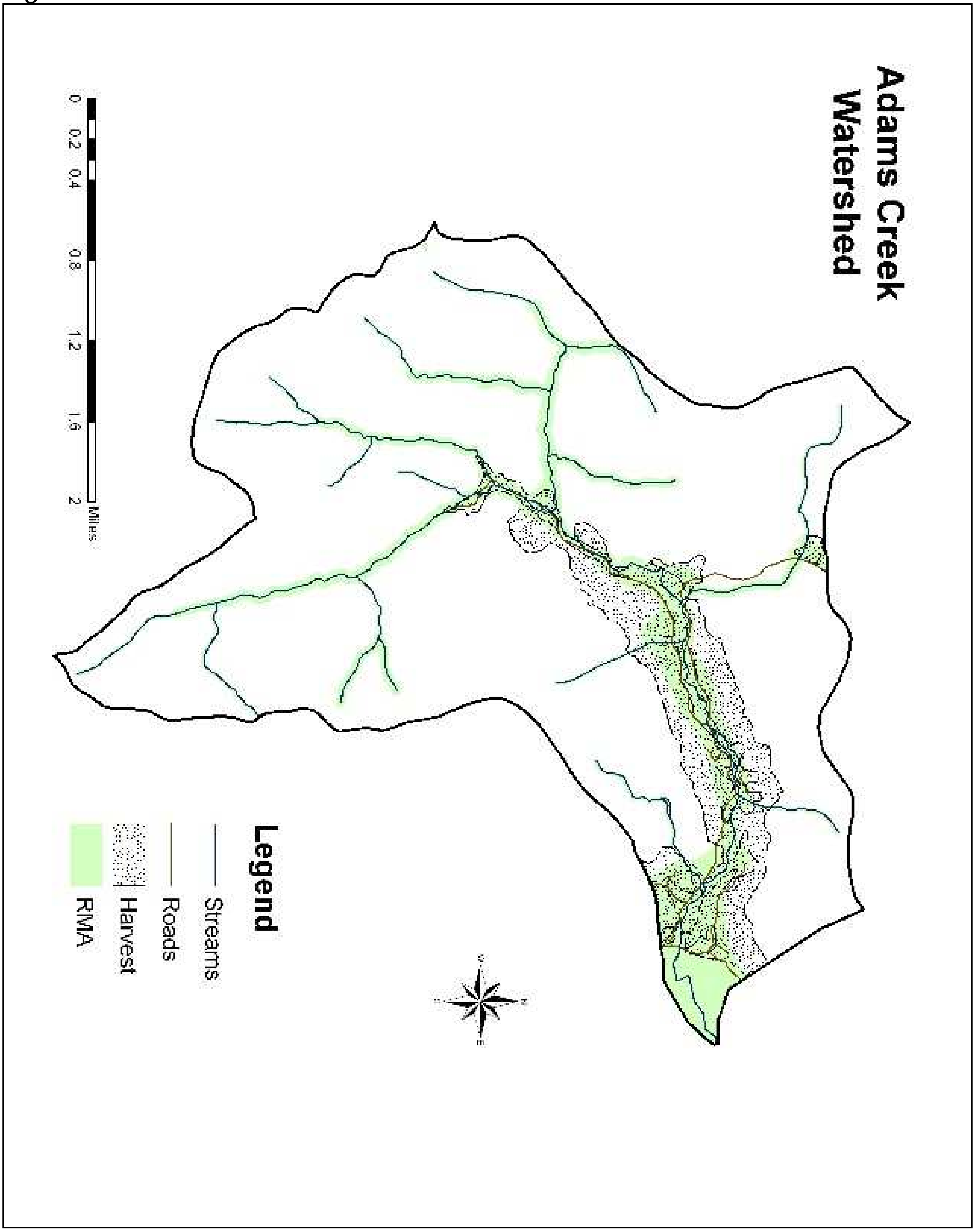


Figure 12. Previous Harvest within the Adams Creek Watershed.



Regeneration

National Forest Management Act (NFMA) regulations state that "when trees are cut to achieve timber production objectives, the cuttings shall be made in a way as to assure that the technology and knowledge exists to adequately restock the lands within five years after final harvest" [(36 CFR 219.27c (3)]. Regeneration of harvested acres on National Forest System (NFS) lands within the Analysis Area has been successful; all previously harvested areas have been certified as regenerated.

Young-Growth Management

The management of young-growth stands is a responsibility that comes with timber harvest and is an important element of timber and land management. At present, 1,449 acres of the harvest generated young-growth stands within the Analysis Area have been precommercially thinned to improve the growth and yield of timber, to change the species mix to favor more profitable species, or to improve wood quality. Additionally, some multiple emphases thinning to primarily to improve fish habitat, and to a lesser extent, wildlife habitat has taken place. These multiple emphasis prescriptions within the Analysis Area occurred within stream RMAs and were designed to maintain, enhance, or restore understory vegetation by delaying canopy closure; maintaining greater species diversity; and restoring riparian structure and/or instream fish habitat by decreasing the time needed to grow large trees that will eventually serve as large wood for instream habitat. To date 313 acres of previously harvested RMAs have been thinned to accomplish these objectives.

Future Logging

Since 1966, no timber harvest has occurred within the Analysis Area. Current LUD designation allow for timber harvest within much of the Analysis Area however, to date, no timber sales are scheduled within the Analysis Area in the foreseeable future.

Precommercial Thinning

Past timber harvest has generated 2,332 acres of young-growth on National Forest System lands within the Analysis Area, which constitutes approximately 15 percent of the entire Analysis Area. To date 882 (51%) acres within the Duffield watershed and 567 (92%) acres within the Adams watershed have been precommercially thinned (Figures 13 & 14). Consequently, the remaining unthinned young-growth in the area is 40 years old and bumping up against the window of opportunity for precommercial thinning. Also, the harvest that is currently within riparian buffers would not be thinned under the precommercial thinning program.

Commercial Thinning

To date, the commercial thinning or other harvest of young-growth timber has been limited in Southeast Alaska due to the small size of the trees, the lack of a market for small logs, and high logging costs. Commercial thinning in the Analysis Area is not likely to occur in the near future for these reasons. However, this could change as new markets develop and technology advances. The Forest Service Alaska Wood Utilization Research and Development Center based in Sitka is conducting research in primary and secondary wood processing in an effort to enhance economic opportunities for the Alaska timber industry. Also, as above, the vast majority harvest by is currently within non-development Land Use Designations (LUDs) or within riparian or beach buffers and therefore would not be thinned under the commercial thinning program.

Figure 13. Thinned Stands within the Duffield Creek Watershed.

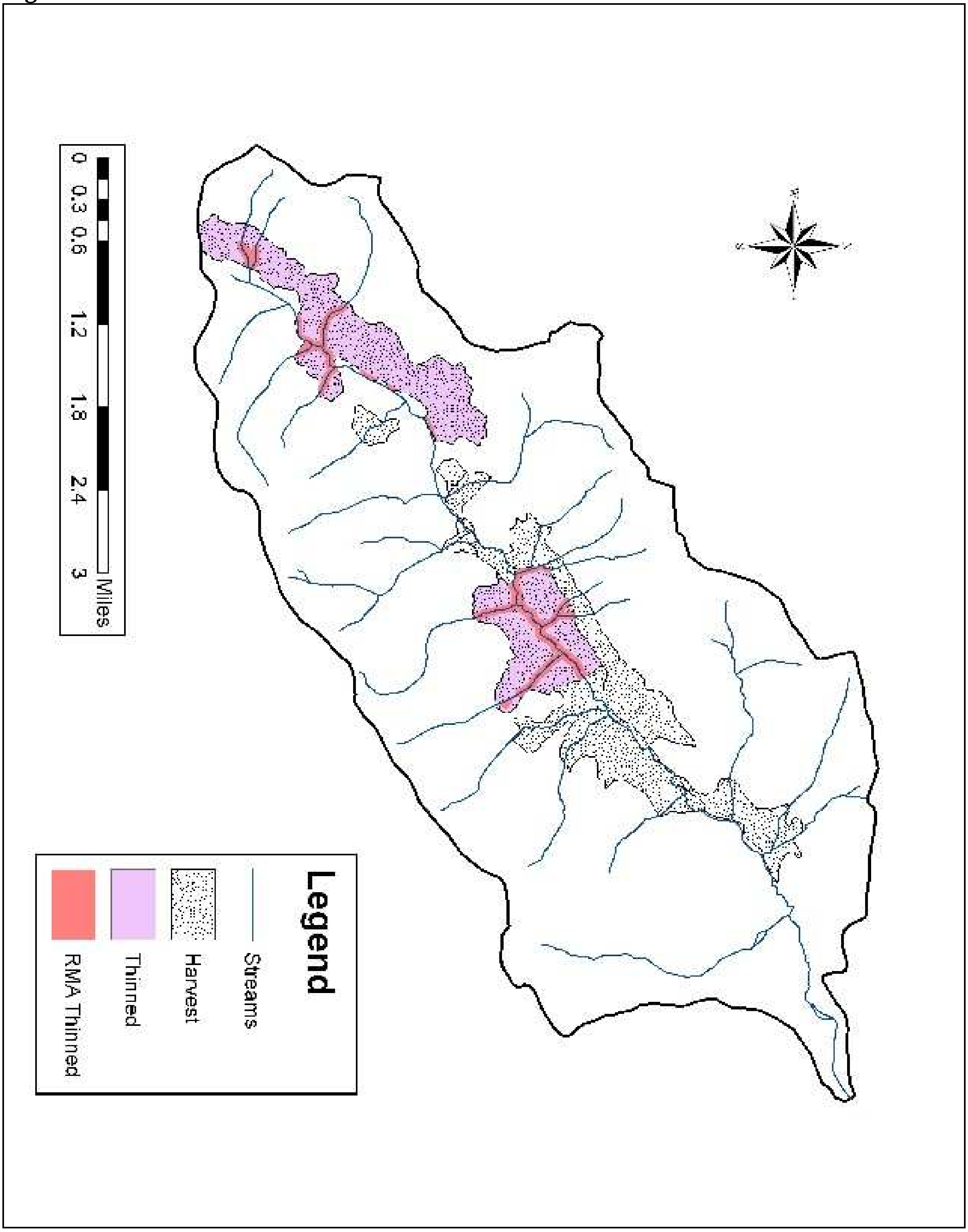
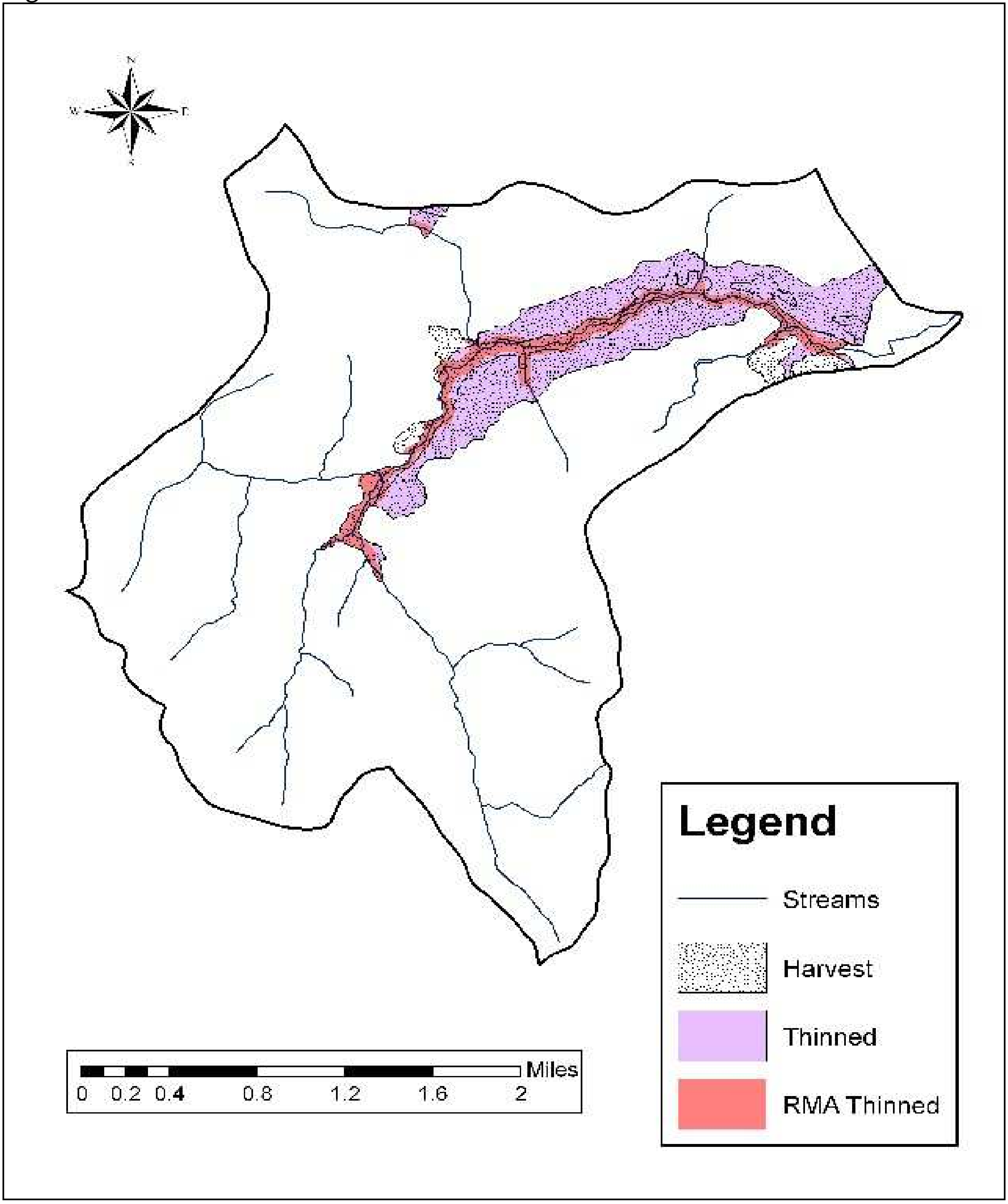


Figure 14. Thinned Stands within the Adams Creek Watershed.



Riparian Vegetation

Disturbance patterns and soil moisture adjacent to streams and lakes create unique riparian vegetation types. The streams and vegetation influence each other. During high flows, streams disturb soils and vegetation, creating opportunities for early successional species such as alder to grow and persist. In addition, soil moisture, which ranges from wet to dry, influences species composition and growth rates (Malanson 1993). The vegetation, in turn, contributes to fisheries habitat by stabilizing riverbanks; partially controlling sediment entry into streams; providing shade, temperature control, and cover; and contributing organic material (woody debris, leaf litter input, insects) to the channel.

As described above, we classify streams into different process groups, which reflect the interaction of watershed runoff, landform, geology, climate, and glacial and tidal influences (USDA-FS, 1992). These process groups each interact with the adjacent vegetation in different ways. Information on stream channel process groups can be found within the Stream Channel Types section and in Region 10: Channel Type Users Guide (USDA-FS 1992).

Based on the average widths for different channel types, stream riparian acres encompass 1,361 acres or 9% of the Assessment Area (Table 15). The distribution of the riparian areas and the harvest that has occurred within them in the Analysis Area is shown in Figures 15 and 16.

Natural Disturbance in Riparian Areas. In addition to disturbance caused by flooding, wind also affects riparian areas. Small-scale windthrow is the most important natural disturbance factor in the Tongass (DeMeo et al. 1992). Ott (1995) found that canopy gaps occupy about 9% of old-growth western hemlock/blueberry/shield fern communities. Most of these were less than 540 ft2 (50 m2) and formed by three or fewer trees.

Harvest in Stream Riparian Zones. Of the 1,361 acres of riparian zones, 536 acres have been harvested (Table 15). Total harvest acres equal approximately 39% of the stream riparian area in the Analysis Area.

Both of the Analysis Area watersheds have had over a third of their stream riparian areas harvested, including harvest along main valley bottom channels (Table 15, Figures 14 & 15). The most extensive streamside harvest and possibly most significant cumulative effects to fish habitat historically within watersheds with significant amounts of fish habitat (> 5 miles), occurred along Class I streams in the Duffield watershed, where harvest occurred along approximately 7.4 miles of Class I streams (Table 11).

In addition, there has been some harvest along the banks of Class III streams that directly influence downstream Class I and II channels. The condition of stream habitats in these channels currently appears to be stable due to regrowth of stands over the past 40 years. Any decline in instream large wood from decomposition and downstream migration will likely be offset by recruitment of streamside stumps, unimpacted upstream reaches and residual old growth trees left during harvest.

Figure 14. Riparian Harvest within the Duffield Creek Watershed.

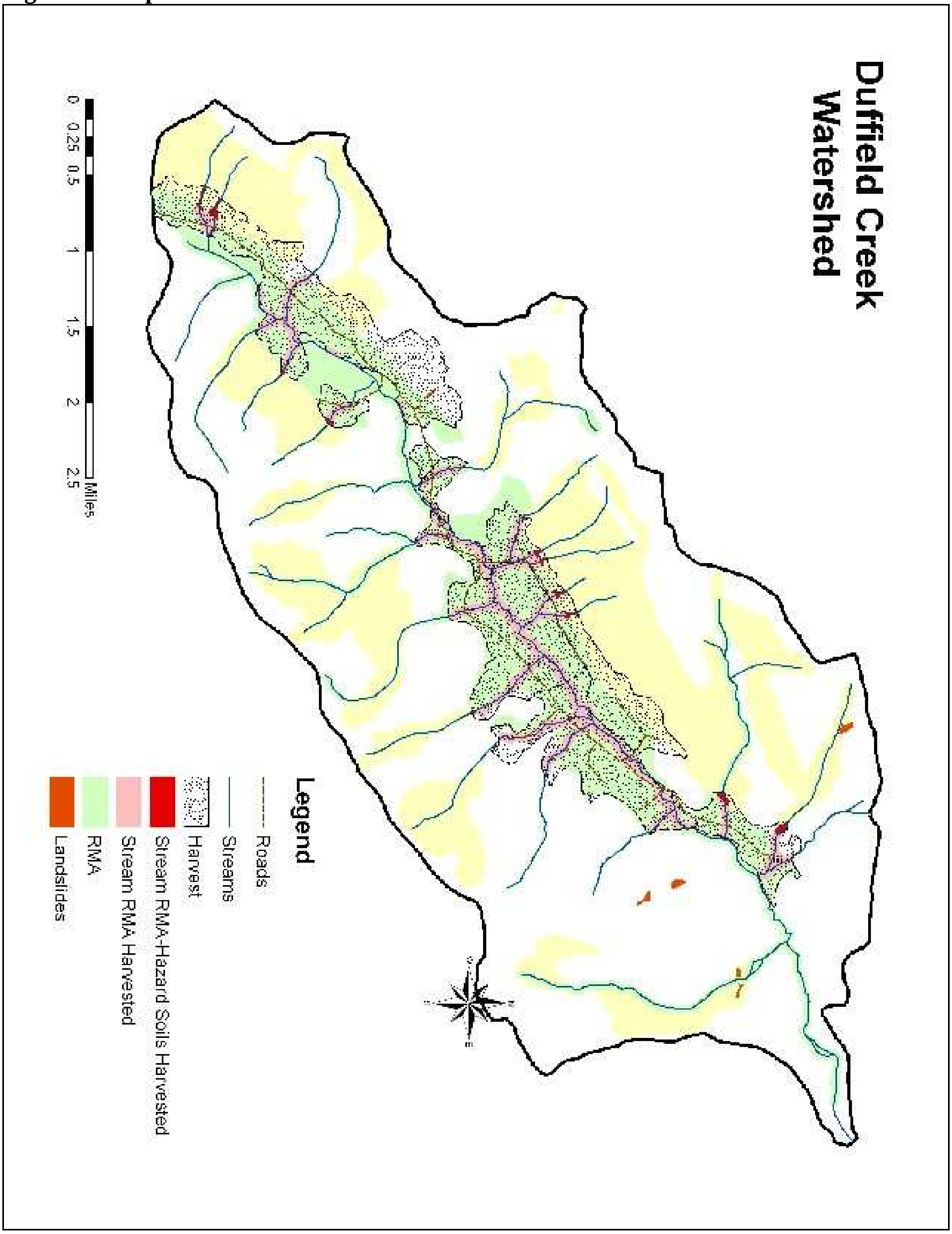


Figure 15. Riparian Harvest within the Adams Creek Watershed.

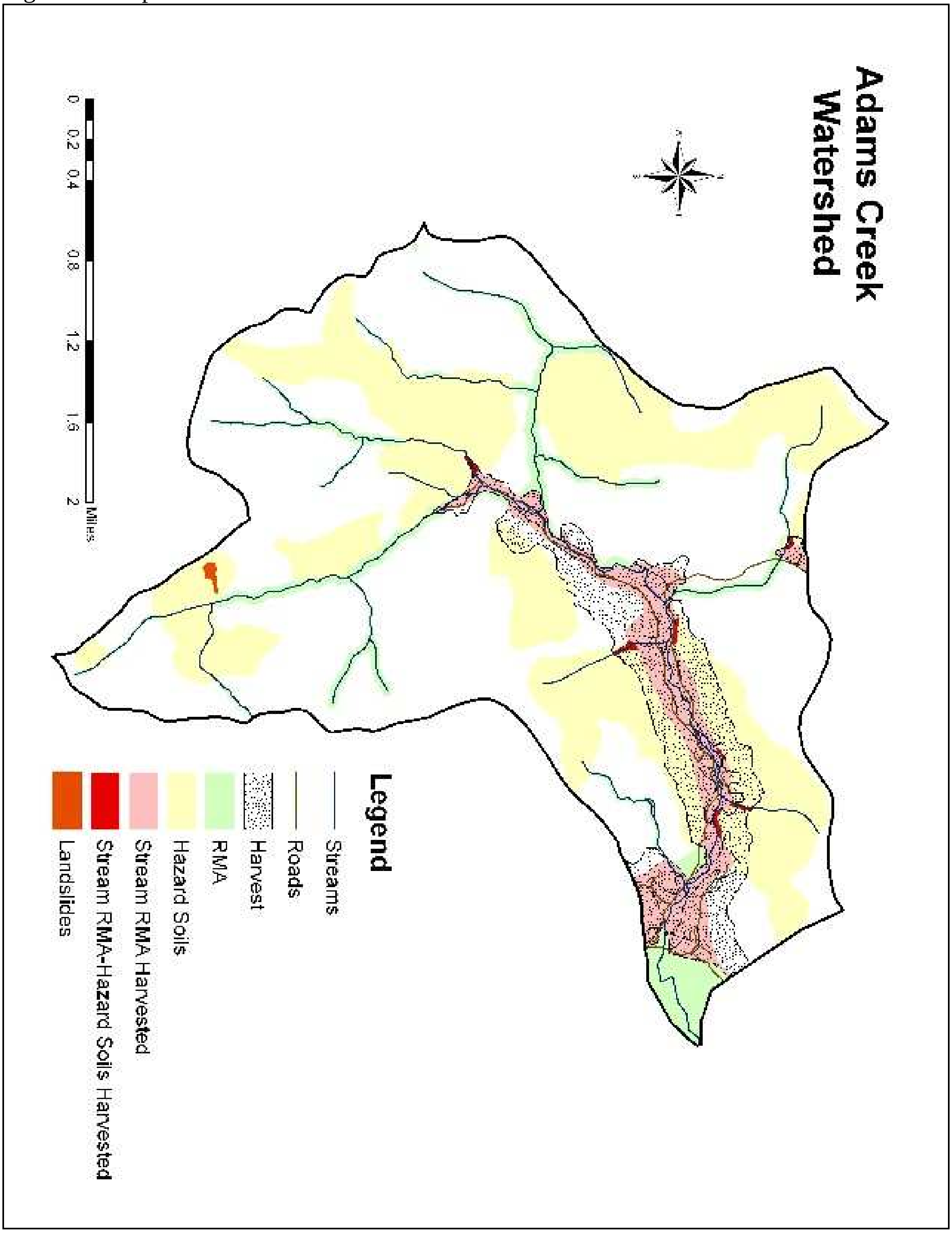


Table 15. Riparian Harvest within the Analysis Area

Watershed Name	Watershed Area (acres)	Total Harvest (acres)	Total RMA In Watershed (acres)	Total RMA In Watershed (%)	RMA Harvested (acres)	Total Riparian Area Harvested (%)
Duffield Creek	10,655	1,716	911	8.5	380	41.7
Adams Creek	5,021	616	450	9.0	156	34.7
Total	**15,676**	**2,332**	**1,361**	**8.7**	**536**	**39.4**

Source: Sitka Ranger District 2006 GIS Coverage.

Riparian vegetation surveys were conducted within three of the Analysis Area watersheds to assess the current condition of harvested riparian stands. Tables 16, 17, and 18 display the riparian stand densities within watersheds.

Table 16. Duffield Creek Riparian Summary (Main Channel).

Species	Average		Tree / Acre						
			Total	By Diameter Class					
	DBH	Height		0-4.9"	5-6.9"	7-8.9"	9-10.9	11-12.9"	>13"
Red Alder	7.5	50.5	346	26	146	104	40	14	16
Sitka Spruce	7.4	41.0	146	54	26	22	16	12	16
Western Hemlock	4.9	26.2	88	54	20	4	8	0	2
Grand Total	**7.1**	**44.4**	**580**	**134**	**192**	**130**	**64**	**26**	**34**

Note: Table includes only live trees.
Note: Dead Standing = 140 trees/acre; (RA=68, SA=6, SS=54, WH=12); Ave DBH=4.4"; Ave Ht=18.8'

Table 17. Duffield Creek Riparian Summary (Trib 1).

Species	Average		Tree / Acre						
			Total	By Diameter Class					
	DBH	Height		0-4.9"	5-6.9"	7-8.9"	9-10.9	11-12.9"	>13"
Red Alder	8.1	51.8	570	40	160	150	170	40	10
Sitka Spruce	6.1	39.3	730	330	180	70	70	50	30
Western Hemlock	5.0	31.4	70	30	40	0	0	0	0
Grand Total	**6.9**	**44.1**	**1370**	**400**	**380**	**220**	**240**	**90**	**40**

Note: Table includes only live trees.
Note: Dead Standing = 570 trees/acre; (RA=200, SS=370); Ave DBH=3.8"; Ave Ht=24.5'

Table 18. Duffield Creek Riparian Summary (Trib 2 – Previously Thinned for Timber Objectives).

Species	Average		Tree / Acre						
			Total	By Diameter Class					
	DBH	Height		0-4.9"	5-6.9"	7-8.9"	9-10.9	11-12.9"	>13"
Red Alder	8.1	46.6	175	15	55	40	30	25	10
Sitka Spruce	10.5	46.5	350	95	15	50	10	45	135
Western Hemlock	9.6	39.5	140	25	15	15	35	25	25
Grand Total	**9.7**	**45.1**	**665**	**135**	**85**	**105**	**75**	**95**	**170**

Note: Table includes only live trees.
Note: Dead Standing = 55 trees/acre; (RA=45, SS=10); Ave DBH=5.1"; Ave Ht=22.3'

Analysis of the riparian stand data shows that most stands are heavily stocked, with average trees per acre (tpa) ranging from 580 to 1,370. Even when comparing the previously thinned tributary stand in Table 18 and unthinned tributary stand in Table 17, the thinned stand is still heavily overstocked. This high stocking, even after thinning, is a result of the thinning being conducted for timber production instead of riparian/wildlife objectives. These higher densities translate into roughly an average 9 foot by 9 foot tree spacing for 580 tpa and 6 foot by 6 foot spacing for 1,370 tpa. Historic stand density for these areas was inferred by measuring average spacing of harvested stumps. These data showed that the harvested dominant tree stands had an average of 70 tpa and a 25 foot by 25 foot spacing. Though larger residual and dominant second growth trees exist in these stands, their numbers are currently below that of historic levels. Additionally, the understories of these stands are heavily overstocked with predominantly smaller diameter trees.

Wildlife

The availability and distribution of productive old growth (POG) in lower elevation habitats is important to some species. Goshawks, bald eagles and other raptors prefer to nest in POG habitat below 1000 feet in elevation. Sitka black-tailed deer prefer high-volume old-growth stands with southern aspects located in areas below 800 feet in elevation for winter habitat use. Figure 16 and 17 show locations of high quality deer winter habitat, productive old growth habitat and harvested areas of Duffield and Adams watersheds.

Figure 16. Duffield Watershed

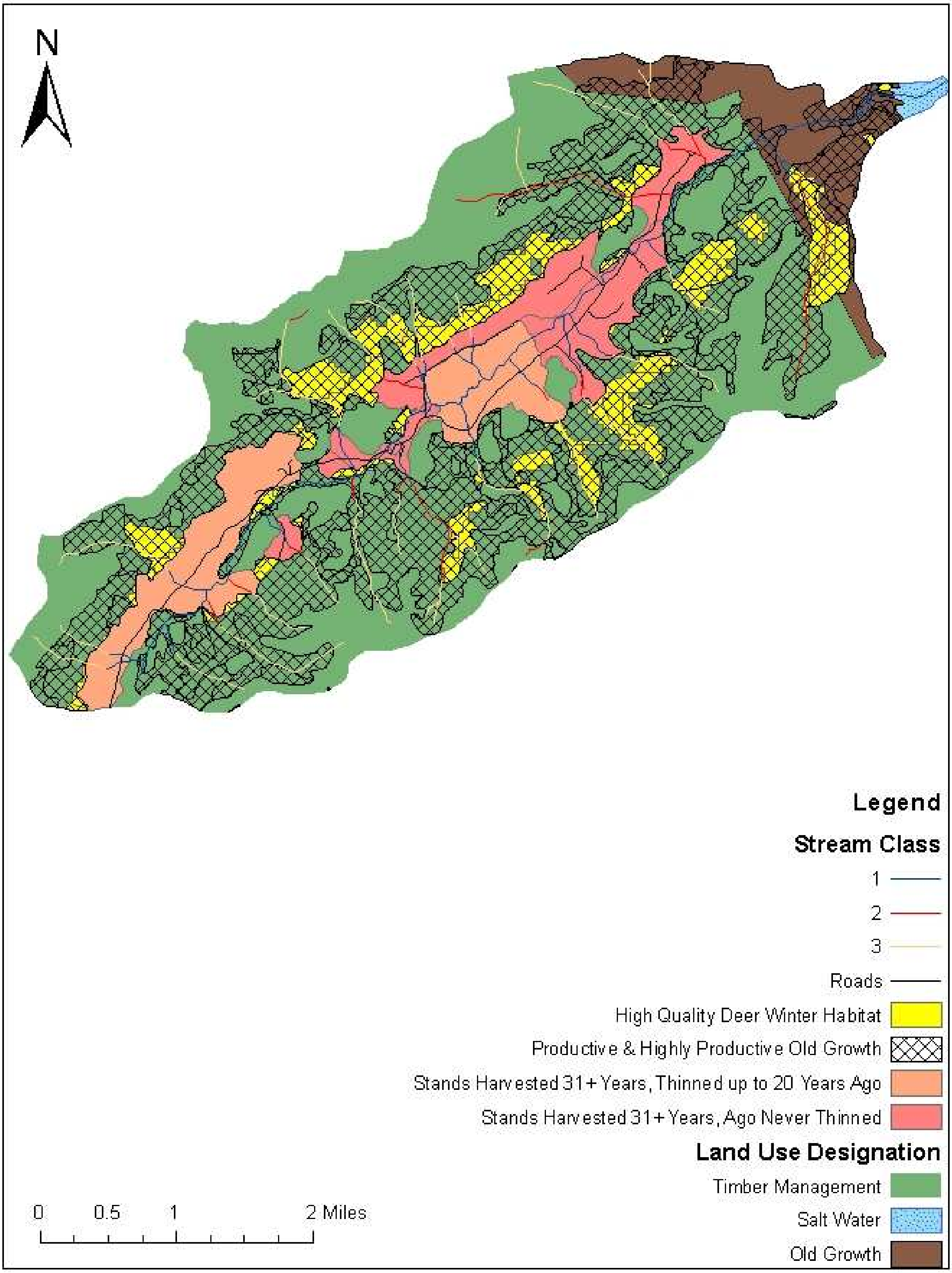
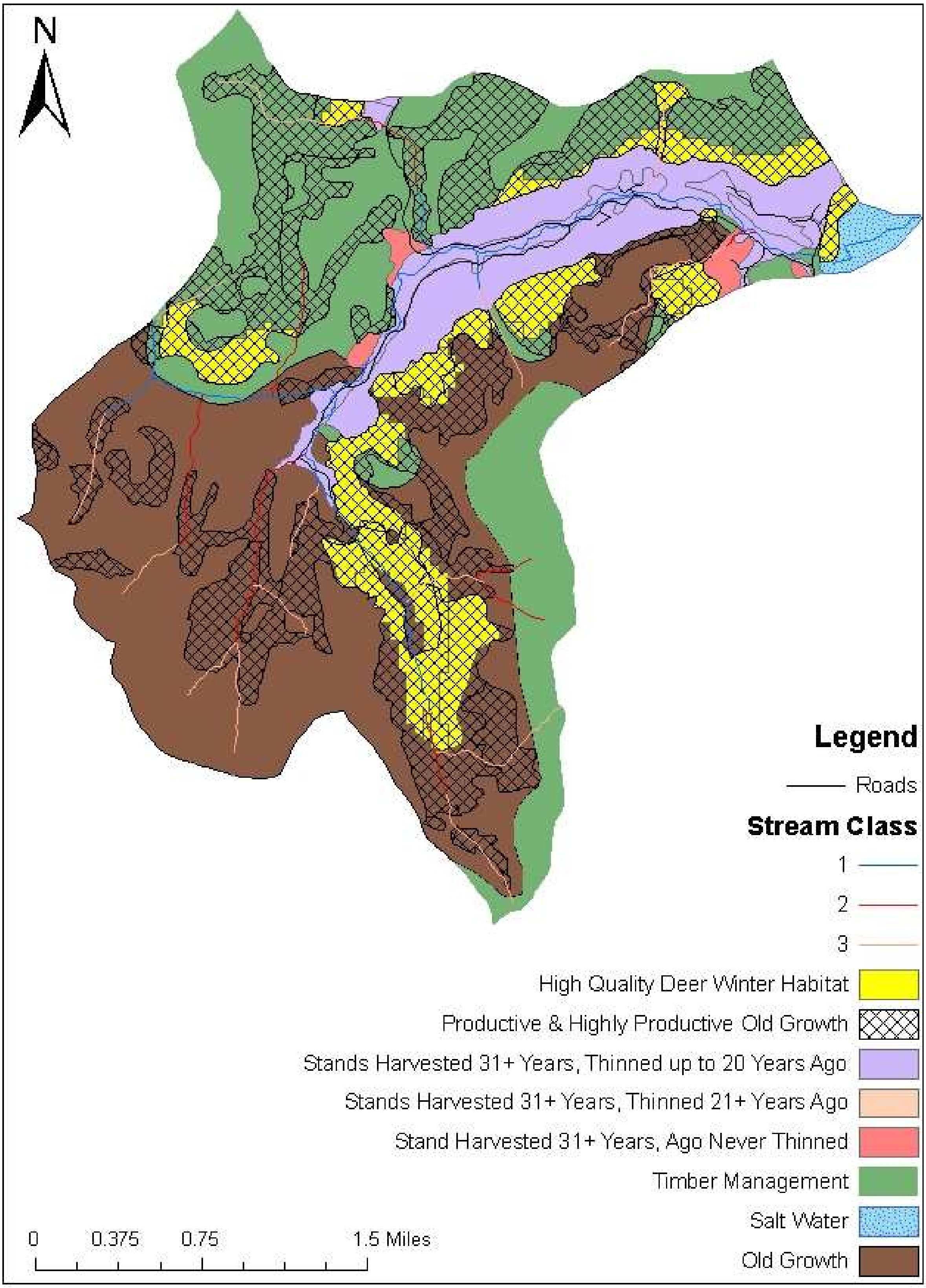


Figure 17. Adams Creek Watershed.



Roads

The vast majority of these roads are at best, single-track trails that are overgrown with alder and at worst undistinguishable from the surrounding landscape. Non-system roads are generally closed to motor vehicles but may be used by hikers and hunters.

A Road Condition Survey (RCS) was performed on the Duffield/Adams road system in 2000. There is a total of approximately 16.8 miles of roads (system and non-system) in the 2 watersheds, all of which are on National Forest System Lands and are not open to motorized vehicles (Table 19). . According to the 2000 RCS data, there were 94 stream crossings along these roads. Fifty of these streams have verified fish presence (Class 1 & 2). The majority of the structures are log bridges or culverts, which are failing and becoming sediment sources into these 94 streams. Many of these structures are currently or will become barriers to fish passage of some life history stage at various flows. Many structures pose a risk of completely diverting the stream courses when they fail. Tongass GIS data shows 2.6 miles of roads in stream Class 1, 2 or 3 RMAs in Duffield watershed and 3.0 miles of roads in stream Class 1, 2 or 3 RMAs in the Adams watershed (Table 19). RCS conducted in 2000, and field surveys conducted in 2005 and 2006 identified additional streams (some of which contain fish) and roads within RMAs that are not currently in the Tongass GIS system.

The total road density average for the Analysis Area is 0.7 mi/mi^2 (Table 19). Both of the watersheds have a relatively low overall density of roads.

Table 19. Road Summaries for the Analysis Area.

Watershed Name	Watershed Area (mi2)	RMA Area (mi2)	Total Miles of Road	Miles of Road within Stream RMA	Total Watershed Road Density (mi/mi2)	Stream RMA Road Density (mi/mi2)
Duffield Creek	16.7	1.4	10..2	2.6	0.6	1.9
Adams Creek	7.8	0.7	6.6	3.0	0.8	4.3
Total	**24.5**	**2.1**	**16.8**	**5.6**	**0.7**	**2.7**

Source: Sitka Ranger District 2006 GIS Coverage.

The effects of roads on water resources vary by the type of road as well as its location in the landscape. Roads and associated ditchlines can intercept surface and groundwater flows, thereby serving as first order streams during wet weather. Roads can also divert water from stream channels where they cross roads. This expanded stream network can serve to increase peak flow and sedimentation to stream channels if their densities and proximity to channels is high and close enough. Though there are no set thresholds for road densities within RMAs, we summarized that data to analyze the potential effects on stream channels, water quality and fish habitats. This analysis shows that the overall average road density within RMAs for the Analysis Area is 2.7 mi/ mi^2, with Adams Creek having the higher of the two with a density of 4.3 mi/ mi^2 (Table 19). RCS surveys and subsequent field visits did not find any OHV use occurring other than past use by Forest Service contract thinners. No resource degradation was identified with this OHV use.

Restoration Projects Completed

In 2005, restoration work started in Duffield watershed when 14 log stringer bridges and culverts were removed by blasting. This project continued in 2006 with the removal of an additional 12 structures and will continue again 2007 with 35 additional structures yet to be removed. In 2002, less than 100 acres of riparian thinning activities were conducted in the Duffield.

In 1989, restoration work in the Adams Creek watershed included: 1) construction of 30 LWD structures to improve Coho rearing, 2) connection of two gravel borrow ponds to Adams Creek to expand available rearing area for Coho, 3) revegetation of a mass wasting site adjacent to the main channel, and 4) beach fringe thinning along Rodman Bay to improve deer winter range characteristics. In 2003, 140 acres of Adams Creek riparian zone were thinned.

III. Problem Identification

Hydrology/Fish

Harvest activities and road construction modified the landscape and streams of the Duffield Peninsula. There are over 10 miles of Class 1, 2, and 3 streams within harvested stands in the Duffield Creek watershed. There are over 9 miles of streams within harvested stands of the Adams Creek watershed. The majority of Class 1 and 2 streams in the two watersheds are channel types that are sensitive to management activities (Tables 20 & 21), when carried out within Riparian Management Areas (RMAs) or along stream channels. Table 7 shows stream channel types in the two watersheds, while Tables 20 and 21 show stream channel types within managed stands.

Table 20. Streams Segments in Managed Stands in the Duffield Creek Watershed

Stream Class	Channel type	Miles	LW	Sediment Retention	Stream Bank Sensitivity	Sideslope Sensitivity	Flood Plain Protection Need	Culvert Fish Passage
I	AF1	3.3	H	H	H	N/A	H	H
	FP3	1.3	H	H	M	N/A	M	M
	FP4	2.8	H	H	H	N/A	H	H
II	AF2	1.9	M	M	H	N/A	H	L
III	HC6	0.9	M	L	M	H	N/A	L
	Total	**10.2**						

Source: Sitka Ranger District 2006 GIS Coverage.

Table 21. Streams Segments in Managed Stands in the Adams Creek Watershed

Stream Class	Channel type	Miles	LW	Sediment Retention	Stream Bank Sensitivity	Sideslope Sensitivity	Flood Plain Protection Need	Culvert Fish Passage
I	AF1	0.2	H	H	H	N/A	H	H
	FP3	0.1	H	H	M	N/A	M	M
	FP4	1.7	H	H	H	N/A	H	H
	LC1	1.2	L	L	L	M	N/A	L
	LC2	0.4	L	L	L	H	N/A	L
	MC1	0.1	L	L	L	L	N/A	L
	MM2	0.5	H	M	H	L	M	H
II	AF2	0.2	M	M	H	N/A	H	L
	MC3	0.2	L	L	L	H	N/A	N/A
III	Data Gap	4.8						
	Total	**9.4**						

Source: Sitka Ranger District 2006 GIS Coverage.

Roads

Roads in RMAs or stream crossing structures such as log stringer bridges and culverts have created migration barriers to fish, modified stream flow regimes, diverted water from natural stream courses, and routed sediment to streams.

A Road Condition Survey (RCS) was performed on the Duffield/Adams road system in 2000. There is a total of approximately 17 miles of roads (system and non-system) in the 2 watersheds. According to the 2000 RCS data, there are 94 stream crossings along these roads. Fifty of these streams have verified fish presence (Class 1 & 2). The majority of the structures are log bridges or culverts, which are failing and becoming sediment sources into these 94 streams. Many of these structures are currently or will become barriers to fish passage of some life history stage at various flows. Many structures pose a risk of completely diverting the stream courses when they fail. Tongass GIS data show 2.6 miles of roads in stream Class 1, 2 or 3 RMAs in Duffield watershed and 3.0 miles of roads in stream Class 1, 2 or 3 RMAs in the Adams watershed. RCS conducted in 2000, and field surveys conducted in 2005 and 2006 identified additional streams (some of which containing fish) and roads that are not currently in the Tongass GIS system.

Harvest

Harvest occurred along over 19 miles of streams in Duffield and Adams watersheds (Table 20 and 21). 380 acres (approximately 42%) of RMAs (stream class 1, 2 and 3) in the Duffield watershed and 156 acres (approximately 35%) of RMAs in the Adams watershed were harvested. Harvest occurred in the main valley bottom of the watershed in depositional stream channel zones.

Many of the stream channel types in the Analysis Area are sensitive to disturbances and are dependant on large wood for proper functioning (Table 20 and 21). Fish habitat and aquatic ecosystem function has been impaired along the watershed due to riparian harvest and the conversion from conifer-dominated riparian areas to red alder-dominated riparian areas. Timber harvest in RMAs and along streams in the Duffield and Adams watersheds directly impacted streams by erosion and sedimentation during logging activities and has caused a reduction of LW currently available to streams by removing trees in RMAs that could have fallen into streams. Red alder growing in many of these areas are too small to effectively function as LW. The loss of LW in streams has increased stream gradient, reduced pool quality and quantity and reduced gravels available for spawning and rearing of anadromous and resident salmonids.

Wildlife/Silviculture

Clearcut harvest was conducted over 40 years ago with thinning activities completed on a very small portion of the managed area, which previously contained productive old growth habitat and served as valuable deer winter habitat. Red alder dominates or is a large component of the harvested area, and it is recognized that much of that forest structure will continue to be even-aged until thinning occurs. Much of the areas of conifer re-growth are in the stem exclusion stage. With a lack of gaps in the forest canopy conifer regeneration is extremely slow. In addition, the lack of light reaching the forest floor prevents the growth of herb/shrubs causing reduced food source for foragers. Other problems associated with these harvested and unthinned units are poor winter habitat for deer and the reduction in connectivity of productive old growth.

Currently, connectivity of old growth habitat is reduced by these large, young growth stands. There are over 750 acres of high quality deer winter habitat adjacent to harvested stands in the Duffield watershed and 480 acres in the Adams watershed as identified in the Sitka Ranger District Strategy for Prioritizing Stands for Treatment (USDA 2005). Some portions of the harvested stands would benefit by pre-commercial thinning activities of conifer and deciduous trees and have the potential to become productive old growth (POG) and provide connectivity for old growth dependent species and high quality deer winter habitat.

IV. Summary and Recommendations

The following recommendations were created to move the existing conditions where problems were identified toward desired future conditions and restoration objectives outlined in the Tongass Forest Plan (1997).

Hydrology/Fish:

Duffield watershed had a total of 59 remaining failing log structures. In 2005, a fisheries enhancement pilot project using explosives was implemented to improve fish habitat and restore fish passage for coho, pink, and chum salmon, steelhead, sculpin and Dolly Varden char to stream habitat impacted. The road is impassable due to failed structures at river crossings and incised stream channels, preventing the use of conventional machinery. This project removed 26 structures in 2005 and 2006, and will continue in 2007 to remove the remaining 33+ structures.

Thinning activities in riparian areas can in the long term restore riparian structure and/or instream fish habitat by decreasing the time needed to grow large trees that may serve as LW in the future. In the short-term, the addition of LW as large, single pieces or aggregates of smaller pieces into streams will bring more immediate benefits to quality and quantity of fish habitat thereby creating conditions to support larger and healthier populations of anadromous and resident fish.

In Adams watershed, there are at least 2 small ponds/lakes that may be connected to the channel to provide valuable off-channel rearing habitat to Adams Creek. Two borrow ponds were connected to Adams Creek in 1989. It is unknown if the ponds are still connected to the stream system because several large stream flow events may have disconnected the ponds. Additional monitoring and stream inventories are needed in Adams Creek watershed to determine effectiveness of this past work and to identify additional opportunities for fish and wildlife habitat restoration.

Wildlife/Silviculture:

The availability and distribution of productive old growth (POG) in lower elevation habitats is important to some species. Goshawks, bald eagles and other raptors prefer to nest in POG habitat below 1000 feet in elevation. Sitka black-tailed deer appear to prefer high-volume old-growth stands with southern aspects that receive little snowfall and are located in areas below 800 feet in elevation for winter habitat use.

Duffield Creek

In the Duffield watershed there are approximately 469 acres of clearcut harvest in the watershed considered as Tier 3 young growth stands as identified in the Sitka Ranger District Strategy for Prioritizing Stands for Treatment (2005). Tier 3 stands are defined as the south aspect, under 800 feet elevation harvested 20+ years ago, not Beech Fringe. There are 407 acres of high quality deer winter habitat adjacent to the Tier 3 young growth stands. High quality deer winter habitat is defined as areas containing productive old growth (POG) or highly productive old growth (HPOG) at elevations under 800 feet and is based on the Tongass deer winter model (Doerr et al. 2005, Suring et al. 1992).

There are approximately 1232 acres of clearcut harvest in the watershed considered as Tier 4 young growth stands as identified in the Sitka Ranger District Strategy for Prioritizing Stands for Treatment (2005). Tier 4 stands are defined as the not south aspect, under 800 feet elevation harvested 20+ years ago, not Beech Fringe. It is important to note that entire stands were assigned the aspect and elevation that represented the majority of the stand area using 60m resolution Digital Elevation Models. This resulted in some stands getting a lower rating because they were not south aspect, but portions of the stands actually were south aspect. Numerous stands are less than 5% slope in some aspect other than south in the wide valley bottom and in reality function the same as Tier 3 stands. This is readily apparent in the valley bottom of Duffield. There are approximately 342 acres of high quality deer winter habitat adjacent to the Tier 4 young growth stands. A large portion of the harvested stands have the potential to become POG or HPOG and provide connectivity for old growth dependent species and high quality deer winter habitat.

Adams Creek

In the Adams Creek watershed there are approximately 616 acres of clearcut harvest rated as Tier 4 young growth stands as identified in the Sitka Ranger District Strategy for Prioritizing Stands for Treatment (USDA 2005). There are 480 acres of high quality deer winter habitat adjacent to these harvested stands. Currently, connectivity of old growth habitat is reduced by these large, young growth stands. Some portions of the harvested would benefit by pre-commercial thinning activities and have the potential to become POG or HPOG and provide connectivity for old growth dependent species and high quality deer winter habitat. Canopy gaps or specific areas to thin should be designated after field inventories are conducted

Like Duffield, all Adams harvest was conducted over 40 years ago (1961-1964) with thinning activities completed in 2002 and 2003. Thinning did not alder dominated stands and consequently, these stands are missing an understory forage component. Without thinning, these areas will take longer to get the desirable old growth characteristics due to suppression of understory plant communities.

The management of young-growth stands is a responsibility that comes with timber harvest and is an important element of timber and land management. At present, only a small amount of the harvest generated young-growth stands within the Duffield watershed has been precommercially thinned to improve the growth and yield of timber, to change the species mix to favor more profitable species, or to improve wood quality. Multiple emphasis prescriptions should be designed to maintain, enhance, or restore understory vegetation by delaying canopy closure and maintaining greater species diversity. Wildlife emphasis thinning treatments to enhance wildlife corridors and deer winter range within uplands stands are recommended for the Duffield Creek watershed. Thinning activities in harvested areas would remove a portion of the red alder component to favor growth of understory coniferous trees species such as Sitka spruce, western hemlock which would accelerate tree growth and stand development of old growth characteristics.

For silviculture purposes, there is no additional thinning recommended for Adams Creek watershed. However, the creation of canopy gaps and thinning corridors to connect productive old growth areas for wildlife would be beneficial in the long term by accelerating stand development toward old growth characteristics.

Inventory Needs

Additional riparian area and stream site visits are required to determine site specific restoration prescriptions. Existing, as well as any additional stream survey data information should used to update Tongass GIS stream data, determine fish habitat quality (compared to reference reaches) and determine where LW placement would benefit aquatic ecosystems based on stream channel types and condition. Additional riparian vegetation survey information should determine if precommercial or commercial thinning activities would enhance riparian function. Riparian and upland vegetation surveys should be conducted to determine if thinning activities would accelerate development of old growth habitat characteristics for dependant mammalian and avian species.

Table 22 summarizes the mechanisms with potential influence on low flows in the Analysis Area. At the landscape scale the most influential factors are location in landscape, and climate change. This mechanism is beyond human control.

Table 22. Summary of Factors Influencing Watershed Health.

Driving Factor	How Factor Influences Streamflow and Watershed Habitats	Relative Degree of Influence
Climate	Decadal trend in warmer temperatures (1977-98) leads to less snowpack available for groundwater recharge, resulting in lower summer streamflows. Seasonal shift between winter and summer low flow is more likely than annual decline.	Low.
Timber harvest and Young Growth Management (Flow)	Reduced canopy may accelerate snowmelt, resulting in earlier depletion of groundwater reserves. Rapid release of conifer seedlings, shrubs and dense second growth may increase evapotranspiration loss.	Low.
Timber harvest and Young Growth Management (Stream Habitat)	Reduced riparian tree heights and stand age due to harvest resulting in future source of LW deficit.	Moderate to high at the stream reach scale.
Timber harvest and Young Growth Management (Wildlife Habitat)	Reduced tree heights and stand age due to harvest resulting in stem exclusion structure and reduced understory vegetation in riparian, upland and beach fringe stands.	Moderate to high at the local stream reach and/or stand scale.
Roads and Related Diversions	Some roads intercept groundwater and may have altered hydraulic gradients, reducing groundwater available to streams. Some roads capture and divert surface water.	Low.
	Bedload deposition up and downstream of removed crossing structures constrictions can result in disappearance of surface flow in vicinity of road during low flow periods.	Low, but moderate at the stream reach scale at individual sites.
ATV trails	Unhardened ATV trails capture/divert surface water, reducing groundwater storage.	Low.

Historic management activities may be contributing to declining hydrologic condition along individual reaches. Roads and ditches capture and redistribute water, which could be influential at sub-basin or stream reach scales. The high extent of forest canopy loss to clearcuts in riparian area over the past forty years may have altered timing and quantity of flows during earlier stages of succession. The valley bottom and lowland alluvium deposits where the most roads and timber harvest have occurred are most sensitive to these factors.

Historic reference hydrologic condition in this area can be found in some respects, through comparison of the Analysis Area watershed data and that of the Regional Habitat Variables and existing gage and water quality data from the Kadashan watershed. There is some evidence that the hydrologic condition of the Duffield and Adams watersheds may be in decline due to human influence.

A summary of recommendations for the Analysis Area at large, and specific to the two watersheds, follows. Watersheds are listed geographically and recommendations are listed in rough priority, without regard to land ownership.

Broad (Landscape) Recommendations

Riparian and Upland Thinning Treatment Areas
Within the Analysis Area, many of the previously harvested stands associated with riparian areas are approaching or have reached the age and size at which canopy closure has begun. Silviculturists and other resource specialists, including those from fisheries, wildlife, hydrology, and soils, should collectively produce prescriptions for these areas and implement thinning activities within the next ten years. Potential silvicultural treatments should address the desirable species mix, understory biodiversity, and site conditions. General suggestions for implementing riparian regeneration treatments are listed in Appendix G of the Forest Plan.

As new markets develop for small diameter wood and/or technology improves to allow the selective harvest of trees without damage to residual crop trees, opportunities for commercial thinning of young-growth may emerge. Most young-growth stands within the Analysis Area are approximately 55-60 years from meeting the minimum 100-year rotation age for regeneration harvest (i.e., even-aged management such as clearcutting).

Instream Large Woody Debris
Future watershed rehabilitation should continue the placement of large wood (LW) into streams currently lacking large wood. Where available, stream survey information should be used to assess the current condition and trends of key stream habitats and to determine the locations at which additional instream LW is needed. Additional stream surveys should be completed in areas impacted by past management activities for which data are lacking.

Road Maintenance and Restoration
Roads within the Analysis Area are, for the most part, deteriorating. All of the system and non-system roads reviewed have some remaining drainage structures in place and are being allowed to “brush in”. The public has expressed a desire for more roads and better quality roads to be used for recreation purposes, and as this desire and use (of all kinds) continues to increase, the existing open road systems on the District will become even less adequate and users will likely branch out for new opportunities.

Access and Travel Management (ATM) planning and Off Highway Vehicle (OHV)for the Analysis Area is currently taking place for the entire Sitka Ranger District, including road, foot travel and OHV use. This effort will determine what road systems are necessary to meet access objectives and follow with maintenance and rehabilitation plans consistent with protection of soil and water resources. The Forest Service recently announced a proposed rule to require each forest to designate a system of roads, trails and areas slated for motor vehicle use. Once the designation process is complete, ATV use would be confined to designated routes and areas, and

ATV use off these routes (cross-country travel) would be prohibited. The development of an OHV plan for the District must include the education and cooperation of ATV users.

Restoration work should involve removing drainage structures and/or ditching at existing washout sites, cleaning partially plugged culverts, stabilizing or removing unstable road fills and cutbanks, and removing artificial barriers to fish passage (as determined from future road inventories).

Timber Harvest
Present market conditions, in conjunction with high logging and transportation costs, currently make timber sale offerings from the Sitka Ranger District marginally attractive to existing purchasers in Wrangell and Hoonah. Although it does not currently exist, there is potential in the Analysis Area and surrounding areas for a small-scale, value-added industry that produces dried, planed, and finished wood products. Consequently, in the short term, economically viable timber sale opportunities within the Analysis Area are quite limited.

Land Use Designations
Determine whether LUDs with the Analysis Area meet Forest Plan standards and guidelines.

Recommendations by Watershed

Duffield Bay Watershed Group

- Continue road rehabilitation plans focused on maintaining natural distribution of surface and groundwater, as well as improve/restore fish passage..
- Consider second growth management objectives in harvested riparian areas. Primary objective should be recovery of old growth structure and canopy for wildlife and fisheries habitat.
- Consider second growth management objectives in harvested upland areas. Primary objective should be recovery of old growth structure and canopy to restore wildlife habitat.
- Complete inventories of remaining non-system roads to assess sediment source areas and potential fish barriers, and remove existing drainage structures and repair other problem areas identified.
- Update the existing stream and riparian GIS layers using field verification, digital orthophoto overlays, and aerial photo interpretation. Use this to updated the information presented in this analysis for the Northwest Baranof Landscape Assessment.
- Complete additional stream surveys for representative channel reaches to assess the current condition and trends of key stream habitat within planning area watersheds. As directed in the 1997 Forest Plan, compare stream survey information (by channel type) to Regional Fish Habitat Variables.
- Focus timber management to minimize windthrow forest canopy alteration. All silvicultural activities should also include objectives to minimize windthrow.
- Maintain habitat connections by utilizing innovative timber harvest techniques to replicate natural disturbances (reduce opening size, selective harvest).
- Work with the Alaska Department of Fish and Game (ADF&G) and the US Fish and Wildlife Service (USFWS) to identify key connectivity routes between non-development LUDs.

Adams Creek Watershed Group

- Continue road rehabilitation plans focused on maintaining natural distribution of surface and groundwater, as well as improve/restore fish passage..
- Consider second growth management objectives in harvested beach fringe areas. Primary objective should be recovery of old growth structure and canopy to restore/enhance deer winter range habitat.
- Complete inventories of remaining non-system roads to assess sediment source areas and potential fish barriers, and remove existing drainage structures and repair other problem areas identified.
- Update the existing stream and riparian GIS layers using field verification, digital orthophoto overlays, and aerial photo interpretation. Use this to updated the information presented in this analysis for the Northwest Baranof Landscape Assessment.
- Complete additional stream surveys for representative channel reaches to assess the current condition and trends of key stream habitat within planning area watersheds. As directed in the 1997 Forest Plan, compare stream survey information (by channel type) to Regional Fish Habitat Variables.
- Complete inventories of remaining non-system roads to assess sediment source areas and potential fish barriers, and remove existing drainage structures and repair other problem areas identified.
- Focus timber management to minimize windthrow forest canopy alteration. All silvicultural activities should also include objectives to minimize windthrow.
- Maintain habitat connections by utilizing innovative timber harvest techniques to replicate natural disturbances (reduce opening size, selective harvest).
- Work with the Alaska Department of Fish and Game (ADF&G) and the US Fish and Wildlife Service (USFWS) to identify key connectivity routes between non-development LUDs.

Monitoring and Information Needs

A variety of hydrologic information needs are briefly identified here

1. How does seasonal and annual streamflow vary in response to continued climate change? Maintain stream gage at Kadashan.
2. How do low flows vary during rainless weather in valley bottom and lowland areas? Maintain/add district stream gages.
3. How does groundwater influence low flows in watershed with and without management activities? Install and maintain monitoring wells on the District.
4. What is the stream temperature regime in these watersheds and their tributaries with respect to state water quality criteria (focus on low flows and harvested reaches)? Install continuous temperature instruments (and/or maintain those near stream gages) and add air temperature.
5. What is the condition of all drainage structures and/or removed structures on roads with respect to flow conveyance, diversion (seasonal or perennial), fish passage, and sediment sources? Continue and expand field inventories and monitoring of removed structures.
6. Are OHV trails diverting streams or resource degradation? Continue and expand field inventories.

7. What are the long term trends in channel morphology and habitat features along harvested reaches within the Analysis Area? Repeat Tier II surveys and establish monumented Tier III surveys and cross sections.
8. How is LW recruitment in the Analysis Area watersheds affecting LW distribution and function? Tag and monitor key pieces.
9. Has past precommercial and riparian thinning activities in Duffield and Adams watersheds achieved the desired conifer species mix and spacing, and has the connectivity of existing productive old growth been enhanced by these management actions or is additional thinning is necessary? Monitor and previously thinned stands to verify that species mix and spacing has been obtained. Thinned unthinned stands to obtain resource objectives
10. Have previous watershed/in-stream restoration measures in Adams Creek obtained their enhancement objectives. Monitor existing in-stream LW and pond enhancement structures and projects.

V. Watershed Restoration Plan

This section outlines the restoration strategy designed to meet the objectives the Hydrologic Condition Assessment (HCA) for the Analysis Area previously completed in this document.

Restoration Objectives

The Tongass Forest Plan (USDA 1997) designates standards and guidelines for the management of different forest resources. The following objectives are pertinent to the Duffield and Adams watersheds:

- **Hydrology/Fish**
  - Restore stream banks and stream channel processes (ie: flow regime, sediment dynamics)
  - Maintain or restore natural quantities of LW
  - Reconnect streams and restore opportunities for fish migration (eliminate current and future blockages)
  - Reduce sedimentation sources - restore water quality to provide for fish production and sustain soil productivity
  - Move physical characteristic (ie: width-depth ratio, pool spacing, incision) and aquatic habitat (ie: spawning, rearing habitat) toward pre-management conditions expected for channel types.

- **Wildlife/Silviculture**
  - Provide productive old growth habitat and connectivity for dependant species (ie: goshawk, brown bear, marten), create deer winter habitat, and enhance forage component.
  - Improve timber growth and productivity

Table 23 displays the criteria used to prioritize watershed improvement activities. The following sections provide detailed project descriptions, objectives, benefits, timelines and estimated project costs.

Table 23. Criteria for Prioritizing Analysis Area Watershed Improvement Activities.

Driving Factor (HCA)	Restoration Issues/Concerns/ Objectives	Relative Degree of Influence	Relative Probability of Success for Restoration	Rehab Priority
Roads and Runoff Diversions	Some roads intercept groundwater and may have altered hydraulic gradients, reducing groundwater available to streams. Some roads capture and divert surface water. Bedload deposition up and downstream of removed crossing structures constrictions can result in disappearance of surface flow in vicinity of road during low flow periods. **Objectives: Restore adequate stream flow conveyance, cross drainage and fish passage along all roads.**	Moderate to high at sub-basin or stream reach scale	High	**#1**
Timber harvest and Young Growth Mgt (Flow).	Reduced canopy may accelerate snowmelt, resulting in earlier depletion of groundwater reserves. Rapid release of shrubs may increase evapo-transpiration loss. **Objective: Implement thinning treatments for dense, young growth stands to accelerate development of mature forest canopy structure.**	Low	Low in the short-term	**#2**

Timber harvest and Young Growth Mgt (Stream Habitat).	Reduced riparian tree heights and stand age due to harvest resulting in future source of LW deficit **Objective: Implement thinning treatments for dense, young growth stands to accelerate development of mature forest canopy structure. Increase tree diameter upon snagging will increase Key LW counts, improving Stream Habitat.**	Moderate to high at the stream reach scale.	High	**#3**
Timber harvest and Young Growth Mgt (Wildlife Habitat).	Reduced tree heights and stand age due to harvest resulting in stem exclusion structure and reduced understory vegetation in riparian, upland and beach fringe stands. **Objective: Implement wildlife emphasis thinning treatments for dense, young growth stands to accelerate development of mature forest canopy structure to improve deer winter range and bear habitat.**	Moderate to high at the local stream reach and/or stand scale.	Low in the short-term, High in long-term	**#4**
Pond/Lake Connection	Several burrow ponds created for road construction are located immediately adjacent to stream channels. **Objective: Connect Ponds to stream channels created off-channel rearing habitat for fish.**	Moderate to high at stream reach scale	Moderate to high	**#5**

Project Descriptions and Implementation Schedule:

1. Duffield Creek Watershed Young Growth Riparian Treatments.

Site Type/Description: Current harvested riparian stand compositions consist of 580-1,370 total trees per acre, with conifer densities at 234-800 trees per acre. Conifer size distribution show the majority of trees are small in diameter and suppressed by extremely high density alders (175-570 trees per acre).

Treatment Objective/Description: Implement thinning strategies that will improve second-growth canopy conditions to improve low flows, riparian wildlife habitat and accelerate dominant tree growth for future sources of instream LW. Objective will involve treatment of 225 acres of previously harvested riparian stands to reduce conifer tree density and improve understory development. Thinning treatments should consist of a combination of girdling and thinning alders to release conifers to a minimum 20 foot by 20 foot.

Benefits: Restored riparian habitat and increased conifer growth for future sources of LWD along 9.3 miles of Class 1 and 2 fish streams, improved fish rearing habitat in natural stream channels, improved bank stability and watershed function.

Outputs: 225 acres of riparian habitat restored

Project Phase/FY: Design and Restoration, FY 2007 (75 acres)
Design and Restoration, FY 2008 (150 acres)

Estimated Cost: $77,298 (FY 2007)
$60,000 (FY 2008)

Funding Type(s): NFVW

Activity Type: Watershed Stewardship

Partnership Contribution: N/A

2. Duffield Creek Watershed Young Growth Upland Treatments.

Site Type/Description: Current harvested stand compositions consist of high density, overstocked stands with little understory development.

Treatment Objective/Description: Implement thinning strategies that will improve second-growth canopy conditions to improve wildlife habitat, understory development and accelerate dominant tree growth for old growth characteristics. Objective will involve treatment of 200 acres of previously harvested stands to reduce conifer tree density and improve understory development. Thinning treatments should consist of a combination of girdling, thinning and gap treatments to release conifers to a minimum 14 foot by 14 foot.

Benefits: Restored upland habitat and increased conifer growth for understory plant development and improved deer winter range habitat.

Outputs: 200 acres of upland habitat restored

Project Phase/FY: Design and Restoration, FY 2008

Estimated Cost: $80,000

Funding Type(s): NFWF

Activity Type: Watershed Stewardship

Partnership Contribution: N/A

3. Duffield-Adams Watershed Group Road Restoration and Structure Removal.

Site Type/Description: 17 miles of road: Scope of problems identified through the RCS process. 33+ stream crossing structures remain on class 1 or 2 fish streams.

Treatment Objective/Description: Remove all remaining 33+ structures through the use of explosives so as not to cause excessive disturbance of vegetated road surface.

Benefits: Restored anadromous and resident fish access, reduced sedimentation and improved watershed function and water quality.

Outputs: 17miles of system road restored.

Project Phase/FY: Design and Restoration, FY 2007 & 2008

Estimated Cost: $87,500 (FY 2007)
$XXXX (FY 2008)

Funding Type(s): CMRD, TRTR, NFWF, NFAF

Activity Type: Watershed Stewardship

Partnership Contribution: Alaska Department of Natural Resources (Personnel, Flight Time and Monitoring)

4. Adams Creek Watershed Stream Inventory.

Site Type/Description: Previous harvest within the Adams watershed has occurred along approximately 5 miles of Class 1 and 2 stream channels. Burrow ponds associated with road construction exist adjacent to stream channels.

Treatment Objective/Description: Complete Tier II and III stream surveys along harvested stream channels to assess impacts of past management activities on water resources and fish habitat. Surveys would also include feasibility analysis of connecting additional burrow ponds to stream channels for rearing habitat for fish.

Benefits: Inventory and condition of stream channels and fish habitats within the watershed. Project development for future restoration and enhancement of stream channels and fish habitats.

Outputs: 5 miles of stream inventory; future project development.

Project Phase/FY: inventory FY 2008

Estimated Cost: $5,000

Funding Type(s): NFVW

Activity Type: Watershed Stewardship

Partnership Contribution: N/A

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APPENDIX A: LAND USE DESIGNATIONS

Timber Production
The goals of this designation are: 1) to maintain and promote industrial wood production from suitable timber lands, providing a continuous supply of wood to meet society's needs; 2) to manage these lands for sustained long-term timber yields; and 3) to seek to provide a supply of timber from the Tongass National Forest which meets the annual and planning-cycle market demand, consistent with the standards and guidelines of this land use designation.

Old-growth Habitat Reserve
The goals of this designation are: 1) to maintain areas of old-growth forests and their associated natural ecological processes to provide habitats for old-growth associated resources; and 2) to manage early seral conifer stands to achieve old-growth forest characteristic structure and composition based upon site capability.

Appendix B: Tongass Stream Habitat Variables

Table 1. Average, Maximum and Minimum for Eight R10 Habitat Parameters.

Habitat Attribute	Process Group=FP		Process Group=MM		Process Group=MC_LC		Process Group=HC	
	Harvested		Harvested		Harvested		Harvested	
	NO	YES	NO	YES	NO	YES	NO	YES
WD	28 (79-9)	29 (66-5)	14 (53-2)	21 (45-11)	19 (60-4)	27 (86-4)	8 (14-2)	11 (15-5)
TLWD/M	.40 (1.68-0.1)	.36 (1.11-0.05)	.34 (.71-.08)	.23 (.32-.03)	.24 (.42-.13)	.20 (.62-0)	.32 (.48-.23)	.26 (NA)
TKWD/M	.11 (.25-.02)	.12 (.30-.02)	.11 (.27-.01)	.002 (NA)	.10 (.29-.01)	.07 (.19-.02)	.26 (.44-.07)	NA
POOL/KM	41 (99-8)	30 (64-5)	58 (164-11)	44 (127-18)	44 (80-9)	38 (181-2)	71 (136-44)	76 (112-50)
POOL SPACE	3.98 (32.4-0.04)	2.70 (11.5-0.02)	0.97 (9.03-.03)	1.18 (3.08-0.02)	2.21 (16.3-.19)	4.62 (45.9-.07)	0.49 (.77-.29)	0.20 (.4-.11)
RPD/CBW	0.05 (.13-.03)	0.04 (.09-.03)	0.09 (.16-.04)	0.07 (.18-.04)	0.07 (.25-.03)	0.07 (.13-.02)	0.08 (.13-.05)	0.10 (.18-.06)
D50	38 (109-6)	36 (68-10)	55 (122-17)	86 (210-25)	117 (319-17)	71 (168-23)	107 (211-29)	345 (1000-93)
PLNGTH/m	.45 (.80-.11)	.47 (.80-.02)	.28 (.43-.10)	.44 (.80-.15)	.29 (.51-.01)	.49 (1.01-.13)	.24 (.58-.03)	.36 (.51-.21)

Note: These data are based on main channel habitat data only, does not include side channel habitat data.

Table 2. Percentiles for Each of the Eight Stream Parameters. (NA=not available)

Habitat Attribute	Percentiles	Process Group=FP		Process Group=MM		Process Group=MC_LC		Process Group=HC	
		Harvested		Harvested		Harvested		Harvested	
		NO	YES	NO	YES	NO	YES	NO	YES
WD	25	18.0	18.6	5.8	13.9	7.3	11.5	6.1	9.6
	50	23.5	23.8	10.7	18.4	14.8	18.5	7.9	11.5
	75	33.6	38.4	16.1	23.7	22.4	39.9	10.3	12.7
TLWD/M	25	.23	.16	.21	.19	.17	.08	.24	NA
	50	.33	.25	.30	.25	.21	.14	.26	NA
	75	.47	.49	.47	.29	.28	.20	.37	NA
TKWD/M	25	.04	.07	.04	NA	.03	.03	.17	NA
	50	.09	.10	.10	NA	.07	.04	.27	NA
	75	.19	.13	.12	NA	.15	.08	.35	NA
POOL/KM	25	24.6	21.4	41.7	24.5	31.5	14.1	48.6	62.4
	50	41.0	28.3	51.0	34.9	44.0	30.9	62.3	71.3
	75	52.7	36.2	68.4	44.9	58.0	44.1	80.0	85.0
POOL SPACE	25	.46	.22	.20	.45	.39	.43	.32	.12
	50	1.84	.57	.37	.62	.81	.83	.50	.16
	75	5.49	4.52	.71	2.22	2.49	2.11	.62	.24
RPD/CBW	25	.039	.035	.066	.048	.057	.042	.069	.068
	50	.045	.042	.075	.056	.066	.065	.081	.076
	75	.060	.046	.098	.076	.077	.076	.091	.107
D50	25	20	20	25	32	53	36	61	113
	50	29	30	49	43	109	53	122	143
	75	50	51	83	143	162	90	132	375
PLNGTH/m	25	.32	.32	.17	.35	.25	.25	.11	.31
	50	.48	.50	.29	.38	.30	.29	.12	.36
	75	.56	.66	.37	.55	.37	.79	.36	.40

Table 3. Data Collection Methods and Equations Used to Calculate the Eight Habitat Response Variables from Field Surveys.

Habitat response variable	Equation	Data Collection
Width-to-depth ratio (WD) a	Bankfull width:bankfull depth	Bankfull width Bankfull depth (mean and maximum)
Total Large Wood pieces/meter (TLWD/M)	# pieces/meters surveyed	Total count of large wood pieces >1 m long and 0.1m in diameter. Total length of stream surveyed
Total Key pieces Large Wood/meter (TKWD/M)	# key pieces/meters surveyed	Total count of key large wood pieces Key piece size based on average channel bed width of stream surveyed. Total length of stream surveyed
Pool/Km (POOL/KM)	# pools/kilometer surveyed	Total count of pools Total length of stream surveyed
Pool Spacing (PL SPC)	(Length of stream surveyed/channel bed width)/total number of pools	Total length of stream surveyed Channel Bed width Total number of pools
Residual Pool Depth/Channel Bed width (RPD/CBW)	Average of all pool residual depth/average channel bed width	Residual Pool depth=maximum pool depth – pool tail depth Channel Bed width (width of stream from bottom of bankfull to bottom of bankfull)
d50 b	Median particle size	Measure intermediate diameter of 100 pebbles
Pool Length/M (PLNGTH/M)	Total pool length/total length of stream surveyed	Sum of all pool lengths Total length of stream surveyed

a (Dunne and Leopold 1978; Rosgen 1996)