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M E M O R A N D U M

DATE: 24 July 2017

TO: Forest Practices Board

FROM: Garren Andrews, Compliance Monitoring Program Manager

SUBJECT: Compliance Monitoring Program 2014-2015 Biennial Report, and Independent Scientific Peer Review Synthesis and Assessment

Attached is the 2014-2015 Forest Practices Compliance Monitoring biennial report, and Independent Scientific Peer Review synthesis and assessment.

The 2014-2015 Compliance Monitoring Program biennial report contains data analysis and interpretation, and trend analysis of the nine standard sample prescriptions for the 2014-2015 sampling window. Trend analysis was conducted to detect compliance trends on data collected from 2010-2015.

An Independent Scientific Peer Review was conducted on the 2014-2015 Forest Practices Compliance Monitoring biennial report, and program analytical study design. Major and minor recommendations from the assembled ISPR team are provided in the synthesis and assessment document.

NATURAL RESOURCES

2014-2015 Biennium Forest Practices Compliance Monitoring Report

August 2016

WASHINGTON STATE DEPT OF
NATURAL RESOURCES
PETER GOLDMARK
COMMISSIONER OF PUBLIC LANDS

2014-2015 Biennium Forest Practices Compliance Monitoring Report

August 2016

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Forest Practices Division
Washington State Department of Natural Resources

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1. Acknowledgments

This biennial report is dedicated to Walt Obermeyer. Walt worked for the Washington State Department of Natural Resources for 29 years and in the Compliance Monitoring Program from 2009 to 2015. Walt will be missed.

The contributions of the following were critical to the completion of this report: the tribal staff and regional staffs of the Washington State Departments of Ecology, Fish and Wildlife, and Natural Resources who performed field reviews in good weather and bad, with special thanks to those who reviewed and entered data, including Todd Olson, Jean Parodi, and John Heimburg. Also thanks to the Forest Practices Division leadership who patiently reviewed various drafts

2. Executive Summary

The Compliance Monitoring Program (CMP) is a key component of the Washington State Department of Natural Resources' (DNR's) Forest Practices Program (FP Program). Compliance monitoring is linked to DNR's responsibility to ensure that operators and landowners are complying with forest practices administrative rules (FP rules) when conducting forest practices activities. Through monitoring, the CMP provides feedback to the FP Program regarding the degree to which specific FP rules are being implemented correctly and highlights where there is a need for focus, training, guidance, or clarity.

The CMP reports on real-world compliance on the ground. The FP rules direct DNR to provide "statistically sound, biennial compliance audits and monitoring reports to the [Forest Practices] Board for consideration and support of rule and guidance analysis" (WAC 222-08-160[4]). In addition to the biennial report produced by the CMP, in 2011 the Commissioner of Public Lands requested an annual report in the intervening years.

This biennial CMP report covers data samples collected during the 2014 and 2015 field seasons. Two years are needed to obtain enough data to attain the desired level of statistical precision. The data from the 2014 and 2015 field seasons have been combined to satisfy the desired precision for statistical estimates.

The CMP evaluates compliance with prioritized FP rules considered to have the greatest potential impact on public resources, defined as water, fish, wildlife, and capital improvements of the state. The rule groupings evaluated by compliance monitoring pertain to riparian and wetland areas and to road construction and maintenance.

Sample Design and Methodology

For the purposes of monitoring and statistical analysis, individual FP rules are grouped into categories of similar rules called "prescriptions." Separate samples are chosen for each prescription type monitored. Estimated populations for individual prescriptions are associated with forest practices applications (FPAs) that include forest practices activities, such as timber harvest or road construction. Sample selections for each prescription type are drawn from the FPAs that contain the prescriptions being monitored that year (numbers in parentheses indicate the estimated population of FPAs with the prescription in the 2014-2015 sample): Roads (1,410), Type A&B Wetlands (237), Forested Wetlands (322), No Inner Zone Harvest (NIZH) (737), Desired Future Condition Option 1 (DFC1) (55), Desired Future Condition Option 2 (DFC2) (152), Non-Fish-Bearing Perennial Stream (Np) (929), and Non-Fish-Bearing Seasonal Stream (Ns) (1018).

For this biennial report, 200 prescriptions were sampled. Sample sizes were calculated from a combination of prescription population size, cluster size, and variance. Prescription sample sizes were as follows: Roads (13), Type A & B Wetlands (35), Forested Wetlands (23), No Inner Zone Harvest (25), Desired Future Condition Option 1 (20), Desired Future Condition Option 2 (14), Non-Fish-Bearing Perennial Stream (35), and Non-Fish-Bearing Seasonal Stream (35).

FP rules monitored annually are referred to as the Standard Sample. In addition, certain rule groups are monitored periodically and are known as an Emphasis Sample. The Standard Sample monitors the following rules:

- Riparian protection (WAC 222-30-021 and 022)
- Wetland protection (WAC 222-30-020[6] and [7] and WAC 222-24-015)
- Road construction, maintenance, and abandonment (WAC 222-24)
- Haul routes for sediment delivery (WAC 222-24)

In addition, the physical criteria of waters (e.g., stream width, stream gradient, etc.) are observed to estimate the number of occurrences in which water types recorded on FPAs are different than what is observed on the ground (WAC 222-16-031).

Changes in Study Design

The CMP made significant modifications in the 2014-15 study design to increase precision in statistical estimates for each prescription type observed. Previously, compliance rates were estimated by dividing 100% compliant samples by the total number of samples for each prescription type. The updated study design divides the number of compliant rules by the number of total sampled rules within each prescription type, resulting in an average compliance rate. This change increases statistical precision in results and provides more information to help determine causes of noncompliance associated with rule interpretation and implementation. The added precision helps discern changes in compliance rates over time. The modified design creates flexibility for future sampling to add or remove different prescription types from the sample as needed, while still providing the desired confidence intervals for each prescription type. As a result of rule overlap, the No Inner Zone Harvest and No Outer Zone Harvest prescriptions have been combined.

Trend analysis was incorporated to detect trends in prescription, and individual rule compliance over time. Data collected from 2010-2013 for the standard prescription types were converted to be consistent with current data collection, and analytical protocols. Weighted least squares multivariate linear regression analysis was used to predict general trends in average compliance through time.

Notable Aspects of CMP Samples

- FPAs are randomly selected.
- Conclusions about average compliance are based on a two year window, with approximately half the samples observed in the first year and half the samples observed in the second year. Two years are needed to obtain enough data to attain the desired level of statistical precision.
- The CMP establishes sample sizes based on an estimated 95% confidence interval width of +/– 6% on compliance estimates.[1]

[1] A 95% confidence internal of +/– 6% means that if the sample was repeated 20 times, one would expect the population mean (the "true" compliance rate) to fall within the confidence interval 19 out of 20 times.

- CMP results are reported for all the landowners combined.
- The Compliant percentages reported for all sampled prescriptions, except the Haul Route prescription, reflect average compliance for the prescription. Compliance with individual rules within the prescription are summed to calculate the percentage of prescription compliance rates. See section 4 for additional information.
- The Haul Route prescription type follows a different sample design. The Compliant percentages reported for the Haul Routes prescription are overall rates of compliance with FP rules for haul routes (instead of the percentage of the sample compliant). See Section 4 for more information.
- A rule application assessed as compliant is rated either Compliant or Exceeds Rule Requirements. The latter is used when a landowner has implemented higher protection standards than required by FP rules.
- When a prescription is assessed as a deviation, it is rated either Low, Moderate, High or Indeterminate to provide the degree of deviation from rule or FPA requirements.
- Compliance is determined both for compliance of the forest practices activity implementation with FP rules, called "rule compliance," and for compliance of the forest practices activity implementation with what was stated on the FPA, called "FPA compliance."

Findings

Findings from the 2014-2015 sampling season are reported in Sections 5 and 6 of this report.

Water Typing

Supplemental Water Information Forms (SWIFs) were completed for 28 samples due to observed water typing differences between water type documentation on FPAs and on-the-ground physical features. Eleven waters were underclassified, 10 waters were overclassified, 6 waters were indeterminate, and 1 SWIF was completed for a non-water typing issue. Additional relevant data and results for water typing are located in Section 5.

Riparian Management Zones

The DFC1 rate of rule compliance for the 2014-2015 sample period was 94%. The DFC2 rate of rule compliance was 98%. The NIZH rate of rule compliance was 94%. The Np activity rate of rule compliance was 94%. The Ns activity rate of rule compliance was 97%. Additional relevant data and results for water typing are located in Section 5.

Wetland Management Zones

The Type A&B Wetlands rate of rule compliance for the 2014-2015 sample period was 94%. The Forested Wetlands rate of rule compliance was 97%. Additional relevant data and results for water typing are located in Section 5.

Roads

The Roads rate of rule compliance for the 2014-2015 sample period was 98%

The rate of rule compliance for the Haul Routes prescription in the 2014-2015 sample period was 90%. Additional relevant data and results for roads are located in Section 6.

Trend Analysis

Trends of year to year increasing prescription compliance rates were observed for DFC2 (1.5%), NIZH (1.0%), and Roads (1.4%). No statistically-significant trends of decreasing prescription compliance were observed. Additional relevant data and results for water typing are located in Section 7.

Changes Made Based on CMP Feedback

A primary goal of the CMP is to provide feedback from compliance monitoring for the purposes of improving compliance with FP rules. The following are some recent changes made to address issues identified as a result of compliance monitoring: Leave tree, DFC, and RMZ length rule and Forest Practices Board Manual clarifications are currently under review and are targeted for 2017 completion. Rule and Board Manual clarifications have been incorporated into the Forest Practices Board work plan.

3. Introduction

Photo by: Monica McMackin

Compliance monitoring is a component of the Washington State Forest Practices Program. Section 1 gives a brief history leading to the development of the Compliance Monitoring Program and explains key factors and concepts regarding compliance monitoring and the forest practices rules that are monitored.

3.1 History and Context

The 1974 Forest Practices Act (FP Act) declared that "forest land resources are among the most valuable of all resources in the state" (Revised Code of Washington [RCW], Title 76.09). This law and its corresponding forest practices rules (FP rules) (Washington Administrative Code [WAC], Title 222) regulate forestry activities on state and private lands in Washington State and are designed to both protect public resources on forestland and ensure that Washington continues to support a viable forest products industry. (WAC 222-16-010 [Public Resources]) Public resources are defined as water, fish, wildlife, and capital improvements of the state or its political subdivisions. The FP Act created the Forest Practices Board (the Board), an independent state agency with 13 members. The Board, working with the public, stakeholder groups, and DNR, adopts FP rules and approves technical guidance (Forest Practices Board Manual) that assists landowners in implementing FP rules. The FP rules are administered by DNR (with input and consultation from other entities where directed by rule).

A flexible Forest Practices Program (FP Program) was developed to implement the FP Act and rules, because knowledge and understanding of natural systems evolves and natural systems

change over time. A flexible FP Program is essential for meeting the intent of the FP Act in an arena where change is expected and ongoing. Components that provide systematic feedback and facilitate change when needed have been intentionally designed and incorporated into the FP Program. These components include the Compliance Monitoring Program (CMP), the Adaptive Management Program (AMP), and the Forest Practices Training Program (FPTP). Other FP Program components that provide critical functions for implementing the FP Act and rules and that provide information to improve the FP Program include forest practices application (FPA) review and FPA compliance and enforcement. When these components provide feedback suggesting that change is needed to better meet the goals of the FP Act and rules, the Board can adopt new FP rules, modify existing ones, and adopt board manual technical guidance. Additionally, the FP Program may adjust its operational practices, within the bounds of the FP Act and rules, to create some of the desired changes. Since promulgation of the FP Act in 1974, the FP Program's flexible design has facilitated many changes to the FP rules to the Board Manual, and to the FP Program.

One such change was the incorporation of the Compliance Monitoring Program into the FP Program. The CMP was not part of the original FP Program established in 1974. The CMP was first formally proposed as an essential element in the 1999 Forests and Fish Report, a multi-stakeholder agreement that delineated acceptable measures to protect water quality and habitat for federally listed aquatic species and other riparian dependent species on private and state forestlands in Washington. The legislature enacted the Forests and Fish Report protection measures into law in 1999 based upon best available science. As a result, compliance monitoring for forest practices became a legal requirement. The CMP was promulgated as part of the FP rules in 2001 when the Board adopted FP rules that reflected the protection measures in the Forests and Fish law.

Regarding compliance monitoring, WAC 222-08-160(4) states: "The department shall conduct compliance monitoring that addresses the following key question: 'Are forest practices being conducted in compliance with the rules?' The department shall provide statistically sound, biennial compliance audits and monitoring reports to the board for consideration and support of rule and guidance analysis. Compliance monitoring shall determine whether forest practices rules are being implemented on the ground. An infrastructure to support compliance will include adequate compliance monitoring, enforcement, training, education and budget."

When funding for the CMP was allocated by the legislature in 2006, DNR, with input from other stakeholders, developed a compliance monitoring program design and implemented an initial sampling effort in the spring of that year. The CMP has completed annual compliance monitoring sampling every year since 2006. Additionally, the program has produced biennial reports starting with the 2006–2007 CMP Biennium Report showing results of field reviews, as directed by WAC 222-08-160(4), for consideration and support of rule and guidance analysis. All completed reports can be found on the CMP website: http://www.dnr.wa.gov/programs-and-services/forest-practices/rule-implementation.The CMP is a key component of a feedback loop intended to improve compliance with the FP rules that protect public resources and maintain a viable forestry industry in Washington State. When sampling results provide sufficient information regarding a need for change, CMP reports include suggestions for potential changes

that could help the FP Program better achieve the goals of the FP Act and rules. See Section 9 for a list of recent changes that resulted from CMP feedback.

3.2 Compliance Monitoring Program

Program Staffing

The Compliance Monitoring Program is directed by the DNR Forest Practices Assistant Division Manager for Operations. The program staff includes a program manager and a field coordinator, along with funded participation of one full-time staff person each from the Department of Ecology and Department of Fish and Wildlife. Additional assistance is provided by tribal biologists and other forest practices staff.

Reports

Field sampling of completed FPAs occurs annually and findings are presented in a biennial report as required by WAC 222-08-160(4). In 2011, the Commissioner of Public Lands requested that the FP Program also begin producing annual reports in the years that a biennial report is not required. This present report is a biennial CMP report and covers data samples collected during the 2014 and 2015 field seasons. The data from the 2014–2015 field seasons has been combined to produce the desired precision for statistical estimates and resulting comprehensive findings, conclusions, and recommendations are detailed in this biennial report.

Forest Practices Activities and Prescriptions

Forest practices activities are operations such as timber harvest and forest road construction that are subject to FP rules. Prescriptions are groupings of similar rules that apply to a forest practices activity. FP rules are divided and grouped by like topic/application for monitoring purposes. For example, forest practices activity types such as road construction and timber harvest are evaluated based on options available for implementing a particular activity, such as the many options available for harvest in the riparian management zone (DFC1, DFC2, etc.); and forest practices activity types are evaluated based on the function/feature being protected, such as water quality. In CMP reports, these rule groupings are called “prescription types.” The CMP obtains data from samples and reports compliance monitoring findings by prescription type.

These prescription types allow for statistical estimation of compliance with specific rule groups rather than an overall forest practices compliance rate. This enhances the ability to determine where additional training, education, or FP compliance efforts might be needed to increase landowner understanding and compliance with FP rules. The CMP, with stakeholder input, determines which FP rule prescription types will be sampled each year and then estimates the number of samples required for statistical precision. This number of samples is then visited by the compliance monitoring field team for each of the FP rule prescription types.

Compliance

Each FPA is observed for compliance with 2 elements: first, how well the conditions on the ground — after completion of forest management activities — meet FP rules; and second, how well the conditions on the ground — after completion of forest management activities — meet what the applicant stated on the FPA. The first is called "rule compliance" and the second is called "FPA compliance." The compliance monitoring field team has found that deviation on a particular FPA can occur in one of the following 3 ways:

1) The conditions on the ground are in compliance with FP rules but not with the FPA. For example, a landowner/applicant states on the FPA that he or she will leave an RMZ along the entire 1000-foot length of the Np stream in the harvest area, but upon completion of harvest the landowner leaves a buffer along 700 feet of the stream length. The 700-foot RMZ buffer is still in compliance with FP rules because the FP rules do not require the entire length of an Np stream to be buffered. However, the 700-foot buffer is not in compliance with what the landowner stated would be done on the FPA.
2) The conditions on the ground are in compliance with the FPA but deviate from the FP rules. For example, a landowner/applicant incorrectly measures the width of the stream in the FPA area and states on the FPA that the stream falls into a smaller (incorrect) width category that requires less protection. Subsequently, if the landowner implements the forest practices activity using the incorrect protection measures, the forest practice has deviated from FP rules but is in compliance with what the landowner stated on the FPA.
3) The conditions on the ground deviate from both the FP rules and the FPA.

The primary intent of the CMP is to determine on-the-ground compliance with FP rules, or "rule compliance." However, understanding deviation from the FPA, or "FPA compliance," can help DNR determine whether improvements should be made in FPA forms, FPA application instructions, or other methods of landowner outreach and education. Information regarding the type of deviation helps to inform the efforts of the FP Program to improve on the ground compliance with FP rules.

Compliance Monitoring Scope Limitations

Compliance monitoring is limited by mandate, and budget, which results in a focused program with a well-defined yet limited scope. Compliance monitoring does not involve the following:

- Focus on individual landowners and compliance specific to those landowners, but rather focuses on 2 overall groups: small and large forest landowners.
- Focus on individual regions and compliance specific to that region, but rather focuses on statewide FP rules and FPAs.
- Track FP rule violations. When field reviewers encounter rule violations, the appropriate DNR regional staff is notified for further review and action.
- Modify water types. Field reviewers do, however, record observed differences between water type documentation on FPAs and on-the-ground physical features. See Section 5.1.

3.3 Forest Practices Rules

Overall, FP rules provide protection for many riparian and upland species and their forest habitat, as well as protection for water quality. Currently, compliance monitoring focuses on rules that protect aquatic and riparian species habitat. FP rules that help protect aquatic and riparian species habitat include rules regarding the following:

- Riparian protection
- Wetland protection
- Water typing
- Road construction, maintenance, and abandonment near water
- Harvest or road construction on unstable slopes

Budget and staffing preclude the ability to monitor with statistical precision all FP rules that might affect aquatic and riparian species habitat, as well those that apply to upland habitat. The CMP prioritizes rule sampling based on a forest practices activity's potential to impact public resources.

The following are the CMP's prioritized rules chosen for sampling during the 2014-2015 field seasons.

Standard Sample

Certain specific FP rule groups are sampled every year and are considered to be part of the CMP Standard Sample. These include the following:

- Riparian rules — Western Washington and Eastern Washington RMZ rules (WAC 222-30-021 and 022)
- Road construction and maintenance rules (WAC 222-24)
- Wetland rules (WAC 222-30-020[6] and [7]; and WAC 222-24-015)
- Haul routes (WAC 222-24) for sediment delivery

Trend Analysis

For 2010-2015 data, rule compliance was carefully tracked to make sure that the compliance determination was consistently applied in all years. Data were converted to ensure consistent application of compliance determinations across the dataset (i.e. 2010 – 2013 data). Where data were not collected in accordance with current field protocols, were incomplete, or un-convertible, the data were removed from the trend analysis dataset. Data for rules were combined and compared through time within each corresponding prescription type. Trends in average compliance within prescriptions and individual rule compliance are tracked to maintain consistency with current methods.

Emphasis Sample

Other FP rule groups are sampled, as necessary, and are considered to be Emphasis Samples. These other FP rule groups govern activities utilized less often than the rules sampled in the Standard Sample. The smaller population size usually leads to the CMP sampling a higher proportion of the total emphasis population than is sampled in Standard Samples.

Note: Due in part to the CMP study redesign, trend analysis project, and staffing changes, there was no Emphasis Sample conducted for the 2014-15 reporting period.

4. Compliance Monitoring Design and Methodology

Compliance monitoring design was developed to be a consistent and repeatable field-based method to determine if forest practices are conducted in compliance with forest practices rules (FP rules). Compliance monitoring design details are found in the document *Washington State Department of Natural Resources Forest Practices Compliance Monitoring Program Design and Compliance Monitoring Protocols*. Section 2 explains key design and methodology concepts used in the forest practices Compliance Monitoring Program.

4.1 Population and Sample Selection

The population designated for sampling consists of the total number of each prescription type identified on forest practices applications (FPAs) that have completed forest practices activities and expire April 1, 2014, through March 31, 2016. Each FPA states all of the forest practices activities that the landowner intends to implement. This information allows the compliance monitoring field team to locate FPAs that list the particular FP rule prescriptions being sampled in a given year. Sample selections for each prescription type are drawn from the FPAs that contain the prescriptions being monitored that year.

Landowner Population Groups

Compliance Monitoring Program (CMP) reports provide riparian and road compliance findings separately for small forest landowners and large forest landowners, in addition to findings for all landowners combined. To date, sample sizes for small forest landowners have been too small to achieve sufficient statistical precision for conclusions regarding small forest landowners as a separate landowner group. Statistical distributions are only calculated for all landowners combined.

Sample Selection

Populations are grouped by prescriptions (DFC1, DFC2, NIZH, etc.) that have been identified on completed individual FPAs to more accurately analyze the collected field data. Therefore, populations are determined by the frequency of prescriptions that occur as part of completed FPAs.

There are thousands of active (not yet expired) FPAs every year, because the majority of FPAs have 3 years in which to be completed. Each FPA has an expiration date. For the current report, to ensure that all active FPAs had an opportunity to be selected, the populations to be sampled are those FPAs that expire between April 1 of the preceding year and March 31 of the sampling year. For the 2014-15 sample, this included 2,797 FPAs in 2014, and 1,949 FPAs in 2015 (including forest practices notifications; see Glossary). Using the April 1 to March 31 window improves the likelihood that the forest practices operations are complete prior to the primary compliance monitoring sampling months (February through November), and that the compliance monitoring field team attempts to visit the site before the FPA expires.

To provide a random selection of FPAs from the sampling population, the FPAs that expire between April 1 and March 31 are assigned a random number as a decimal fraction between 0 and 1 and then are ordered from the smallest to the largest number. The selection methodology involves reviewing the FPAs in this random order. Each FPA is reviewed to determine the sample FP rule prescription types it includes. This selection process continues through the ordered list of FPAs until the target population/sample size is reached for each prescription type.

All FPAs in the population are ordered by the assigned generated random number and categorized by region. Division staff review FPAs in the random order assigned for monitored activities that are completed. Region staff determine if the activities identified in the FPA have been completed. FPAs that do not contain monitored activities and FPAs that are not complete are discarded from the population. Sample sizes are applied in proportion to region population size for each prescription type.

For each riparian prescription, the population to be sampled consists of FPAs that included that prescription. In some cases, a single FPA contains multiple implementations of the same riparian prescription type. If this is the case, 1 prescription implementation is randomly selected for assessment. Table 1 lists the Standard Sample prescriptions monitored in 2014 and 2015.

For roads prescriptions, compliance with a single rule on a single FPA is the percentage of applications of that road rule that were compliant. Thus, for road rules only, compliance with a single rule can be a number between 0 and 1. For example, if a single rule is applied 6 times on one FPA and is compliant 5 out of 6 times, the compliance is 0.833 instead of 0 or 1 for that road rule on that FPA. The remaining analysis is the same for riparian prescriptions.

Table 1. 2014-2015 Standard Sample Prescriptions Monitored

	Statewide	Western WA Only
Roads	Road Construction and Abandonment	
	Haul Routes	
Harvest	RMZ — Type Ns Prescriptions	
	RMZ — Type Np Prescriptions	
	Wetlands (Type A&B and Forested)	RMZ — Type S or F Inner Zone Harvest DFC1
	RMZ — Type S or F No Inner Zone Harvest	RMZ — Type S or F Inner Zone Harvest DFC2

To be efficient with staff time and funding, haul routes were sampled on a subset of FPAs that were selected for other prescription compliance sampling, rather than from a separately randomized list.

Sample Size and Confidence Values

Standard Sample

In the biennial compliance monitoring design used by the CMP, the Standard Sample uses a significance level of 95%. The CMP set a desired half-width of the 95% confidence interval (CI) at 6%. A 95% CI at +/– 6% means that if the sample was repeated 20 times, one would expect the population mean (the "true" compliance rate) to lie within the confidence interval 19 out of 20 times. The CMP sets the sample size to provide an approximate +/– 6% CI for the average compliance rate of each prescription type sampled for the biennium. This sample size is an estimate based on assuming that the variance in compliance rates and average number of applicable rules within each prescription is similar to historical observations. If there is significant variation from the estimates with the actual numbers the following year's sample size may increase to account for the variation. The population of FPAs in any given year is finite. Therefore, the size of the population impacts the variance of compliance rates and, by extension, the width of CIs and the estimated sample sizes. Thus, infrequent prescriptions may need fewer samples to attain the desired precision levels. Estimated population sizes for each prescription are used in the sample size estimation to estimate a "finite population correction factor." This means that a smaller sample is required than would be for an infinite population.

For this biennial report, variance and cluster size (mean number of rules per prescription) were estimated based on the sample values from 4 years of data (2010–2013) prior to the 2014 sampling, and from 5 years of data (2010-2014) for the 2015 sample. Based on these data and the estimated FPA population size for the biennium, sample sizes were set for the biennium, and 40% of this sample size was applied to 2014. Only 40% of the biennial sample was completed in 2014 due to staffing changes. The remaining 60% of the biennial sample was completed in 2015. The sample sizes were set based on an estimate of the sample sizes required to attain a width of +/– 6% for a 95% CI for the combined 2014–2015 sample. The CI for this estimation was formed by assuming an approximate normal distribution for the average compliance ratio, so the half-width of a 95% CI is the estimated standard error multiplied by an appropriate t-statistic (approximately 2).

As a result of varying population values the CMP updated variance estimates prior to 2015 sampling to include 2014 results in the variance and cluster size estimates. This 2-year approach assumes that there is no change in compliance between the 2 years, so that no bias is introduced by having unbalanced population sampling between the 2 years.

To reach the desired sample size, population sizes for each prescription type are estimated based on the proportion of the entire population viewed (Table 2). Total population sizes for prescription types are estimated. See Appendix A for more information regarding statistical methodologies.

Table 2. 2014-2015 Standard Sample Count by Prescription Type

Geographic Region	Prescription Type		Sample Count	Estimated Population Size of FPAs with the Prescription
Statewide		Road Construction and Abandonment	13	1410
		Haul Routes	27	n/a*
		RMZ — Type Ns Prescriptions	35	1018
		RMZ — Type Np Prescriptions	35	929
		Type A & B Wetlands	35	237
		Forested Wetlands	23	322
		RMZ — Type S or F No Inner Zone Harvest	25	737
Western WA		RMZ — Type S or F Inner Zone Harvest DFC1	20	55
		RMZ — Type S or F Inner Zone Harvest DFC2	14	157

*The Haul Routes prescription does not have an estimated population.

The sample size for haul routes is not set based on statistical precision.

4.2 Field Review and Data Collection

The compliance monitoring field team uses two primary data collection methods of field observations and field measurements. These two methods determine whether the landowner/applicant met the requirements of FP rules while implementing forest practices activities. Field observations are visual assessments that help provide answers to the questions asked on CMP Field Forms. Specific measurements are taken to determine attributes such as tree/stump counts, RMZ length, RMZ width, and bankfull width. Examples of types of field observations and field measurements follow.

Riparian Harvest

- Observations:
  - Presence of alluvial fans, headwall seeps, and springs
  - Location of uppermost point of perennial flow

    - Presence of unstable slopes

- Measurements:
    - Bankfull width (BFW) — Measured for Type S, F, and N waters, except where the stream obviously exceeds or is below a threshold width (i.e., under or over 10 feet in Western Washington; under or over 15 feet in Eastern Washington). The channel width is measured (using a tape measure) at even intervals along the stream reach within the boundaries of the FPA. The goal is to obtain a minimum of 10 measurements.
    - Stream length — Measured using a hip chain. The length is used to determine the stationing for BFW measurements and RMZ width measurements.
    - RMZ and WMZ widths — RMZ widths (and the 3 zones within the RMZ) and WMZ widths are measured using a laser hypsometer to ensure accurate horizontal distances. Lasers with reflectors (held in place) are used to ensure measurement precision. RMZ widths are marked with flagging for visual reference.

Road Construction and Abandonment and Haul Route Assessment

The assessment of road construction and abandonment is based on answering a series of questions found on the CMP Roads Field Form. The questions address observed site conditions based on the required management practices in FP rules (WAC 222-24-010, 020, 030, and 040). The assessment of haul routes is based on observation of fulfillment of road rule requirements and on professional judgment from CMP participants, used to rate sediment delivery levels resulting from each haul route. Haul Route compliance is calculated by distance. Whereas, the compliance rate is the distance compliant divided by the distance sampled.

4.3 Compliance Assessment and Ratings

The CMP utilizes average compliance for a prescription among FPAs rather than the proportion of completely compliant FPAs. Each FPA is analyzed as a cluster of rules within each prescription. FPAs are then grouped according to relevant riparian prescriptions or road activities. Haul Routes, Roads, No Inner Zone Harvest (NIZH), Desired Future Condition Option 1 (DFC1), Desired Future Condition Option 2 (DFC2), Non-Fish-Bearing Perennial Waters, Non-Fish-Bearing Seasonal Waters, Type A&B Wetlands, and Forested Wetlands comprise the evaluated prescriptions. Compliance with individual rules is given a Bernoulli 0/1 result; the prescription compliance is the sum of compliant rules divided by the sum of all rules applied across all FPAs. For example: If a prescription has 17 rules that apply to it (across all sampled FPAs), and 16 of those rules are implemented per rule requirements, then the average compliance for that prescription is 94% (16 compliant rules ÷ 17 total rules = 94%).

Haul Routes

Because haul routes were not sampled in proportion to regional population sizes, a stratified mean ratio compliance estimate was used to estimate statewide compliance. The stratified mean ratio is the ratio of the stratified mean length of compliant haul routes divided by the stratified mean length of total haul routes sampled. Because the sampling has not generally been done in a

strictly random manner, there is potential for bias in the final estimate. Therefore, limiting potential conclusions based on statistical analysis of the Haul Route prescription. Conclusions may be fallaciously attributed to a phenomenon rather that to the method of sampling.

Compliant/Deviation Determination

Compliance percentages disseminated in CMP reports do not necessarily represent the complete picture of compliance with FP rules because there are varying levels of compliance that are difficult to quantify. The terminology describing compliance was changed to better acknowledge and respond to this issue. In past CMP reports, prescriptions have been described as Compliant or Noncompliant. Beginning with the 2012 report, prescriptions were considered Compliant with or a Deviation from FP rules. The former Noncompliant category has been relabeled Deviation to more accurately acknowledge that while a prescription as a whole may deviate from FP rules, several of the FP rules that comprise a prescription may be compliant. Section 4.1 of this report explains that a prescription is a grouping of FP rules. These groups were constructed by the CMP for the purposes of estimating compliance. The following example illustrates this concept.

The DFC2 prescription type (leaving trees closest to Type S or F water in Western Washington) is not a single FP rule but rather a grouping of several rules, some of which are listed below (WAC 22-30-021):

- Core zone — "No timber harvest or construction is allowed in the core zone."
- Inner zone — "Forest practices in the inner zone must be conducted in such a way as to meet or exceed stand requirements" (see Glossary). "Trees are selected for harvest starting from the outer most portion of the inner zone first."
- Outer zone — "Timber harvest in the outer zone must leave twenty riparian leave trees per acre." "Dispersal strategy-riparian leave trees, which means conifer species with a diameter measured at breast height (DBH) of twelve inches (12") or greater, must be left dispersed approximately evenly throughout the outer zone."

These examples are only a few of the FP rules that are part of the DFC2 prescription type. When the DFC2 prescription in a CMP report is shown with a compliance of 98%, this refers to the average compliance of the sampled relevant rules within the DFC2 prescription. The corresponding Deviation category includes any FPAs that are a part of the DFC2 sample that deviated from compliance on at least 1 of the FP rules included in the prescription type.

It is important for readers to understand the meaning and severity of deviation from FP rules. To aid in this understanding, compliant and deviation assessments are assigned a compliance rating. Compliant prescriptions are rated either Compliant or Exceeds Rule Requirements. Prescriptions that deviate from FP rules are rated either Low, Moderate, or High. When the compliance monitoring field team, due to a variety of circumstances, cannot determine the degree of deviation, it is rated Indeterminate. These ratings help to convey the relative magnitude of deviation from what was required by the relevant rule.

Compliance Ratings and Reasons Descriptions

This section describes five compliance ratings and three reasons for deviation that are applied after the Compliant/Deviation assessment is made, as well as the Indeterminate rating. There are two categories for a Compliant assessment: Compliant and Exceeds Rule Requirements. There are three ratings for a Deviation assessment — Low, Moderate, High — as well as the Indeterminate rating. There are three reasons for a Deviation assessment — Layout, Operational, and Administrative.

Compliant Rating Determinations

The Compliant rating means that an activity meets the requirements of the individual FP rule that is relevant to that activity. By signing and submitting an FPA, a landowner conveys the intention to conduct specific forest practices activities on lands with specific site characteristics as described on the FPA. The landowner's signature on the FPA acknowledges that the landowner understands that FP activities must comply with the FP Act and rules.

Implementing this system requires the following assumptions:

- All participants acknowledge that this process relies on professional judgment and does not represent determinations of rule effectiveness.
- There will be no statistical analysis beyond the narrow scope intended.

Compliant Ratings Definitions

- Compliant rating — The activity is compliant with the FP rule.
- Exceeds Rule Requirements (or Exceeds) rating — While implementing their forest practices activities, landowners/applicants chooses to provide more protection than required by FP rules.

Deviation Rating Determinations

The Deviation rating means that an activity does not meet the requirements of the individual FP rule that is relevant to that activity. In order to gauge the magnitude of the deviation and where DNR might focus training efforts to improve compliance, the compliance monitoring field team uses professional judgment to rate deviations. It is important to note that these deviation ratings employ professional judgment and should not be used to excuse activities that violate FP rules or approved FPAs. There are three Deviation categories — Low, Moderate, High — as well as an Indeterminate rating. The following guidelines are used to assist professional judgment when rating the impact of deviation in the field:

- Low Deviation — Minor deviation from requirements of the rule. Examples include:
    - Outer zone has less than the required number of leave trees after harvest.

- Moderate Deviation — Moderate deviation from requirements of the rule. Examples include:
    - Trees harvested from the inner zone are larger than allowed by the Desired Future Condition harvest strategy.
- High Deviation — Major deviation from requirements of the rule. Examples include:
    - No leave trees left in the outer zone.
- Indeterminate — The rule is out of compliance, but the compliance monitoring field team cannot determine the degree of deviation.

Deviation Reasons Determinations

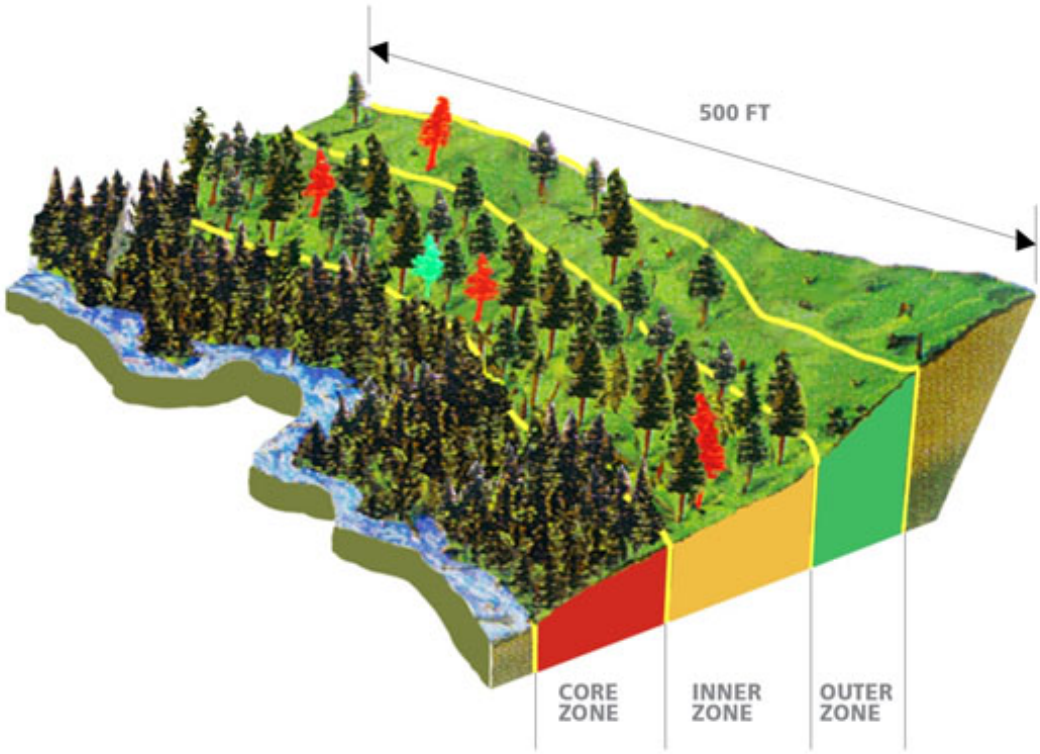
The Deviation reason assessment is determination made by the field team as to a potential cause for non-compliance. It is important to note that these deviation reasons employ professional judgment. There are three Deviation categories — Layout, Operational, and Administrative. The following guidelines are used to assist professional judgment when rating the impact of deviation in the field:

- Layout — The arrangement of the harvest unit did not meet the specifications of the rule. Examples include:
    - A stream meander is unaccounted for in the layout of an RMZ.
- Operational — The timber harvest and related activities process did not follow the arrangement of the harvest unit or associated activity. Examples include:
    - Designated leave trees harvested within a no-cut inner zone.
- Administrative — Information and/or data provided on the Forest Practices Application and associated documents deviates from the conditions observed on the ground. Examples include:
    - An incorrect site class is recorded on an FPA.

The following examples of deviations from FP rules illustrate that there can be a level of compliance for many of the rules included in a prescription type, even when they are assessed as a Deviation. The examples show the process of assigning ratings to the deviation.

Figure 1 illustrates a riparian harvest adjacent to Type F water assessed as a Deviation and rated as Low. A riparian zone harvest is subject to a number of complex FP rules. In this example, the landowner/applicant followed multiple FP rules by typing the stream accurately; measuring the stream width correctly; correctly measuring the core, inner, and outer zone widths; and leaving the core zone intact.

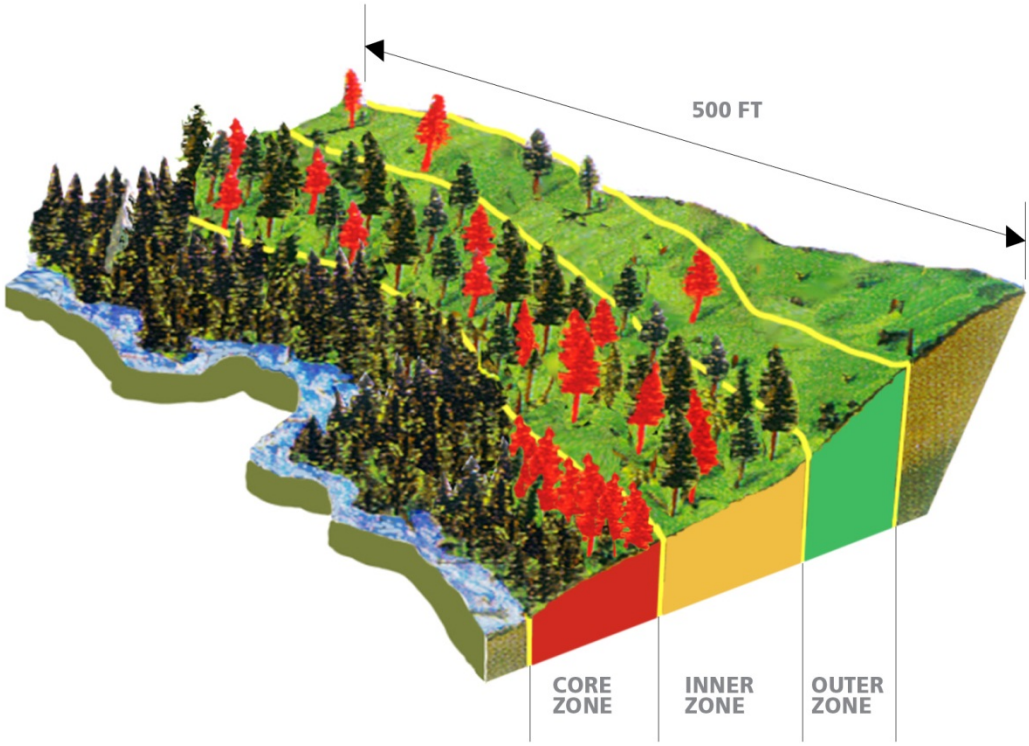
Figure 1. Inner Zone Harvest with Deviation Rated as Low



The red trees in the image represent trees that were required by rule to be left but were harvested. An offsetting factor in representing the average number of trees per acre required is that 1 tree per 500 feet was taken out of the outer zone, 3 trees too many were harvested from the inner zone, and an additional tree that had *not* been required to be left was left in the inner zone (represented in Figure 1 by the lime green tree outline).

In contrast, Figure 2 illustrates an example of inner zone harvest assessed as a Deviation and rated as High, on fish-bearing waters. In this scenario, the landowner/applicant planned a riparian zone harvest and followed the same FP rules as in the example above, except that harvest rules were not followed completely in any of the 3 zones. Each zone would be assessed for individual rule compliance. In this example, core zone trees were harvested, as were many inner zone trees and outer zone trees that were required to be left.

Figure 2. Inner Zone Harvest with Deviation Rated as High



In Figure 2, 11 trees are missing per 500 feet of the inner zone and 3 trees are missing per 500 feet of the outer zone. Additionally, some harvest occurred in the core zone.

The expectation is for landowners to follow all relevant FP rules. However, there is more to evaluating compliance with FP rules than estimating average compliance for prescription types. The CMP continues to work toward finding better ways to explain a more complete picture of compliance in the reports.

4.4 Design/Methodology Changes

Evaluation of Rule Compliance

An FPA contains a set of rule applications for a particular prescription. As part of the former study design, each FPA was evaluated as either compliant or not compliant for the prescription, based on 100% compliance with all rules in the prescription. The prescription compliance was the number of FPAs that were 100% compliant divided by the total number of FPAs containing the prescription. This can be viewed as a binomial proportion, and confidence intervals were formed under this assumption. This is statistically simple, but the sample sizes required for precise estimates of these proportions were costly and difficult to attain, and the pass/fail aspect

of the compliance assessment did not adequately identify or explain the exact rules being deviated from.

The CMP has integrated a more quantitative estimate of compliance with each rule, with an increase of precision associated with the overall sample estimates. The sampling method remains cluster sampling. There are 2 levels of sampling units: the prescriptions and the rule application. The prescriptions are clusters of rule applications. In the previous method, only 1 assessment was made for each prescription per FPA, so the FPAs were all clusters of size 0 or 1, and the zeros dropped out of the population for the prescription. The changes made are to the methodology of assessing compliance with each prescription, rather than changes to the sampling design. These changes under the current sampling design amount to multiple applications of rules on single FPAs (i.e., the number of rules under prescription A on a single FPA = 0, 1, 2 … up to the total number of rules under prescription), so the FPAs are treated as clusters.

The purpose of the change is to estimate the *average* compliance for a prescription or rule group among FPAs rather than the proportion of completely compliant activities among FPAs. As discussed above, each FPA is a cluster of rule prescriptions, which can be grouped in various ways (prescription or rule group) or evaluated individually. If a single rule is of interest, the compliance proportion for that rule is a simple binomial proportion — FPAs that do not apply the rule drop out of the population. When groups of rules (or prescriptions) are of interest, all FPAs that contain at least 1 of the rules are part of the population (from a random sample). Multiple implementations of a rule on a single FPA are not independent, the FPA is a cluster sample, and each has a different number of rules. The mean or average compliance and the variance of the mean are calculated according to the rules of estimation for cluster samples (Cochran 1963; Scheaffer et al. 1990). Compliance rates calculated using this approach will most likely be higher than the compliance rates previously estimated. For example, if there are many rules in a prescription, bad performance on a single rule will have little effect on overall average compliance. On the other hand, compliance for each individual rule can be evaluated and tracked separately, although precision is not be controlled for individual rule compliance.

Sample Size Estimation

Three independent factors are used to calculate the biennial sample size for each individual prescription: (1) population size; (2) the expected variation within that population; and (3) the desired level of precision in the sampling estimate. The variance of the mean prescription compliance depends on the total number of FPAs that contain the prescription (the population size; because this is a finite population), the sampled number of FPAs that contain the prescription, the average number of rules per prescription applied on each FPA, and the variability of compliance among FPAs. Data from the previous five years of sampling are used to estimate compliance variance for each prescription by year and to approximate sample sizes that should attain reasonable standard errors. Population sizes for each prescription are needed to approximate sample sizes. Because population sizes can vary from year to year, upper bounds for population sizes were used as initial estimates. When good estimates or census data are available before sampling is complete, the population sizes can be updated in the sample size estimation worksheet and the sample sizes can be adjusted. However, it is important to remember that the

variance used for the sample size estimates is also only an estimate. There is no guarantee that the estimated confidence intervals will be the exact width that was projected.

4.5 Compliance Monitoring Challenges

Challenges are not uncommon for any complex assessment program. This section reviews current challenges for the CMP.

Sample and Measurement Error

Sampling error occurs when rule or Board Manual guidance specifies that average values are to be used during the layout of a specific prescription type. This is because averages vary depending on where measurements are taken. It is unlikely that the compliance monitoring field team can duplicate the exact same ten measurements made along a stream reach for calculating stream width as were measured by a landowner. The result is that the compliance monitoring field team's average stream width value is likely different from the landowner's average stream width value. The CMP resolves the inability to determine statistical variability for average values by assigning an absolute 5% measurement error tolerance. This measurement error tolerance applies for 3 specific measurements: when determining 1) leave tree to edge of bankfull width; 2) buffer widths and lengths or floors within RMZs 3) bankfull width of N and F/S streams. When a landowner's average value is within 5% of the compliance monitoring field team's average value, the landowner's values are considered accurate. If the landowner's average value falls outside the 5% error tolerance, the compliance monitoring field team value is assumed to be correct and the landowner's average value incorrect.

Variation in Natural Conditions

Natural systems such as forests are highly variable and difficult to measure with precision. Forest practices rules require precise measurements to implement forest practices activities. Applying precise measurements becomes difficult for forest practice activity implementation as well as for FPA compliance and compliance monitoring. When precise measurements required in the FP rules are confounded by variable site conditions, the CMP follows the most protective interpretation of the FP rules to determine compliance.

A frequent example of precise FP rules conflicting with imprecise on-site conditions occurs when a stream reach has FP rule–defined characteristics of both a Type Np stream and a Type F stream. Type Np streams are defined as streams that are perennial non-fish habitat streams. Type F streams are defined as having a gradient equal to or less than 20%. When a stream reach meets the physical criteria for a Type F stream, and lies upstream of a portion of a stream reach that has a gradient greater than 20%, the stream is considered Type F. The only exception is when an approved Water Type Modification Form or supporting Interdisciplinary Team documentation has been submitted endorsing the change of the water type.

5. Forest Practices Rule Compliance for Water Types and Riparian, Wetland, and Equipment Limitation Zones

Forest practices rules (FP rules) are designed to protect aquatic resources and related habitat adjacent to typed waters and wetlands when forest practices activities are carried out. Riparian and wetland areas provide fish, amphibian, and wildlife habitat and protect water quality. A riparian management zone (RMZ) is the area adjacent to Types S, F or Np streams (see definitions below) where trees are retained to provide functions required by aquatic and riparian species, maintain water quality, as well as for protection from disturbance. A wetland management zone (WMZ) is the area located around the perimeter of a wetland where trees are left to provide protection from disturbance, maintain hydrologic functions as well as shade and nutrients for the wetland. Both RMZ and WMZ buffers filter runoff to minimize sediment entering water; provide long-term large woody debris recruitment and organic material crucial for fish and amphibian habitat; maintain shade to help regulate stream temperatures; and provide amphibian and wildlife habitat. Protection on Type Np and Ns streams also includes an equipment limitation zone (ELZ). This is a 30-foot-wide zone adjacent to Type Np and Ns streams. There are limitations on equipment use within the ELZ, and on-site mitigation measures are required if activities expose the soil on more than 10% of the zone.

FP rule protection measures that guide timber harvest options within RMZs depend on the water type (Type S, F, Np, Ns), width of the stream (bankfull width), and the site class (I, II, III, IV, V) of the RMZ. Wetland protection depends on the type and size of the wetland.

Section 5.1 through 5.4 provides FP rule and on-site review descriptions and compliance monitoring findings for the following within the Standard Sample:

- Water type observations
- Western Washington RMZs
- Eastern Washington RMZs
- Statewide wetlands

While maintaining adequate shade is an important part of riparian prescriptions, the forest practices shade rules are not yet part of the FP rules being monitored by CMP. Consequently, the riparian descriptions throughout the remainder of this report do not include shade, even though shade is integral to the overall protection provided in riparian areas. The CMP will initiate sampling for shade compliance after the program has adopted methods suitable to produce relevant information.

5.1 Statewide Water Type Observations

In the initial years of compliance monitoring, compliance monitoring field team observations indicated that at times water types observed on the ground did not match water type classifications provided on submitted and approved forest practices applications (FPAs). This led to a focus on consistency and accuracy of water type information on FPAs, because the width and length of riparian buffers required under FP rules are directly linked to water type. In the FP rules, water is classified in specific stream and wetland categories, or "types," based on several factors (WAC 222-16-030, 031, and 035). Stream and wetland type classification is a fundamental aspect of determining which FP rules apply to forest management activities taking place adjacent to typed water. Specific FP rules apply to specific water types because different water types fulfill unique and cumulative functions for aquatic and riparian species and water quality. Waters of the state were initially classified by type using local knowledge and orthophotos and were represented on a set of water type maps. Currently, the public can find information about the water type assigned to a particular stream on the FPARS mapping site: http://www.dnr.wa.gov/programs-and-services/forest-practices/forest-practices-application-review-system-fpars. Because waters depicted on DNR water type maps were originally typed without a field visit, the maps can display incorrect water types and must be field verified by landowners prior to FPA approval.

FP Rules for Water Type

Forest practices water typing rules define 4 types of streams (S, F, Np, and Ns) and three types of wetlands (forested, nonforested Type A [including bogs], and nonforested Type B). The four types of streams are classified hierarchically based on stream function and level of protection required for the stream. The following are the stream types in hierarchical order starting with the highest level (requiring the most protection):

- Type S streams — The highest level of classification, "Shorelines" of the state as designated by the Department of Ecology.
- Type F streams — The second highest level of classification, with fish or specifically defined human uses or both.
- Type Np streams — The next lowest classification in the stream hierarchy, these are non-fish-bearing streams that have a perennial flow of water during a normal rainfall year and include intermittent dry portions of the perennial channel.
- Type Ns streams — The lowest level of classified streams, seasonal non-fish-bearing streams where surface flow is not present year-round.

Wetlands are classified into two broad categories: Forested and Nonforested. Nonforested Wetlands are further divided into Type A and Type B.

- Forested Wetlands — Wetlands that have a crown closure of 30% or more (see Glossary).
- Nonforested Wetlands — Wetlands that have a crown closure of less than 30%.
    - Type A Wetlands — Greater than 0.5 acre in size and associated with at least 0.5 acre of ponded or standing open water present for at least 7 consecutive days between April 1 and October 1, and all bogs greater than 0.25 acre.
    - Type B Wetlands — All other nonforested wetlands greater than 0.25 acre.

On-site Review for Statewide Water Types

Field observations sometimes indicate that water types depicted on water type maps are incorrect. Landowners may use existing DNR water type maps as a starting point for information as they prepare their FPA for submittal to DNR, but must verify water types located within the areas proposed for forest management activities and indicate the correct water types on the FPA. Correct and accurate water typing is critical. When water is incorrectly underclassified, inadequate riparian protection measures may be applied, which may ultimately impact public resources; conversely, if a water is overclassified, excessive protection may be provided to the detriment of the proponent's objectives for the forest practice activity. Water type verification occurs through measurement of the water's physical characteristics as defined in WAC 222-16-031 and 035, or through a protocol (fish) survey (to confirm fish presence/absence) as specified in Forest Practices Board Manual, Section 13. Applicants are encouraged but not required to complete water type classification worksheets or protocol surveys and submit them with their FPA as supporting documentation for the water types indicated on the FPA.

Changes to DNR water type maps can be made when data from field observations indicate that the water type on the water type map is incorrect and/or if a stream is found on the ground in a

different location than depicted on the map or not at all. To propose a permanent water type change from the water type indicated on the DNR water type map, an individual submits a Water Type Modification Form to DNR. The Water Type Modification Form goes through a concurrence process that provides opportunity for review by all TFW stakeholder groups.

The compliance monitoring field team observes physical criteria (such as stream width, stream gradient, etc.) to determine if there appear to be differences between water types recorded on FPAs and what is observed on the ground. These observations are made on the same stream reaches and wetlands that have been randomly selected for compliance monitoring for other rules that year. The compliance monitoring field team evaluates only the stream reach or wetland within the proposed boundary shown on the FPA; therefore, the information is not sufficiently comprehensive to determine all water types, depending on the length and location of the water within the FPA. Water types can sometimes only be determined by continuing to observe and measure upstream or downstream of the FPA harvest unit boundary.

The CMP developed the Supplemental Water Information Form (SWIF) to be, used specifically for the purpose of recording potential water type and other water related discrepancies. A SWIF is completed when potential inconsistencies are found by the compliance monitoring field team between on-the-ground measurements and observations and what is described in the FPA. The information is reported in the compliance monitoring report. If an FP rule violation occurred because of the water type inaccuracy observed (i.e., the water did not receive enough riparian protection — buffer width and length), then the information relating to the violation is sent to the appropriate DNR region for follow up. The intent of using SWIFs is to obtain a sense of both the overall magnitude of possible water typing discrepancies on the landscape and the potential incorrect implementation of riparian buffers designed to protect aquatic resources. The compliance monitoring field team does not engage in formal water typing (e.g., fish protocol surveys) with the intent of changing water types, because that action has a defined process beyond the scope of the compliance review. The responsibility is on the landowner to ensure that the water types on the FPA have in fact been field validated.

Findings for Statewide Water Types

Water types recorded on a SWIF are further broken down into waters correctly classified, underclassified, overclassified, and indeterminate. The latter three categories are defined as follows:

- Underclassified — Physical characteristics indicate that the water should have been typed on the FPA and protected on the ground at a higher level of the hierarchical water typing system. For example, the FPA depicts a Type Np water that after observation is found to have Type F physical characteristics or observed fish.
- Overclassified — Physical characteristics indicate that the water should have been typed on the FPA and protected on the ground at a lower level of the hierarchical water typing continuum. For example, the FPA inaccurately depicts a Type Ns water that after observation is found to actually be an untyped stream.
- Indeterminate — Waters for which the compliance monitoring field team determines there is not enough information to make a water typing determination. For example,

when the compliance monitoring field team visits a site in the wettest part of the year (winter) and cannot determine if the water would flow in the driest part of the year (summer), the compliance monitoring field team cannot determine with certainty if the water is a Type Np (perennial) or Ns (seasonal).

Table 3. 2014-2015 Water Typing Observation Information

Water Type on FPA	# Waters in Standard Sample	# Waters Recorded on SWIF	SWIF # Waters Underclassified	SWIF # Waters Overclassified	SWIF # Waters Indeterminate
F or S	59	1	*	0	0
Ns	35	8	2	5	1
Np	35	5	3	0	2
Type A Wetlands	17	8	4	2	2
Type B Wetlands	18	5	1	3	1
Forested Wetlands	23	1	1	0	0
Total	187	28	11	10	6

*Compliance Monitoring field protocols stipulate that F or S waters are not to be evaluated for underclassification, as there is no higher order water.

Water typing observations from 2014 and 2015:

Of the 187 sampled waters in 2014 and 2015, 28 samples called for SWIFs due to water discrepancies.
Eleven samples were underclassified, resulting in an underclassification rate of roughly 6%. No protocol surveys or approved Water Type Modification forms were attached to the FPAs with underclassified waters. Of the 11 underclassified waters, 9 were segments that met fish habitat physical characteristics or fish presence was visually observed. Of those, 5 were wetlands where fish presence was observed or were associated with F streams. Three Np streams and 1 Ns stream met fish habitat physical characteristics, respectively. Another underclassified water was typed as Ns, but water flow was observed during the compliance monitoring field visit in September. Additionally, a type B wetland was determined by the DNR wetland specialist to be a bog (treated as an A wetland by FP rules).
Ten samples were overclassified, resulting in an overclassification rate of 5%. Five Ns waters were determined to be wet swales or channels with no connectivity to higher order waters. An A wetland was determined to be non-existent, and 2 type B wetlands were measured to be smaller in area than what was reported on their respective FPAs. The 2 type B wetlands were determined to be a Forested wetland, and a non-forested wetland respectively.
Six samples were indeterminate. Three of the indeterminate observations were for wetlands. Bog indicators were observed by the compliance monitoring field team for a sampled Type B wetland. However, due to physical sampling limitations, a final water typing determination was

not possible. Two of the indeterminate observations were for Np waters. Sampled segments at both sites met fish habitat physical characteristic criteria. At one site the bottom 2-3 stations met fish physical criteria, however, the remaining portion of the segment did not, with no supporting documentation or data a final water typing determination could not be made. At the second site, an approved WTMF was submitted along with the FPA. However, the WTMF was devoid of any typing information and was unclear to which portion of the stream segment it applied to. (Table 3.)

Additionally, 3 SWIFs were completed for non–water typing issues. A SWIF was filled out when the compliance monitoring field team observed a channel migration zone that was unreported on the accompanying application. Rule compliance was unaffected due to an excessively large no-cut buffer left by the landowner. Two SWIFs were completed for overstated stream size (by the applicant) on a Type F water (stream was less than 10 feet wide).

5.2 Statewide Summary for FP Rule Compliance for RMZs, WMZs, and ELZs

Section 5.2 provides 2 summary tables: Table 4 lists the RMZ, WMZ, and ELZ prescriptions sampled in 2014 & 2015; Table 5 shows statewide results for compliance with RMZ and WMZ FP rules. The data and findings for each prescription are discussed in Section 5.3 (Western Washington RMZs) and Section 5.4 (Statewide RMZs, WMZs, and ELZs).

Table 4. RMZ, WMZ, and ELZ Prescriptions Sampled in 2014 & 2015

Western WA	Eastern WA	Statewide
RMZ — Option 1, Thinning from Below RMZ — Option 2, Leaving Trees Closest to Water	No sample unique to Eastern WA	WMZ — Wetlands RMZ — No Inner Zone Harvest ELZ — Type Ns & Np Activities RMZ — Type Np

Each prescription has a unique set of timber harvest requirements and includes the use of a corresponding set of protocols and questions to determine compliance status. FP rule prescriptions for Type F and N streams can be different for Eastern and Western Washington. However, samples were not separated by Eastern and Western Washington. Wetland rules are the same for Eastern and Western Washington.

The small proportion of small forest landowner FPAs in Table 5 reflects the small proportion of total small forest landowner FPAs within the total FPA population containing the prescriptions assessed.

Table 5. 2014-2015 Compliance with FP Rules for Riparian, Wetland Harvest, and Roads Prescriptions

		Western WA		Statewide					
	Status of Compliance	DFC1	DFC2	No Inner Zone Harvest	Np Activities	Ns Activities	Type A&B Wetlands	Forested Wetlands	Roads
Small Forest Landowners	# Compliant Rules	n/a	n/a	17	2	6	36	11	n/a
	# with Deviation	n/a	n/a	0	0	1	6	0	n/a
	% of Sample Compliant	n/a	n/a	100%	100%	86%	86%	100%	n/a
	Confidence Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Prescriptions Assessed	0	0	4	1	5	12	7	0
Large Forest Landowners	# Compliant Rules	131	98	99	126	53	84	27	81.7
	# with Deviation	8	2	8	8	1	1	1	1.3
	% of Sample Compliant	94%	98%	93%	94%	98%	99%	96%	98%
	Confidence Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Prescriptions Assessed	20	14	21	34	30	23	16	13
All Landowners	# Compliant	131	98	116	128	59	120	38	81.7
	# with Deviation	8	2	8	8	2	7	1	13
	% of Sample Compliant	94%	98%	94%	94%	97%	94%	97%	98%
	Confidence Interval	(91, 97)	(95, 100)	(87, 100)	(89, 99)	(92, 100)	(89, 100)	(92, 100)	(95, 100)
	Prescriptions Assessed	20	14	25	35	35	35	23	13

5.3 Western Washington RMZs

5.3.1 Western WA Type S and F Waters

Section 3.3.1 addresses Type S and F riparian prescriptions: DFC1, Thinning from Below; and DFC2, Leaving Trees Closest to the Water.

On-site Review for Western WA Type S and F Waters

During the compliance monitoring field review, there are questions on the Western Washington Riparian Field Forms common to all riparian harvest options for Type S and F waters, including the following:

- Is there any harvest within the core, inner, and outer zones?
- Is the site class (variable in determining inner zone width) consistent with DNR site class maps?
- Is the stream width (variable in determining inner zone width) the same as stated on the FPA? If not, does it impact the inner zone width?
- Are unstable slopes with the potential to deliver (sediment) bounded out of the harvest unit?

In addition to common questions relevant to all Type S and F water riparian prescriptions, specific Western Washington riparian prescription questions are asked on the Western Washington Riparian Field Forms that assess the unique rules directed at individual harvest options.

5.3.1.1 Western WA Type S and F Waters — DFC1, Thinning from Below

Desired Future Condition Option 1 is available if DFC growth modeling results show an available surplus basal area that allows for harvest to take place in the inner zone. DFC calculations indicate if a forest stand meets basal area requirements (that is, if the stand is on a trajectory to meet the DFC of 325

square feet of basal area per acre at a stand age of 140 years) then harvest is allowed. When DFC calculations indicate harvest is allowed because the model projects more basal area is available than needed to meet the target basal area in the FP rule, then the smallest diameter trees are allowed to be harvested, followed by the harvest of progressively larger trees until the surplus basal area limit has been reached (also referred to as "thinning from below"). This selection process is intended to establish a forest environment where the leave trees in the inner zone can grow larger in a shorter time and meet desired large wood, fish habitat, and water quality requirements more quickly. The widths of the inner zone and outer zone vary depending on the bankfull width of the stream and the site class. A minimum of 57 conifer trees per acre must be left in the inner zone. A minimum of 20 conifer trees per acre greater than 12 inches (12") diameter breast height (DBH) must be retained in the outer zone. The leave trees in the outer zone may be dispersed evenly throughout the zone or clumped around sensitive features such as seeps, springs, and forested wetlands.

Findings for Western WA Type S and F Waters — DFC1, Thinning from Below

Desired Future Condition Option 1 is the most complex Type F prescription to implement in terms of the number of requirements to be met. It occurs relatively rarely in the population of FPAs. In the 2014-15 sample, 20 FPAs were selected for review with DFC1 chosen as the harvest option from a total population of 55 FPAs. The resulting DFC1 prescription sample size was 20, and a total of 139 rules were evaluated.

Table 6. 2014-15 Compliance Ratings for Western WA Type S and F Waters — DFC1, Thinning from Below

RMZ Prescription	FP Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (part of Compliant)	**Compliant**	**Low**	**Moderate**	**Major**	**No Assessed Deviation Rating**	**Indeterminate**
DFC1 (%)	9.9%	94.2%	5.0%	0.7%	0%	0%	0%
DFC1 (Rule Count)	13	131	7	1	0	0	0

Sample size = 20

One hundred thirty one of the sampled 139 rules were compliant for the DFC1 prescription sample, resulting in a 94.2% compliance rate +/- 3%. Of the 20 sites sampled, 14 were 100% compliant and 6 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 8 non-compliance determinations across 6 sample sites. An unaccounted for meander in a stream course that was approximately 10 feet wide was observed at one site, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be layout. At the second site, 4 required inner zone leave trees were missing from the 12" diameter class, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be a layout issue. The third site had less than the required number of outer zone leave trees, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be operational. At the fourth site, 4 trees removed from a yarding corridor in the core zone were observed, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be operational. At the same site, trees were removed from the inner zone that were larger than allowed by the Desired Future Condition

harvest strategy, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be a result of a layout deficiency. At the fifth site, as a result of a stream meander 2 trees were removed from the core zone, resulting in a Low Deviation rating, and the reason for non-compliance was the result of a layout issue. At the sixth site, as a result of an incorrectly completed Desired Future Condition Worksheet trees were removed from the inner zone that were larger than allowed by the Desired Future Condition harvest strategy, resulting in a Moderate deviation rating, and the reason for non-compliance was determined to be a result of an administrative error. (See table 6.)

Exceeds ratings were assessed for excess Outer Zone leave trees in 9 samples.

5.3.1.2 Western WA Type S and F Waters — DFC2, Leaving Trees Closest to the Water

Desired Future Condition Option 2 only applies to RMZs in site classes I, II, and III on streams that are less than or equal to 10 feet wide and to RMZs in site classes I and II for streams greater than 10 feet wide. For this option, DFC growth modeling results show an available surplus basal area that allows for harvest to take place in the inner zone. Trees are selected for harvest starting from the outermost portion of the inner zone first and then progressively closer to the stream. Twenty conifer trees per acre with a minimum DBH of 12 inches must be left in the harvested area of the inner zone. The widths of the inner zone and outer zone vary depending on the bankfull width of the stream and the site class. For site classes I, II, and III on streams less than or equal to 10 feet, there is a 30-foot no-harvest extension beginning at the outer edge of the core zone. For site classes I and II on streams greater than 10 feet, there is a 50 foot no-harvest extension beginning at the outer edge of the core zone. Twenty conifer trees per acre greater than 12 inches DBH must be retained after harvest in the outer zone, unless a large woody debris in-channel placement strategy is selected. Leave trees in the outer zone may be evenly dispersed throughout the zone or clumped around sensitive features.

Findings for Western WA Type S and F Waters — DFC2, Leaving Trees Closest to the Water

Desired Future Condition Option 2 harvest is easier to implement and is chosen by proponents more frequently than DFC1. In the 2014-15 sample, 14 DFC2 prescriptions were sampled from an estimated population of 157 FPAs. A total of 100 rules were evaluated.

Table 7. 2014-15 Compliance Ratings for Type S and F Waters in Western WA — DFC2, Leaving Trees Closest to the Water

RMZ Prescription	FP Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (part of Compliant)	Compliant	Low	Moderate	Major	No Assessed Deviation Rating	Indeterminate
DFC2 (%)	22.4%	98%	2%	0%	0%	0%	0%
DFC2 (Rule Count)	22	98	2	0	0	0	0

Sample size = 14

Ninety-eight of the sampled 100 rules were compliant for the DFC2 prescription sample, resulting in a 98% compliance rate +/- 3%. Of the 14 sites sampled, 12 were 100% compliant and 2 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 2 non-compliance rule determination. At the first site, harvest in the floor zone was observed for the non-compliant sample. 3 harvested stumps were counted, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be operational. At the second site, eight harvested stumps were counted in the floor zone, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be a layout issue. (Table 7.)

Exceeds ratings were the result of leaving more than the required amount of inner, and outer zone leave trees in 14 samples. Additionally, Exceeds ratings were assessed for excess outer portion of floor zone leave trees in 7 samples.

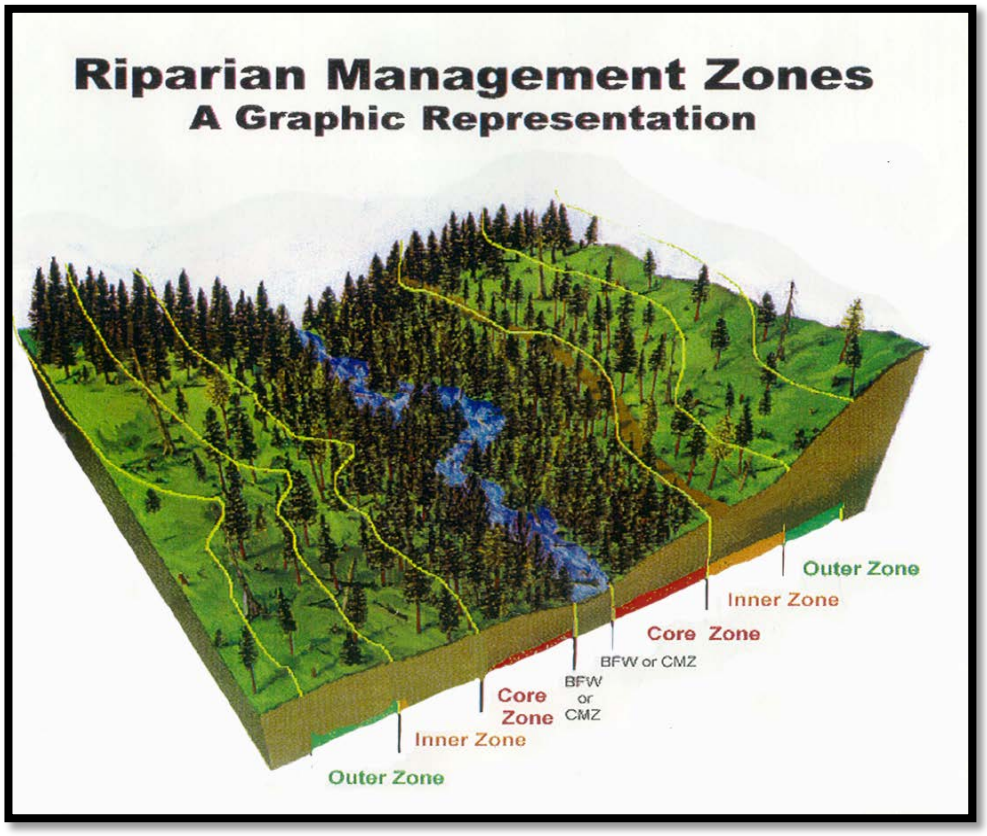
5.4 Statewide RMZs, WMZs, and ELZs

5.4.1 Statewide Typed Waters

Protection measures adjacent to typed water in the state of Washington include protecting channel migration zones (CMZs); establishing riparian management zones (RMZs) along the full length of fish-bearing waters and along a portion of the length of perennial non-fish-bearing waters; retaining no-harvest buffers adjacent to sensitive sites; and establishing equipment limitation zones (ELZs), where equipment is limited along non-fish-bearing waters. RMZs adjacent to fish-bearing streams include a core zone, inner zone, and outer zone, with differing prescriptions delineated in FP rules for inner and outer zones (see Figure 3).

In Western Washington, no timber harvest or road construction is allowed in the 50-foot core zone on fish-bearing waters (zone closest to the water), except for the construction and maintenance of road crossings and the creation and use of yarding corridors. The inner zone (middle zone, not including core zone) ranges from 10 to 100 feet, depending on width of the stream and the site class (see Glossary) of the forested stand. Timber harvest of excess trees in the inner zone is only allowed if predetermined stand requirements are met, which are intended to result in a mature riparian forest stand at 140 years of age (called “desired future condition,” or DFC). Timber harvest is allowed in the outer zone (adjacent to and outside the inner zone), with 20 riparian leave trees per acre retained following harvest.

Figure 3. Type S and F Water RMZs



Protection along non-fish-bearing waters in Western Washington includes RMZs along at least 50% of the length of Type Np waters and around sensitive sites, and the establishment of ELZs for both Np and Ns waters. An ELZ is a 30-foot-wide area where equipment use is restricted in order to minimize ground and soil disturbance. The ELZ protects stream bank integrity and helps minimize sediment delivery to non-fish-bearing waters that could potentially be routed farther downstream to fish-bearing waters.

In Eastern Washington, riparian management is intended to result in stand conditions that vary over time. Management is designed to mimic local disturbance (such as wildfire) regimes in a way that protects riparian function conditions and maintains general forest health. Harvest adjacent to a Type S, F, or Np stream is based on the DNR site class map, timber habitat type, basal area, and shade requirements needed to protect the stream. Habitat types include Ponderosa Pine, Mixed Conifer, and High Elevation. The no harvest core zone along type S and F waters is 30 feet. Harvest units within the Bull Trout Habitat Overlay must leave all available shade within 75 feet of the bankfull width or CMZ, depending on which is greater. Np and Ns waters have an ELZ of 30 feet.

5.4.1.1 Statewide Type S and F Waters — No Inner Zone Harvest

For the No Inner Zone Harvest (NIZH) option, DFC results show that existing stands in the combined core and inner zone do not meet stand requirements in western Washington. Therefore, inner zone harvest cannot take place, or sometimes the landowner elects not to harvest in the inner zone for operational or other reasons.

Findings for Statewide Type S and F Water — No Inner Zone Harvest

No Inner Zone Harvest is the most frequently selected harvest strategy adjacent to fish-bearing waters. This harvest strategy occurred on an estimated 737 FPAs in the 2014-15 population. The resulting NIZH prescription sample size was 25, and a total of 124 rules were evaluated.

Table 8. 2014-15 Compliance Ratings for Statewide Type S and F Waters — No Inner Zone Harvest

RMZ Prescription	FP Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (part of Compliant)	Compliant	Low	Moderate	High	No Assessed Deviation Rating	Indeterminate
No Inner Zone Harvest (%)	8.6%	93.5%	4.0%	0%	1.6%	1%	0%
No Inner Zone Harvest (Rule Count)	10	116	5	0	2	1	0

Sample size = 25

One hundred sixteen of the sampled 124 rules were compliant for the NIZH prescription sample, resulting in a 94% compliance rate +/- 7%. Of the 25 sites sampled, 17 were 100% compliant and 8 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 8 non-compliance determinations across 5 sample sites. At the first site, an incorrect site class determination was recorded, resulting in a Low deviation rating, and the reason for non-compliance was determined to be administrative. As a result of the incorrectly applied site class, harvest occurred within the inner zone, and no leave trees were left within the outer zone, resulting in a High Deviation rating, and was administrative per the previous explanation. At the second site, 4 merchantable trees were harvested within the inner zone, resulting in a Low deviation rating, and no determination could be made for the reason for non-compliance. At the third site, an incorrect site class determination was recorded, with the reason for non-compliance was determined to be administrative. As a result of the incorrectly applied site class, harvest occurred within the inner zone, 94 trees were removed from the no-cut Inner Zone. These non-compliance determinations resulted in a High deviation rating, and the reason for non-compliance was determined to be administrative. At the fourth site, 2 trees were removed from the no-cut Inner Zone, resulting in a Low deviation rating, and the reason for non-compliance was determined to be operational. At the fifth site, a Channel Migration Zone was observed that was unreported on the FPA resulting in a Low deviation rating, and the reason for non-compliance was determined to be administrative. (Table 8.)

Exceeds ratings were assessed for excess Outer Zone leave trees on 10 samples. Additional outer zone leave trees were left beyond what was required by rule.

5.4.1.2 Statewide Type Np Waters

Type Np streams and sensitive sites contribute to the quality of water and fish habitat in downstream Type S and/or F streams. They also provide habitat for some wildlife.

Fifty-foot-wide RMZs are required along portions (and specified locations) of Type Np streams. For example, a 50-foot-wide no-harvest RMZ is required where Type Np streams join a Type S or F stream.

In western Washington, the total distance of the 50-foot buffer required along a Type Np stream varies and depends on the length of the Type Np stream from the confluence with the Type S or F stream. At least 50% of a Type Np water's length must be protected by buffers on both sides of the stream (2-sided buffers). If the Type Np water on the FPA is located more than 500 feet upstream from the confluence of a Type S or F water, and if the Type Np water is more than 1,000 feet in length, then the minimum percentage of the length of Type Np water to be buffered varies per the table in WAC 222-30-021(2)(b)(vii).

Sensitive sites associated with Type Np streams must also be protected with buffers or harvest restrictions. These include headwater springs or the uppermost point of perennial flow; the intersection of 2 or more Type Np waters; perennially saturated side-slope seeps; perennially saturated headwall seeps; and alluvial fans. No harvest is allowed within alluvial fans.

In eastern Washington, within fifty horizontal feet of the outer edge of bankfull width of the stream, the landowner must identify either a no cut, partial cut and/or clearcut strategy for each unit to be harvested. For partial cut strategies, basal area requirements must be met that are specified for the timber habitat type. For cleat cut strategies, a two-sided no-harvest fifty-foot buffer along the stream reach must be left that is equal in total length to the clearcut portion and meets the upper end of basal area requirements for the respective timber habitat type (WAC 222-30-022(2)(b)(i)&(ii)).

Type Np streams also require a 30-foot-wide ELZ. Equipment use and other forest practices are specifically limited, and mitigation is required if activities expose more than 10% the soil within the ELZ.

On-site Review for Statewide Type Np Waters

Questions asked on the Field Form for Type Np streams differ from those for Type S and F fish-bearing streams. Examples include the following:

- Is there evidence of equipment entry into the 30-foot ELZ? If so, was less than 10% of the soil within the ELZ exposed due to activities?
- Was the appropriate length of 50-foot no-harvest zone left on the given stream segment?

Findings for Statewide Type Np Waters

Type Np streams were commonly encountered with an estimated 929 FPAs having 1 or more Np streams within their harvest boundaries. The resulting Np prescription sample size was 35, and a total of 136 rules were evaluated.

Table 9. 2014-15 Compliance Ratings for Statewide Type Np Waters

RMZ Prescription	FP Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (part of Compliant)	**Compliant**	**Low**	**Moderate**	**High**	**No Assessed Deviation Rating**	**Indeterminate**
Np Water (%)	0%	93.4%	2.9%	1.5%	0%	1.5%	0%
Np Water (Rule Count)	0	128	4	2	0	2	0

Sample size = 35

One hundred twenty eight of the sampled 136 rules were compliant for the Type Np prescription sample, resulting in a 93.4% compliance rate +/- 5%. Of the 35 sites sampled, 28 were 100% compliant and 7 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 8 non-compliance determinations across 7 sites. At the first site, harvest within the buffer of the uppermost point of perennial flow was observed, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be layout. At the second site, the location of the F/N break was inaccurately identified, resulting in the lower 150 feet of the stream being mistyped. The reason for non-compliance was determined to be administrative. At the same site timber harvest was observed within the upper most point of perennial flow no-cut buffer, resulting in a Low Deviation rating, and the reason for non-compliance was determined to be layout. At two additional sites, the sampled stream met fish physical characteristics with no supporting water type modification form or Interdisciplinary Team documentation for Np determination, resulting in the mistyping of the respective sampled segments, the reason for non-compliance was determined to be administrative. No deviation rating is given for inaccurately typed stream segments. At the fifth site, 130 feet of required no-cut buffer was absent, yielding an inadequate buffer length. The resulting deviation rating was Moderate, and the reason for non-compliance was indeterminate. As a result of the inadequate buffer length, harvest was observed within the 50 foot no-cut buffer, leading to a deviation rating of moderate, and the reason for non-compliance was again indeterminate. At the sixth site, a cut stump was observed 46 feet from the edge of Bankfull Width, resulting in a non-compliance determination for harvest within the 50 foot no-cut buffer. The deviation rating was Low, and the reason for non-compliance was operational. At the seventh site, a cut stump was observed 48 feet from the edge of the Upper Most Point of Perennial Flow (UMPPF), resulting in a non-compliance determination for harvest within the 56 foot UMPPF no-cut buffer. The deviation ration was Low, and the reason for non-compliance was operational. (Table 9.)

5.4.1.3 Statewide Type Ns Waters

Buffers are not required for Type Ns streams. There is a 30-foot ELZ requirement, and mitigation measures are required if more than 10% of the soil in the ELZ is exposed.

Findings for Statewide Type Ns Waters

Type Ns waters are common, occurring in an estimated 1018 FPAs in the statewide population for the 2014-15 sample. The resulting Ns prescription sample size was 35, and a total of 61 rules were evaluated.

Table 10. 2014-15 Compliance Ratings for Statewide Type Ns Waters

RMZ Prescription	Forest Practices Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (part of Compliant)	**Compliant**	**Low**	**Moderate**	**High**	**No Assessed Deviation Rating**	**Indeterminate**
Ns Water (%)	0%	96.7%	0%	0%	0%	3.2%	1.6%
Ns Water (Rule Count)	0	59	0	0	0	2	1

Sample size = 35

Fifty-nine of the sampled 61 rules were compliant for the Ns prescription sample, resulting in a 96% compliance rate +/- 5%. Of the 35 sites sampled, 33 were 100% compliant and 2 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 2 non-compliance determinations across 2 sites. At the first site, the stream was incorrectly typed. The compliance monitoring team observed flowing water in the channel during the month of September of a stream that had been typed Ns by the landowner. The reason for non-compliance was administrative, and no deviation rating is given for inaccurately typed stream segments. At the second site, based on field measurements collected by the Compliance Monitoring field team, the stream segment met fish physical characteristics, resulting in the mistyping of the sampled segment. The reason for non-compliance was determined to be administrative, and no deviation rating is given for inaccurately typed stream segments. The 1 Indeterminate rating resulted from the landowner/applicant's wording on the FPA regarding water typing. (Table 10.)

5.4.2 Statewide Wetland Management Zones

Forest practices wetland rules are the same for Western and Eastern Washington. Wetland management Zones (WMZs) have variable widths based on the size and type of wetland. Type A Wetlands greater than 5 acres have a minimum 50-foot WMZ width, and an average 100-foot WMZ width. Type A&B Wetlands of 0.5 to 5 acres have a minimum 25-foot WMZ width and an average 50-foot WMZ width, while Type B Wetlands less than 0.5 acre and Forested Wetlands require no WMZ. Leave trees are required (by size and number) within the WMZ. There are no leave tree requirements for the Forested Wetlands type. Restrictions also apply regarding the maximum width of openings created by harvesting within the WMZ. Additionally, ground-based harvesting systems shall not be used within the minimum WMZ width without written approval from DNR.

On-site Review for Statewide Wetlands

Protection measures for wetlands depend on the size and type of wetland. The information collected by the compliance monitoring field team varies depending on the type of wetland. Only one of the questions answered by the team is applicable to all wetlands:

- Were the wetlands typed and sized appropriately on the ground and consistent with the FPA?

In addition, for Type A&B Wetlands, the compliance monitoring field team evaluates the following:

- Leave trees in the WMZ for species, number, and size
- Is the variable buffer width appropriate relative to the WMZ table in the rules?
- If operations were conducted within the WMZ, were the openings less than 100 feet wide?
- If operations were conducted within the WMZ, were the openings no closer than 200 feet from each other?
- Approval by DNR for use of ground-based harvesting systems within the minimum WMZ and for any timber that was felled into or cable yarded across the wetland
- Protections applied when a WMZ overlaps an RMZ
- For particular leave tree requirements, if the harvest within the WMZ is greater than or less than 10%

If harvest occurs within a forested wetland, the compliance monitoring field team determines whether the harvest method is limited to low impact harvest or cable systems; and whether the wetland boundaries (if greater than 3 acres within the harvest unit) are delineated correctly and shown on the activity map by the landowner/applicant.

5.4.2.1 Statewide Type A&B WMZs

Findings for Type A&B WMZs Statewide

Type A&B Wetlands are estimated to occur on 237 FPAs statewide in the 2014-15 population. The resulting Type A&B Wetlands prescription sample size was 35, and a total of 127 rules were evaluated.

Table 11. 2014-15 Compliance Ratings for Statewide Type A&B WMZs

WMZ Prescription	FP Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (Part of Compliant)	Compliant	Low	Moderate	High	No Assessed Deviation Rating	Indeterminate
Type A&B (%)	5.0%	94.5%	2.4%	0%	0.8%	2.4%	0.8%
Type A&B (Rule Count)	6	120	3	0	1	3	1

Sample Size = 35

One hundred twenty of the sampled 127 rules were compliant for the Type A&B WMZ sample, resulting in a 94.5% compliance rate +/- 5%. Of the 35 sites sampled, 30 were 100% compliant and 5 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 7 non-compliance determination across 5 sites. At the first site, a wetland was incorrectly typed. The selected Type A Wetland was determined to be associated with a fish-bearing lake (i.e. Type F water). No deviation rating is given for mistyped wetland segments, and the reason for non-compliance was administrative. At the second site, harvest was observed within the 25' minimum WMZ leading to inadequate leave tree counts in the 6", 12", and 20" diameter classes respectively. A deviation rating of Low was given for each of the 3 non-compliant rules, and the reason for non-compliance was determined to be administrative. At three additional sites, the sampled wetland segments were determined to be fish bearing water, resulting in the mistyping of the three sampled wetland segments. The reason for non-compliance was determined to be administrative, and no deviation rating is given for mistyped wetland segments. The 1 indeterminate rating was a result of a Type A Wetland being potentially associated with a fish-bearing lake. A final determination could not be ascertained due to seasonal water flow conditions, and the associated Type S water in question was located on another landowner's property. (Table 11)

5.4.2.2 Statewide Forested WMZs

Findings for Statewide Forested WMZs

Approximately 322 FPAs statewide contained Forested Wetlands in the 2014-15 sample population. The resulting Forested Wetlands prescription sample size was 23, and a total of 39 rules were evaluated.

Table 12. 2014-15 Compliance Ratings for Statewide Forested WMZs

WMZ Prescription	FP Rule Compliance Ratings						
	Compliant Ratings		Deviation Ratings				
	Exceeds (Part of Compliant)	Compliant	Low	Moderate	High	No Assessed Deviation Rating	Indeterminate
Forested (%)	7.9%	97.4%	0%	0%	2.6%	0%	0%
Forested (Rule Count)	3	38	0	0	1	0	0

Sample size = 23

Thirty-eight of the sampled 39 rules were compliant for the forested WMZ sample, resulting in a 97.4% compliance rate +/- 5%. Of the 23 sites sampled, 22 were 100% compliant and 1 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 1 non-compliance determination. The 1 noncompliant rule recorded was the result of an incorrectly typed wetland. Fish were observed in the selected Forested Wetland, the reason for non-compliance was determined to be administrative. (Table 12.)

6. Forest Practices Rule Compliance for Roads and Haul Routes

Section 6 provides rule and on-site review descriptions and compliance monitoring findings regarding the Standard Sample for roads and haul routes statewide.

Although Roads prescription sampling follows the same design as riparian sampling, Haul Routes prescription sampling is designed differently. Haul Routes sampling assesses each 0.1 mile segment of forest road for correct design and for construction or maintenance of roads to protect typed waters from sediment delivery. This strategy enables determination of the rate of compliance for the entire haul route specified on the FPA.

A well-designed, located, constructed, and maintained system of forest roads is essential to both forest management and protection of public resources. Washington State forest practices rules — including those for road construction, maintenance, and abandonment and for "best management practices" — are some of the most, if not the most, stringent in the country. The FP rules are designed to help ensure that forest roads are constructed, maintained, and abandoned to do the following:

- Provide for fish passage
- Prevent mass wasting
- Limit delivery of sediment and surface runoff to all typed waters
- Avoid capture and redirection of surface water or groundwater
- Divert road runoff to the forest floor
- Provide for the passage of some woody debris
- Protect stream bank stability
- Minimize construction of new roads

- Assure no net loss of wetland function

FP rules accomplish these goals through ensuring the proper location, design, construction, maintenance, and abandonment of forest roads, landings, and stream crossings.

The CMP collects data annually on sites where one or more of the following exists:

- Road construction
- Landing construction
- Type N stream road crossing construction, including fords
- Road abandonment
- Haul routes (forest roads used to truck timber to market)

FP Rules for Statewide Roads and Haul Routes

FP rules for road construction, landing construction, Type F and N stream road crossings, road abandonment, and haul routes are explained below.

Forest Road Construction

Road construction is composed of 3 components: road location, road design, and actual construction. The road rules require specific standards for road location, design, and construction, which are reflected in the questions found in the compliance monitoring Roads Field Form (defined in the on-site review section, below).

1) Road location — FP rules require that roads be located to fit the topography to minimize alteration of natural features (WAC 222-24-020). Examples of FP rule requirements related to road location are the requirement that the landowner/applicant minimize the number of stream crossings and not locate roads in bogs or within natural drainage channels (except for crossings).
2) Road design — FP rules include road design standards that address construction techniques and water management (WAC 222-24-020). For example, new road construction on side slopes exceeding 60% that have the potential to deliver sediment to any typed water or wetland need to utilize full bench construction techniques (WAC 222-24-020[8]).
3) Road construction — Road construction requirements focus on maintaining stable road prisms and water crossing structures, and on minimizing sediment delivery to surface waters and wetlands (WAC 222-24-030). For example, road construction requires that erodible soil disturbed during road construction needs to be located where it could not reasonably be expected to enter the stream network or needs to be seeded with noninvasive plant species.

Landing Location and Construction

Landings are subject to several FP rules. Landings must not be located within specific areas such as natural drainage channels, RMZs, or WMZs. Landings must be constructed so that they are sloped to minimize accumulation of water on the landing. Excavation material shall not be sidecast where there is high potential for material to enter WMZs or within the bankfull width of any stream or the 100-year flood level of any typed water (WAC 222-24-035).

Type F and N Stream Crossings

Installation, maintenance, and removal of bridges, culverts, and temporary water crossings must follow several FP rules (with technical guidance provided in Forest Practices Board Manual Chapter Section 5). For example, culvert placement must be designed so that the alignment and slope of the culvert parallels the natural flow of the stream and so that placement does not cause scouring of the streambed and erosion of the stream banks in the vicinity of the project. Additionally, bridges must not constrict clearly defined channels, and temporary water crossings must be constructed to facilitate abandonment (WAC 222-24-040).

Road Abandonment

Landowners have the option to abandon forest roads, with the exception that in some watersheds landowners are required to abandon roads to keep the road ratio at a certain level. When a landowner chooses to abandon a forest road, specific standards delineated in the FP rules must be followed (with additional technical guidance provided in Board Manual Chapter Section 3). For example, abandoned roads must be out-sloped, water barred, or otherwise left in a condition suitable to control erosion and maintain water movement within wetlands and natural drainages. An abandoned road must be blocked so that four-wheeled highway vehicles cannot pass the point of closure at the time of abandonment, and water crossing structures must be removed (WAC 222-24-052[3]).

Haul Routes

FP rules state that roads currently used or proposed to be used for timber hauling must be maintained in a condition that prevents potential or actual damage to public resources (WAC 222-24-051[12]). The compliance monitoring field team observes and records observations for haul routes regarding level of sediment delivery.

On-site Review for Statewide Roads and Haul Routes

In order to determine road compliance, the compliance monitoring field team visited FPA sites where forest road construction, landing construction, Type N stream road crossings, abandoned roads, and haul routes are present. The compliance monitoring field team used the Roads Field Form and the Haul Route Field Form to record information onsite. The data recorded on the Roads Field Form and the Haul Route Field Form helped the team determine road compliance for each FPA sampled.

Roads Field Form

The compliance monitoring field team used the Roads Field Form to record data observed for forest road construction, landing construction, Type N stream road crossings, and abandoned roads. The initial series of questions on the Roads Field Form helped guide systematic assessment of road surface conditions, drainage structure placement and stabilization, routing of drainage water to the forest floor, and potential delivery of sidecast. Stream crossing questions helped guide systematic stream crossing placement, frequency, culvert sizing, positioning, and stabilization. Other questions were used to address wetland crossings, road location, wetland replacement, abandonment and stabilization of temporary roads, road abandonment, and proper construction and drainage for forest road landings.

The following are examples of questions found on the Roads Field Form:

- Road location — "Does new road construction minimize stream crossings?" (WAC 222-24-020[5])
- Road design — "Where the potential for sediment delivery existed, was full bench construction utilized for roads built on slopes greater than 60%?" (WAC 222-24-020[8])
- Road construction — "Were erodible soils disturbed during construction stabilized to prevent the potential to deliver to typed waters?" (WAC 222-24-030[4])
- Road landing location and construction — "Was the landing sloped to minimize accumulation of water on the landing?" (WAC 222-24-035)
- Type N stream crossings — "Are the alignment and slope of all culverts on grade with the natural streambed? (WAC 222-24-040[2], [3], [4], and [5])
- Road abandonment — "Was the road blocked so that four-wheel highway vehicles cannot pass the point of closure at the time of abandonment?" (WAC 222-24-052)

Haul Route Field Form

The compliance monitoring field team uses the Haul Route Field Form to guide the systematic assessment of haul routes. The sampling method provides information for reporting the proportion of compliance/deviance, the level of sediment delivery (Table 13), and the cause of the noncompliance (Table 14).

There were five recorded levels of sediment delivery (No Delivery, De Minimis, Low, Medium, and High) used by the team for rating levels of sediment delivery, as well as one decision type (No Consensus). (Table 13.)

Table 13. Haul Route Sediment Delivery Level Categories

Delivery Level	Delivery Level Description
No Delivery	Complete disconnection of sediment delivery to typed water. Considered compliant.
De Minimis	Overland flow from roads reaches typed waters, but sediment delivery is indeterminable from background levels of turbidity. Considered compliant.
Low	Low chronic or temporary delivery. Effects are observable at the site of entry (distance downstream less than 1 channel width) only are and not expected to magnify over time given the existing activity.
Medium	Measurable but noncritical levels of delivery. Visual plume at the reach scale.
High	Extensive or critical levels of delivery. Substantial violations of turbidity criteria or significant visual plumes that occupy the channel and go beyond the reach scale (for example, around multiple bends in a stream).
No Consensus	The observers do not agree on the classification. Comments are essential to determine the scope of the difference, recording each observer's classification and the basis of disagreement.

It is helpful to determine, where possible, causes for sediment delivery. The compliance monitoring field team observes and records both primary and secondary causes of sediment delivery. (See Table 14.)

Table 14. Potential Causes of Sediment Delivery

Potential Causes	Cause Description
Faulty cross drainage	Inadequate frequency of or nonfunctioning drainage structures that carry road prism runoff or seepage, allowing sediment delivery to typed water
Inadequate water crossing structures	Absence of or nonfunctioning structures designed to pass typed water across a forest road, resulting in sediment delivery
Obstructed or bermed ditch line	Features of the road surface or ditch that divert water normally serviced by the ditch, causing sedimentation of typed water
Intercepted water	Water intercepted by road features and diverted to a channel other than its channel of origin prior to the road construction
Contaminated ditchwater	Ditchwater containing suspended sediment that flows into typed water
Ruts/inadequate crown	Perturbations of the road surface contributing sediments to runoff that reaches typed water
Driving in ditch line	Vehicular disturbance of stabilized ditches, resulting in sediment reaching typed water
Haul on native surface or inadequate rock	Road haul on a running surface containing fine particles that are captured by runoff and contributed as sediment to typed water
Water channeled to eroded/failing slopes	Water flow or runoff across unstabilized road features that contributes sediment to typed water
Road fill failure	Sediment resulting from the effects of gravity on the fill (slumps, raveling, etc.) being deposited in or carried by runoff to typed water
Cut slope failure	Sediment resulting from the effects of gravity on the cut slope (slumps, raveling, etc.) being carried by ditch flow to typed water

Findings for Statewide Roads and Haul Routes

This section summarizes data from both the Roads Field Forms and Haul Route Field Forms.

Roads Findings

Road construction or abandonment occurred on an estimated 1405 FPAs in the 2014-15 sample. The resulting Roads prescription sample size was 13, and a total of 83 rules were evaluated.

Table 15. FP Rule Compliance for 2014-2015 Road Activities

Statewide Road Activities for 2014 & 2015		
All Landowner Types	**Status of Compliance**	**Road Activities Rule Compliance**
	# of Rules Sampled	83
	# Compliant Rules	81.7
	# with Deviation	1.3
	Compliance %	98.4%
	95% Confidence Interval	CI (95, 100)

Sample size = 13

Eighty-one point seven of the sampled 83 rules were compliant for the Roads prescription sample, resulting in a 98.4% compliance rate +/- 3%. Of the 13 sites sampled, 11 were 100% compliant and 2 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2014 and 2015 accounted for 2 non-compliance determinations across 2 sites. At 1 of the noncompliant sites, water was observed running across the road surface due to an inadequately sized ditch, resulting in a deviation. The other noncompliant observation was the result of a drainage structure not installed at the natural grade of the stream. Both noncompliant rules had a rating of Low Deviation. (Table 15.)

Haul Routes Findings

The Haul Route prescription sample included an inspection of haul routes along forest roads from the farthest points in the FPA to public access roads. In each sample, the entire road was observed if it was less than 5 miles long. If the entire road was over 5 miles, ten 0.5-mile-long road segments were observed. Within each 0.5 mile, every 0.1-mile segment was observed as to its actual or potential delivery of sediment to typed water; and the primary and secondary causes for the delivery (see Table17) were also recorded. The compliance monitoring field team recorded compliance information for haul routes in general and also specifically for haul routes categorized by side slopes less than or greater than 60%. The data for side-slope percentage provide information needed to fulfill requirements for Clean Water Act assurances. (For more information see *2009 Clean Water Act Assurances Review of Washington's Forest Practices Program.*)

Table 16. Haul Route Compliance Summary

Compliant		Deviation		
90% (82, 98) CI*		9.6% (1.5, 18) CI		
No Delivery	**De Minimis**	**Low**	**Medium**	**High**
86% (76, 95) CI	4.7% (0, 11) CI	3.9% (0, 10) CI	5.6% (0, 24) CI	0.1% (0, 2.4) CI

*CI is confidence interval at the 95% confidence level

Table 17. Haul Route Deviation by Cause

Primary Cause	% Deviation with This Primary Cause
Inadequate water crossing structures	10%
Contaminated ditchwater	3%
Other (described in comments)	17%
Faulty cross drainage	14%
Stream of Spring Intercepted	5%
Road fill failure	2%
Sediment from stream adjacent parallel road	44%
Obstructed or bermed ditch line	2%
Water channeled to eroding slopes	2%

For 61.5 miles of the 67.4 miles of haul routes evaluated, no delivery or de minimus sediment delivery was observed, resulting in a compliance rate of 90% (Table 16). Sediment from stream adjacent parallel roads accounted for 44% of the deviation mileage (Table 17). The 17% that aggregates the “other” category is comprised of non-point-source sediment delivery and blocked drainage structures (Table 17). Faulty cross drainage accounted for 14% of the deviation mileage, and inadequate water crossing structures accounted for 10%, of the deviation mileage. All other primary cause categories accounted for less than 0.3 miles of deviation each respectively. For efficiency reasons, haul routes were observed on FPAs that had been selected for the harvest prescription sample.

7. Forest Practices Rule Trend Analysis

FPA rule compliance has been monitored since 2006. In that time, there have been multiple changes to the methods for monitoring compliance. The current monitoring methods include tracking compliance with individual rules, while sampling the rule applications in clusters (FPAs). One of the goals of the current analytical methodology is to detect trends in prescription, and individual rule compliance over time. The Compliance Monitoring Program feels this goal is best achieved by converting data collected prior to 2014 to be consistent with current data collection, and analytical protocols.

The sample size for each year is set based on maintaining a set precision level (+/- 6%) for average compliance within a set of rules (a prescription) over a two-year period. Because the population of FPAs available in any given year is finite and varying, the number of samples necessary to achieve a specific precision level also varies by year. Differing priorities and compliance estimation methods have caused differences in precision levels attainable by the samples collected in different years. In addition, methods for determining compliance with some individual rules has changed since 2006. These differences create challenges in determining and evaluating trends through time. However, with careful consideration, the difficulties are not insurmountable. On that basis, this report includes an analysis aimed at seeking to discern patterns of changes in compliance rates measured over time.

Methods

For the 2010-2015 dataset, rule compliance was carefully tracked to make sure that the compliance determination was consistently applied in all years. Data were converted to ensure consistent application of compliance determinations across the dataset. Where data were not collected in accordance with current field protocols, were incomplete, or un-convertible, the data were removed from the trend analysis dataset. Data for rules were combined and compared through time within each corresponding prescription type. Trends in average compliance with prescriptions, and individual rule compliance are tracked to maintain consistency with current methods.

Multivariate linear regression analysis was used to predict general trends in average compliance through time. However, because of the varying precision levels among years, the regression assumption of homogeneous variance in average compliance was not satisfied. In general, higher sample sizes as a proportion of the population result in lower variance. Because average compliance is a ratio, the standard error of the average is a function of the proportion of the population sampled in each year and the number of rules within the prescription applied on each FPA. Weighted least squares multivariate linear regression, where the average compliance is weighted by the inverse of the estimated mean standard error for each year, was employed, to correct for the nonhomogeneous variance. In this way, years with better estimates of average compliance receive more weight in the regression, which compensates statistically for unequal variance. Statistical significance was determined with $\alpha = 0.10$. The results for weighted linear regression are supplied. Residuals from regressions are tested for approximate normality using Shapiro-Wilks test with alpha = 0.05. P-values for significance of regressions were calculated, as well as 95% confidence intervals for linear regression coefficients for the weighted regression.

Although there is weak and varying precision within any given year for compliance with a single rule, it can still be useful to track changes through time for the FP rules. Statistical tests are not applied, but graphical trends are displayed for each prescription type.

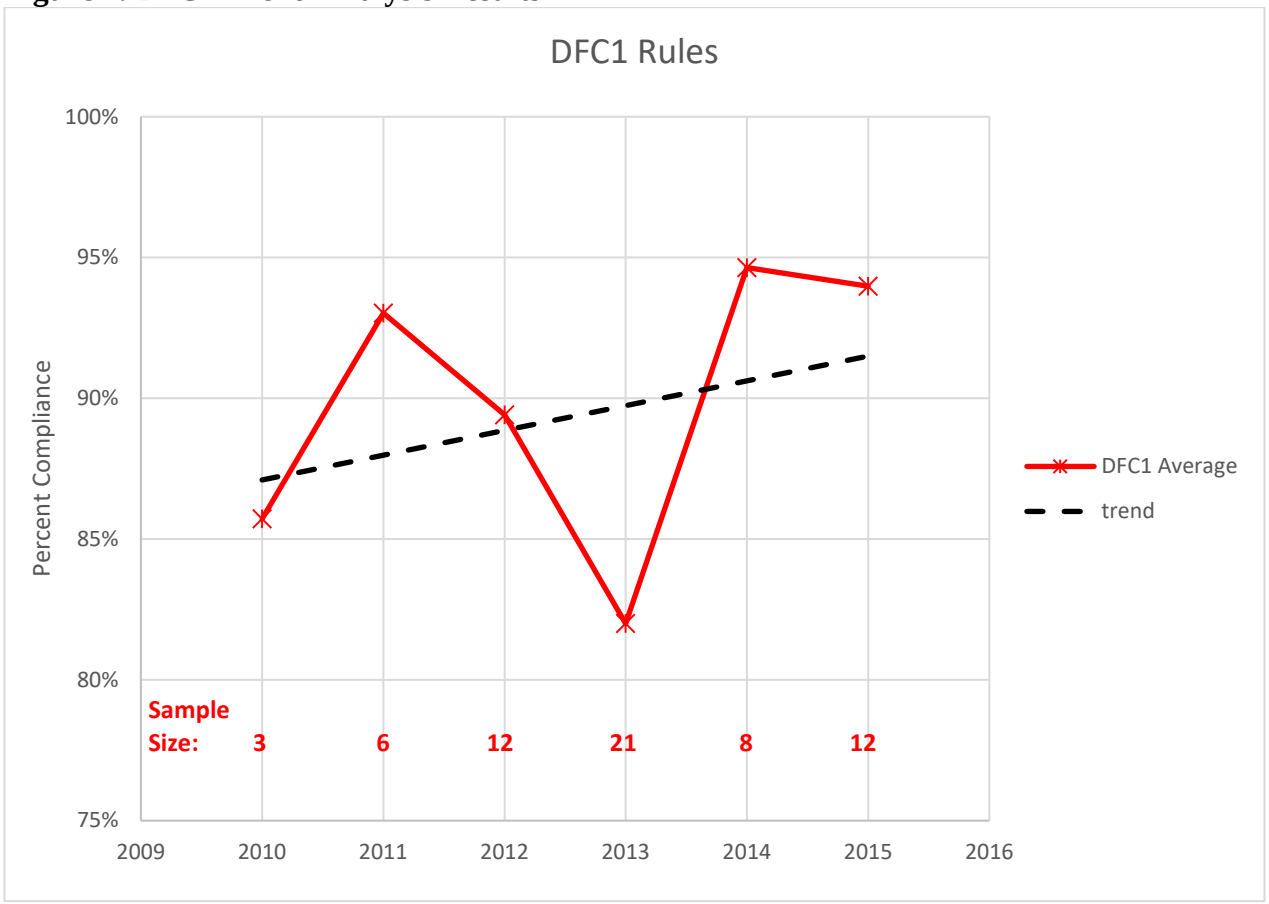
Since no individual rules are measured or tracked for Haul Routes trend analysis was not conducted for the Haul Route prescription type.

Results

Desired Future Condition 1

Trend analysis results for the DFC1 prescription type revealed varying compliance rates for the prescription, and the individual rules from year to year. Prescription compliance rates varied from 82% to 94% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.61$) were observed for the weighted DFC1 prescription type. (Figure 4.)

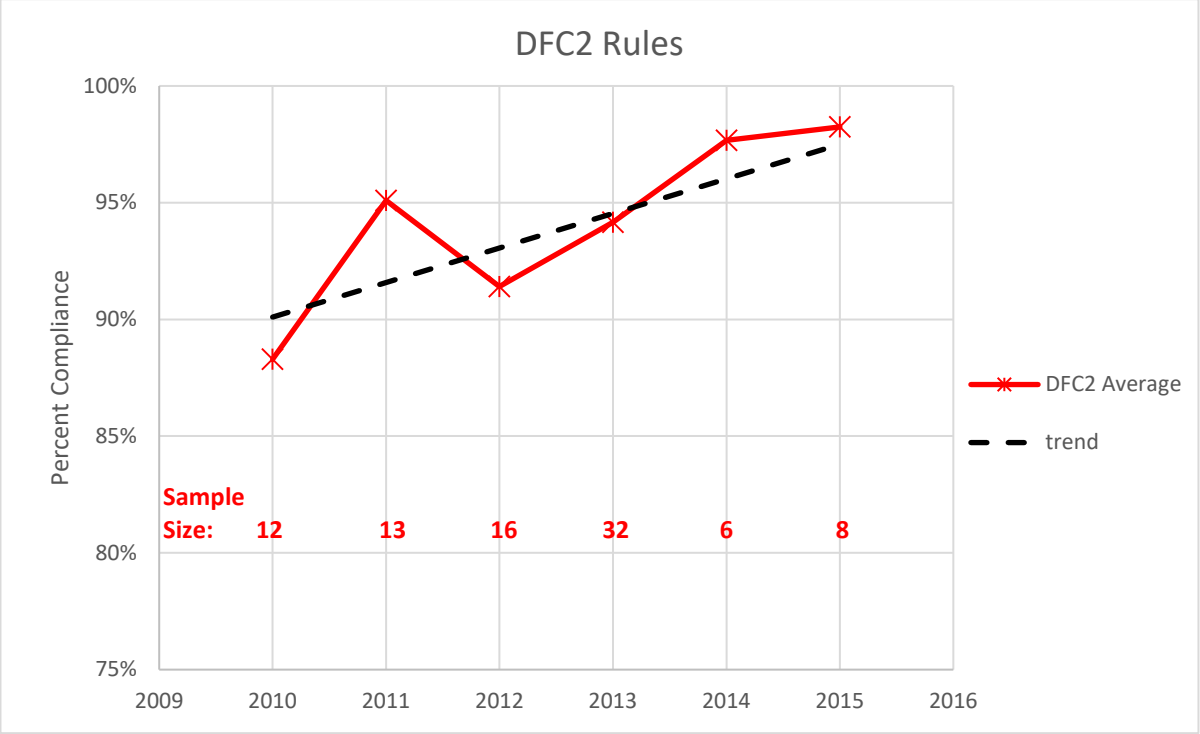
Figure 4. DFC1 Trend Analysis Results



Desired Future Condition 2

Trend analysis results for the DFC2 prescription type revealed varying compliance rates for the prescription, and the associated FP rules from year to year. Prescription compliance rates varied from 88% to 98% over the course of the evaluation period. As a result of the oscillating prescription compliance rate, no significant trend results for weighted regression analysis (p = 0.11) were observed for the weighted DFC2 prescription. (Figure 5.)

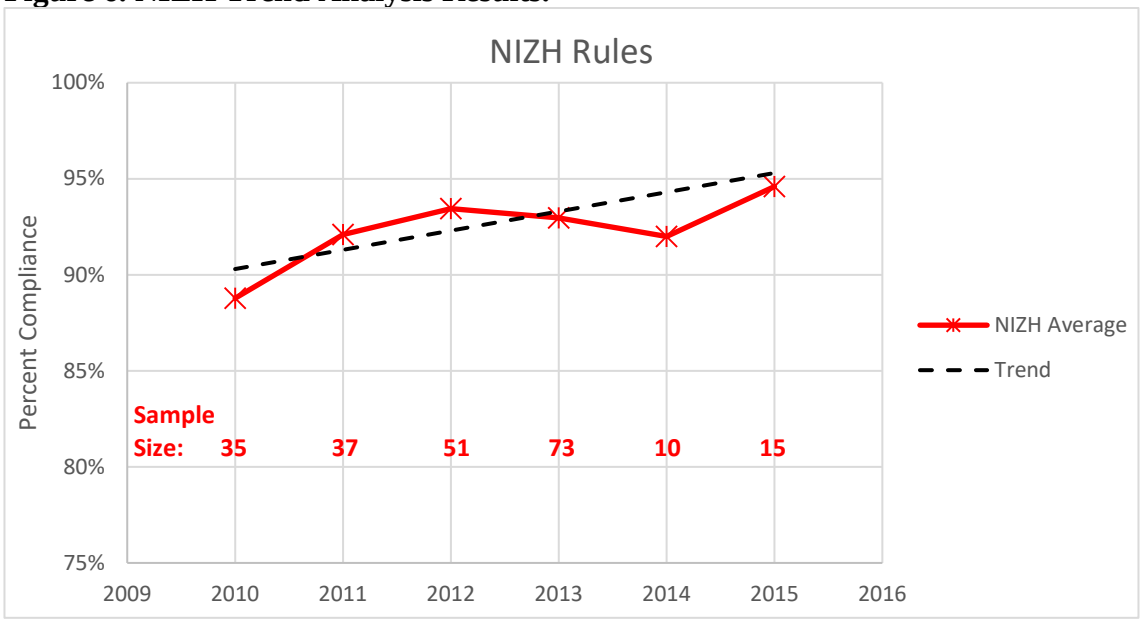
Figure 5. DFC2 Trend Analysis Results



No Inner Zone Harvest

Trend analysis results for the NIZH prescription type revealed relatively consistently increasing compliance rates for the prescription, and the associated FP rules from year to year. Prescription compliance rates varied from 89% to 94% over the course of the evaluation period. As a result of the increasing prescription compliance rate, significant trend results (weighted $p = 0.07$) were observed for the weighted NIZH prescription. A year over year increase of 1.0% of the overall prescription compliance rate was observed. (Figure 6.)

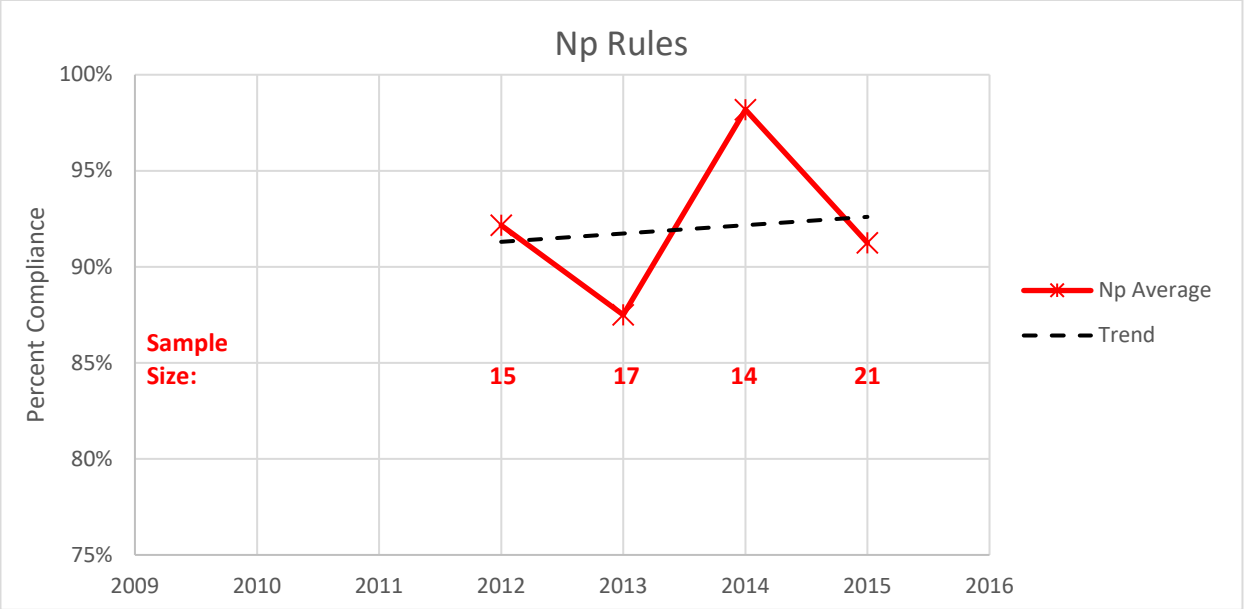
Figure 6. NIZH Trend Analysis Results.



Non-fish Bearing Perennial Streams

As a result of data transformation issues, Np data collected from 2010 and 2011 were excluded from current trend analysis results. Trend analysis results for the Np prescription type revealed varying compliance rates for the prescription, and the associated FP rules from year to year. Prescription compliance rates varied from 88% to 98% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.77$) were observed for the weighted Np prescription type. (Figure 7.)

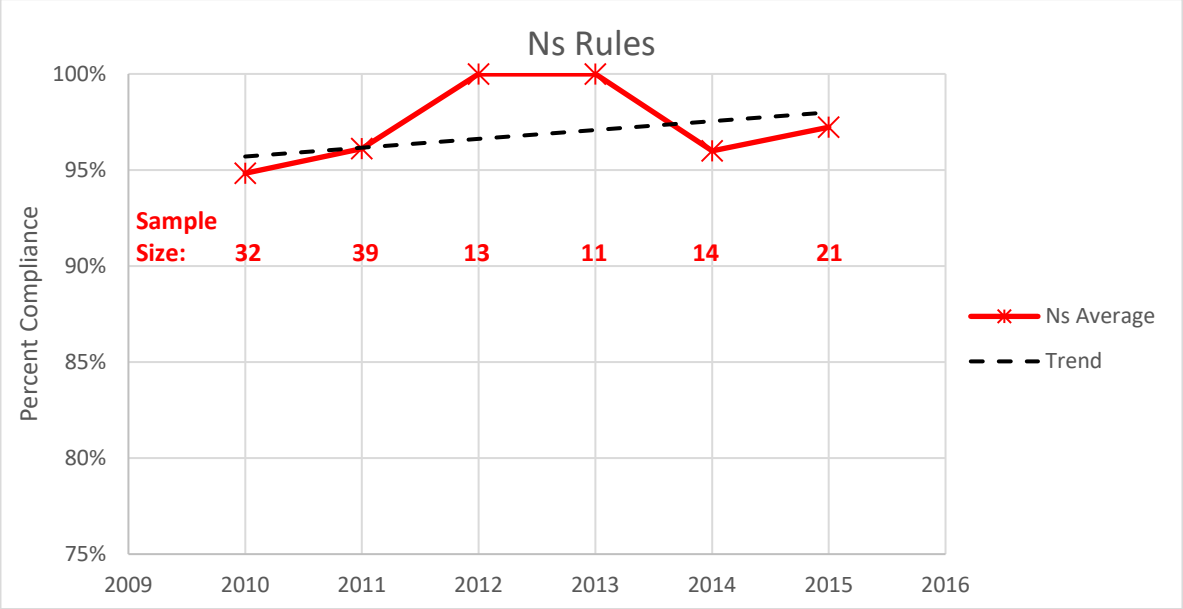
Figure 7. Np Trend Analysis Results



Non-fish Bearing Seasonal Streams

Trend analysis results for the Ns prescription type revealed increasing compliance rates for the prescription, and the associated FP rules from 2010 to 2012 and a decrease in compliance rates from 2013 to 2015. Prescription compliance rates varied from 95% to 100% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.30$) were observed for the weighted Ns prescription type. (Figure 8.)

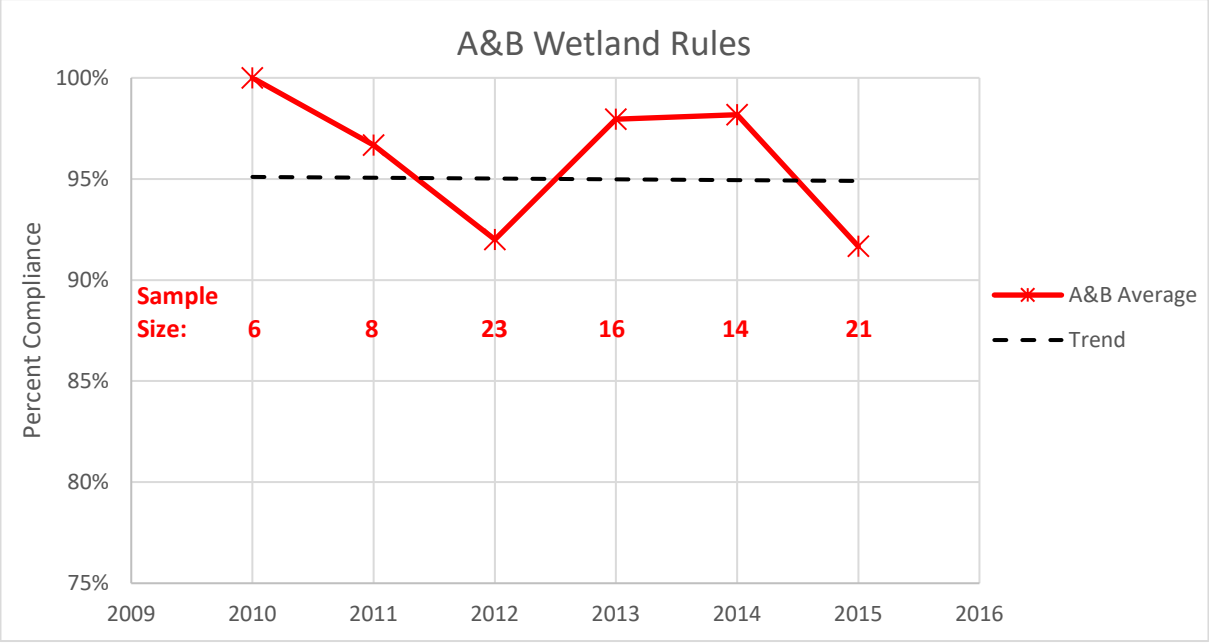
Figure 8. Ns Trend Analysis Results



A & B Wetlands

Trend analysis results for the A & B Wetlands prescription type revealed varying compliance rates for the prescription, and the associated FP rules from year to year. Prescription compliance rates varied from 92% to 100% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.97$) were detected for the weighted A & B Wetlands prescription type. A flat trend line for prescription compliance was observed. (Figure 9.)

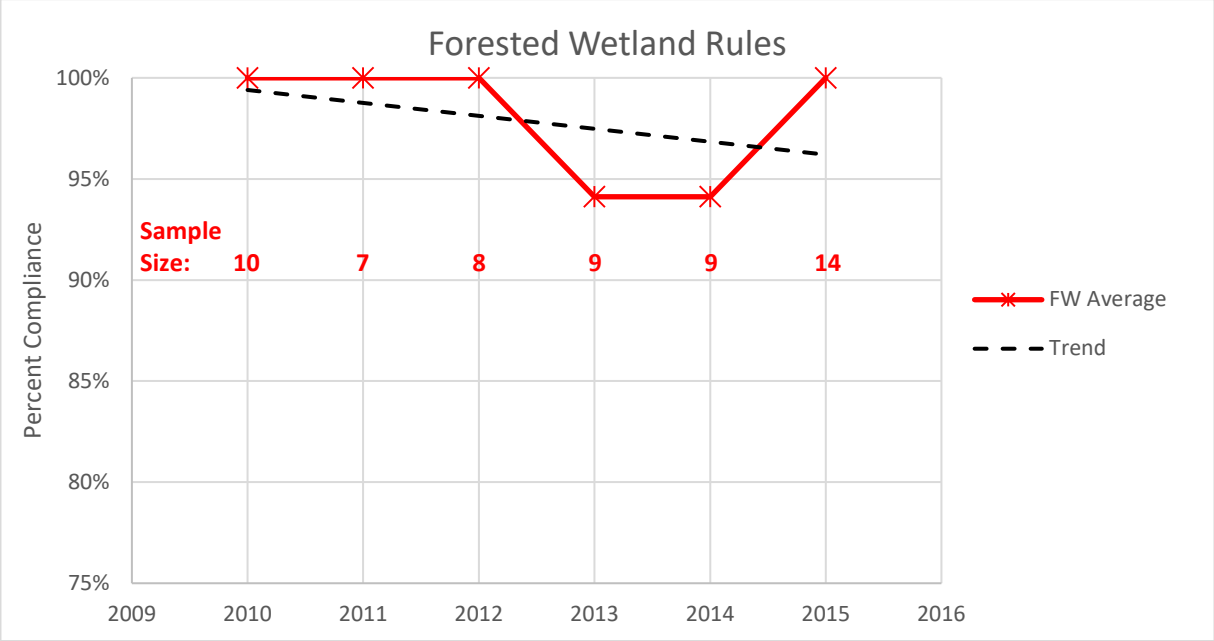
Figure 9. A & B Wetlands Trend Analysis Results



Forested Wetlands

Trend analysis results for the Forested Wetlands prescription type revealed 100% compliance rates for the prescription, and the associated FP rules from 2010 to 2012, and varying compliance rates from 2013 to 2015. Prescription compliance rates varied from 94% to 100% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.41$) were observed for the weighted Forested Wetlands prescription type. (Figure 10.)

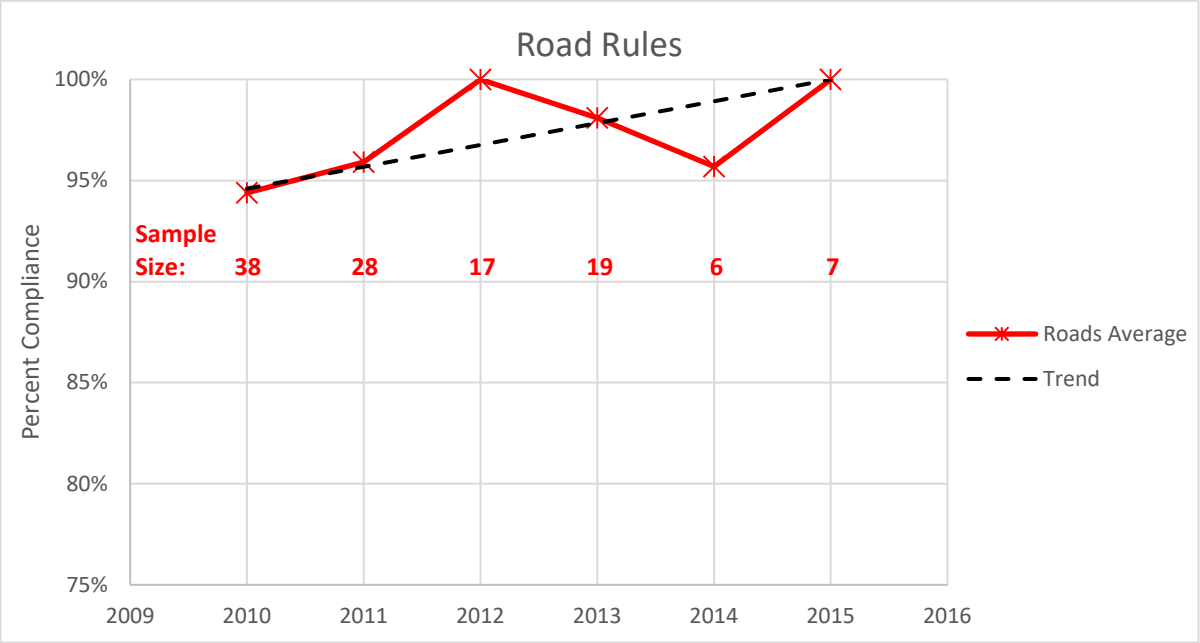
Figure 10. Forested Wetlands Trend Analysis Results



Roads

Due to the large number of individual rules that comprise the Roads prescription (42), only prescription compliance is visually represented in the report. Trend analysis results for the Roads prescription type revealed a possible increasing trend in prescription compliance, and varying compliance for individual rules from year to year. Prescription compliance rates varied from 94% to 100% over the course of the evaluation period. As a result of the relatively increasing prescription compliance rates, significant trend results for weighted regression analysis (p = 0.035) depicting a year over year increase of 1.4% of the overall prescription compliance rate were observed for the Roads prescription type. (Figure 11.)

Figure 11. Roads Trend Analysis Results



Additional results that depict the relationship between individual rules and the prescription types they comprise can be found in Appendix C.

8. Forest Practices Application Compliance

Section 8 addresses compliance with the forest practices application (FPA).

Overall FPA compliance generally mirrors FP rule compliance on individual FPAs; however, occasionally one may be compliant while the other is not. When the prescription deviates from the FP rules but is compliant with the FPA, per professional opinion the deviation is a result of the timber harvest design layout and/or approval process. When the FPA is compliant with FP rules but deviates from the landowner's stated protections on the FPA, typically what the landowner proposed, and committed to, conduct activities that were more conservative than what was implemented. (Table 18.)

Table 18. 2014-15 Compliance with FPAs for Riparian and Wetland Harvest Prescriptions

		Western WA		Statewide					
	Status of Compliance	DFC1	DFC2	No Inner Zone Harvest	Np Activities	Ns Activities	Type A&B Wetlands	Forested Wetlands	Roads
Small Forest Landowners	# Compliant Rules	4	0	9	1	4	33	4	n/a
	# with Deviation	1	0	1	0	0	1	0	n/a
	% of Sample Compliant	80%	n/a	91%	100%	100%	97%	100%	n/a
	Confidence Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Prescriptions Assessed	1	0	4	1	4	9	4	0
Large Forest Landowners	# Compliant Rules	68	56	61	99	25	73	13	70
	# with Deviation	6	2	4	8	0	5	0	1.3
	% of Sample Compliant	92%	97%	94%	93%	100%	94%	100%	98%
	Confidence Interval	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Prescriptions Assessed	19	14	21	34	25	27	12	12
All Landowners	# Compliant Rules	72	56	71	100	29	106	17	69.7
	# with Deviation	7	2	5	8	0	6	0	1.3
	% of Sample Compliant	91%	97%	93%	93%	100%	95%	100%	98%
	Confidence Interval	(88, 94)	(92, 100)	(88, 99)	(87, 99)	n/a	(88, 100)	n/a	(95, 100)
	Prescriptions Assessed	20	14	25	35	29	36	16	12

Table 19. 2014-2015 Comparison between FPA and Rule Compliance Assessments by Count

	RMZ Prescription	Total Prescriptions Sampled	FPA and Rule Compliance the Same	Deviation from FPA and Rule Compliant	FPA Compliant and Deviation from Rule	Deviation from Rule and FPA Indeterminate	FPA Compliant / Rule Indeterminate
Statewide	RMZ — No Inner Zone Harvest	25	123	1	1	0	0
	RMZ — Type Np Prescriptions	35	34	0	1	0	0
	RMZ — Type Ns Prescriptions	35	34	0	0	1	0
	WMZ — Type A&B Wetlands	35	31	2	3	0	0
	WMZ — Forested Wetlands	23	22	0	1	0	0
	Roads	13	13	0	0	0	0
Western WA	RMZ — Type S or F Inner Zone Harvest DFC1	20	19	0	1	0	0
	RMZ — Type S or F Inner Zone Harvest DFC2	14	14	0	0	0	0

Findings for FPA/FP Rule Compliance Differences

There are few differences between FPA compliance and FP rule compliance for the 2014-2015 sample. Differences were found in the statewide NIZH, DFC1, Type Np, Ns, Type A&B Wetlands, and Forested Wetlands prescription samples. (Table 19.)

2014 and 2015 field observations resulted in the following differences between FPA compliance and FP rule compliance:

Within the DFC option 1 prescription, the difference occurred as a deviation from FPA compliant/ Rule non-compliant, where, the landowner incorrectly measured the RMZ length resulting in the harvest within the Inner Zone not meeting the requirements of the Inner Zone leave tree strategy by diameter class. Using the correct RMZ length in the DFC software program revealed that Inner Zone harvest is not supported at the site, and no DFC harvest option would have been allowed.

Within the NIZH prescription, 2 samples deviated from either rule or application compliance. For the first sample, the landowner incorrectly identified site class on their FPA resulting in harvest occurring within the Inner Zone. The landowner met the requirements based on the site class identified on their FPA. However, the compliance monitoring field team determined that the site class was incorrect resulting in an insufficient Inner Zone buffer. The sample was compliant with the FPA, and non-compliant with the rule. For the second sample, as a result of an incorrectly identified site class on their FPA the landowner left a no-cut Inner Zone buffer larger than required. The landowner indicated that the harvest area was within site class 2, however, the compliance monitoring field team determined that site class 5 was correct for the area in question. Resulting in wider buffers than required. The sample was compliant with the rules, and non-compliant with the FPA.

Within the Np prescription, the difference occurred as a deviation from the Rule/FPA Compliant, where the landowner treated the stream as an Np but it was determined to be an F by the CMP field staff. Neither a Water Type Modification Form nor related Interdisciplinary Team documentation was received by region FP staff. During the compliance monitoring field visit, the stream met the criteria of a Type F stream (> 2’ wide and < 16% gradient). The sample was determined to be compliant with the wording on the FPA, and non-compliant with the rule.

Within the statewide Type Ns prescription, the difference occurred as a deviation from the Rule/FPA Indeterminate, where the landowner treated the stream as an Ns but it was determined to be an Np by the CMP field review. The landowner used ambiguous “typing” related language on the FPA. The FPA indicated that if no flowing water was observed in the channel, the stream would be typed Ns for harvest related operations. Neither a Water Type Modification Form nor related Interdisciplinary Team documentation was received by region FP staff. During the compliance monitoring field visit, flowing water was observed in the channel, resulting in the determination of Type Np water. The field visit occurred in September, near to the time of seasonally low water flows. The sample was concluded to be a deviation from FP rules; however, due to the ambiguous language on the FPA, application compliance was rated Indeterminate.

Within the Type A&B Wetlands prescription, 5 samples deviated from either rule or application compliance. For the first sample, the landowner declared on the FPA that a 50-foot no-cut buffer would be utilized around a Type B wetland, when only a 25-foot no-cut buffer was required by FP rules. During the compliance monitoring site visit, it was observed that the landowner met the 25-foot requirement but harvested within 50 feet of the wetland. The sample was compliant with FP rules but not compliant with the language on the FPA. For the second sample, the landowner declared that the

selected wetland was Type A. However, during the compliance monitoring field review, it was determined that the wetland was an associated wetland of a fish-bearing water. This determination resulted in the sample being compliant with the FPA but non-compliant with the FP rules. For the third sample, the difference occurred as a deviation from the Rule/FPA Compliant, where the landowner treated the water as an A wetland, but it was determined to be an F water by the CMP field staff. A stream flowing into the wetland met the criteria for Type F per was observed by the compliance monitoring field team. The wetland was determined to be associated with the F stream. Neither a Water Type Modification Form nor related Interdisciplinary Team documentation was received by region FP staff. The sample was determined to be compliant with the wording on the FPA, and non-compliant with the rule. For the fourth sample, the difference occurred as a deviation from the rule/FPA Compliant, where the landowner treated the water as an A wetland, but it was determined to be an F water by the CMP. A stream flowing through the wetland was typed as an F stream on the DNR hydro layer. The wetland was determined to be associated with the F stream. Neither a Water Type Modification Form nor related Interdisciplinary Team documentation was received by region FP staff. The sample was determined to be compliant with the wording on the FPA, and non-compliant with the rule. For the fifth sample, the variable buffer width was not appropriate relative to the WMZ. The landowner left a buffer that was wider than required. The sample was compliant with the rules, and non-compliant with the FPA.

9. Report Discussion

Riparian and Wetland Compliance Proportioned across the Population

Tables that describe 2014-2015 riparian and wetland findings are located in Sections 5.2, 5.3, and 5.4 for individual prescription types. Section 5 also provides estimates of the population sizes for each prescription type. Table 20 (below) summarizes FP rule compliance according to these estimated populations. The sampling methodology employed provides desired precision for a biennial sample but does not support an unbiased approach to combine rates and weight by their proportion in the population. Therefore, CMP cannot offer, for example, an overall compliance rate for fish-bearing streams.

Table 20. 2014-15 Estimated Population Size and Associated FP Rule Compliance

Prescription Type	Estimated Population of FPAs with the Prescription	Compliance Percentage
RMZ — Type Np Prescriptions	929	94%
RMZ — Type Ns Prescriptions	1018	97%
RMZ — Type S or F No Inner Zone Harvest	737	94%
Forested Wetlands	322	97%
Type A&B Wetlands	237	95%
Western WA RMZ — Type S or F Inner Zone Harvest DFC2	157	98%
Western WA RMZ — Type S or F Inner Zone Harvest DFC1	55	94%
Roads	1405	98%
Haul Routes	NA*	90%

*The Haul Routes prescription does not have an estimated population.

Compliance Monitoring Program Challenges

Representation of Complete Compliance

In most scenarios where there is deviation from at least one FP rule within a specific prescription there is compliance with the remaining FP rules in that prescription. In fact, it is not unusual for prescriptions rated a minor deviation to also exceed rule requirements for some other FP rules in that prescription. For example, with DFCs, if there were too few outer zone trees, there were often also excess trees in the inner zone, where trees have greater riparian benefits to streams. In this example, although letter of the rule was not met, more trees remained within the RMZ than the minimum required by rule.

The expectation is for landowners to follow all FP rules. However, there is more to evaluating compliance with FP rules than simply a compliance rating for prescription types. The CMP continues to work toward finding better ways to report a more complete picture of the results.

Sample and Measurement Error

The CMP resolves the inability to determine statistical variability for average values by assigning a standard absolute 5% measurement error tolerance. This measurement error tolerance applies for only 3 specific measurements: when determining 1) stream bankfull width; 2) leave tree to edge of bankfull width; and 3) buffer widths and lengths or floors within RMZs. When a landowner's buffer is within 5% of the compliance monitoring field team's measured buffer, the values are considered the same. If the landowner's buffer value falls outside the 5% error tolerance, the compliance monitoring field team's measured buffer is assumed to be correct and the landowner's buffer incorrect.

Variation in Natural Conditions

Because natural features are variable, on-site conditions sometimes do not fit neatly into FP rule categories. When this occurs, review team members may opt to record the compliance as Indeterminate. The challenge is to improve understanding of the conditions and rule to minimize and ultimately eliminate indeterminate determinations. This may involve revisiting rule interpretation and how to apply the rules in imprecise situations or developing suggested changes to make clarification in FP rules and/or board manual guidance.

Shade

Shade is a key function provided by the RMZ and as such is of interest to the CMP for monitoring. However, compliance monitoring of riparian shade rules has presented challenges that have precluded the ability to monitor for shade compliance.

Checking shade documentation for compliance and taking measurements in the field to determine if the required amount of vegetation was left to meet temperature standards both continue to be issues. Measurement repeatability is of concern when using a densiometer (the instrument used to determine shade). Also, when the compliance monitoring field team conducts an on-site review, the trees have been harvested, so it is impossible to re-create original conditions. Currently, the CMP does not take shade measurements in the field.

10. Forest Practices Program/Forest Practices Rule Changes Based on Compliance Monitoring Feedback

Several rule and Board Manual updates are currently in process as a result of the 2012–2013 CMP biennium report. Leave tree, DFC, and RMZ length rule and Board Manual clarifications are currently under review and have been scheduled in the 2017 Forest Practices Board work plan. Rule and Board Manual clarifications were presented at the May 2015 and 2016 Forest Practices Board meeting.

11. Glossary

bankfull width (BFW).

a) **For streams** — the measurement of the lateral extent of the water surface elevation perpendicular to the channel at bankfull depth. In cases where multiple channels exist, bank full width is the sum of the individual channel widths along the cross section (see Board Manual, Section 2).
b) **For lakes, ponds, and impoundments** — the line of mean high water.
c) **For tidal water** — the line of mean high tide.
d) **For periodically inundated areas of associated wetlands** — The line of periodic inundation, found by examining the edge of inundation to ascertain where the presence and action of waters are so common and usual, and of so long a duration in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland.

Basal area. The area in square feet of the cross section of a tree bole measured at 4.5 feet above the ground.

Bull Trout Habitat Overlay. Those portions of Eastern Washington streams containing bull trout habitat as identified by the Department of Fish and Wildlife's bull trout map.

Channel migration zone (CMZ). The area within which the active channel of a stream is prone to move, resulting in a potential near-term loss of riparian function and associated habitat adjacent to the stream, except as modified by a permanent levee or dike. For this purpose, "near-term" means the time scale required to grow a mature forest. (See Board Manual, section 2, for descriptions and illustrations of CMZs and delineation guidelines.)

Clear-cut. A harvest method in which the entire stand of trees is removed in 1 timber harvesting operation (except for trees required by rule or law to be left uncut).

Confidence interval. A type of interval estimate of a population parameter, used to indicate the reliability of an estimate. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter.

Crown closure. The percentage of canopy overlying the forest floor.

Desired future condition (DFC). The stand conditions of a mature riparian forest at 140 years of age, the midpoint between 80 and 200 years. Where basal area is the only stand attribute used to describe 140-year-old stands, these are referred to as the "target basal area." The DFC is a reference point on a pathway and not an endpoint for forest stands.

Diameter breast height (DBH). The diameter of a tree at 4.5 feet above the ground measured from the uphill side.

Dominant and co-dominant trees.

a) **Dominant** — Trees or shrubs with crowns receiving full light from above and partly from the side. Typically larger than the average trees or shrubs in the stand, with crowns that extend above the general level of the canopy and are well developed but possibly somewhat crowded on the sides.

b) **Co-dominant** — a tree that extends its crown into the canopy and receives direct sunlight from above and limited sunlight from the sides. One or more sides of a co-dominant tree are crowded by the crowns of dominant trees.

Equipment limitation zone (ELZ). A 30-foot-wide zone measured horizontally from the outer edge of the bankfull width of Type Np or Ns waters. ELZ rules apply to all perennial and seasonal non-fish-bearing streams.

End hauling. The removal and transportation of excavated material, pit or quarry overburden, or landing or road cut material from the excavation site to a deposit site not adjacent to the point of removal.

Finite population correction factor. A formula frequently used in statistics and probability that allows adjustment to a population from larger to smaller or to indicate no change in the population. The result of the formula's calculation is called the "z-factor."

Forest practices application or notification (FPA or FPN). The DNR form used by forest landowners to apply for approval of a class III or IV forest practice or to notify DNR that they are conducting a class II forest practice.

a) **FPA** — an application for a permit to conduct a site class III or IV forest practice. Site class III and IV forest practices have a higher potential to impact a public resource than does a site class II forest practice.
b) **FPN** — a notification to DNR that a class II forest practice will take place. Class II forest practices have less than ordinary potential to damage a public resource.

Forest road. Since 1974, lanes, roads, or driveways on forestland used for forest practices. "Forest road" does not include skid trails, highways, or local government roads except where the local governmental entity is a forest landowner. For road maintenance and abandonment planning purposes only, "forest road" does not include forest roads used exclusively for residential access located on a small forest landowner's forestland.

Full bench road. A road constructed across a slope without using any of the material removed from the hillside as part of the road. This construction technique is usually used on steep or unstable slopes.

Laser hypsometer. An instrument that measures the distance to the top and bottom of an object and that measures the angle between the lines from the observer to each top and bottom to calculate height of the object.

100-year flood level. A "100-year" event means a calculated flood event flow based on an engineering computation of flood magnitude that has a 1% chance of occurring in any given year.

Partial cut strategy. The removal of a portion of the merchantable volume in a stand of timber so as to leave an uneven-aged stand of well-distributed residual, healthy trees that will reasonably utilize the productivity of the soil.

Prescription. A grouping of similar rules by forest practices activity type (e.g., No Inner Zone Harvest, Desired Future Condition Option 1, Desired Future Condition Option 2, Non-Fish-Bearing Perennial Stream, Non-Fish Bearing Seasonal Stream, Type A&B Wetlands, Forested Wetlands, Roads, and Haul Routes).

Public resources. Water, fish, and wildlife; also, capital improvements of the state or its political subdivisions.

Riparian function. Includes bank stability, the recruitment of woody debris, leaf litter fall, nutrients, sediment filtering, shade, and other riparian features important to both riparian forest and aquatic system conditions.

Riparian management zone (RMZ). The area located on each side of a Type S, F, or N stream, where trees are left to provide protection from disturbance when forest practices activities such as timber harvest are conducted.

Sensitive sites. Areas near or adjacent to Type Np water and that have one or more of the following:

a) **Headwall seep** — a seep located at the toe of a cliff or other steep topographical feature and at the head of Type Np water, connecting to the stream channel network via overland flow and characterized by loose substrate and/or fractured bedrock with perennial water at or near the surface throughout the year.
b) **side-slope seep** — a seep within 100 feet of Type Np water located on side slopes with grades greater than 20%, connected to the stream channel network via overland flow and characterized by loose substrate and fractured bedrock, excluding muck with perennial water at or near the surface throughout the year. Water delivery to the Type Np channel is visible by someone standing in or near the stream.
c) **Type Np intersection** — the intersection of 2 or more Type Np waters.
d) **Headwater spring** — A permanent spring at the head of a perennial channel. Where a headwater spring can be found, it will coincide with the uppermost extent of Type Np water.
E) **Alluvial fan** — a depositional landform consisting of a cone-shaped deposit of waterborne, often coarse-sized sediments.

Sidecast. The act of moving excavated material to the side and depositing such material within the limits of construction or dumping it over the downhill side and outside the limits of construction.

Significance level. A fixed probability of wrongly rejecting the null hypothesis H0, when the hypothesis is in fact true. The smaller the significance level, the better the protection for the null hypothesis. Including a significance level prevents the investigator, as far as possible, from inadvertently making false claims.

Site class. A growth potential rating for trees within a given area based on soil surveys. The designated site class along Type S or F streams will determine the width of the RMZ.

Site index. An index based on ranges of site classes. For example:

50-year site index range (state soil survey)

Site class	Years
I	137+
II	119–136
III	97–118
IV	76–96

V < 75

Stand requirement. The number of trees per acre, the basal area, and the proportion of conifers in the combined core and inner zone such that the growth of the trees would meet the desired future condition.

Stream adjacent parallel roads. Roads (including associated right-of-way clearing) in an RMZ on a property that have an alignment parallel to the general alignment of the stream, including roads used by others under easements or cooperative road agreements. Also included are stream crossings where the alignment of the road continues to parallel the stream for more than 250 feet on either side of the stream. Not included are federal, state, county, or municipal roads not subject to forest practices rules, or roads of another adjacent landowner.

Temporary road. A forest road constructed and intended for use during the life of an approved FPA or FPN.

Uppermost point of perennial flow. The point in the stream where water begins to flow perennially (year-round) downstream.

Wetland management zone (WMZ). The area located around the perimeter of a wetland where trees are left to provide protection from disturbance, as well as shade and nutrients for the wetland.

Yarding corridor. A narrow, linear path through an RMZ to allow suspended cables necessary to support cable logging methods, or to allow suspended or partially suspended logs to be transported through these areas by cable logging methods.

12. Appendix A: Statistical Methods

Methods for Calculation of Compliance and Confidence Intervals

Estimation of Compliance

The mean or average compliance and the variance of the mean are calculated according to the rules of estimation for cluster samples (See, for example, Cochran, 1963; Schaeffer et al., 1990). The mean compliance for a prescription is the ratio of the number of compliant rules divided by the total number of rules sampled across all FPAs in the prescription:

$$\hat{p} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i},$$

Where n is the number of FPAs sampled for the prescription, x_i is the number of rules applied on the ith FPA in the sample, and y_i is the number of rules that were complied with on the ith FPA.

A 95 percent confidence interval for the proportion compliant is formed as follows:

$$\hat{p} \pm t_{.025,(n-1)} \cdot SE(\hat{p})),$$

where $t_{.025,(n-1)}$ is the 97.5th percentile of the student-t distribution with (n-1) degrees of freedom,

$$SE(\hat{p}) = \frac{\sqrt{n \cdot (1 - \frac{n}{N}) \cdot \sum_{i=1}^{n} (y_i - \hat{p} x_i)^2}}{\sqrt{(n-1)} \cdot \sum_{i=1}^{n} x_i}$$ (Cochran, 1977),

and N is the estimated population size for the prescription.

These confidence intervals are symmetric. It is possible for the upper confidence bound to exceed 100% - in these cases the confidence bound is set to100%.

Ratio Proportions

Some compliance proportions are estimated using a ratio proportion. This is necessary when both the numerator and the denominator of the proportion are random variables. The only estimation that used a ratio proportion was the haul route analysis. The haul route compliance for each FPA is the length of road that is compliant divided by the length of road evaluated. The denominator of the compliance ratio is a random variable because the length of road being evaluated differs among FPAs. In this case, the estimated compliance proportion is

$$\hat{p} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i},$$

which is the total length of compliant haul route segments divided by the total length of haul route segments that were sampled across all FPAs (*n* is the number of FPAs sampled).

A 95% confidence interval for the proportion compliant is formed as follows:

$$\hat{p} \pm t_{.025,(n-1)} \cdot SE(\hat{p})),$$

where $t_{.025,(n-1)}$ is the 97.5th percentile of the student-*t* distribution with (*n*–1) degrees of freedom, *n* is the number of sampled FPAs, and

$$SE(\hat{p}) = \frac{\sqrt{n \cdot (1 - \frac{n}{N}) \cdot \sum_{i=1}^{n} (y_i - \hat{p}x_i)^2}}{\sqrt{(n-1)} \cdot \sum_{i=1}^{n} x_i}$$ (Cochran 1977: 32).

These confidence intervals are symmetric. Note that the FPCF is already built in to this equation. It is possible for the upper confidence bound to exceed 100% — in these cases the confidence bound is set to 100%.

13. Appendix B: 2014-2015 Biennium Individual Rule Compliance by Prescription

Table column headers may not reflect actual field form question wording

Desired Future Condition Option 1

DFC1 (n=20)	Overstory Tree Species match DFC worksheet (222-30-021(ii)(B)(I))	Site Class (222-16-010)	Stream Size (222-16-031(2)(3))	No harvest in Core Zone 222-30-021(a)	Inner Zone meets diameter leave tree strategy (222-30-021(ii)(B)(I))	Largest 57 TPA left in Inner Zone (222-03-021(ii)(B)(I)	Unstable slopes bounded out (222-16-050(d))	Correct # Outer Zone leave trees (222-30-021(iii)(c))
Compliance	19	20	20	17	17	19	0	19
Assessed	19	20	20	20	20	19	1	20
% compliant	100%	100%	100%	85%	85%	100%	0%	95%
95% CI	(85, 100)	(86, 100)	(86, 100)	(66, 95)	(66, 95)	(85, 100)	n/a	(79, 100)

Desired Future Condition Option 2

DFC2 (n=14)	Overstory Tree Species match DFC (222-30-021(ii)(B)(II))	Site Class (222-16-010)	Stream Size (222-16-031(2)(3))	No harvest in Core Zone (222-30-021(a))	No harvest in floor Zone (222-30-021(ii)(B)(II)	20 conifer TPA in outer portion of IZ (222-30-021(ii)(B)(II))	Unstable slopes bounded out (222-16-050(d))	Correct # Outer Zone leave trees (222-30-021(iii)(c))
Compliance	14	14	14	14	12	14	2	14
Assessed	14	14	14	14	14	14	2	14
% compliant	100%	100%	100%	100%	86%	100%	100%	100%
95% CI	(78, 100)	(78, 100)	(78, 100)	(78, 100)	(58, 98)	(78, 100)	(19, 100)	(78, 100)

No Inner Zone Harvest

NIZH (n=25)	Stream Size (222-16-031(2)(3))	Site Class (222-16-010)	No harvest in Core Zone (222-30-021(a))	No harvest in Inner Zone (222-30-021(b)	Correct # Outer Zone leave trees (222-30-021(iii)(c))	Unstable slopes bounded out (222-16-050(d))	Observed CMZ 0222-30-020(13)
Compliance	24	22	25	22	22	1	0
Assessed	24	24	25	25	23	1	2
% compliant	100%	92%	100%	88%	96%	100%	0%
95% CI	(86, 100)	(73, 99)	(86, 100)	(69, 97)	(78, 100)	n/a	n/a

Non-Fish Bearing Perennial Streams

Np (n=35)	Np stream size (222-16-031(4))	Is ≤ 10% of ELZ exposed (222-30-021(2)(a))	Appropriate Length of 50 foot buffer (222-30-021(2)(b)(vii))	No harvest within required 50 foot buffer (222-30-021(2)(b)(i))	No harvest 50 feet from headwall seeps & springs (222-30-021(2)(b)(ii)(iii))	56ft PIP & Confluence buffer (222-30-021(2)(b)(iv)(v))	Unstable slopes bounded out (222-16-050(d))	Salvage within the Np RMZ (222-30-045(5))
Compliance	32	15	26	26	3	19	4	3
Assessed	35	15	27	28	3	21	4	3
% compliant	91%	100%	96%	93%	100%	90%	100%	100%
95% CI	(77, 98)	(79, 100)	(81, 100)	(77, 99)	(30, 100)	(70, 99)	(41, 100)	(30, 100)

Non-Fish Bearing Seasonal Streams

Ns (n=35)	Ns stream size (222-16-031(5))	Is ≤ 10% of ELZ exposed (222-30-021(2)(a))
Compliance	33	26
Assessed	35	26
% compliant	94%	100%
95% CI	(81, 99)	(87, 100)

A & B Wetlands

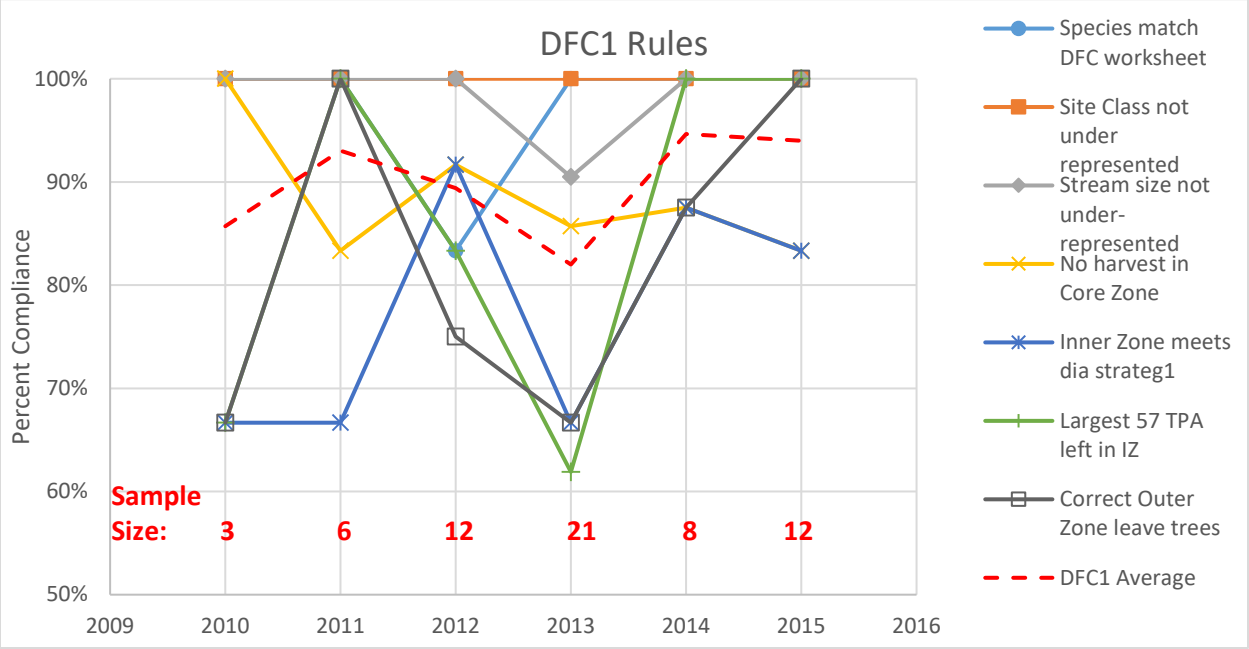
A&B Wetlands (n=35)	Wetlands type & size (222-16-035(1)(a) &(b))	Variable buffer width appropriate (222-30-020(8)(a))	Openings less than 100' wide (222-30-020(8)(d)	Leave trees species represent pre-harvest (222-30-020(6))	Ground based in min WMZ had approval (222-30-020(8)(e))	WMZ-RMZ overlap-best protection used (222-30-020(8)	50 TPA GT 6in WW (4in EW) (222-30-020(8)(b))	20 TPA GT12in,where they exist (222-30-020(8)(b))	5 TPA GT20in, where they exist (222-30-020(8)(b))
Compliance	28	22	1	24	3	3	14	14	11
Assessed	32	22	1	24	3	3	15	15	12
% compliant	88%	100%	100%	100%	100%	100%	93%	93%	92%
95% CI	(72, 96)	(86, 100)	(6, 100)	(87, 100)	(33, 100)	(33, 100)	(70, 100)	(70, 100)	(64, 100)

Forested Wetlands

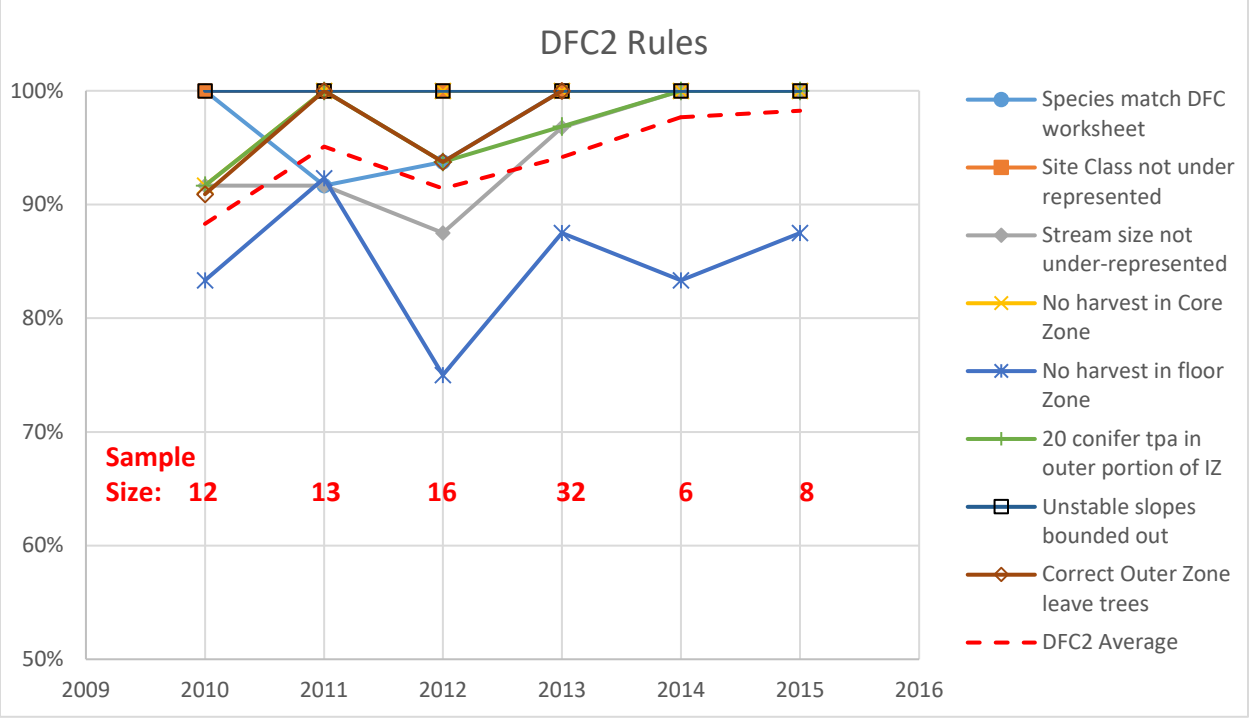
Forested Wetlands (n=23)	Wetlands type & size consistent (222-06-035(2))	If harvest occurred, low impact used (222-30-020(7))	If greater than 3 acres, was it mapped (222-16-036(3))
Compliance	22	11	5
Assessed	23	11	5
% compliant	96%	100%	100%
95% CI	(79, 100)	(72, 100)	(49, 100)

14. Appendix C: Trends of Individual Rules

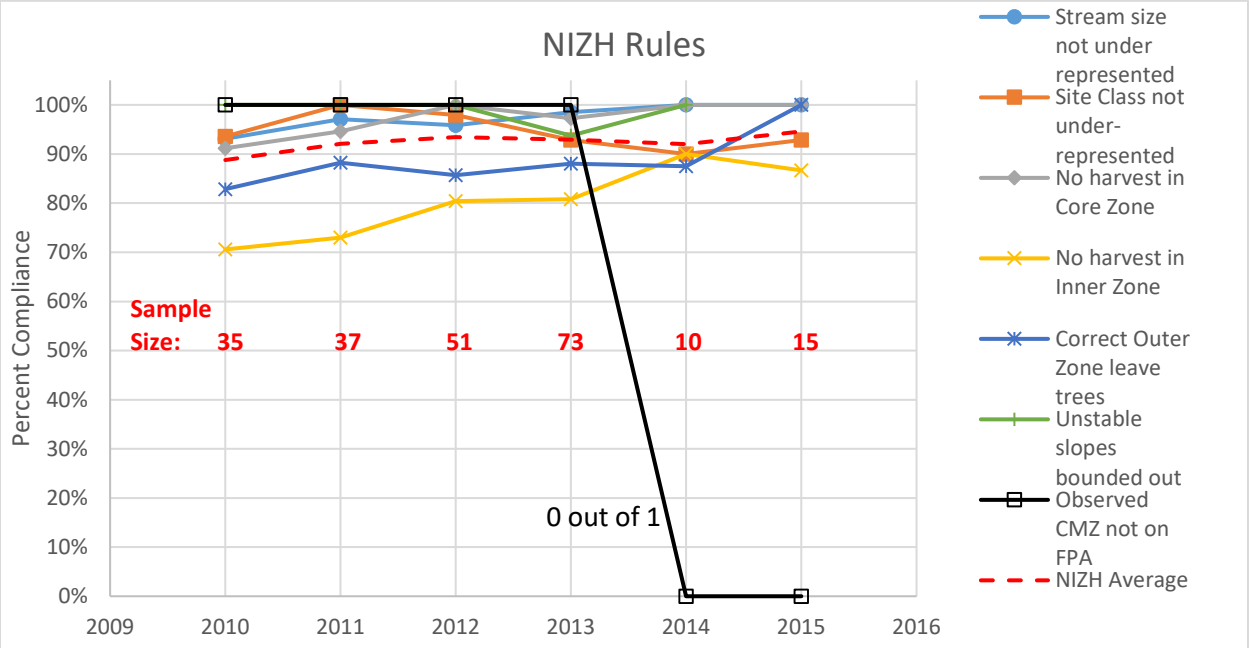
Desired Future Condition 1



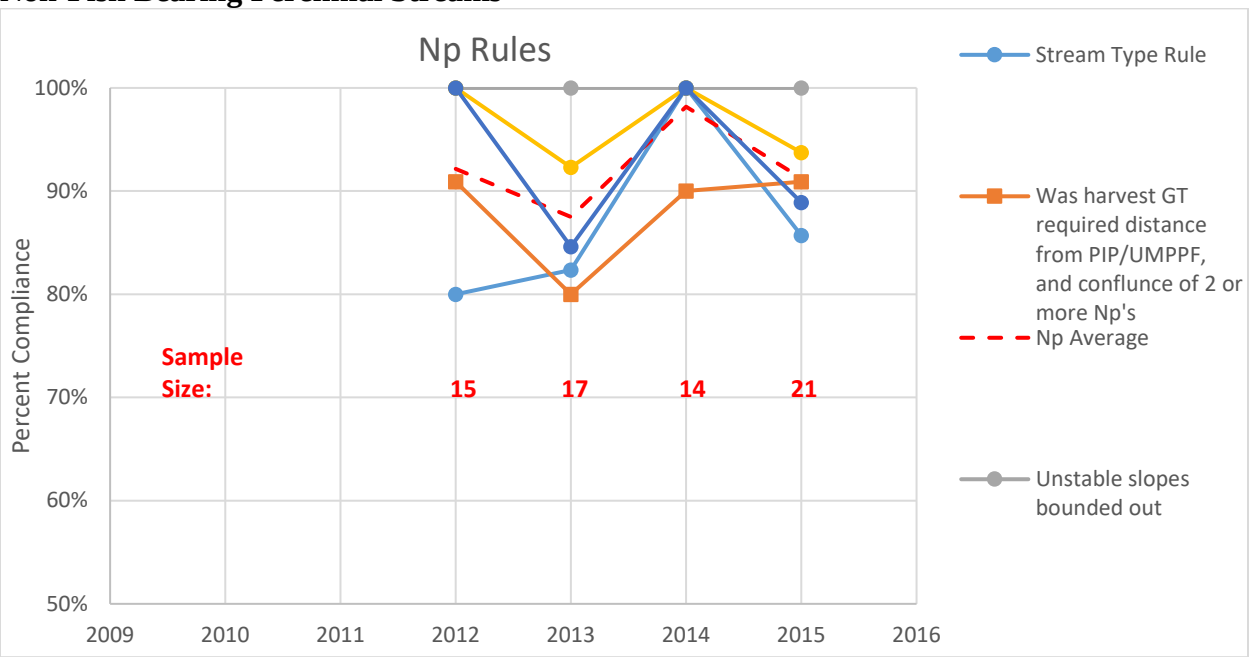
Desired Future Condition 2



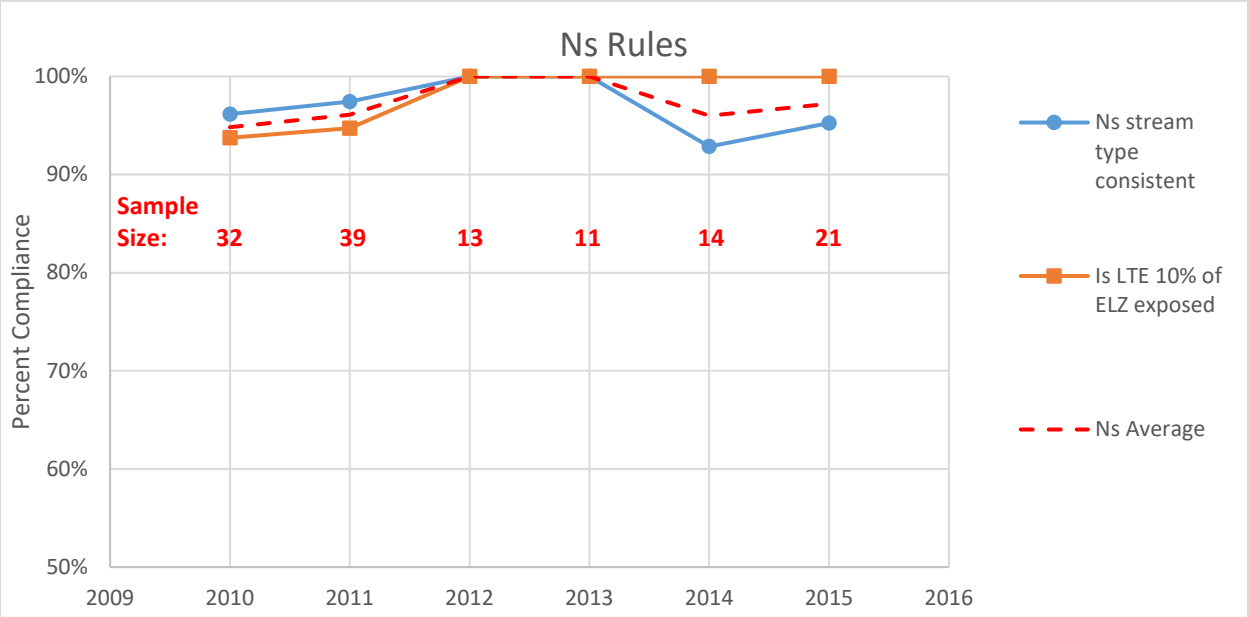
No Inner Zone Harvest



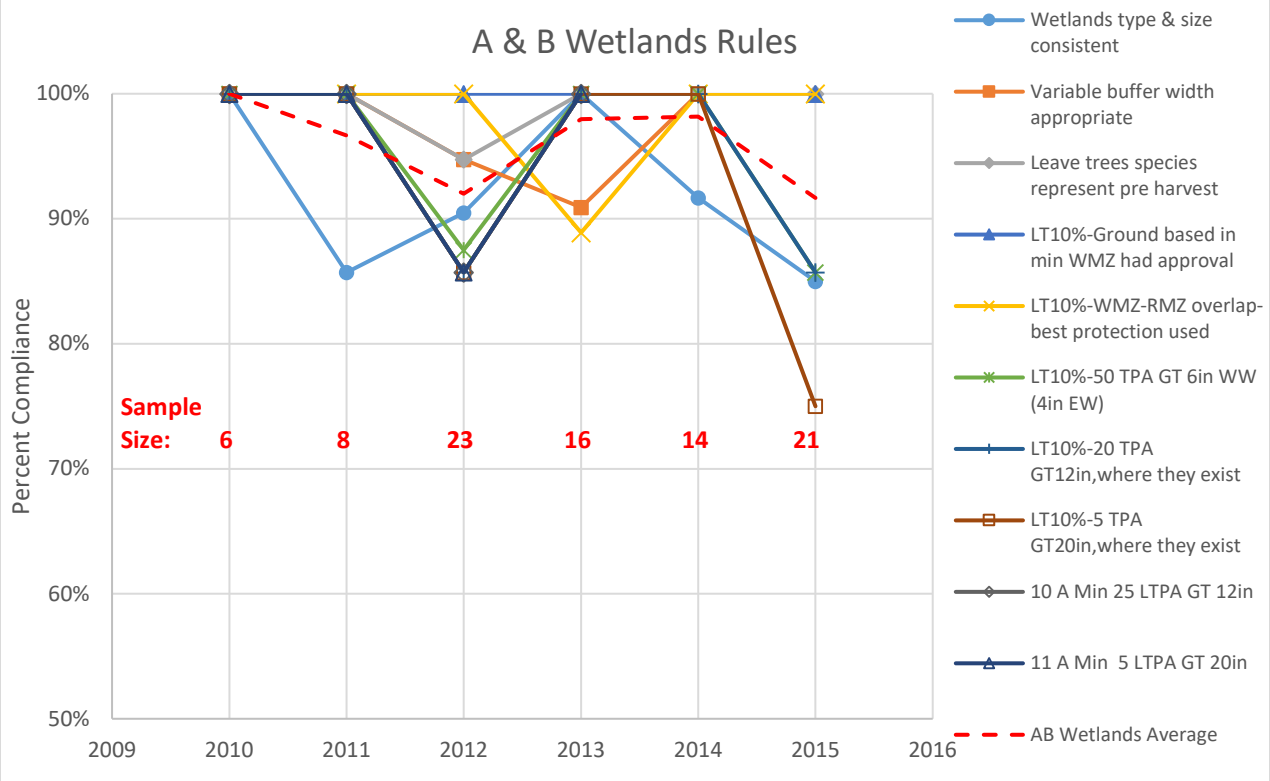
Non-Fish Bearing Perennial Streams



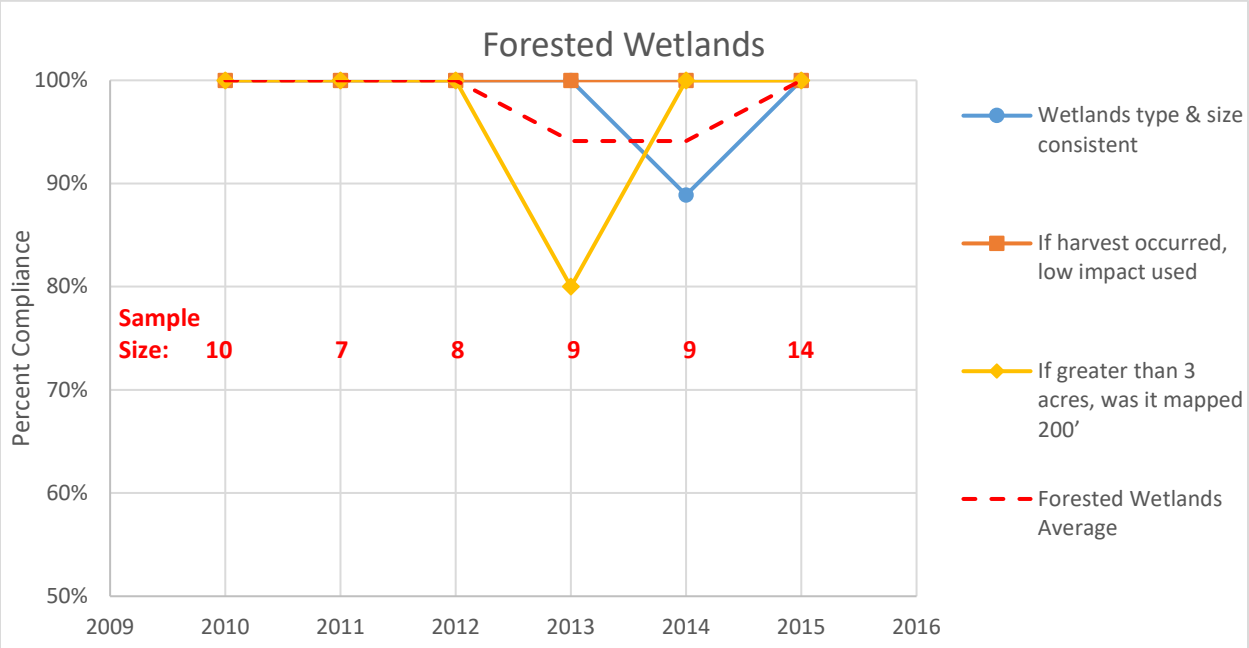
Non-Fish Bearing Seasonal Streams



A & B Wetlands



Forested Wetlands



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Hans Berge
Adaptive Management Program Administrator
Forest Practices Division
WDNR

Reviews for: (**ISPR 16-17_01)**
for WaDNR

Jun 1, 2017

Dear Hans Berge

Attached with this email you will find 4 files (besides a copy of this letter). One attached pdf file is the summarization by Associate Editor (AE), Dr. Loveday Conquest, of the reviews of "2014-2015 Biennium Forest Practices Compliance Monitoring Report-August 2016*"* for WaDNR. Three other attached pdf files are the three reviewers' comments. WaDNR asked for 3 reviewers to review this report. This was an 'open' type review (interaction between AE, reviewers and WaDNR). As stated by the AE about all the reviewers, they are ".. recognized scientists with combined expertise in statistics, quantitative ecology and resource management, forest biometry, and silviculture."

The Associate Editor and reviewers have presented their comments relative to the *revised* basic questions for ISPR's reviews for this Forest Practices Compliance Monitoring Report. In synthesizing the reviews, the AE stated that all the reviewers and she concluded that "*The statistical approach regarding the sampling procedure and construction of the ratio estimator for compliance is generally sound."* The AE went on to say that they *"recommend that a longer Appendix A containing the technical details of the sample selection procedure, including how one gets from the FPA, to the prescription, to the rules within the prescription, and ultimately to the estimate of compliance rate, be included."* Also that they "*strongly recommended that use of a "jackknifed" form of the ratio estimator be considered*." The AE and reviewers also included additional comments to consider for improvement of the compliance monitoring procedure.

If you have any other questions, let me know!

Sincerely

Daniel J. Vogt
Managing Editor

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Synthesis and Assessment from Independent Scientific Peer Review (ISPR 16-17-01)

2014-2015 Biennium Forest Practices Compliance Monitoring Report

for the

Cooperative Monitoring, Evaluation and Research Committee (CMER)
and
Washington Department of Natural Resources (DNR)

by
Dr. Loveday L. Conquest
Associate Editor for the Independent Scientific Peer Review Committee

Executive Summary

The 2014-2015 Biennium Forest Practices Compliance Monitoring Report is a result of the analysis of data from a probability sample, based upon completed forest practice applications (FPAs) over the two-year period. For each of the various categories of similar forest practice rules (known as prescriptions): Roads, Type A&B Wetlands, Forested Wetlands, No Inner Zone Harvest [NIZH], Desired Future Condition Option 1 [DFC1], Desired Future Condition 2 [DFC2], Non-Fish-Bearing Perennial Stream [Np], Non-Fish-Bearing Seasonal Stream [Ns]), the statewide rate of compliance with the associated forest practice rules is estimated. Statewide compliance rate is also estimated for Haul Routes, whose sample is obtained in a different manner. (Details regarding the sample selection procedure and the estimator for compliance rate appear in the Responses to Questions below.)

The statistical approach regarding the sampling procedure and construction of the ratio estimator for compliance is generally sound. The Review Team and the Associate Editor recommend that a longer Appendix A containing the technical details of the sample selection procedure, including how one gets from the FPA, to the prescription, to the rules within the prescription, and ultimately to the estimate of compliance rate, be included. This needs to occur in order for anyone to attempt to reproduce the study or simply to truly understand the sampling selection and data analysis process. Some of the requested information could be gathered from current DNR documents. It would be helpful to see another chapter titled “The Life of a Completed FPA” (details below), but this is not as important as the need for an expanded Appendix A.

It is strongly recommended that use of a “jackknifed” form of the ratio estimator be considered. This could reduce bias and yield much better variance estimates. This would require additional

lines of code in the data analysis, but would not change the sample selection procedure. A jackknifed ratio estimator could also be applied to older data sets.

Review Process and Participants

A peer review was conducted through the Independent Scientific Peer Review Committee (ISPR) of the University of Washington (UW) of the 2014-2015 Biennium Forest Practices Compliance Monitoring Report for Washington State's Department of Natural Resources and for the Cooperative Monitoring, Evaluation and Research (CMER) Committee in spring 2017. The review team consisted of three peer reviewers and the Associate Editor (**AE**) Dr. Loveday Conquest (UW). Reviewers were selected by the **AE** in consultation with Dr. Daniel Vogt, Managing Editor (ME) of ISPR. In addition to reviewing the document, the Review Team met with the ME and DNR personnel (including an outside consultant for the DNR Compliance Program) in April 2017 to obtain further information and clarification on issues such as the sample selection procedure, the process for creating the database, and estimation of compliance rates.

The **AE** and the three reviewers are recognized scientists with combined expertise in statistics, quantitative ecology and resource management, forest biometry, and silviculture. Dr. Tamre Cardoso (**TC**) is a Principal Consultant with TerraStat Consulting Group and is a part-time Lecturer in the UW's Department of Statistics. For over twenty years, she has provided statistical consulting services for natural resource studies to both government agencies and private companies. Dr. James Flewelling (**JF**) is a consulting forest biometrician with extensive experience in growth and yield modeling, and forest inventory. Dr. Eric Turnblom (**ET**) holds the B. Bruce Bare Endowed Chair in Forest Resources and is Director of the Stand Management Cooperative in UW's School of Environmental and Forest Sciences. Turnblom is Associate Professor of Quantitative Silviculture and Forest Biometrics and has a long teaching career in forest measurements and statistics. Associate Editor Conquest is Director Emeritus of the Quantitative Ecology and Resource Management Program at UW, in addition to being Professor Emeritus of the College of the Environment's School of Aquatic and Fishery Sciences. A Fellow of the American Statistical Association, Conquest researched and taught experimental design and statistical methods for forty years through the Center for Quantitative Science in Forestry, Fisheries, and Wildlife.

Review of ISPR 16-17-01
2014-2015 Biennium Forest Practices Compliance Monitoring Report
AE Synthesis – L Conquest

General Comments

It is helpful to set down a brief summary of the process concerning an FPA, from the time that it is filled out, to its role in the sample selection process. The **AE** concurs with Reviewer **ET's** following observations about the process concerning an FPA:

[1] A given FPA is filled out by a single entity (e.g., a forest manager, landowner, contracted firm) that pertains to one or more planned forest practices (e.g., building a road, implementing a DFC1 prescription). Each FPA involves a set of rules, although not every rule that could apply to an FPA actually does apply for that particular instance.

[2] Only completed FPAs in the stated biennial window (here, 2014-2015) are eligible for inclusion in the population for a particular prescription type in that biennium. A given FPA may contain a combination of forest practices. There may be more than one occurrence of a prescription type in a given FPA, and these multiple occurrences may not be statistically independent.

[3] The goal is to provide a statewide average compliance rate for each prescription. Compliance is defined as the proportion of correctly applied rules in the set of applicable rules used for that prescription.

[4] DNR wishes to select a statistically representative sample of prescriptions of a given type, as represented in completed FPAs. DNR also desires spatial coverage of landowner/contractor/operator combinations appearing in FPAs across the six regions of Washington. This process is coordinated with knowledge of DNR field effort available across the six regions.

[5] The sample selection process has several stages, beginning with a random selection of FPAs containing a given prescription. Completion of each FPA must be verified, applicable rules noted, compliant rules noted, ending with a compliance assessment for an instance of a forest practice event on the ground. Costs are incurred at each successive step.

[6] In keeping with considerations of labor costs and spatial coverage, within a given FPA, DNR samples a single instance of a prescription type, even if a prescription type appears more than once in an FPA. This maintains control over allocation of forest practice event samples to the six regions and also enables the balancing of the compliance assessment workload across regions.

The **AE** agrees with the three Reviewers that the current sample selection procedure should be maintained in order to have consistency through the years when assessing temporal trends in compliance rates.

Review of ISPR 16-17-01
2014-2015 Biennium Forest Practices Compliance Monitoring Report
AE Synthesis – L Conquest

The List of Review Questions

Each reviewer was asked to specifically address the following twelve peer-review questions from CMER:

1. Are rigorous, transparent and sound research and statistical methods followed?
    a. Is the estimator used to estimate average compliance a proper statistical estimator?
    b. If the answer to a) is no, what estimator would you propose as an alternative estimate of average compliance for a prescription?
2. Is the statistical design (using the described estimator) a sound method for method for determining compliance with forest practices rules?
3. Is there sufficient detail in the document to reproduce the study?
4. Were data reasonably interpreted?
5. Do the literature citations include the latest applicable information and represent the current state of scientific understanding on this topic?
6. Are uncertainties and limitations of the work stated and described adequately?
7. Are assumptions stated and described adequately?
8. Is the information presented in an accurate, clear, complete, and unbiased manner and in a proper context?
9. Currently, there are several rules included in compliance calculations that are based on the proper classification of a site rather than on compliance with the rules specific to a particular classification. Thus, if an FPA is non-compliant for site class, the other rules are not applicable, so the FPA cluster has size one, with compliance = 0%. Because these FPAs have only one rule applied, they are not given high weight in the ratio estimate of average compliance. Specific questions:
    a. Does this amount to a bias in the estimate of average compliance for a prescription?
    b. If the answer to a) is yes, what would be the best way to remove this bias:
        i. Separate the compliance estimates into classification versus operational rules for those affected prescriptions
        ii. Change the method for estimating average compliance
10. Should compliance be calculated separately for administrative (site characteristics) versus layout and operational (on the ground) rule applications?
11. Recognizing there is a relationship between cost and sampling precision objectives, do you have suggestions for narrowing sampling statistic confidence intervals without significantly increasing the biennial sample size in order to improve the ability to discern trends over time?
12. What suggestions do you have for improving the clarity of the report narrative for an audience with general understanding of natural resources management: (1) the results of the report's two-year data; and (2) the description of trends?

Review of ISPR 16-17-01
2014-2015 Biennium Forest Practices Compliance Monitoring Report
AE Synthesis – L Conquest

In these following responses to the questions, any citations referred to are references cited and presented in the Compliance Monitoring Report, unless otherwise noted. The response to Question 5 contains new literature citations with explanations. A list of references also appears at the end of this review.

1. Are rigorous, transparent and sound research and statistical methods followed?

There is general agreement that sound research and sound statistical methods are used. The underlying methodology uses a design-based approach; design-based estimators require no assumptions about the population. The ratio estimator used is well studied, nearly unbiased, and documented in many statistics textbooks (the Report references Cochran [1963, 1977] and Scheaffer et al. 1990). However, many of the details are not that transparent in the Report itself; hence the recommendation for an expanded *Appendix A*. As expected, things became much clearer for the Review Team following the meeting with DNR. See the response to Question 3 for suggestions regarding making more details about the statistical methods more transparent.

Reviewer **JF** argues for a clearer definition of the population of interest and of the population attribute of interest. Assuming that a site has been properly classified (addressed in Question 9), the Report states (p. 12), "For each riparian prescription, the population to be sampled consists of FPAs that included that prescription." The **AE** agrees with the Report; the issue of a valid sample selection process is addressed elsewhere. The Report (p. 2) states the (updated) method for calculating average compliance: "divide[s] the number of compliant rules by the number of total sampled rules within each prescription type, resulting in an average compliance rate." The issue of how to define a prescription's "overall compliance" arises because a given prescription type may appear more than once in an FPA. This is discussed below in the response to Question 1b.

a. Is the estimator used to estimate average compliance a proper statistical estimator?

Overall, the three Reviewers feel that as implemented, the ratio estimator used to estimate average compliance is a proper statistical estimator. When estimates rates or proportions are the objective, ratio estimators are often used. That said, there is room for improvement. The **AE** agrees with the statements by Reviewers **TC** and **JF** that ratio estimates carry some bias. **TC** points out that the amount of bias associated with the standard ratio estimator goes down on the order of (1/n) as the sample size n increases. For large n this is not a problem; for small n this could be problematic. To help reduce this bias, a jackknifed version of the ratio estimator in suggested below in 1b.

Another issue (noted by **JF**, **TC**, and the **AE**) arises from the use of the standard finite population correction, (1 – n/N), where n is the sample size and N is the population size. What is used in the calculation of standard errors is $\widehat{N}$, the estimated population size as shown in the Report's Table 2 (p. 15). This adds another random component to the formula for the standard error of $\hat{p}$, the estimated proportion of compliance for a given prescription. Thus, SE($\hat{p}$) in the Appendix should really denoted as $\widehat{SE}(\hat{p})$. Reviewer **JF** offers further comments concerning the (estimated) proportion sampled, that as n approaches N (which means that the sample selection is approaching an actual census), n/N will approach 1.0 and the calculated standard error will approach zero. The (estimated) proportion sampled for the prescription types in Table 2 are respectively (excluding Haul Routes): Roads 0.01, Ns 0.03, Np 0.04, Type A & B Wetlands 0.15, Forested Wetlands 0.07, NIZH 0.03, DFC1 0.36, 0.09. The maximum value of 0.36 is that for DF1, so there does not appear the possibility of attaining a zero standard error. Regarding the statement from Reviewer **JF**: "[T]he formula for standard errors is correct only if the population of interest is defined as the set of prescriptions consisting of one prescription on each FPA having exactly one prescription of a given type, and a randomly selected prescription from every FPA having more than one prescription of that type", the **AE** agrees with the definition from the Report's p. 12 (stated above). The number of prescriptions of a given type contained in an FPA is rather an issue of subsampling; all FPAs containing at least one prescription of a given type are included in the population to be sampled.

b. If the answer to a) is no, what estimator would you propose as an alternative estimate of average compliance for a prescription?

TC suggests the use of a jackknife ratio estimator (Cochran 1977, cf. p. 175) to help reduce potential bias in estimating average rule compliance for prescriptions using a smaller number of FPA samples. In this scenario, for a given prescription, jackknife estimation would require recalculation of ratio estimates leaving out one FPA each time. For example, if there were 13 FPAs being used to estimate DFC1 compliance, 13 ratio estimates would be calculated from the data, using 12 FPAs per estimate. The 13 estimates would then be averaged to come up with a less biased estimate of DFC1 compliance. Estimator variance may increase for the jackknifed ratio, but only on the order of $1/n^2$ (Cochran 1977). Use of the jackknife would not necessarily reduce any bias to zero. However, jackknife ratio estimates could be compared to original ratio estimates to, say, determine the sample size at which the difference between the two becomes negligible. The **AE** concurs and believes that further evidence from forestry studies (see Question 5) promotes the use of the jackknife estimator here. Additional coding steps would be needed to obtain the estimator and the associated variance; the **AE** sees this as entirely doable. Jackknife ratio estimates on datasets from previous years could also be calculated.

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In Reviewer **JF's** response to Question 1 and Appendix A (not to be confused with Appendix A from the Report itself), "Compliance percentage: definition and estimator", **JF** considers two different ways of calculating the compliance estimate. The first estimator involves weights that vary according to the number of times a prescription type occurs in an FPA. The second one is the one used by DNR. For illustration, considering a small population of four FPAs, suppose only two are sampled for a given prescription, yielding six possible combinations ("4 choose 2" = 6) of FPAs being chosen. Some FPAs indeed have more than one occurrence of a prescription type, and according to DNR sampling protocol only one of the multiple occurrences is sampled. Since here one is looking at the entire population of four FPAs, the actual compliance for the population can be computed under **JF's** Option A and Option B. Further, the expected value of each of the two estimators (based on all possible samples of two FPAs) can also be computed. Each estimator yields an expected value close to its population value for this defined population. For a single FPA, if all prescriptions of a given type were sampled, the compliance estimate would be the same for both estimators. As an example, consider FPA 2 from **JF's** example, with a double occurrence of a given prescription. There are 6 and 5 rule applications respectively, and 4 and 4 compliant rule applications respectively. One can compute the compliance rate as:
(# of compliant rule applications)/(# of rule applications) = (4+4)/(6+5).
Alternatively, one can compute the compliance rate as:
(average # of compliant rule applications)/(average # of rule applications) = ((4+4)/2) / ((6+5)/2).
The answer is the same, 0.73, in both cases. However, when they are summed up over than one FPA (summing up the "straight number" of occurrences in both numerator and denominator versus summing up the average number of occurrences in both numerator and denominator), the numbers do change. **JF's** discussion following the computations notes that the choice between the two estimators is really administrative rather than statistical (the **AE** concurs and therefore there is no reason to change from the current ratio estimator). **JF** further notes DNR's desire to spread the sampling out among FPAs, rather than allowing multiple prescriptions of the same type to be sampled from the same FPA.

Reviewer **JF** also offers an alternative calculation to the finite population correction (FPC, currently based on n/$\widehat{N}$, # of sampled FPAs containing one or more of that prescription type/estimated FPA population size for that prescription type). **JF** suggests using a single, overall FPC: # of sampled FPAs/estimated FPA population size. If each FPA had at most one occurrence of a prescription type, these two FPCs would be the same. (As an alternative, **JF** recommends calculating a variance first assuming an infinite population, then reducing the variance using an FPC whose value is known with certainty; but this would necessitate knowing the exact count of a given prescription type). The **AE** notes that the crux of this issue has to do with, when a prescription type occurs more than once in a single FPA, how representative a

single prescription (chosen at random) for analysis is of the other prescriptions of that type that did not end up in the sample. If multiple prescriptions of the same type in an FPA are "well mixed", the random sampling argument may be all that is needed. The **AE** sees no association between the number of occurrences of a prescription type in an FPA and the prescription's compliance rate for that FPA.

JF's discussion noted, the **AE** concludes that DNR's present use of the ratio estimator is still a good way for DNR to proceed, with the added recommendation noted above that DNR consider using a jackknifed version of the present ratio estimate.

2. Is the statistical design (using the described estimator) a sound method for determining compliance with forest practice rules?

Recognizing the need to meet objectives for compliance monitoring while staying within the bounds of budget constraints, the Review Team agrees that the statistical design is a sound method for the eight standard prescription types. Furthermore, sampling proportional to available regional effort should result in a random sample of FPAs with statewide spatial coverage.

The FPAs are clusters (in the statistical sense) of prescriptions, since a given FPA may contain a variety of prescriptions. It is also true that two or more prescriptions of the same type may contain different rules, and differing numbers of rules. DNR states that a prescription is itself a "cluster of rules", since the number of rules is random and since the particular rules may differ. The **AE** agrees with Reviewer **TC** that it is nonetheless important to note that the sample selection procedure is still single-stage cluster sampling and not two-stage cluster sampling, since (for a given prescription type) the random sample is a sample of FPAs containing that prescription. Reviewer **ET** refers to the sampling procedure as a "modified single-cluster sampling strategy" (the modification being how multiple occurrences of a prescription are handled), which the **AE** views as a good way to describe things. While some may view this point as largely an issue of "statistical semantics", the Report must do all it can to provide clarity on what exactly is involved in the sampling procedure.

"Haul routes" is different from the standard prescription types, since for efficiency reasons haul routes are sampled on a subset of FPAs that have already been selected for other prescription compliance sampling. (In the example given on the Report's p. 49, haul routes were observed on FPAs selected for the harvest prescription sample.) Thus, one may question whether the harvest-prescription-based haul route sample is statistically representative (in the way a random sample of FPAs with haul route prescriptions would be) of the haul route prescription applications throughout the state. The Report does make note of this, for example, when it points out that

there is no population estimate for haul routes (p. 15). But Table 16 (p. 49) lists haul route CIs for percent compliance and other parameters in the standard "assuming a random sample" way. While the **AE** does not recommend deletion of these CIs for haul routes, a qualifier similar to that on p. 15 should be added here too.

3. Is there sufficient detail in the document to reproduce the study?

In its present form, the Report does not provide enough detail to reproduce the study. This statement holds both for obtaining the random sample of FPAs for a prescription across the six regions throughout the state, and for using the data from the sample to obtain an estimate of compliance. The 2 ½-hour meeting with DNR in April 2017 (including handouts, and discussions around schematics drawn on a whiteboard) proved extremely helpful in deepening the Review Team's understanding of the Compliance Monitoring Program. Without that meeting, the Review Team would not have been able to properly interpret the Report.

The Review Team is keenly aware that the Report must serve a variety of audiences. Thus, it would not be a good idea to add to Chap. 4 the extensive level of statistical detail required to completely understand the sampling process and how to get to the compliance estimates. This is better done in the Report's Appendix A. An expanded Appendix A could include:

[1] a description of the random selection of the FPAs for a given prescription, including the stratification across Washington State's six regions for purposes of spatial coverage and labor efficiency;

[2] an explanation of why the simple random sampling estimate approach, even though the sample was obtained via stratified random sampling, "works" statistically (as was explained at the meeting and via handouts);

[3] an example for the "roads" prescription, from sample selection to obtaining the compliance estimate from the sample (because the way roads compliance is measured is slightly different from the other prescriptions;

[4] a further example for a prescription other than roads, where each applied rule is scored as either a 0 or a 1;

[5] an example of how sample sizes are determined. Much of this is in the information that was conveyed to the Review Team at the meeting with DNR. The handouts and notes from the meeting could be used as a starting point for expanding Appendix A, which could be updated yearly or biennially. To minimize additional writing effort, the **AE** notes that information similar to the handouts is available in existing DNR publications, which could be referenced with specific page numbers. For example, pp. 11-13 of the DNR Compliance Monitoring Program Description (Lingley et al. 2010, see Question 5)

lists the sample selection steps in place at that time, along with a flow chart. An updated version of this was presented at the meeting with DNR staff.

Ideally, the Report, with its current appendices and the expanded Appendix A, could allow the entire compliance assessment process, from creation of the samples to obtaining the estimates, to be reproduced in another part of the country where FPAs and prescriptions are used. The **AE** concurs with the Reviewers that while this request may appear to call for an excessive level of documentation, the documentation would also serve as the basis to explore other sampling designs and estimation methods.

A suggestion for another Appendix is the inclusion of "The Life of a Completed FPA". This would take a particular completed FPA through the entire process. A listing of its associated prescriptions would reveal in which populations of prescriptions this FPA would end up. For each unique prescription, the computing of the compliance rate could be illustrated. For a prescription that appears more than once, one would be chosen at random and its compliance rate computation illustrated. The Review Team saw schematics illustrating some of this at the DNR meeting. It certainly would be helpful to anyone trying to get a firm grip on the sampling process, what kinds of data go into the database, and the process to get to the compliance estimates. The written summary from the meeting with DNR would be a good start on such an Appendix.

4. Were the data reasonably interpreted?

The **AE** concurs with the Reviewers that the data do appear to have been reasonably interpreted. The report presents a summary of rule compliance rates, with 95% CIs by prescription types. The Report does not judge whether a stated level of compliance is "good" or "bad". That interpretation is left to those who will make use of the Report, which is as it should be. The **AE** notes that the additional information categorizing the level of deviation from compliance, and the level of compliance, was illustrated very well.

5. Do the literature citations include the latest applicable information and represent the current state of scientific understanding on this topic?

For the most part, yes. The **AE** will not attempt to add to the Report's list of texts on sampling, except to note that for readers who find the level of mathematics in Cochran (1977, the classic sampling text) difficult to digest, Scheaffer et al. (1990) provides a good starting point to understanding sampling, including cluster sampling and stratified sampling. A reference from

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Reviewer **TC** regarding use of the jackknife statistic in forestry is given below. Three references from Reviewer **JF** dealing with applications, effectiveness, and compliance with forestry management practices, including sample selection procedures, are also presented. The **AE** has added Lingley et al. (2010), a DNR publication. Each reference appears with a descriptive comment.

Gregoire, T.G. 1984. The jackknife: an introduction with applications in forestry data analysis. *Canadian Journal of Forest Research 14(4)*: 493-497.
This article introduces the notion of a statistic called the "jackknife" (due to its handy nature requiring no further additional sampling), and illustrates its usefulness in terms of a ratio estimator in forestry applications, completely relevant to DNR's Compliance Monitoring Program.

Egan, A.F., R.D. Whipkey and J.P. Rowe. 1998. Compliance with forestry best management practices in West Virginia. *Northern Journal of Applied Forestry 15(4):* 211-215.
This study features a well-defined sampling frame: "The focus was to randomly select harvested sites for investigation. . . . Based on records developed from logging operation notification forms, sites were randomly selected from lists of retired operations provided by each of the six WVDOF Forest Districts." This is the sample selection procedure used later by Wang and Goff (2008).

Phillips, M. J. and C. R. Blinn, 2007. Practices evaluated and approaches used to select sites for monitoring the application of best management practices: a regional summary. *Journal of Forestry 105(4):* 179-183.
This survey article summarizes various state monitoring programs. Because they are so different, the idea of a "compliance monitoring clearinghouse" is put forth, along with regional meetings among natural resource managers and agencies. A clearinghouse would "permit states to compare and contrast approaches and to share information about what does and does not work," with the goal being continuous improvement of states' programs.

Wang, J. and W.A. Goff, 2008. Application and effectiveness of forestry best management practices in West Virginia. *Northern Journal of Applied Forestry 25(1)*: 32-37.
This article reports the results of a compliance monitoring program in West Virginia. The program bases its sample selection process on Egan et al. (1998).

Lingley, L., A. Shelly and W. Obermeyer. 2010. Washington State Department of Natural Resources Compliance Program Description. 34 pp.
Material from this document could be added to the recommended expanded Appendix A. Appears as a .pdf under http://www.dnr.wa.gov/programs-and-services/forest-practices/rule-implementation

6. Are uncertainties and limitations of the work stated and described adequately?

Generally, yes. For the prescriptions whose samples were obtained by random sampling from a population of FPAs containing a given prescription type (this excludes haul routes), the 95% CIs are quite suitable for describing the uncertainty. Limitations such as the use of professional judgement or potential biases in estimates are noted many times throughout the report, to the authors' credit.

Reviewer **JF** would like to see an estimate of the number or proportion of FPAs not considered for sampling due to one or more prescriptions being incomplete. **JF's** Appendix B offers further comments regarding keeping this number as low as possible, including revisiting an FPA in a subsequent year to assess completion, or by each FPA having a completion date recorded. If budgetary constraints allow, the **AE** encourages DNR to find a way to include the completion date information, which would essentially make this a non-issue.

7. Are assumptions stated and described adequately?

For the most part, yes. Various assumptions are noted in the Report and seem clear. Reviewer **JF's** comments regarding the definition of percent compliance are under Question 1. See Question 12 below regarding some extra statements needed regarding the weighted regression model in Chap. 7. For the sample selection procedure and computation of compliance rate, the assumptions would probably appear in Appendix A.

8. Is the information presented in an accurate, clear, complete, and unbiased manner and in a proper context?

The **AE** concurs with the Reviewers that the answer is "Yes". The report is logically organized, and the history and context is useful for readers with less familiarity with the objectives of the Compliance Monitoring Program. The **AE** echoes the comment from Reviewer **ET** that the context and tone of the Report are outstanding. Considerable effort by the authors has been made to present results for the reader without any "editorial spin".

That said, the Review Team reiterates that Chapter 4, Compliance Monitoring Design and Methodology, needs its expanded Appendix A so that interested readers (who may actually wish to reproduce the study) can get the technical details (including diagrams) on determining sample size, selecting the sample using random sampling of FPAs containing a particular prescription,

estimating the compliance rate, and computing an accompanying CI for the rate. To save effort, the **AE** recommends the use of text and diagrams from existing DNR documents.

Reviewer **JF** suggests that more details might appear in Appendix C: Trends of Individual Rules. These are presented without counts of individual rule applications, nor level of compliance. Nonetheless, they allow a reader to look for possible trends, or to see which rules do better than others in terms of compliance over the years. (*The **AE** notes that overall level of compliance can be read from the graph without too much difficulty*). **JF** recommends including a table of results by individual rule, including the number of rule applications assessed, the compliance rate, and counts by the various levels of compliance, thus allowing the reader to see which rules were causing problems. The **AE** notes that Appendix B does contain compliance information on certain rules (Standard Sample rules, Site Class, Physical Criteria of Waters, and others); however, the "roads" prescription is not included. In Appendix C, the number of FPAs sampled is given, but not the number of rules monitored. The **AE** agrees that this would be useful information if labor costs permit.

9. Currently, there are several rules included in compliance calculations that are based on the proper classification of a site rather than on compliance with the rules specific to a particular classification. Thus, if an FPA is non-compliant for site class, the other rules are not applicable, so the FPA cluster has size one, with compliance = 0%. Because these FPAs have only one rule applied, they are not given high weight in the ratio estimate of average compliance. Specific questions:

a. Does this amount to a bias in the estimate of average compliance for a prescription?

That depends upon how often this occurs. From the DNR meeting, the Review Team got the idea that this does not occur very often. Reviewer **ET** views this as less a question of bias and more of a question of information (rules other than site classification) not being allowed to be used. At any rate, occurrences like these (with the resulting 0% compliance estimate) would not contribute to any upward inflation of a compliance estimate, but rather the opposite. Rare instances of misclassification should have little downward effect on a compliance estimate. The **AE** concurs with Reviewer **TC** that frequent classification errors could lower the estimate of compliance rate, not from actual lack of compliance with forest practices, but from errors in classification; this could be more pronounced for prescriptions with smaller sample sizes. In terms of looking for temporal trends, it is likely the case that the data for each biennium would have the same small proportion of FPAs wrongly classified for site class. Thus, any downward effect present would likely be the same from year to year.

b. If the answer to a) is yes, what would be the best way to remove this bias:

i.) Separate the compliance estimates into classification versus operational rules for those affected prescriptions.

The **AE** concurs with the Reviewers that FPAs that are non-compliant for site class should be separated out. Reviewer **JF** notes that if analyzed, this separated group would likely exhibit small sample sizes, so confidence intervals should not be required. To what degree they should be further analyzed depends upon whether DNR feels that it makes sense to assess operational rules for compliance on a misclassified prescription (**TC**).

The **AE** concurs with Reviewer **TC** that if an FPA is found to be non-compliant for site class, it could be discarded and another one further down the list of FPAs (recall the list is in a random order) substituted instead. This essentially changes the population of inference for a given prescription to "those FPAs classified correctly with respect to site class". Misclassified FPAs could be tracked and percentages reported. Simulation could be used to look at effects of varying levels of misclassification on compliance rate estimates. See also the response to Question 10.

ii.) Change the method for estimating average compliance.

No. The Review Team agrees with that exceptions need to be noted, but a consistent method to estimate compliance over all prescriptions is essential.

10. Should compliance be calculated separately for administrative (site characteristics) versus layout and operational (on the ground) rule applications?

Reviewer **JF** refers the reader back to Question 9, and Reviewer **ET** asks for more specifics. Reviewer **TC** notes that this should be an easy exercise to test but that the question, "how will the resultant compliance rates be used?" should be answered first.

The **AE** offers the following: to investigate this issue, let us assume that there is interest in presenting compliance rates for [1] administrative; i.e., noting correct site characteristics, separate from [2] on-the-ground rule applications. There would be additional effort involved in classifying each rule as (say) "A for Administrative" vs. "L for Layout/Operational" and entering this information into a database. Then, for a given obtained sample of FPAs for a prescription, compliance rates could be estimated for both "A" type rules and "L" type rules. However, the number of rules (i.e., the denominator of the compliance estimate) for each rule type, "A" or "L", would naturally be smaller than that for the combined "A + L" set of rules. Smaller denominators lead to larger variance estimates, which could have an effect upon the stated +/- 6% error desired in a 95% CI (**TC**). If larger sample sizes are needed, that means sampling more FPAs for a given

prescription—more effort and more labor costs. Thus, one needs to think about how the separate compliance rates would be used, and if any particular forest land management practices or procedures might change as a result. If little change would actually result, then the additional effort required to get information into the database for the separate calculations may not be worth the effort.

One way to gauge additional labor costs would be to choose a prescription and actually use the above procedure on currently existing data to generate separate compliance rates for that prescription. That would also yield an example of by how much sample sizes decrease when the rules are split into "A" and "L" types.

11. Recognizing that there is a relationship between cost and sampling precision objectives, do you have suggestions for narrowing sampling statistic confidence intervals without significant increasing the biennial sample size in order to improve the ability to discern trends over time?

The data points necessary to improve the ability to discern trends over time are simply--more time points, which means more years of data. Over short time periods, trends have to be quite strong (big year-to-year changes) in order to be detected (**TC**). Without more years of data, the only way to narrow the CI would be to lower the level of confidence to, say, 90% from 95%. This would be an administrative rather than a statistical decision. If there are prescription types that are more important than others, Reviewer **JF** suggests that the target confidence intervals and sample sizes could be changed to better focus on the prescription types most in need of improved compliance information. If administrative changes allowed for the recording of actual FPA completion dates, and all review and monitoring occurred after those recorded dates, less effort would be spent in visiting unsuitable sites, and the population of interest would be better defined. The **AE** adds that if differing levels of confidence are used (say, both 90% and 95%) and/or differing levels of the allowable error (e.g., +/-5% and +/-6%), DNR will have to provide good reasons for this.

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12. What suggestions do you have for improving the clarity of the report narrative for an audience with general understanding of natural resources management: (1) the results of the report's two-year data; and (2) the description of trends?

(1). Results of the Report's two-year data.

The reader is referred back to the response to Question 8. Review **JF** adds that tables showing results by individual rule could be helpful. The **AE** concurs, keeping in mind the need to balance the benefit of DNR and others being able to view results to that level of detail, versus the cost to produce them.

(2). The description of trends (Chap. 7 of the Report).

Some clarification is required in the Methods section of Chap. 7 regarding the regression method used. The word "multivariate" should be dropped from paragraph 2 under Methods (p. 50, paragraph 2, lines 1 and 6), as it caused more than one Reviewer (and the **AE**) to wonder whether the response term consisted of a multivariate vector. It was clarified at the DNR meeting that for each of the eight prescription types, the response variable in the weighted regression analysis is the statewide percent compliance. Also, since this is "ordinary weighted regression", that means the usual assumptions about the error structure are present; therefore they should be clearly stated. That includes normally distributed (i.e., Gaussian) random error, but with nonhomogeneous variance. Paragraph 2 discusses the nonhomogeneous variance and the structure of the weights, so the only things requiring specific mention are the assumed normal distributions and the independence of the random error terms.

A suggestion that has come up in discussion is considering the use of logistic regression. This could be appropriate for those prescriptions where compliance rate is the ratio of two integers. A quick way to assess the feasibility of this would be to plot the logit of compliance rate (log(p/(1-p)) against time to see if things tend to "look more linear" than before. If so, logistic regression might be appropriate, or even ordinary weighted regression using logits instead of the rates themselves as the response (this from the **AE**). Still, this will not make up for the small number of years available to assess trends.

Page 9 of the Report and comments at the DNR meeting have made it clear that DNR is not focusing on individual regions, but rather statewide. If in future DNR is interested in regional variation regarding compliance rates, then the following comments from Reviewer **JF** may be pertinent (details may be found in **JF's** response to Question 12):

Reviewer **JF** posits a hypothesis that every rule has a constant compliance rate over time, but that rate may vary by region (space). If that were the case, then depending upon the regional

distribution of FPAs, variation (possible trends) in the rate of compliance over space (regions) might be interpreted as variation (possible trends) over time. A statistical model is offered with terms for region, rule, and year, which could potentially be analyzed via logistic regression, using random effects to account for the fact that various rules within a given prescription would likely be correlated.

References

Egan, A.F., R.D. Whipkey and J.P. Rowe. 1998. Compliance with forestry best management practices in West Virginia. *Northern Journal of Applied Forestry 15(4):* 211-215.

Gregoire, T.G. 1984. The jackknife: an introduction with applications in forestry data analysis. *Canadian Journal of Forest Research 14(4)*: 493-497.

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Phillips, M. J. and C. R. Blinn, 2007. Practices evaluated and approaches used to select sites for monitoring the application of best management practices: a regional summary. *Journal of Forestry 105(4):* 179-183.

Wang, J. and W.A. Goff, 2008. Application and effectiveness of forestry best management practices in West Virginia. *Northern Journal of Applied Forestry 25(1)*: 32-37.

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Comments to Specific Pages in the Report

Regarding color coding found below and in the Reviewers' Comments:
Green = recommend for consideration to improve the manuscript,
Turquoise = strongly suggested for improvement,
Yellow = required change to the manuscript.

From Reviewer TC (also listed under **TC's** Comments):

1) Page 2, second paragraph under "Changes in Study Design" change last sentence to correctly reflect the applied regression methods to something like, "Weighted least squares linear regression was used to assess general trends in average compliance rates through time."
2) Page 2, footnote 1. A 95% CI means that if the sample was repeated 20 times … The +/- 6% has nothing to do with the interpretation of the confidence level. The +/- 6% is the targeted margin of error that is used to estimate requisite sample sizes.
3) Page 7, paragraph under "Reports". Last sentence, add "that" before are detailed in this biennial report.
4) Page 12, "Sample Selection" section. Needs to reference a new Appendix or specific sections of an expanded Appendix A.
5) Page 12, second to last paragraph, last sentence. May want to explain rationale behind the statement, "Sample sizes are applied in proportion to region population size for each prescription size." During the meeting, I left believing that regions only enter the sample selection as a means to distribute effort, and regions are not really strata of interest.
6) Page 14, first paragraph. Need to decide if rules per prescription are going to be referred to as clusters. The primary level of sampling are FPAs and FPAs are treated as clusters in the sampling sense. To alleviate any confusion with two-stage cluster sampling, you may want to refer to groups or sets of rules per prescription. It's a bit confusing because the mean number of rules per prescription is used in the sample size estimation procedure.
7) Page 16, first paragraph under "Compliance Assessment and Ratings". Reference any updated/new Appendix with details/example.
8) Page 17, first paragraph, last sentence. Change "…that to the method of sampling." to "…than to the method of sampling."
9) Page 39, Table 9 and first paragraph after the table. Change Np water Compliant from 93.4% to 94.1%. Similarly, change the value in the first sentence of paragraph below the table. The value reported in Table 5, page 30 appears to be correct.
10) Page 50, second paragraph under "Methods" section. Update to reflect regression method that was applied, weighted least squares regression of compliance rate on time.

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From the AE:

1) Page 12, Changes in Study Design, 2nd paragraph, delete "multivariate" so that it reads "Weighted least squares linear regression analysis …".
2) Page 16. Keep the CIs for haul routes but add a qualifier similar to that on p. 15.
3) The word "multivariate" should be dropped from paragraph 2 under Methods (p. 50, paragraph 2, lines 1 and 6)
4) In Appendix B, whenever only a single rule occurrence has been assessed, the resulting compliance percentage is either 0% or 100%, and there should be no accompanying 95% CI. This is displayed correctly once under DFC1 and once under NIZH. However, under A & B Wetlands, a 95% CI appears for "Openings less than 100' wide" even though only a single rule has been assessed; the CI here should read "n/a".
5) For NIZH "Observed CMZ", two rules have been assessed with 0% compliance. Even with only two rules assessed, a (wide) 95% CI should still be calculable, as for "Unstable slopes bounded out" in DFC2.
6) Also in Appendix B, the results for the "Roads" prescription are missing. If there is a valid reason for this, it should be stated.