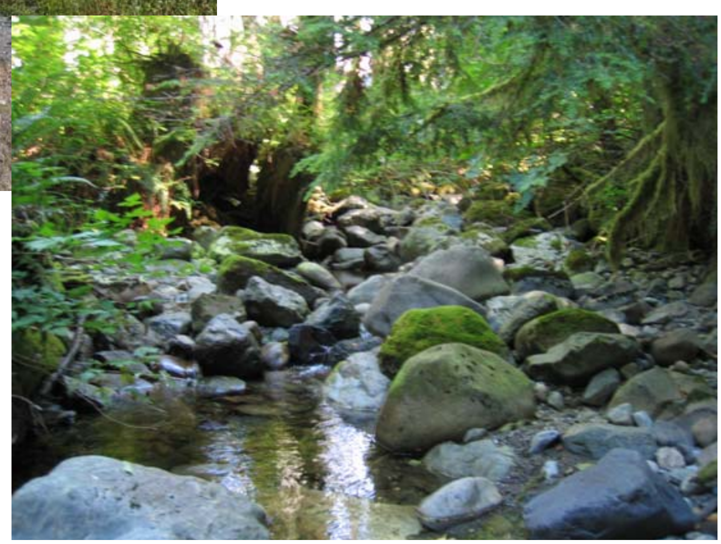
NATURAL RESOURCES

Habitat Conservation Plan for State Trust Lands
2006 Implementation Monitoring Report

October 2007



WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

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Ecosystem Services Section
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Special Contributors
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Contributions are by DNR staff unless otherwise indicated.
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2006 Implementation Monitoring

1. Introduction

The Washington State Department of Natural Resources (DNR) developed a multi-species Habitat Conservation Plan (HCP) for managing forested state trust lands. Authorized under the Endangered Species Act (ESA), the HCP is a partnership between DNR and the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (now known as NOAA Fisheries Service) (collectively, the federal Services). The 70-year HCP guides all DNR management activities on approximately 1.6 million acres of forested state trust lands throughout Washington State (WADNR 1997).

To manage habitats more effectively, lands under the HCP were divided into nine planning units based primarily on large watersheds. A contractual agreement was established in 1997 between DNR and the federal Services to implement and monitor activities under the HCP.

The 2006 Implementation Monitoring Report focuses on documenting whether selected HCP conservation strategies were implemented as written.

Implementation monitoring priorities are identified each year so that one or more of the three main strategies is monitored. The three main conservation strategies are for the northern spotted owl, marbled murrelet, and riparian forest ecosystems.

2006 Priority

The riparian forest strategy is composed of several elements, including provisions for management of unstable slopes, riparian management zones, roads, and hydrologic maturity in the rain-on-snow zone. Because the riparian management zone (RMZ) portion of the riparian conservation strategy had not been monitored since 2003, monitoring of RMZs was listed as a priority for 2006. Thus in 2006, implementation monitoring of RMZs was conducted in the five Westside HCP planning units (North Puget, South Puget, Straits, South Coast and Columbia).

Riparian management zones are vegetated buffers applied alongside streams. These buffers are designed to protect and restore high quality aquatic habitat for salmon and other species. By contributing large trees, down woody debris, and standing snags, these riparian zones provide a variety of habitat features. They also help to stabilize stream banks and prevent sediment from entering the stream, creating healthier ecosystems. Monitoring RMZs involves examining several components in order to determine whether they are properly implemented. These include stream typing surveys, site index verification, RMZ width measurements, and, where appropriate, wind buffer verification.

The objectives of this report are to:

- Describe new 2006 field methods;
- Explain how multiple changes in stream typing rules have affected HCP implementation monitoring;
- Analyze the effect of global positioning system (GPS) accuracy on determining Riparian Management Zone width compliance;
- Report and discuss results for RMZ width compliance; and
- Present suggestions to improve methods for future monitoring.

2. Methods

The Riparian Management Zone portion of the riparian conservation strategy was monitored in 2003 and again in 2006. The methods used differ significantly between the two field seasons. The methods section aims to first briefly compare methods from 2003 and 2006 before detailing the sampling strategy and field methods applied in 2006.

Comparison between 2003 and 2006 Implementation Monitoring

One of the main differences between monitoring in 2003 and 2006 was the field method used for measuring RMZ widths. In 2003, the team used a series of individual width measurements (a more traditional method for determining width). In 2006, we employed the latest GPS technology in the field to gain a more comprehensive vision of the total area of an RMZ. Table 2.1 illustrates the main differences between sampling strategies and field methods for RMZ width measurements between 2003 and 2006. Figures 2.1 and 2.2 illustrate the difference between the two field methods.

Table 2.1. Differences in implementation monitoring for riparian management zones between the 2003 and 2006 field seasons

	2003	2006
Differences in sampling strategy	Monitored multiple strategies at a given timber sale site.	Monitored a single strategy at a given timber sale site.
	Monitored all streams and RMZs at a given timber sale site.	Monitored a random sample of streams—up to two per timber sale unit.
Differences in field methods for RMZ width measurement	Individual width surveys (using laser rangefinder) along each stream segment (Figure 2.1).	GPS (Trimble Pro XR) surveys encompassing entire RMZ segment—100% width measurement (Figure 2.2).

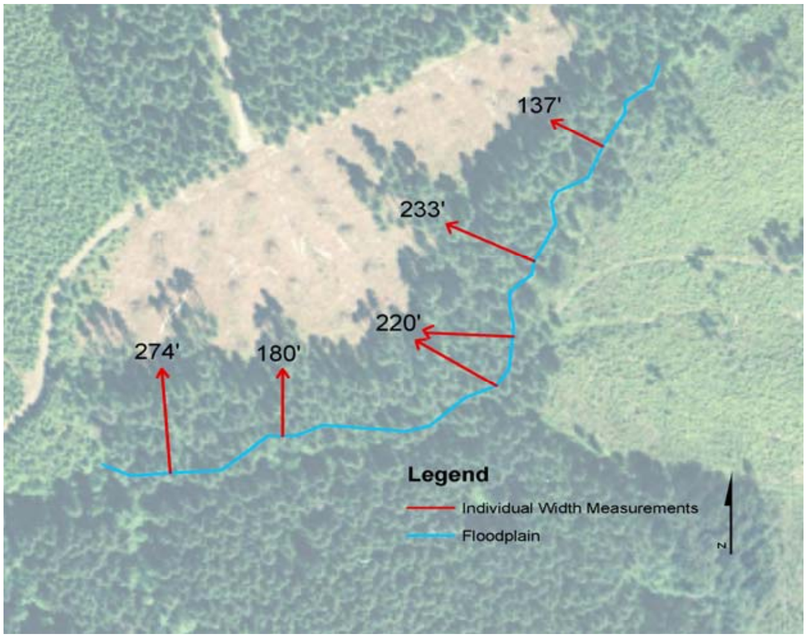


Figure 2.1. Type 3 stream segment illustrating the method of measuring an RMZ using individual width measurements. Measurements are taken perpendicular to the floodplain.

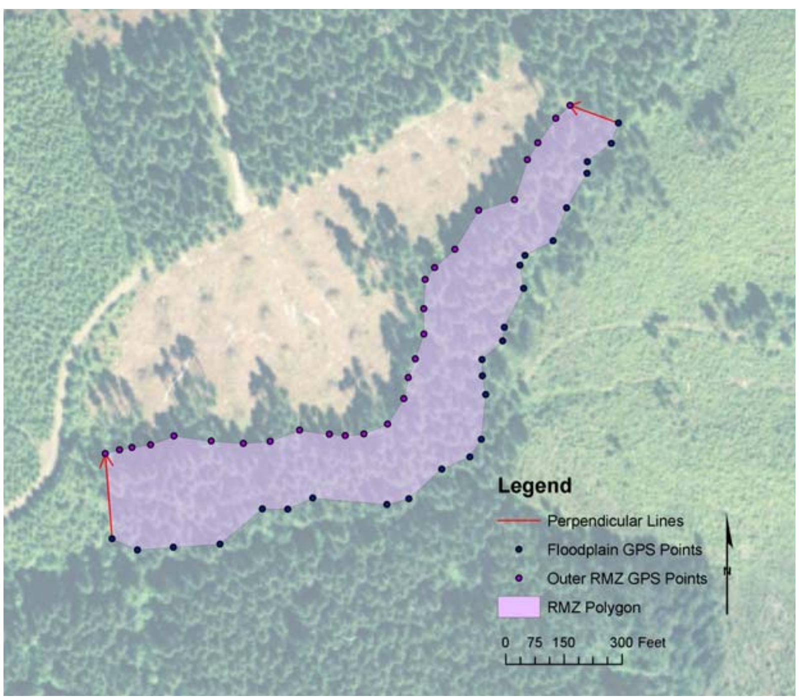


Figure 2.2. Type 3 stream segment illustrating the method of measuring an RMZ using the GPS method. GPS points are collected along the floodplain and outer RMZ with the ends perpendicular to the floodplain.

As part of the 2006 implementation monitoring, we planned to verify the site potential height of trees in a mature conifer stand at base age 100 (this is how RMZ width is determined for Type 1, 2, and 3 streams). However, due to time constraints, we did not meet this goal. Therefore, we assumed the site potential tree height listed by the forester in timber sale documents was correct. We focused on three implementation monitoring criteria: 1) stream typing, 2) RMZ measurements, and 3) wind buffer verification.

Sampling Strategy

In 2006, 20 percent of the timber sales that closed in fiscal year 2005 were randomly selected to be monitored for implementation of the RMZ portion of the riparian conservation strategy in each Westside region (Northwest, South Puget Sound, Pacific Cascade, and Olympic). We chose to monitor 20 percent of timber sales per region, based on the amount of work we predicted we could accomplish with two technicians in the field every day for five months.

Maps for each selected timber sale were taken from individual timber sale jackets. It was estimated we would be able to monitor two stream segments per timber sale unit. If fewer than two streams were shown on the map, a single stream was selected. If more than two streams were shown, we randomly selected two for monitoring. Type 2, 3, and 4 streams (Type 1 streams were absent in the total population of stream segments) were assessed for all three monitoring criteria. Selected Type 5 streams were assessed for correct stream type only because RMZs for Type 5s are used only when necessary (WADNR 1997). Two Type 9 streams were also randomly selected. Type 9 streams are considered an unknown stream type and the assignment of a Type 9 typically occurs prior to field checking the streams. All streams are to have an appropriate stream type (1, 2, 3, 4, or 5) assigned when the sale is set up. The compliance issue here is that stream typing on two sales was incomplete prior to harvest. Table 2.2 lists the 36 selected timber sales and the number of stream segments by type.

Table 2.2. Selected timber sales, by region, and the number of stream segments, shown by stream type

Region	Timber Sale	Stream Type				
		2	3	4	5	9
Pacific Cascade	Airball		1		4	
	Short Stand		1		5	
	Rotten Tags			2	5	
	Shift		1		1	
	Walker Ridge				2	
	Horizontal Elk BD				2	
	Ellsworth Flats				2	
	Burnett		2		2	
	Patchy Knight				1	
	Salsa		4	1	2	
	Mulligan Thinning		2	5	2	
	Crazy Diamond			2	1	
	Bradley Partial Cut	1	3	1		
	North Branch		1	1		
	Browns Vantage		1		1	
	Impulse			1	1	
	Totals	**1**	**16**	**13**	**31**	**0**
Northwest	Gasping Goodwin					1
	Zinfandel		1		3	
	Capriccio		1	1	5	
	Chipper		1	1		
	Back Hat		1	1		
	Loquat		1		1	
	J Dozer					1
	Black Top Hat[1]		1		1	
	Waterworks			1	1	
	Totals	**0**	**5**	**4**	**10**	**2**
Olympic	East Siebert		1		2	
	Walker Road #2	1	2		1	
	Nineteenth Hole		1			
	Rainforest Thinning			1	1	
	Totals	**1**	**4**	**1**	**4**	**0**
South Puget Sound	McDonald Ridge			2	2	
	Jagged Edge			1	6	
	Five Shares		1		1	
	East Boundary		1	1	4	
	Moon Glow		2			
	Catch 2 Pole		2		1	
	Betty Beaver				4	
	Totals	**0**	**6**	**4**	**18**	**0**
	Westside Totals	**2**	**31**	**22**	**63**	**2**

Note: No Type 1 streams are listed as none were available to sample.

[1] Due to a major wind storm and winter weather Black Top Hat timber sale was not sampled, and the streams are not included in the total.

Stream Typing Rules

DNR's stream typing system has evolved since the HCP was signed in 1997. The following timeline describes the major changes.

- 1997 — Streams were typed based on the Forest Practices 1996 emergency rules for stream typing (Washington Administrative Code (WAC) 222-16-031; WADNR 1997).
- 2000 — Forest Practices stream typing rules were changed from 1996 emergency rules to the Forest and Fish rules (WAC 222-16-030). In 2000, division staff used the new rules and DNR region employees were instructed to implement the Forest and Fish stream typing rules on the ground. The change inadvertently put the agency at odds with its HCP. In addition, if we were to type streams using the Forest and Fish rules, we would not be conducting HCP implementation monitoring as it was written (B. Livingston, personal communication, February 20, 2007).
- 2006 — When the implementation procedures for the Riparian Forest Restoration Strategy (RFRS) were published (Bigley and Deisenhofer 2006), DNR's HCP stream typing rules were again changed. This time, we reverted to the 1996 emergency rules, but the authors called them the "Water Typing System for Forested State Trust HCP Lands." In this document, we will refer to this stream typing system as the RFRS rules.

Table 2.3 illustrates the main differences and similarities in physical criteria between the RFRS and 2000 rules.

Table 2.3. A comparison of stream typing rules

Water Type	RFRS Rules (1996 Emergency Rules)	Water Type	2000 Rules (i.e. Forest and Fish Rules)
Type 1	Shorelines of the state	**Type S**	Shorelines of the state
Type 2	>20' ordinary high water mark <4% gradient Fish	**Type F**	>20' stream width <4% gradient Fish
Type 3	≥ 2' ordinary high water mark <16% gradient or >16% or <20% with >50 acres contributing basin size Fish	**Type F**	≥ 2' stream width <16% but not greater than 20% gradient >16% or <20% with >50 acres contributing basin size Fish
Type 4	≥ 2' ordinary high water mark > 20% gradient or >16% or <20% with <50 acres contributing basin size	**Type NP**	Stream segment contains water at all times during normal rainfall year Downstream from perennial source Basin size ≥ 52 acres (outside of Sitka spruce zone) Basin size ≥ 13 acres (in Sitka spruce zone)
Type 5	< 2' ordinary high water mark May not have a well defined channel Water may be seasonal	**Type Ns**	Seasonal water Stream segment physically connected to a Type 1, 2, 3, or 4 water

Ideally, we would have checked Type 4 and Type 5 streams using both the Riparian Forest Restoration Strategy rules and the 2000 rules. It is impossible to determine proper stream typing if the rules used to check streams are not the same rules implemented on the ground by foresters. However, due to an initial lack of understanding by the foresters and our monitoring staff concerning the history of stream typing rules, how they apply to HCP monitoring, and confusion around the similarities between the two sets of rules streams were monitored based only on the RFRS rules. The RFRS rules are the only rules that are consistent with HCP implementation monitoring (B. Livingston, personal communication, February 20, 2007).

Given the similarities and differences between the 1996 and 2000 rules, we would have been able to evaluate mistyping between Type 2 and Type 3 streams. However, we did not find any mistyped Type 2 or 3 streams. For Type 4 and Type 5 streams, we assessed stream typing but will not suggest any type changes because we were checking how well stream types matched the RFRS rules, whereas foresters may have implemented stream typing using the 2000 rules. We assumed that foresters typed streams correctly based on the rules they were using, even in cases where we thought the stream was mistyped based on RFRS rules. Therefore we assumed that RMZ widths could still be considered for compliance analysis.

It is crucial to establish that we are not attempting to correct any stream types because of the differences in rules. In addition, there may be streams that were mistyped according to the rules they were set up under, but we did not check the appropriate criteria in the field to make that determination. The stream typing methods and results can be found in Appendix 2.

RMZ Width Measurements

The purpose of measuring Riparian Management Zone widths is to make certain the width of a particular RMZ segment meets the requirements defined in the HCP (Table 2.4). RMZ width is determined based on stream type and site potential tree height at base age 100 years (WADNR 1997). Site potential tree height is based on the 100-year site index for the dominant conifer species.

Table 2.4. Required RMZ widths for stream types

	Stream Type		
	1, 2, & 3	**4**	**5**
Required RMZ Width	Site potential height of mature conifer Site index = 100 years	100 feet	Guidelines are based on mass wasting for water quality, fish habitat, streambanks, wildlife, and other important elements of the aquatic ecosystem

To check for wind buffers and areas of unstable slopes, we relied on information contained in timber sale jackets. We found no documentation of wind buffers thus we assumed none were applied to the RMZs we monitored. RMZ widths were measured using a combination of GPS and geographic information system (GIS) technologies. A Trimble Pro XR (Figure 2.3) was used for collecting GPS data in the field, which is referred to as the GPS method.

Figure 2.3. A member of the field crew using the Trimble Pro XR to collect GPS data at a survey monument

“In the field, the width of the riparian buffer shall be measured as the horizontal distance from, and perpendicular to, the outer margin of the 100-year floodplain” (WADNR 1997, p. IV.56). After determining the location of a particular RMZ segment, the 100-year floodplain was identified using physical features such as ordinary high water mark, topography, and vegetation, as outlined in the Habitat Conservation Plan (WADNR 1997). A perpendicular line was marked and measured from the outer margin of the floodplain to the outer edge of the RMZ (Figure 2.4).

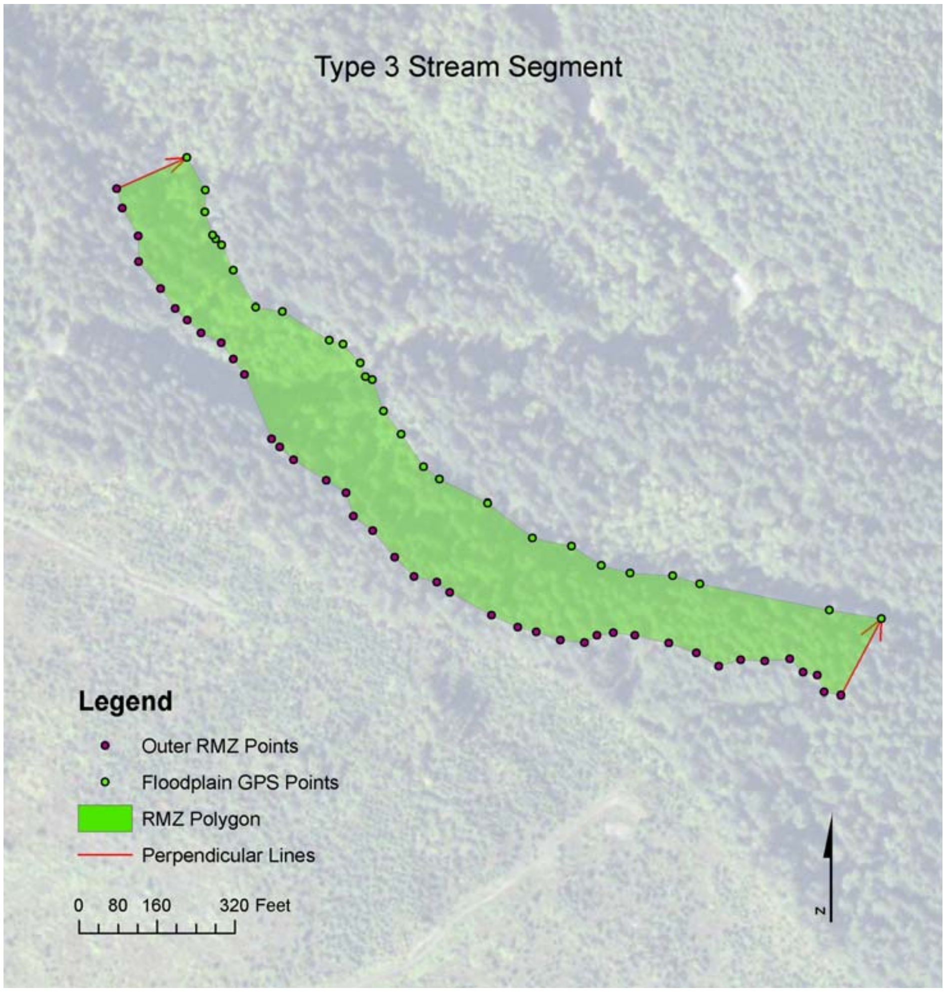


Figure 2.4. Map showing lines perpendicular to stream and GPS positions marking the floodplain and outer edge of an RMZ

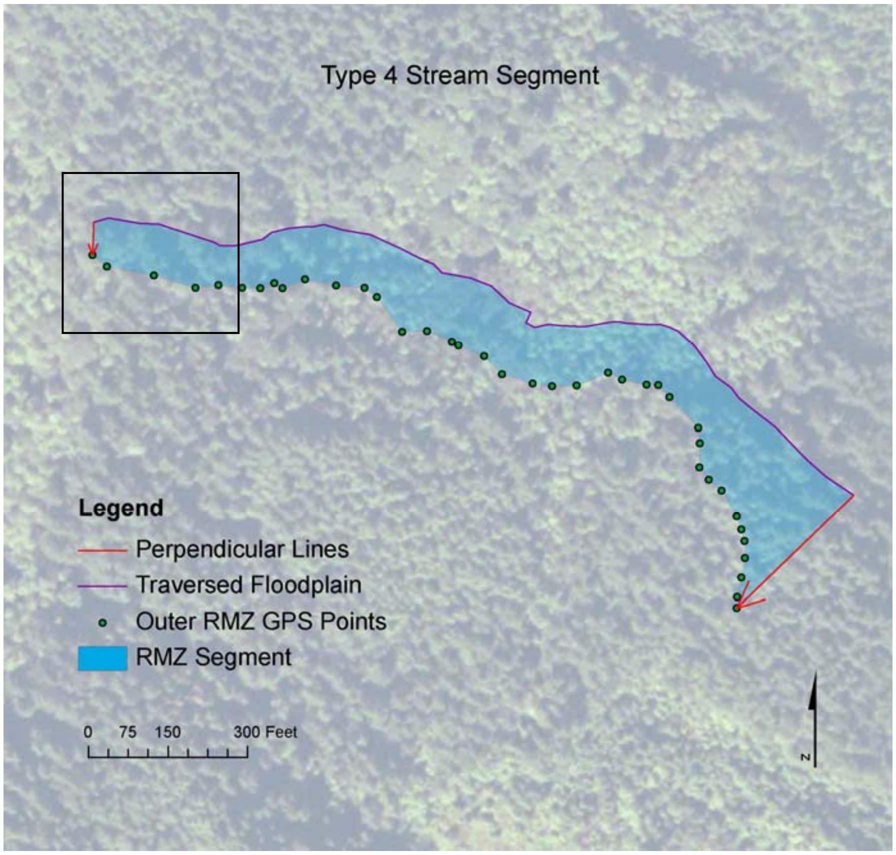
Global positioning system points were collected approximately every 50 feet along the floodplain. We attempted to capture any changes in floodplain direction. GPS points were also collected approximately every 50 feet along the outer edge of the RMZ, at trees marked with boundary tags. We collected GPS position data at a spot between each tagged tree and the nearest stump. Typically, stumps were only a few feet from the tagged trees, so this was not a point of subjectivity.

There are several opinions regarding where an RMZ stops and a timber harvest begins. We chose a point on the outer edge of the RMZ, typically at a tagged tree (Figure 2.5). However, if there was a stump on the line, we selected a location on the RMZ side of the stump to collect GPS data. When a tagged tree had fallen, we approximated a location between the root wad or hole left by the fallen tree and the nearest stump. In most cases, stream segments were on the edge of timber sale units, so RMZs only needed to be measured on one side. When a stream ran through the middle of a timber sale unit, we measured RMZs on both sides of the stream.

Figure 2.5. Boundary tag marking the outer edge of an RMZ

In order to collect data when GPS was not available due to terrain, canopy cover, or time of day, we developed two alternative methods for recording the location of the 100-year floodplain and/or the outer RMZ. Both alternative methods, known as the "traverse method" and the "offset method" are variations on the GPS method and capture the same information that the GPS method captures.

When conducting the traverse method we started from a GPS location associated with the stream segment (there were no situations when we could not collect some GPS points). We used a laser rangefinder and compass to take distance and bearing measurements where needed to collect data on the entire RMZ segment (Figure 2.6). For both methods, distance and bearing measurements were recorded on a traverse field form (Appendix 4).



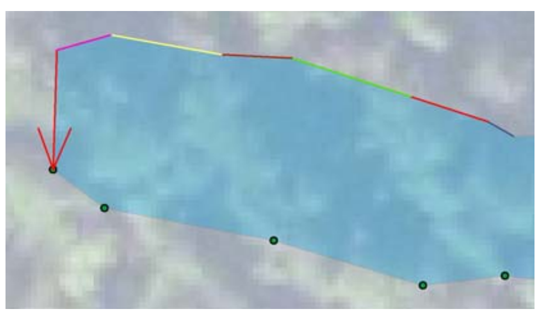


Figure 2.6. A Type 4 stream RMZ segment in which the floodplain needed to be traversed as a result of poor satellite coverage (above). Distance and bearing measurements were taken as traverse segments. These data were input to GIS to create the floodplain line. The lower image shows several traverse segments (outlined in the above image), each highlighted in a different color.

The offset method entailed using a GPS point as the known location, and then measuring a distance and bearing to a particular point using a compass and laser rangefinder; for example, a specific location on the floodplain where GPS was not available, as shown in Figure 2.7.

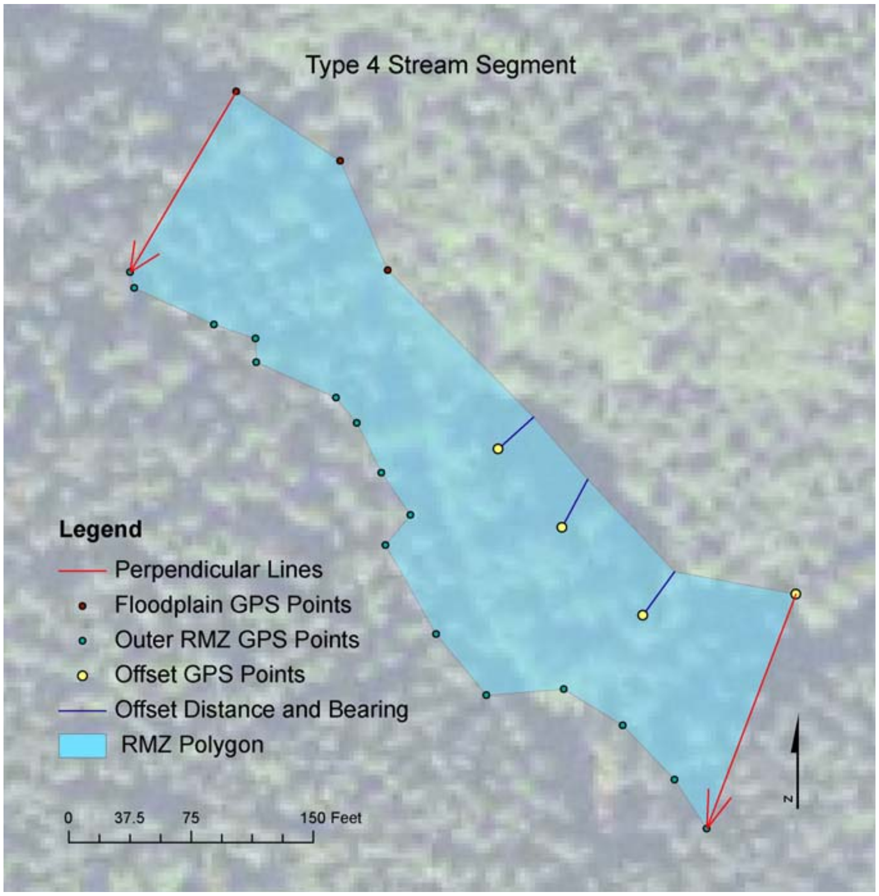


Figure 2.7. An illustration of the offset method

The offset method was also implemented when RMZs were measured on both sides of a stream segment. Offset was used to measure the width of the drainage gradient from one side of the floodplain to the other (Figure 2.8).

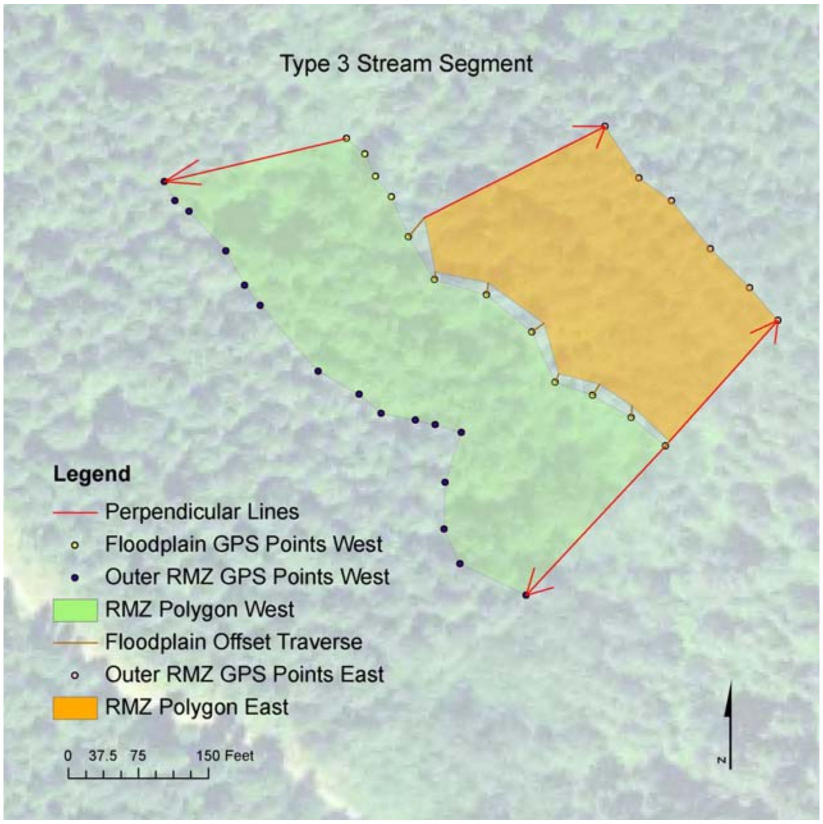


Figure 2.8. Another version of the offset method in which GPS points are taken on one side of the floodplain, then a distance and bearing is measured to the opposite side of the floodplain

In the office, GPS data were corrected using Pathfinder Office software (a more detailed discussion is in Appendix 3) and corrected shape files were added to the GIS project created for each timber sale. Polygons were created for each RMZ and used to calculate the average width.

Once an average width was determined it was compared to the required width, as documented by the forester in the timber sale jacket. The average RMZ width, as calculated from the field data, was then divided by the required RMZ width to determine the percent of the required width actually applied, which would indicate how well the RMZ met HCP guidelines.

Setting a Threshold for RMZ Width Compliance

Determining whether Riparian Management Zone widths are compliant or non-compliant is a complex issue. The following points may introduce error in measured RMZ width.

1. **The 100-year floodplain.** Frequently the 100-year floodplain is the same as the ordinary high water mark. However, occasionally it is not, and floodplain locations can vary in interpretation depending on slope and vegetation. It was assumed that our delineated location of the floodplain did not differ greatly from that delineated by the forester. We may have introduced some bias especially

when determining the floodplain on wide, flat streams. We may have tended to underestimate the floodplain, thus overestimating the RMZ.

2. **Outer RMZ trees.** We took GPS locations on the outer RMZ at trees marked with boundary tags. In some cases there was not a tree at the measured outer RMZ edge that could be tagged. In those cases, foresters may have marked the next tree in (towards the stream), leaving the RMZ measurement narrower than required.
3. **Traverse and offset measurements.** Of the 61 RMZs that we measured, we used the traverse method on 16, and the offset method on10. We did not quantify the error generally involved in conducting a traverse, but these errors were minimized by taking short measurements (measuring distance was usually affected by the presence of thick brush), and by using the offset method as often as possible. We assumed the offset method error would be less than that of a traverse because each distance and bearing is associated with a GPS point, which would reduce cumulative error.
4. **Wind buffers.** We assumed that each RMZ did not include a wind buffer, unstable slope buffer, or unmarked leave trees. Wind buffers and unstable slope buffers should have been documented in the individual timber sale jacket, but not necessarily marked on the ground. Several times we did find clumps of leave trees along the outer RMZ but they were typically well marked.
5. **GPS accuracy.** In order to determine a level of compliance for RMZ width, we relied on an acceptable level of error according to the accuracy of the GPS, which was quantified through survey monument analysis and additional information from other studies and publications.

Before reporting the results for RMZ width measurements it is important to discuss GPS accuracy and how it relates to determining HCP compliance. We thought it made sense to base a level of compliance on GPS accuracy (see Appendix 3 for details on setting up the GPS for accuracy and differential correction). For example, if we determined that a particular RMZ width was 95 percent of the required width, the question arises, how accurate was the GPS in measuring RMZ average width? We attempted to address this question by:

- Comparing our GPS accuracy to that of Washington State Department of Transportation surveyed monuments; and
- Using the results from other studies to determine a level of accuracy in forested areas.

Root mean squared error (RMSE) can be used to determine deviations of GPS points from an independent source of identical points with higher accuracy by summing the measurements and then taking the square root (Federal Geographic Data Committee 1998). Our survey monument data showed an average error of 2.9 feet (n = 48) and a 95 percent confidence accuracy value of 5.0 feet. These points were collected mostly along roads with few obstructions. The United States Forest Service conducted a study (R.K. Karsky, personal communication, January 18, 2007) looking at the 95 percent confidence accuracy of several types of GPS receivers under different levels of canopy cover. Table 2.5 summarizes results from our survey monument data and other studies.

Table 2.5. Summarized results from four studies of GPS accuracy for the Trimble Pro XR and the Trimble Pro XH

		Receiver Type	RMSE[1] (feet)	NSSDA[2] 95% Confidence (feet)
Implementation Monitoring (2006)	Survey Monuments (relatively open canopy)	Trimble Pro XR	2.9	5.0
Karsky (2007)	"Open Canopy"	Trimble Pro XR	1.6	2.7
	"Medium Canopy"		5.2	9.0
	"Heavy Canopy"		5.2	9.0
Piedallu and Gégout (2005)	"High Forest"	Trimble Pro XH	7.2	12.5
Naesset (1999)	"Forested Canopy"	Trimble Pro XH	2.6 - 5.9	4.5 - 10.2

1 Root mean squared error

2 National Standard for Spatial Data Accuracy

We compared GPS accuracy with several studies using the root mean squared error and the 95 percent confidence accuracy value to calculate GPS accuracy (Table 2.5). Based on information provided by R.K. Karsky (personal communication, January 18, 2007), the 95 percent confidence accuracy value under medium and heavy canopy is nine feet. Other studies which used a different type of Trimble receiver (Naesset 1999; Piedallu and Gégout 2005) reported an RMSE comparable to, but slightly higher than, the results of the Trimble Pro XR. We used results from studies using the Pro XR and the Pro XH to estimate a threshold. These results support our decision to set a compliance threshold.

The 95 percent confidence limit of the Pro XR under medium and heavy canopy was nine feet, which is nearly 10 percent of a 100 foot RMZ. Based on this, we set the GPS accuracy threshold for percent required RMZ width at 90 percent for Type 1, 2, 3, and 4 streams. We applied this threshold as a percent in order to standardize the required width calculations. An argument could be made that because we collected GPS data on both sides of an RMZ the 10 percent should be applied to both the floodplain and outer RMZ edge. However, GPS points on the outer RMZ edge are mostly collected under open canopy (at least 80 percent of the RMZs we looked at were adjacent to regeneration harvests) making it easier to collect data with higher accuracy. The 90 percent threshold based on GPS accuracy is strictly an approximation which when applied to Type 1, 2, or 3 streams is conservative because 10 percent is not the same average distance for RMZs whose width typically ranges between 150 and 200 feet.

To include room for human error in determining the location of the floodplain and the outer buffer (per the assumptions previously discussed) additional calculations were made to determine the average number of feet required to make an RMZ width meet the 90 percent threshold. Based on these calculations we decided to change the minimum percent required width to 87 percent to allow for a five foot discrepancy in average width. In other words, any RMZ that required more than an additional five feet of average width to meet the required width fell below the percent required width and was considered non-compliant.

The following categories were used to express how RMZ widths met (or didn't meet) the requirements set up under the HCP.

1. **Less Than 87 Percent Required Width –** For the purposes of this report any Riparian Management Zone that did not meet the expectations for required width is considered non-compliant. Where expectations were not met it was because the RMZ width was less than the threshold with the added 3 percent for human error.
2. **At Least 87 percent Required Width –** For the purposes of this report RMZs that did meet the expectations for required width are considered compliant.

3. Results

In 2006, we typed 120 stream segments and measured 61 RMZs within a total of 35 timber sales across DNR's four Westside regions. The remainder of this analysis looks at results — first by all Westside regions, and then by individual region.

Stream Typing

Because of the changes in stream typing rules, we did not always use the same rules for implementation monitoring that the foresters used to type streams at the time the timber sales were set up. Consequently, it is impractical to evaluate whether streams were typed correctly. We made the assumption that streams were typed correctly in order to assess RMZ width. All stream typing results are based on using the Riparian Forest Restoration Strategy rules, located in Appendix 2.

RMZ Width Measurements

Of the 61 RMZ widths we measured in all Westside regions, 11 (18 percent) were less than 87 percent of the required width and 50 RMZs (82 percent) were at least 87 percent (Figure 3.1). Results are displayed first, by distribution of RMZ compliance for all RMZs by region; and second, by compliance for RMZ width for each stream, by region.

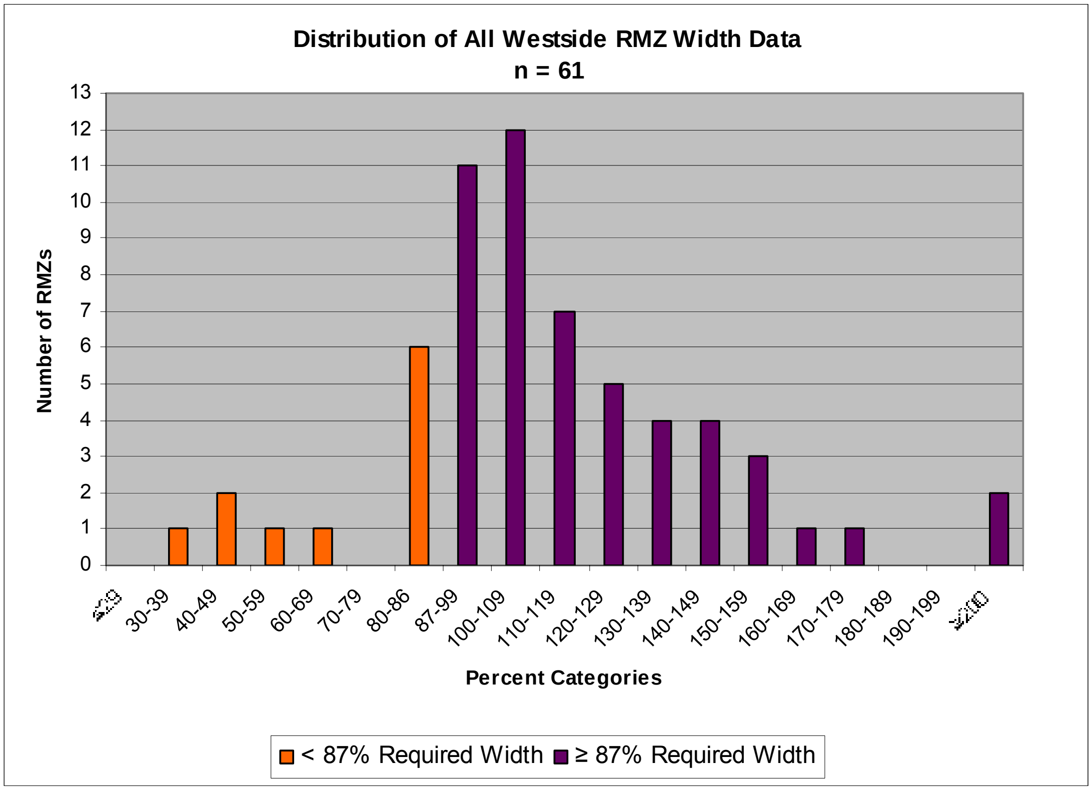


Figure 3.1. Distribution of all Western Washington 2006 RMZ width compliance data

NORTHWEST REGION

In Northwest Region, one RMZ was less than 87 percent of the required width and nine were at least 87 percent (Figure 3.2).

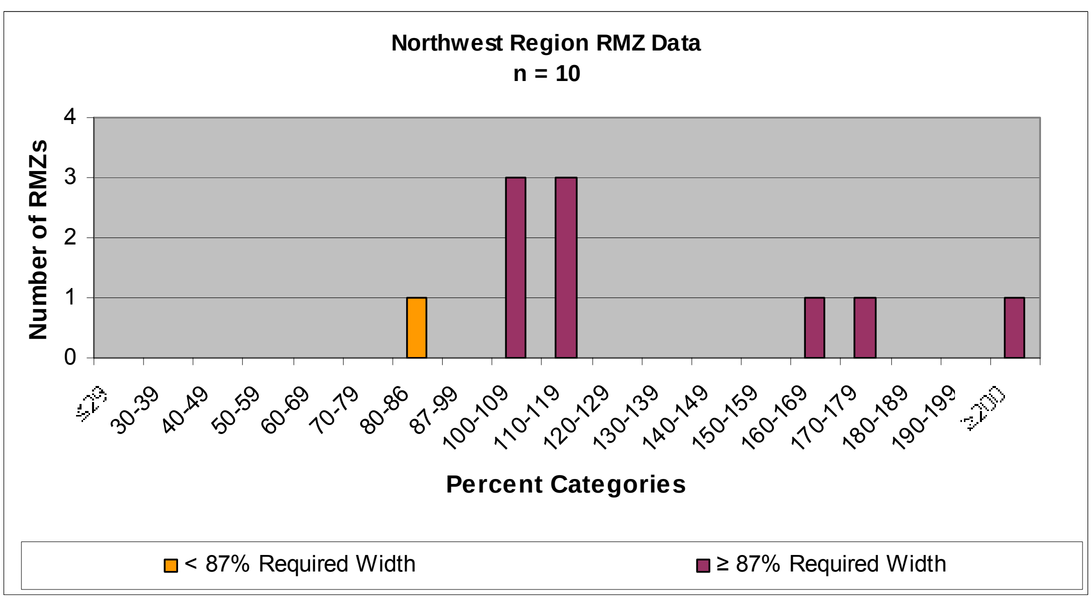


Figure 3.2. Distribution of Northwest Region 2006 RMZ compliance data

Table 3.1. Northwest Region RMZ data for individual timber sales

Timber Sale Name	Measured Width (in feet)	Required Width (in feet)	Additional Average Width (in feet) Required to be Compliant	Percent Required Width Applied	Compliant?
Back Hat	112	100	-	112	Yes
	465	153	-	304	Yes
Capriccio	110	100	-	110	Yes
	121	144	4	84	No
Chipper	162	100	-	162	Yes
	158	158	-	100	Yes
	166	158	-	105	Yes
Loquat	271	152	-	178	Yes
Waterworks	102	100	-	102	Yes
Zinfandel	170	153	-	111	Yes

The RMZ that was less than 87 percent of the required width applied 84 percent (121 feet out of 144 feet). The stream was a Type 3. The widest spot on the RMZ was approximately 167 feet and the narrowest was 93 feet. Because a large section of the RMZ width was less than 130 feet wide, the overall average did not meet the required width. This RMZ needed an additional average width of four feet to be compliant (Figure 3.3).

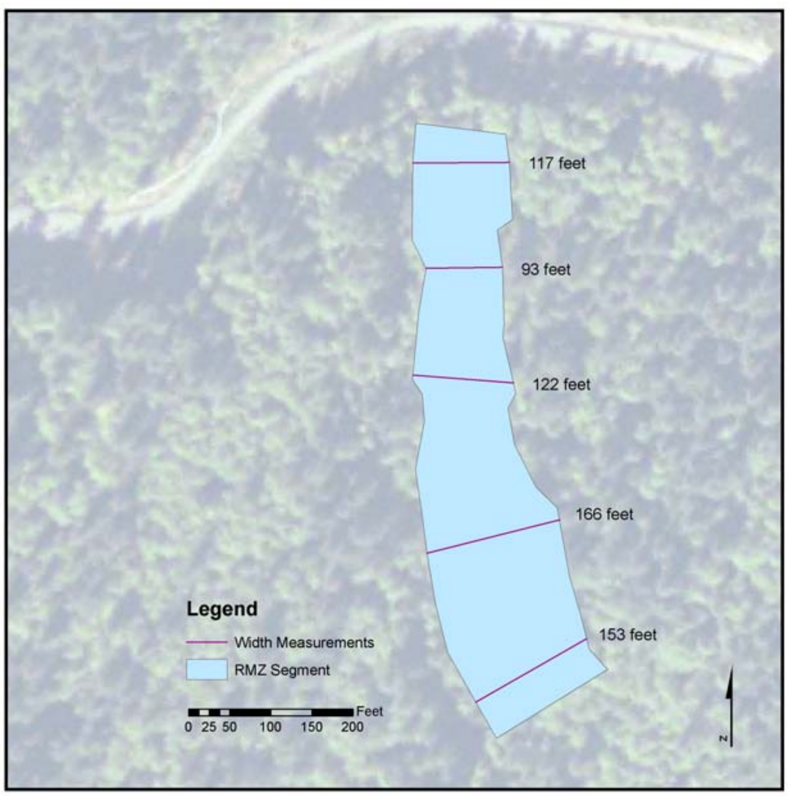


Figure 3.3. Riparian Management Zone on Type 3 stream in Northwest Region that was 84 percent of the required width

Of the ten RMZs measured, one applied more than 200 percent of the required width. The required width was 153 feet and we measured the average width to be 465 feet (304 percent of the requirement). A section of extremely steep slopes in the RMZ may account for the relatively large average RMZ width. In this case, additional detailed documentation regarding the RMZ boundary would have been helpful.

OLYMPIC REGION

In Olympic Region, one of the five RMZs measured was less than 87 percent of the required width and four were at least 87 percent (Figure 3.4 and Table 3.2).

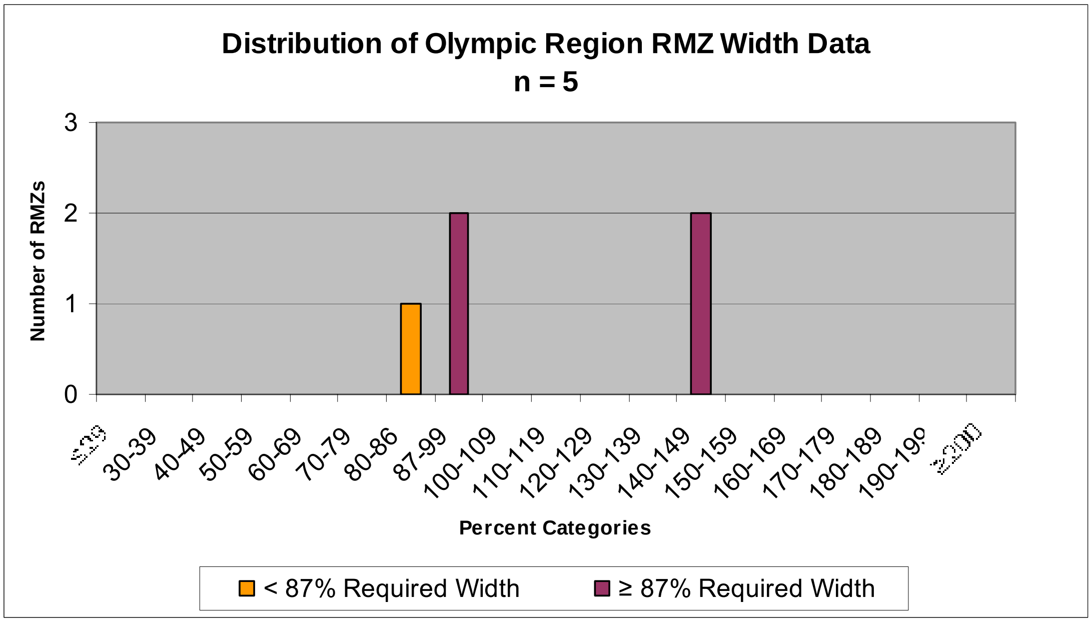


Figure 3.4. Distribution of 2006 Olympic Region RMZ compliance data

Table 3.2. Olympic Region 2006 RMZ data for individual timber sales

Timber Sale Name	Measured Width (in feet)	Required Width (in feet)	Additional Average Width (in feet) Required to be Compliant	Percent Required Width Applied	Compliant?
East Siebert	211	150	-	141	Yes
Nineteenth Hole	135	157	2	86	No
Walker Road #2	159	177	-	90	Yes
	174	177	-	98	Yes
	258	177	-	146	Yes

SOUTH PUGET SOUND REGION

In South Puget Sound Region, we sampled 11 RMZs. One was less than 87 percent of the required width and ten were more than 87 percent (Figure 3.6 and Table 3.3).

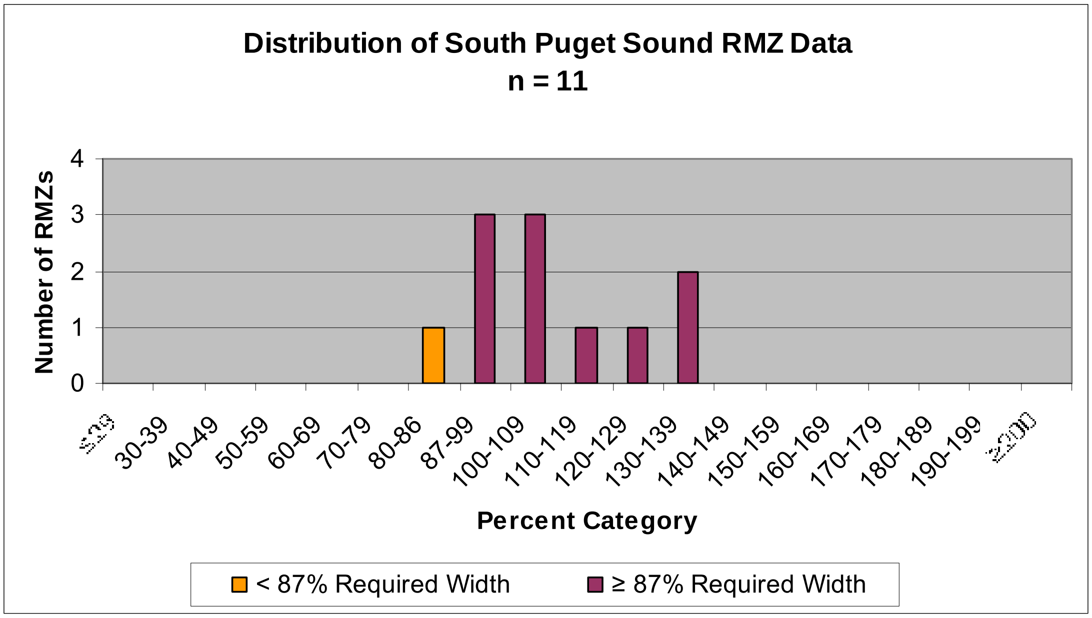


Figure 3.6. Distribution of South Puget Sound 2006 Region RMZ compliance data

Table 3.3. South Puget Sound Region 2006 RMZ data for individual timber sales

Timber Sale Name	Measured Width (in feet)	Required Width (in feet)	Additional Average Width (in feet) Required to be Compliant	Percent Required Width Applied	Compliant?
Catch 2 Pole	245	186	-	132	Yes
	252	186	-	135	Yes
East Boundary	135	165	9	82	No
	163	165	-	99	Yes
	105	100	-	105	Yes
Five Shares	147	160	-	92	Yes
Jagged Edge	88	100	-	88	Yes
McDonald Ridge	113	100	-	113	Yes
	129	100	-	129	Yes
Moon Glow	186	176	-	106	Yes
	187	176	-	106	Yes

The RMZ that was less than 87 percent of the required width applied 82 percent. We measured the average width to be 135 feet and the required average width was 165 feet (Figure 3.7). The RMZ needed an additional average nine feet of RMZ to be compliant.

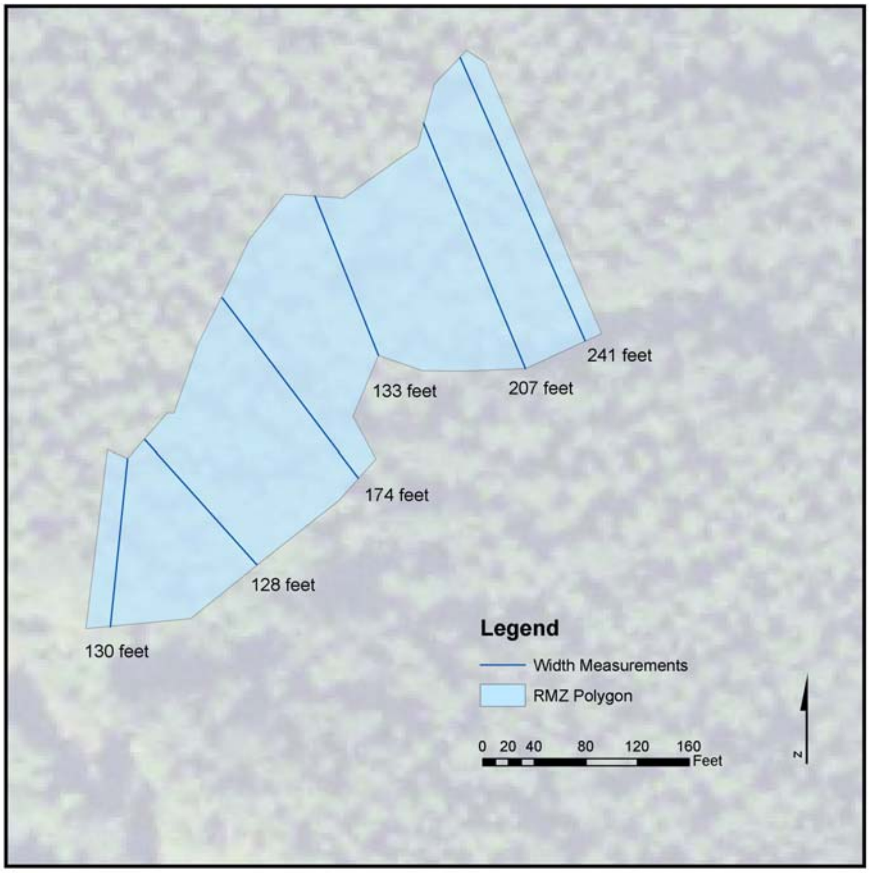


Figure 3.7. Riparian Management Zone in South Puget Sound Region that was 82 percent of the required width

PACIFIC CASCADE REGION

Of the 35 RMZs we sampled in Pacific Cascade Region, eight were less than 87 percent of the required width and 27 were at least 87 percent (Figure 3.8 and Table 3.4).

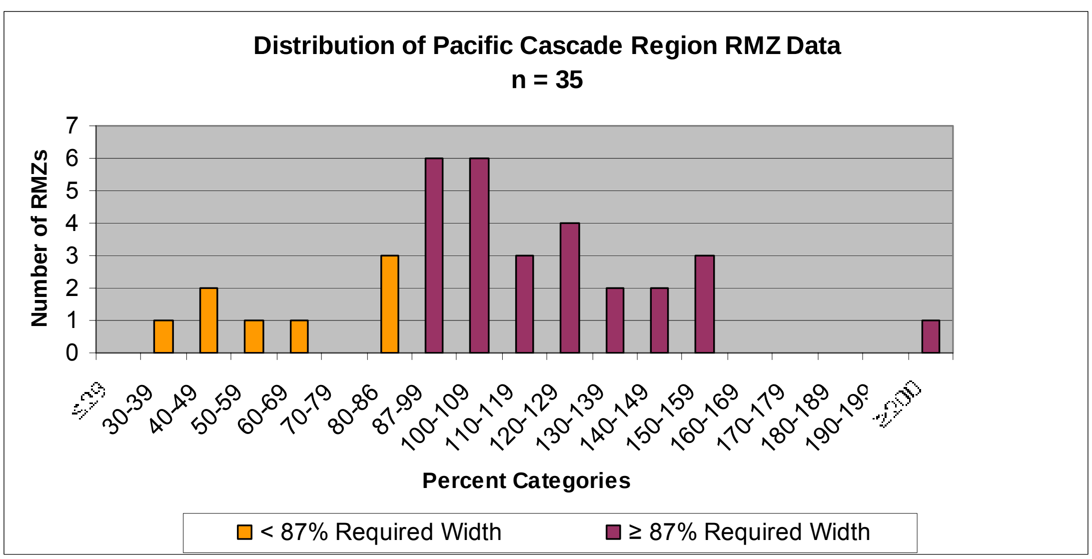


Figure 3.8. Distribution of Pacific Cascade Region 2006 RMZ compliance data

Table 3.4. Pacific Cascade Region 2006 RMZ data for individual timber sales

Timber Sale Name	Measured Width (in feet)	Required Width (in feet)	Additional Average Width (in feet) Required to be Compliant	Percent Required Width Applied	Compliant?
Airball	257	200	-	129	Yes
Burnett	92	175	60	53	No
	160	175	-	91	Yes
	176	175	-	101	Yes
Rotten Tags	111	100	-	111	Yes
	119	100	-	119	Yes
Shift	172	200	2	86	No
Short Stand	175	200	-	88	Yes
Bradley Partial Cut	35	100	52	35	No
	74	180	83	41	No
	85	180	72	47	No
	112	180	45	62	No
	125	100	-	125	Yes
	236	180	-	131	Yes
	238	180	-	132	Yes
Crazy Diamond	99	100	-	99	Yes
	104	100	-	104	Yes
Impulse	121	100	-	121	Yes
Mulligan Thinning	159	100	-	159	Yes
	136	170	12	80	No
	147	170	1	86	No
	89	100	-	89	Yes
	101	100	-	101	Yes
	103	100	-	103	Yes
	189	170	-	111	Yes
	145	100	-	145	Yes
	453	100	-	453	Yes
North Branch	191	175	-	109	Yes
Salsa	97	100	-	97	Yes
	141	131	-	108	Yes
	161	131	-	123	Yes
	192	131	-	147	Yes
	196	131	-	150	Yes
	198	131	-	151	Yes
Browns Vantage	197	200	-	99	Yes

The RMZ in Pacific Cascade Region that applied the smallest percent of the required width was a Type 4 stream that was 35 percent of the required width. RMZs bordered both the south and north sides of the stream. The RMZ was complicated by having two stream channels instead of one. (Only one was indicated on the timber sale map.) One channel looked as if it may have once contained water, but during our visits (August and September 2006) it did not. A second stream channel that did contain water was approximately 100 feet west of the dried up channel and in some places appeared to be contained by the ditch of an old road bed. The channel containing running water was very close to the edge of the tagged outer south RMZ edge, in some places only a few feet away. We visited the RMZ with the unit forester and district manager and all agreed to base our RMZ measurements on the stream with running water. As a result of this decision the south RMZ met 35 percent of the required width and north RMZ met 125 percent of the required width (Figure 3.9). The south RMZ needed an additional average 52 feet to be compliant (Table 3.4).

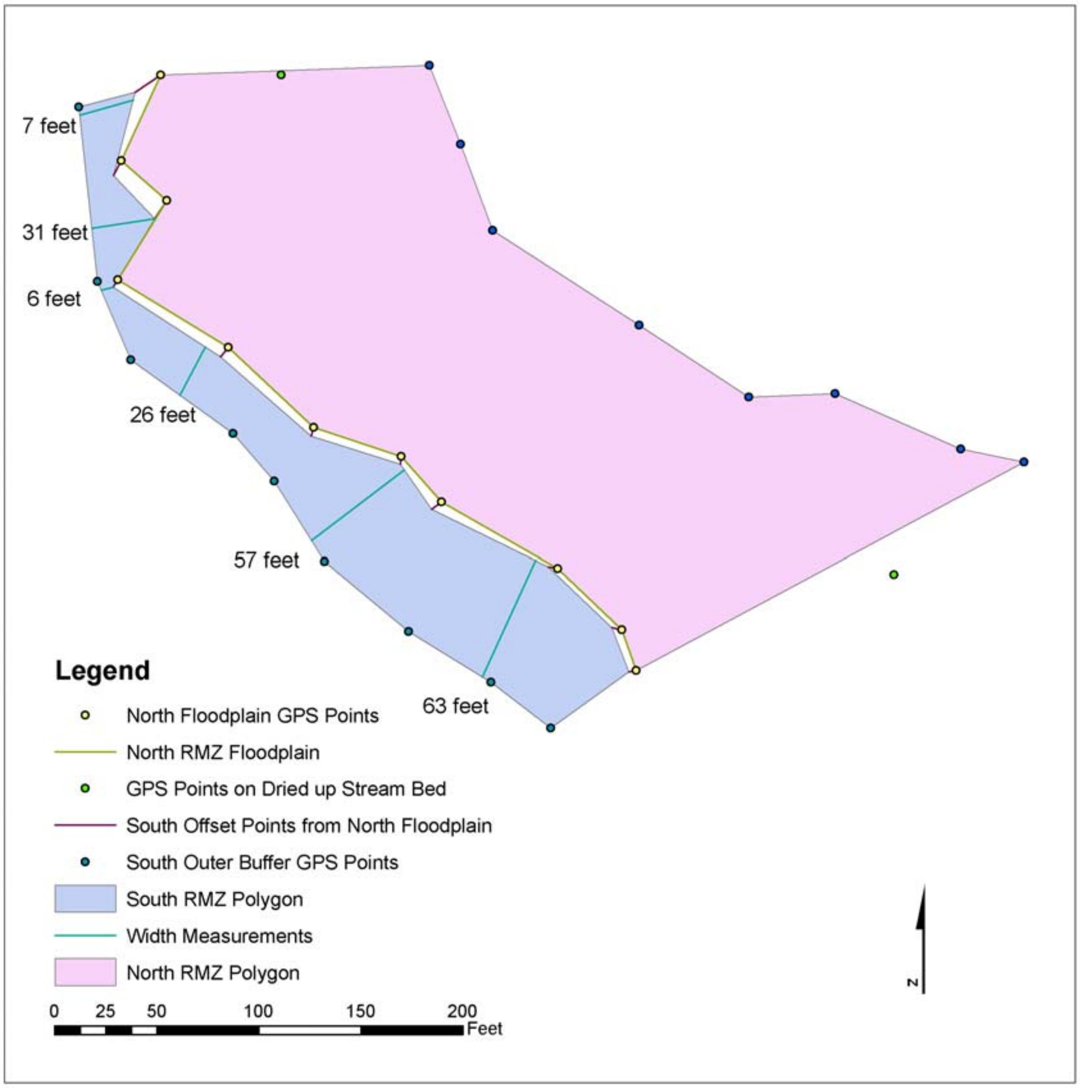


Figure 3.9. A Type 4 stream segment showing the north (compliant) and south (non-compliant) RMZ segments

The RMZ that was more than 200 percent was a Type 4 stream that was 453 percent of the required width (100 feet). The only documentation we found in the timber sale jacket that might explain the wide RMZ was information regarding unstable slopes and potential mass wasting within the sale. We attempted to use LiDAR to check for extremely steep slopes but it was not available for that sale. A possible explanation is based on information presented in a memo by Stephanie Zurenko (Pacific Cascade Region Geologist) on September 23, 2002 in which she recommended no harvest on inner gorge slopes. She specifically mentioned in her description of mass wasting that “there may be ‘intradraw earthflows’ present…possibly along the higher slopes in the east portions of units 3 and 5.” The RMZ in question was located in unit three. Additional documentation on how the forester applied Zurenko’s recommendations would have been helpful.

4. Discussion

Overall, 82 percent (50 of 61) of RMZs were compliant. The distribution of the results for RMZs was not normal because of events occurring at the lower and upper ends of the distribution (Figure 4.1). On average, RMZs were 117 percent of the required width.

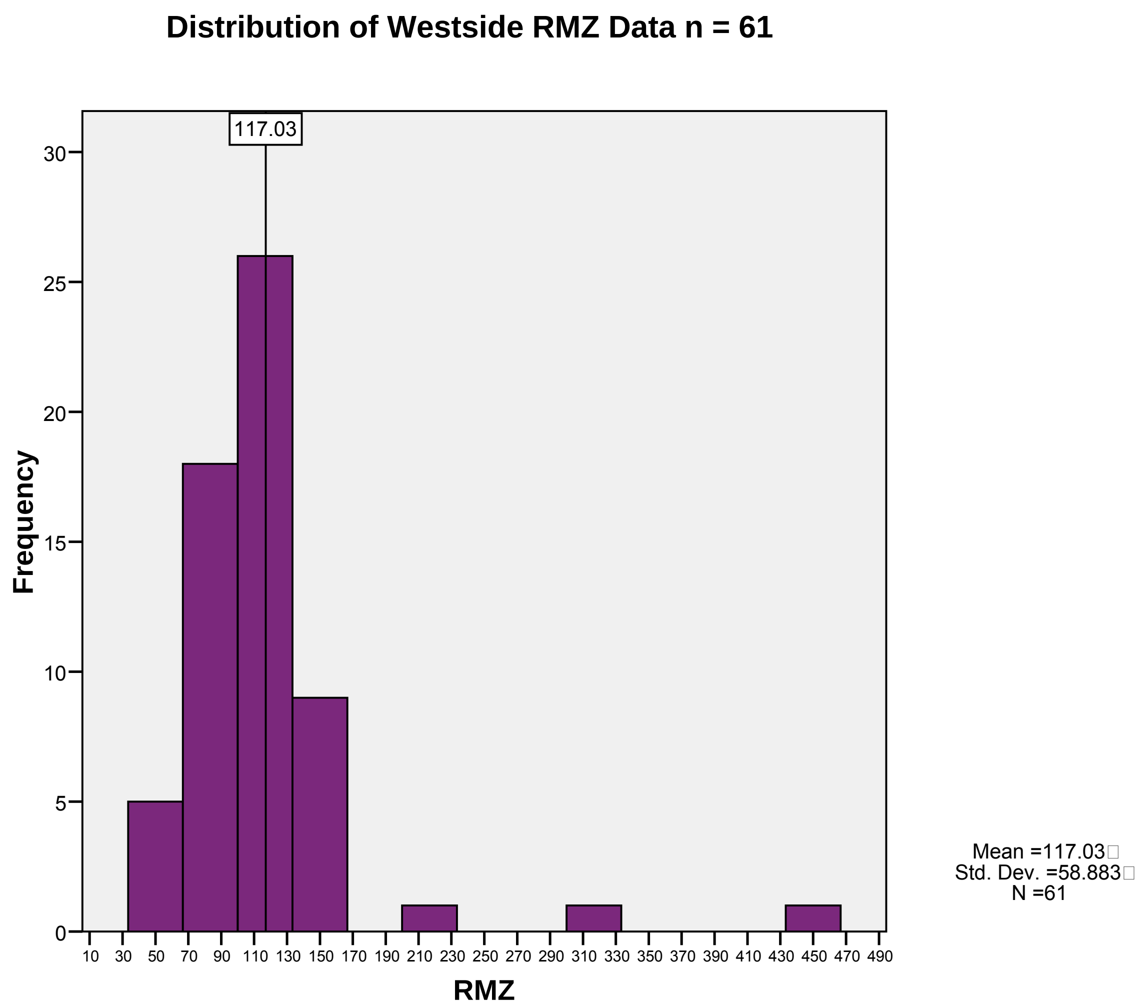


Figure 4.1. Distribution of 2006 RMZ data across all Westside regions

The RMZ compliance data is not normally distributed because the majority (39 of 61, or 64 percent) of measured RMZ widths was more than 100 percent of the required width. This causes the distribution to be weighted to the right, giving it a positive skew. The following factors may contribute to very wide RMZs (we checked each timber sale jacket but did not find any pertinent information that would change our measurements):

- **Slope break.** Foresters may mark the edge of an RMZ where it is practicable to stop harvesting due to topography, effectively increasing the buffer width.
- **Floodplain determination.** In cases where we underestimated the floodplain, the RMZ may appear to be wider than it actually was.
- **Unstable slope buffers, wind buffers or leave trees.** Sometimes they are included in the RMZ but not documented or marked on the ground.

It is unknown why some RMZ widths were too narrow. Techniques used by foresters to measure the width of an RMZ may need to be assessed for accuracy. It is difficult to say where the problem lies. It could be in new forester training, time constraints, or even misinterpretations of RMZ requirements. We suggest more comprehensive documentation be provided in timber sale jackets and DNR databases. This would help to determine why and how decisions were made.

Table 4.1 shows overall compliance rates for each region. While many (eight of the eleven) of the non-compliant RMZ widths were found in the Pacific Cascade Region sample, RMZ sample size was at least three times greater for Pacific Cascade than any other region.

Table 4.1. Summary of 2006 RMZ compliance for all Westside regions

	Number of Compliant RMZs	Number of Non-Compliant RMZs	Total Number Sampled RMZs	Percent Compliance for Sampled RMZs
Northwest	9	1	10	90%
Olympic	4	1	5	80%
South Puget Sound	10	1	11	91%
Pacific Cascade	27	8	35	77%
TOTAL	**50**	**11**	**61**	**82%**

While overall compliance levels appear to be relatively high, the RMZs that were too narrow should not be dismissed because one third (4 of 12) of these provided less than 60 percent of the required width. Less than 60 percent does not seem close to being acceptable insofar as meeting the intent of the HCP requirements for protecting streams and habitat. Three of the four RMZs were adjacent to regeneration harvest units. However, one of the four RMZs was adjacent to a thinned unit which may raise questions regarding whether or not the narrow RMZ should be considered non-compliant. DNR’s intent in leaving RMZs is to restore a range of ecological functions including large conifer trees, complex stand structure, and long-lived tree species that can provide riparian zone stability (Bigley and Deisenhofer 2006). An RMZ adjacent to a thinned stand may provide the important characteristics for riparian zone stability whether or not the actual RMZ meets the required width. However, an RMZ adjacent to a regeneration harvest that meets less than 87 percent of the required width may compromise the intent of the HCP.

Compliance for RMZs has improved since 2003. In 2003 overall compliance was 69 percent compared to 82 percent in 2006. Note, however, that in 2003, a stream had to meet 100 percent of the required width to be considered compliant. In addition, the methods in 2003 were very different from those used in 2006. One observation that remains the same is the need for accurate and detailed documentation.

Using GPS to measure RMZ widths has proven to be an efficient method. One of the objectives in 2006 was to increase the number of timber sales included in the sample. Compared to the 2003 monitoring, the number of monitored timber sales was increased by 13 percent (though the number of stream segments monitored decreased). DNR region employees have also begun using GPS for pre-sale activities, including delineating RMZs. In the future, using region provided GPS data may help us increase the number of RMZ widths we monitor. By decreasing some of the field work for RMZ measurements more time could be devoted to checking stream types, which some believe is a greater source of implementation error.

We recommend that GPS data be used in future RMZ width measurements. Currently, Dr. Peter Schiess (2006; personal communication, January 19, 2007) is working on protocols for a study being conducted in Capitol State Forest which will look at GPS accuracy under a variety of forest canopies. We anticipate that his study and others will improve our understanding of GPS accuracy and help us fine tune our methods.

Sample Size

We tried to determine if a 20 percent sample size was large enough to make inferences about overall timber sale implementation of the RMZ and stream typing components of the riparian conservation strategy. We used Raosoft® (www.raosoft.com/samplesize.html) to calculate adequate sample sizes based on two levels of confidence. It is crucial to note that sample size analysis assumes that all streams within a timber sale were monitored. We monitored only a sample of stream segments for each timber sale. Because of this assumption, the number of 2006 timber sales and the number suggested by sample size analysis is not an equal comparison. Table 4.2 lists each region, the total population of timber sales, the number of timber sales sampled and the sample size required for 90 and 95 percent confidence levels.

Table 4.2. Westside regions and 2006 sample size analysis

	Total Number of Timber Sales Available	Number of Timber Sales Sampled (20%)	Sample Size for 95% Confidence Level	Sample Size for 90% Confidence Limit
Northwest	44	9	41	27
Olympic	20	4	20	16
South Puget Sound	33	7	33	23
Pacific Cascade	78	16	67	37

Meeting the required sample size for a 95 percent confidence level would be very difficult to accomplish in a single season. Meeting the sample size for a 90 percent confidence level would also be difficult because of the assumption that all stream segments would need to be monitored. In addition to nearly tripling the 2006 sample size to meet the 90 percent confidence level, we would be monitoring an increased number of stream segments within the sale. In the future we strongly recommend conducting sample size analysis on the number of streams within the population instead of the number of timber sales. The randomly selected streams could then be stratified by timber sale, region, or HCP planning unit. This would focus sample size analysis on the unit of measurement, which should be streams not timber sales.

It may not be efficient or economical for us to attempt to meet sample sizes suggested by the analysis. However, certain measures can be taken to increase sample size and data quality, given available resources:

- Use at least one additional Trimble Pro XR GPS unit. Having two to three people in the field using two GPS units is much more efficient than using only one unit.
- Use region-provided GPS data.
- Use aerial photos and LiDAR to collect preliminary measurements.
- Extend the field season. Monitoring of the riparian strategy would be possible at least eight months out of the year. In 2006, the crew started in June and finished in October. We recommend starting field work in March and continuing through October.
- Conduct implementation monitoring year round. This would be possible in most regions where snow typically does not reach the lower elevations.

Based on results from the sample size analysis for timber sales, our sample sizes were low and it is not possible to make extrapolations from our sample to the entire population of timber sales. However, the information we collected regarding the timber sales we did sample is a very important indicator of how well the HCP requirements for riparian areas are being implemented on the ground.

In conclusion, overall compliance for the RMZ portion of the riparian conservation strategy was high given the relatively small number of RMZs that were on average too narrow. However there were problems especially where RMZs were significantly narrower than the required width.

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Appendices

Appendix 1. Stream Typing Field Form

STREAM TYPING DATA SHEET	NOTES:
Region	
Timber Sale	
Date	
Your Name	
Stream type indicated on timber sale map	
Verify stream with timber sale map?	
If not verifiable, was survey conducted?	
If survey was conducted what was the determined stream type?	

Appendix 2. Stream Typing Methods

Stream typing was conducted following the RFRS rules (Bigley and Deisenhofer 2006). In the field we applied physical criteria like channel width and drainage gradient to determine stream type (Table A2.1).

Table A2.1. Stream typing criteria used in the field in 2006

Water Type	1996 Emergency Rules or RFRS Rules
Type 1	Shorelines of the state
Type 2	>20' ordinary high water mark <4% gradient Fish
Type 3	≥ 2' ordinary high water mark <16% gradient or >16% or <20% with >50 acres contributing basin size Fish
Type 4	≥ 2' ordinary high water mark > 20% gradient or >16% or <20% with <50 acres contributing basin size
Type 5	< 2' ordinary high water mark May not have a well defined channel Water may be seasonal

In the field, stream typing was conducted by checking each stream against the typing criteria. Each stream segment was observed to see if it matched the stream type designated on the timber sale map. In addition, a description of the stream surveyed and any measurements taken were recorded on a stream typing survey form (Appendix 1).

If there were contradictions between our typing and the stream type indicated on the map a stream survey was conducted using Forest Practices guidelines for stream surveys (WADNR 2000). In addition to conducting a stream survey, we also looked to the timber sale jacket for further explanation regarding other stream type criteria not easily seen in the field, like water diversions, basin size, seasonal water, or presence of fish.

Stream Typing Results

Of the 120 stream segments we surveyed for stream type, 109 (90 percent) were typed correctly. Six (five percent) stream segments were unverifiable, one (less than one percent) was partially mistyped, and four (three percent) were typed incorrectly. Of the six stream segments that were unverifiable two were not found in the field, one was almost completely destroyed by a blown down RMZ, one was obliterated by slash, and two were not typed and instead left as type 9. Sampled streams were stratified by region. Table A2.2 shows the four Westside regions and the number of streams that were found to be typed correctly, unverifiable, partially mistyped, or mistyped. Partially mistyped refers to stream segments that appeared to be typed correctly for part of the segment and incorrectly for part of the segment. It should be noted that while the stream survey protocol calls for measuring 500 feet of a stream segment, many segments were shorter than 500 feet. We measured as much of the stream segment as possible.

Table A2.2. The number of stream segments by region that were typed correctly, mistyped, partially mistyped, or unverifiable.

	Northwest n = 21	**Olympic n = 10**	**South Puget Sound n = 28**	**Pacific Cascade n = 61**
Typed Correctly	18	9	27	55
Partially Mistyped	0	0	1	0
Mistyped	0	1	0	3
Unverifiable	3	0	0	3

NORTHWEST REGION

In Northwest Region two streams were classified as Type 9 streams. Typically streams are labeled as Type 9 because their type has not been field verified, thus they are considered unknown. These two streams should have been assigned a type (1, 2, 3, 4, or 5) prior to harvest, thus we considered them unverifiable. As a result of observing these streams in the field, we believe they should have been classified as type 5 streams.

SOUTH PUGET SOUND REGION

In South Puget Sound Region, one stream in the Jagged Edge timber sale was partially mistyped. The stream had a well defined channel and was confirmed to be a Type 5 until the last 150 feet of the stream where it widened significantly to more than two feet. The stream channel was greater than two feet wide until it met the junction of a Type 3 stream. If the 150 feet in question was changed from a Type 5 to a Type 3 it would not necessarily affect any RMZ that should have been delineated because the section in question runs perpendicular to another Type 3 stream segment and the RMZ from that Type 3 may cover the 150 feet in question.

OLYMPIC REGION

In Olympic Region, we found one stream to be mistyped in the Rainforest Thin timber sale. The stream was mapped as a Type 4 and we determined it was a Type 3. A stream survey resulted in an average stream channel width of 3.8 feet and an average gradient of four percent. The slope was never measured greater than seven percent. It is unknown whether or not the type change would affect the RMZ as it was within the Olympic Experimental State Forest (OESF). Because in the OESF RMZs in a thinned sale are not required and/or clearly identified we could not measure the RMZ for average width.

PACIFIC CASCADE REGION

In Pacific Cascade Region, three stream segments were found to be mistyped. The first stream segment was mapped as a Type 4 and was in the Mulligan Thinning sale. Our measurements showed an average gradient of 10 percent (a Type 4 stream would be greater than 16 percent) and an average width of 4.2 feet. We checked the timber sale jacket and found no documentation that the basin size was greater than 50 acres or that the stream had been shocked for fish presence. Thus we concluded the stream should have been typed as a 3. The RMZ average width was 159 feet so it may or may not meet the required width depending on the site index.

The second stream we found to be mistyped in this region was located in the Bradley Partial Cut timber sale and was designated a Type 3 on the timber sale map. We conducted a stream survey on the short segment (about 150 feet)—a third of which did not have a defined channel—and determined the channel width was slightly less than two feet. Because of the narrow channel width (where it could be measured) and because a portion of the stream was only wet soil, we concluded the stream segment should have been typed as a 5.

The third stream segment we found to be mistyped in Pacific Cascade Region was labeled on the timber sale map as a Type 3 and was also in the Bradley Partial Cut timber sale. We conducted a stream survey and found the portion of the stream segment within the sale was a Type 4, with a slope of 16.8 percent. The gradient results make it difficult to determine whether the stream was mistyped because the gradient is borderline Type 3/Type 4. However, if the stream was mistyped it would explain why the associated RMZ width came up narrow (discussed in the RMZ width section).

Appendix 3. GPS Accuracy

Determining GPS accuracy refers to measuring the degree of bias in the measurement process. While GPS is an excellent tool for measuring RMZ width, questions arise about the accuracy of the location data that is collected. The benefit of using GPS data is that the accuracy can be quantified through differential corrections, root mean squared error (RMSE), and 95 percent confidence values. Unlike GPS data, traverse data is not easily measured for accuracy. We attempted to minimize error by taking shorter distance and bearing measurements and by using a GPS point as a known location from which to begin a traverse. We minimized error further by using the offset method. This decreased the amount of cumulative error involved in a traverse and required a GPS point for each measurement.

This section identifies position filter settings used to increase GPS accuracy (as recommended by Trimble and DNR staff familiar with the Pro XR); describes how GPS accuracy can be further improved through differential correction; and discusses an exercise that was conducted to compare our GPS locations to those surveyed by Washington State Department of Transportation (WSDOT) using RMSE.

Position Filter Settings

Our initial effort to limit GPS error was in setting position filters. These settings dictate a level of acceptance for positional data. In other words, when the GPS unit is attempting to receive data from a satellite, certain quality thresholds must be met before the unit will accept the position and allow the user to collect GPS data. We used the following position filters:

1. Averaging – Averaging multiple positions increases the accuracy of a single point location (Trimble 2001; D. Wolfer, personal communication, 2006). We enabled averaging and set the number of GPS positions to be collected at 30. The number 30 was suggested by Jim Lahm a GPS/GIS specialist that trained us in GPS data collection and processing. Other GPS users collect anywhere between ten and one hundred positions.
2. Position Dilution of Precision (PDOP) – This measures satellite geometry. The lower the PDOP the better the accuracy. Trimble Navigation Limited (2001) recommends a PDOP of six. We typically set ours at eight because we found the application of real-time and post processing differential corrections made up for the slightly higher PDOP.
3. Signal-to-noise ratio (SNR) – SNR measures the strength of the satellite signal. An increased SNR increases the accuracy of the data. We set SNR at 39.0 (Trimble 2001).
4. Velocity filter – Velocity filtering removes data spikes and outliers when satellite reception is poor (Trimble 2001; J. Ricklefs, personal communication, December 5, 2006). We turned on velocity filtering.
5. Elevation mask – Satellites low on the horizon have decreased signal strength because of the increased travel distance. We set our unit to collect data from satellites at a minimum of 15 degrees above the horizon (Trimble 2001).

Differential Correction

Despite setting relatively high standards for collecting GPS data, error does occur. Data collection errors can occur as a result of signal bounce off various structures (multipath error), atmospheric delays, and satellite position errors (which occur when a satellite drifts off its predicted course). "Differential correction is a method of removing the errors, both man-made and natural, that affect GPS measurements" (Trimble 2004, p. 2).

There are two types of differential correction that can be applied to GPS position data. The first type of correction is called real-time. This is applied while data is being collected in the field. The other type is called post processing, which is applied in the office. Post processing uses data collected at a base station to correct errors in field collected data. We applied both real-time and post processing differential corrections to our GPS data. We used Pathfinder Office software for post processing, including using shape correct to apply differential corrections to field collected GIS shape files.

Accuracy Exercises

In addition to setting position filters and applying differential corrections to the field data, we also conducted an exercise to estimate GPS accuracy. This involved collecting GPS data at WSDOT survey monuments throughout western Washington. Survey monument locations can be found on the WSDOT website (http://www.wsdot.wa.gov/monument/). We collected data at monuments that had an accuracy of five centimeters or less. After we collected GPS position data at the monuments, we applied differential corrections and processed the data using the same methods as the RMZ data. Trimble recommends using RMSE calculations to estimate GPS error. We used RMSE and National Standard for Spatial Data Accuracy (NSSDA) 95 percent confidence value calculations recommended by geospatial positioning accuracy standards (Federal Geographic Data Committee 1998) to calculate the error between survey monument locations and our GPS.

Appendix 4. Traverse Field Form

Traverse Data Sheet	**Traverse**	**Direction**	**Distance**	**Notes**
Region	1			Where were GPS points taken?
	2			What were perpendicular bearings if GPS was used?
Timber Sale	3			Are names consistent between data sheet and GPS?
	4			
Date	5			
	6			
Your Name	7			
	8			
Stream Identification	9			
	10			
Stream Side Surveyed	11			
	12			
PerpendicularA Bearing/Location	13			
	14			
PerpendicularB Bearing/Location	15			
	16			
	17			
	18			
	19			
	20			
	21			
	22			
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