NATURAL RESOURCES

# 2016-2017 Biennium Forest Practices Compliance Monitoring Report

September 2018

WASHINGTON STATE DEPARTMENT OF
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HILARY S. FRANZ | COMMISSIONER OF PUBLIC LANDS

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# 1. Acknowledgments

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# 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 follow forest practices administrative rules (FP rules) when they conduct forest practice 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, on-the-ground rule compliance. 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]). The CMP does not report on *effectiveness* of the rules: that responsibility lies with the Adaptive Management Program's Cooperative, Monitoring, Evaluation, and Research (CMER) committee.

This biennial CMP report covers data samples collected during the calendar year 2016 and 2017 field seasons. Two years are needed to obtain enough data to attain the desired level of statistical precision. The data from the 2016 and 2017 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 in RCW 76.09.020(25) as water, fish, wildlife, and capital improvements of the state and its political subdivisions). The evaluated rule groupings pertain to riparian and wetland areas and to road construction and maintenance.

**Sample Design and Methodology**

For the purposes of monitoring and appropriate statistical sampling, individual FP rules are grouped into categories of similar rules called "prescriptions." Separate samples are chosen for each prescription type monitored. The overall sampling population for compliance include forest practices applications (FPAs) that include forest practices activities, such as timber harvest or road construction. The sampling population for each prescription type consists of the subset of FPAs that contain the prescription. The prescriptions monitored in the 2016-2017 biennium include (numbers in parentheses indicate the estimated population of FPAs with the prescription in the 2016-2017 sample): Roads (2,275), Type A&B Wetlands (313), Forested Wetlands (463), No Inner Zone Harvest (NIZH) (1,408), Desired Future Condition Option 1 (DFC1) (86), Desired Future Condition Option 2 (DFC2) (331), Non-Fish-Bearing Perennial Waters (Np) (1,776), and Non-Fish-Bearing Seasonal Waters (Ns) (1,868).

For this report, 198 standard prescriptions were sampled from a total of 135 FPAs. The number of samples chosen for each prescription were those required to attain the desired precision based on preliminary statistical estimates of prescription population size, cluster size, and variance. Prescription sample sizes for the 2016-2017 biennium were as follows: Roads (15), Type A & B Wetlands (43), Forested Wetlands (17), No Inner Zone Harvest (24), Desired Future Condition

Option 1 (20), Desired Future Condition Option 2 (13), Non-Fish-Bearing Perennial Waters (35), and Non-Fish-Bearing Seasonal Waters (31).

FP rules monitored annually are referred to as the Standard Sample. In addition, certain rule groups are monitored periodically and are referred to as Emphasis Samples.

The Standard Sample monitors the following rules:

- Riparian protection (WAC 222-16-030, 222-30-021 and 022)
- Wetland protection (WAC 222-16-030, 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 parameters 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).

**Study Design**

The CMP modified the compliance study design beginning with the 2014-2015 biennium in order to increase precision in statistical estimates for each prescription type observed. Previously, compliance rates were estimated by dividing fully-compliant samples by the total number of samples for each prescription type. The 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 changes the interpretation of compliance, 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 study design also 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. In addition, as a result of rule overlap, the No Inner Zone Harvest and No Outer Zone Harvest prescriptions have been combined.

The estimated rate of compliance for a prescription is the proportion of sampled rules that were compliant. Compliance rates have been adjusted for bias per Independent Scientific Peer Review recommendations. These adjustments were insignificant (0.0029% - 0.0997%), but in some cases result in a change in the whole number percentage. Additional information is located in Appendix D.

Trend analysis is used to assess 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 linear regression analysis was used to predict general trends in average prescription compliance through time.

**Notable Aspects of CMP Samples**

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

**Independent Scientific Peer Review**

An Independent Scientific Peer Review (ISPR) was conducted on the 2014-2015 Compliance Monitoring biennial report, with a focus on sample selection and analytical methodology. The review concluded that current form of the ratio estimator for average compliance is valid. The review made two recommendations for improvement: to implement a jackknifed form of the ratio estimator; and, to integrate descriptions of population development and sample selection into the statistical analysis appendix. Both changes were made for this report. Additional information is located in Section 5.

**Findings**

The 2016-17 rule prescription compliance rates range from 87-100%, indicating generally high compliance with the forest practice rules selected for monitoring. Findings from the 2016-2017 sampling season are reported in Sections 6 and 7 of this report.

[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.

*Water Typing*

Differences between observed and FPA-reported water types were observed for 16% of the waters observed; approximately the same number was under-classified as was over-classified (Table 3). Supplemental Water Information Forms (SWIFs) were completed for 29 samples due to observed water typing differences between water type documentation on FPAs and on-the-ground physical features.

- Fourteen waters were underclassified; 1 Ns, 6 Np, 2 A wetlands, and 5 B wetlands.
- Twelve waters were overclassified; 1 F water, 4 Ns, 2 A wetlands, and 5 B wetlands.
- Three waters were indeterminate, 2 B wetlands, and 1 A wetland.

Additional relevant data and results for water typing are located in Section 6.

*Riparian Management Zones*

RMZ compliance rates ranged from 87% to 100%. The DFC1 rate of rule compliance for the 2016-2017 sample period was 92%, 128 of the 139 sampled rules were compliant. The DFC2 rate of rule compliance was 95%; 86 of the 91 sampled rules were compliant. The NIZH rate of rule compliance was 95%, 112 of the 118 sampled rules were compliant. The Np activity rate of rule compliance was 87% (biased corrected, see appendix D), 96 of the 111 sampled rules were compliant. The Ns activity rate of rule compliance was 100%; all 31 sampled rules were compliant. Additional relevant data and results for compliance estimates are located in Section 6.

*Wetland Management Zones*

Wetland management zone compliance ranged from 92% - 100% (Table 5). The Type A&B Wetlands rate of rule compliance for the 2016-2017 sample period was 92%; 101 of the 110 sampled rules were compliant. The Forested Wetlands rate of rule compliance was 100%; all 34 sampled rules were compliant. Additional relevant data and results for wetland management zones are located in Section 6.

*Roads*

Roads-related compliance ranged from 90-95% (Tables 16 and 17). The Roads rate of rule compliance for the 2016-2017 sample period was 95%, and that for the Haul Route prescription was 90%. Additional relevant data and results for roads are provided in Section 7.

*Trend Analysis*

Trends of improving compliance were observed for three prescription groups and there are no trends showing declining compliance. Statistically significant trends were not observed for most of the prescription groups. Trends of year-to-year increasing prescription compliance rates (significant at a two-tailed alpha-level of 0.10) were observed for DFC2 (compliance rates rose from 92% during 2010/2011 to 95% during 2016/2017)), NIZH (compliance rates rose from 90% during 2010/2011 to 95% during 2016/2017), and Ns (compliance rates rose from 96% during 2010/2011 to 100% during 2016/2017). No statistically significant trends of decreasing

prescription compliance were observed. Additional relevant data and results for trend analysis are located in Section 8.

*Unstable Slopes*

The Unstable Slopes Emphasis sample was implemented in 2017 after a successful pilot study was conducted during the Fall of 2016. The pilot study tested methodologies for population development, field data collection, and data analysis. Revisions to the study design were instituted based on the results of the pilot study. The Unstable Slopes Emphasis Sample resulted in a compliance rate of 92%. Additional relevant data and results for unstable slopes are located in Section 10.

**Changes Made Based on CMP Feedback**

A primary goal of the CMP is to provide objective information about the degree of rule compliance to the forest practices program about where emphasis, including training and education, should be placed to bring about improved compliance with FP rules. The following are some recent and on-going forest practices program adjustments aimed at addressing issues identified through compliance monitoring results:

- Forest Practices Board Manual modifications are currently being considered for guidance about leave tree, DFC, and RMZ length.
- Updates to the Forest Practices Application form and instructions will be implemented October2018.
- Rule and Board Manual change recommendations have been incorporated into the Forest Practices Board work plan.

# 3. Introduction

Photo by: Garren Andrews

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, "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 DNR Forest Practices Assistant Division Manager for Operations directs the Compliance Monitoring Program. 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. As of September 2017, the Department of Fish and Wildlife have ceased Compliance Monitoring field participation because of budgetary issues. 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 FP Program began producing annual reports in the years that a biennial report was not required but ceased annual reporting in 2016 This present report is a biennial CMP report and covers data samples collected during the 2016 and 2017 field seasons. The data from the 2016–2017 field seasons has been combined to produce the desired precision for statistical estimates and resulting comprehensive findings, conclusions, and recommendations that 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 of prescription compliance rates. 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 waters 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 waters 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.

- Modify water types. Field reviewers' record observed differences between water type documentation on FPAs and on-the-ground physical features. See Section 6.1.

## 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 2016-2017 field seasons.

**Standard Sample**

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

- Riparian rules — Western Washington and Eastern Washington RMZ rules (WAC 222-16-030, 222-30-021 and 022)
- Road construction and maintenance rules (WAC 222-24)
- Wetland rules (WAC 222-16-030, 222-30-020[6] and [7]; and WAC 222-24-015)
- Haul routes (WAC 222-24) for sediment delivery

**Trend Analysis**

For 2010-2017 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). If compliance for a particular rule was not assessed in accordance with current protocols, were incomplete, or un-convertible, the rule was not included in 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 based on current methods.

**Emphasis Sample**

Other FP rule groups are sampled, as necessary, and are considered 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.

During the 2016-2017 sampling period, two pilot studies were conducted. During the 2016, sampling window a pilot study was developed and executed for Unstable Slopes that focused on FPA compliance. Additionally, the Compliance Monitoring Program developed and commenced a Forest Practices Hydraulic Projects pilot study that solely focused on FPA compliance.

# 4. Compliance Monitoring Design and Methodology

Photo by: Chris Briggs

The Compliance monitoring study 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 forest practices applications (FPAs) that have completed forest practices activities and expire April 1, 2017, through March 31, 2019. 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 sampled in a given year. The sample population for each prescription type is the subset of FPAs that contain the prescriptions being monitored that year.

**Landowner Reporting 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. Confidence intervals 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 for sample selection. Therefore, population sizes 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 2016-17 sample, this included 2,114 FPAs in 2016, and 2,194 FPAs in 2017 (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 2016 and 2017.

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 as for riparian prescriptions.

**Table 1. 2016-2017 Standard Sample Prescriptions Monitored**

| | Statewide | Western WA Only | Eastern 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 | RMZ – Type S or F Inner Zone Harvest EWa |

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 observed variance in compliance rates and average number of applicable rules within each prescription will be similar to historical observations. Estimates for population variance are updated after each biennium, and increases in these estimates will lead to increased sample sizes in the following year. The population of FPAs in any given year is finite. Therefore, the size of the population affects 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.

Variance and cluster size (mean number of rules per prescription) were estimated based on the sample values from 6 years of data (2010–2015) prior to the 2016 sampling, and from 7 years of data (2010-2016) for the 2017 sample. Based on these data and the estimated FPA population size for the biennium, sample sizes were set for the biennium, and 50% of this sample size was

applied to 2016. The remaining 50% of the biennial sample was completed in 2017, after any adjustments for updated variance estimates. 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 2016–2017 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).

To provide closer adherence to the +/– 6% standard for the 95% CI, the CMP updated sample size estimates prior to 2017 sampling to include 2016 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 estimate appropriate sample sizes, finite 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 methods.

**Table 2. 2016-2017 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 | 15 | 2275 |
| | Haul Routes | 12 | n/a* |
| | RMZ — Type Ns Prescriptions | 31 | 1868 |
| | RMZ — Type Np Prescriptions | 35 | 1776 |
| | Type A & B Wetlands | 43 | 313 |
| | Forested Wetlands | 17 | 463 |
| | RMZ — Type S or F No Inner Zone Harvest | 24 | 1408 |
| **Western WA** | RMZ — Type S or F Inner Zone Harvest DFC1 | 20 | 86 |
| | RMZ — Type S or F Inner Zone Harvest DFC2 | 13 | 331 |
| **Eastern WA** | RMZ – Type S or F Inner Zone Harvest EWaIZ** | 7 | 7 |

*The Haul Routes prescription does not have an estimated population.
**Eastern Washington Inner Zone prescription were sampled as a census

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

*Pilot and Emphasis Samples*

**Unstable Slopes Pilot Study**

In the biennial compliance monitoring design used by the CMP, the Unstable Slopes uses a significance level of 90%. The CMP set a desired half-width of the 90% confidence interval (CI) at 6%. A 90% 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 18 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 study year.

**Table 3. 2016-2017 Pilot and Sample Prescriptions Monitored**

| Year | Statewide |
|---|---|
| **2016** | Unstable Slopes Pilot Study |
| **2017** | Forest Practices Hydraulic Projects Pilot Study |
| | Unstable Slopes Study |

**Table 4. 2016-2017 Pilot and Emphasis Sample Count by Prescription Type**

| Prescription Type | Sample Count | Estimated Population Size of FPAs with the Prescription |
|---|---|---|
| 2016 Unstable Slopes Pilot Study | 9 | 978 |
| 2017 Unstable Slopes Study | 43* | 960 |
| 2017 Forest Practices Hydraulic Projects Pilot Study | 15 | 562 |

*Sample size were calculated based off a 90% C.I.

## 4.2 Field Review and Data Collection

The compliance monitoring field team uses two primary data collection methods, 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 waters 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 evenly spaced 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%). As a result of the ISPR review, this average compliance rate is then adjusted for potential bias using a jackknife estimation process (see Appendix D for further explanation). In some cases, the bias adjustment is large enough to change the compliance rate by up to one percentage point (e.g., 86% is adjusted to 87%).

**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. The sample size for haul routes is not set based on statistical precision. 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 is recommended. Conclusions may be fallaciously attributed to a phenomenon rather than 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:

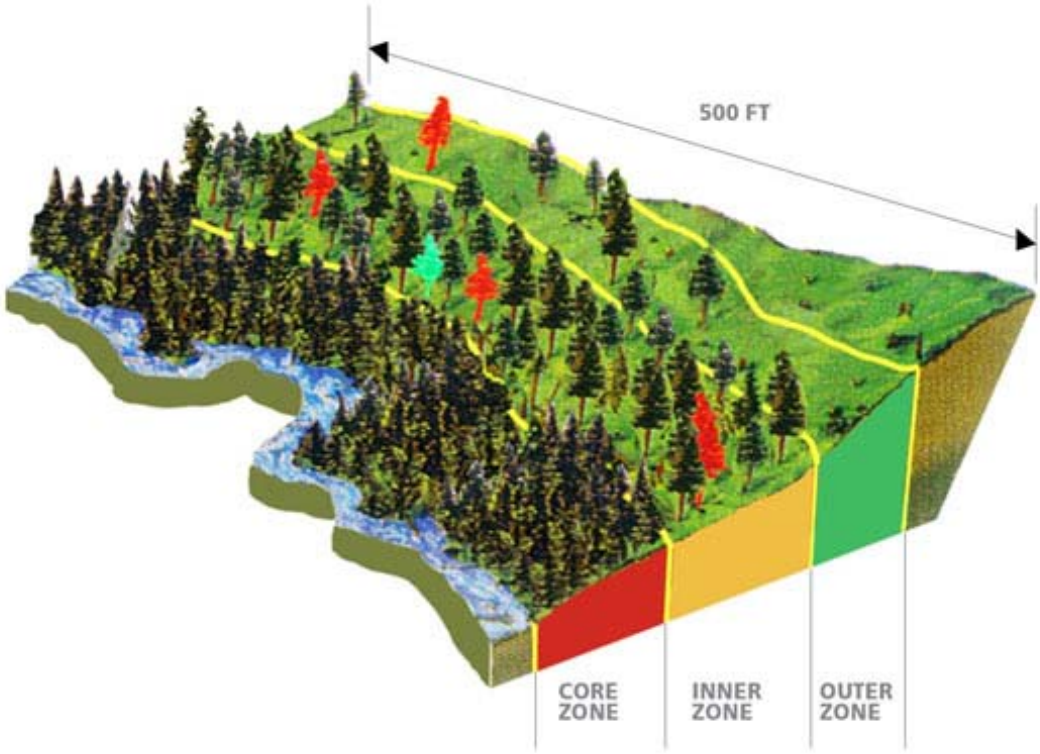
- Layout — The arrangement of the harvest unit did not meet the specifications of the rule. Examples include:
    - A stream meander is unaccounted for in the layout of an RMZ.
- Operational — The timber harvest and related activities process did not follow the arrangement of the harvest unit or associated 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.

*Note: Deviation ratings and determinations are not assessed for site characteristic rules (i.e. water type, site class, dominant overstory tree species). These data points are also not recorded when the field team cannot make an accurate assessment of the rating or determination.*

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 waters accurately; measuring the stream width correctly; correctly measuring the core, inner, and outer zone widths; and leaving the core zone intact.

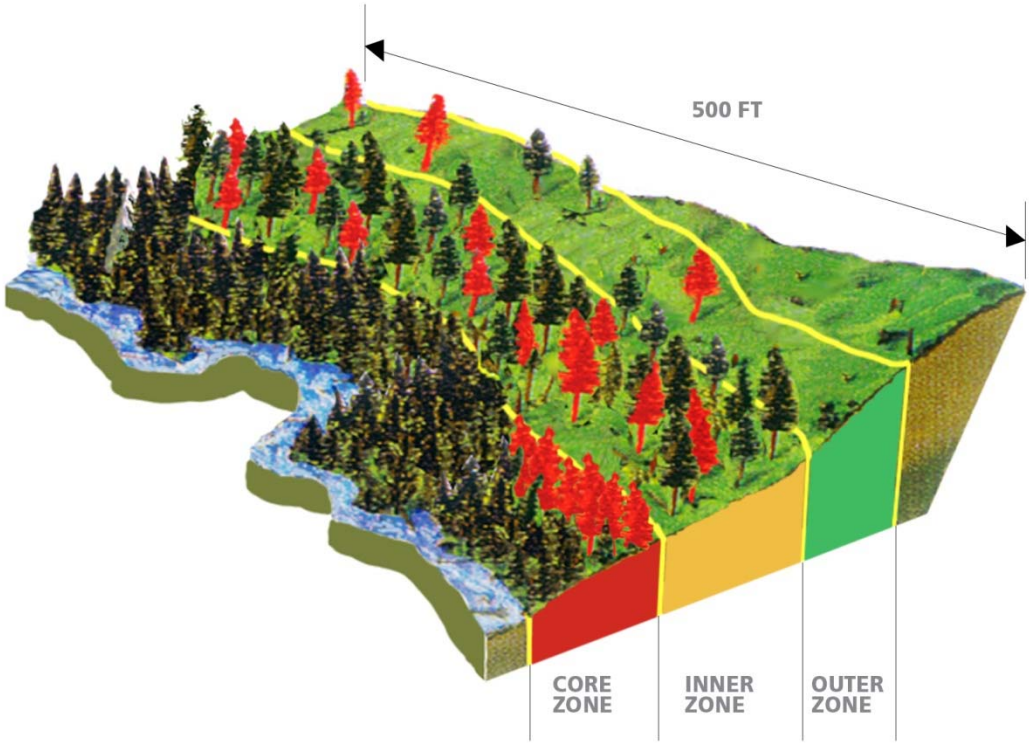
**Figure 1. Inner Zone Harvest with Deviation Rated as Low**




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 Evaluation of Rule Compliance

The CMP utilizes 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 current sampling design evaluates 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 CMP estimates 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). If there are many rules in a prescription, bad performance on a single rule will have little effect on overall average compliance. Compliance for each individual rule can be evaluated and tracked separately, although precision is not be controlled for individual rule compliance.

## 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 waterss. 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 water and a Type F water. Type Np waters are defined as waters that are perennial non-fish habitat waters. Type F waters are defined as having a gradient equal to or less than 20%. When a stream reach meets the physical criteria for a Type F water, and lies upstream of a portion of a stream reach that has a gradient greater than 20%, the water 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. Independent Scientific Peer Review

As part of the 2014 redesign of the Compliance Monitoring data analysis methods, an Independent Scientific Peer Review was conducted on the new methodology, and the 2014-2015 data analysis and results.

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 Forest Practices Board established the independent scientific peer review process to determine if the scientific studies that address program issues are scientifically sound and technically reliable. The review team consisted of three peer reviewers and the Associate Editor (AE). Reviewers were selected by the AE in consultation with the 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.

**The List of Review Questions**

Each reviewer were asked to specifically address the following twelve peer-review questions and sub 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 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 a size of 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?

**Overview of results**

The statistical approach regarding the sampling procedure and construction of the ratio estimator for compliance was determined to be generally sound. The Review Team and the Associate Editor recommended that a more thorough Appendix A containing the technical details of the sample selection procedure be included in the biennial report. The expansion of Appendix A will improve the reproducibility of the study and improve understanding surrounding the sampling selection and data analysis process. The updated 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.

It was strongly recommended that use of a "jackknifed" form of the ratio estimator be incorporated into data analysis. By using a jackknifed form of the ratio estimator, bias may be reduced yielding a more accurate variance estimate. This will require additional lines of coding in the data analysis, but will not change the sample selection procedure. A jackknifed ratio estimator can also be applied to older data sets.

Jackknife analysis would require recalculation of ratio estimates leaving out one sample each time. For example, if there were 13 samples being used to estimate DFC1 compliance, 13 ratio estimates would be calculated from the data, using 12 samples per estimate. The 13 estimates are then 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/n2 (Cochran 1977). Use of the jackknife would not necessarily reduce any bias to zero. However, jackknife ratio estimates can be compared to original ratio estimates to determine the sample size at which the difference between the two becomes negligible.

# 6. 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 waters (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 water temperatures; and provide amphibian and wildlife habitat. Protection on Type Np and Ns waters also includes an equipment limitation zone (ELZ). This is a 30-foot-wide zone adjacent to Type Np and Ns waters. 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 water (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 6.1 through 6.4 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.

## 6.1 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 categories, or "types," based on several factors (WAC 222-16-030, 031, and 035). Water 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 water 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 water types in hierarchical order starting with the highest level (requiring the most protection):

- Type S waters — The highest level of classification, "Shorelines" of the state as designated by the Department of Ecology.
- Type F waters — The second highest level of classification, with fish, specifically defined human uses, or both.
- Type Np waters — The next lowest classification in the water hierarchy, these are non-fish-bearing waters that have a perennial flow of water during a normal rainfall year and include intermittent dry portions of the perennial channel.
- Type Ns waters — The lowest level of classified waters, seasonal non-fish-bearing waters 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 guided by Forest Practices Board Manual, Section 13. Applicants are encouraged but not required to complete water type classification worksheets or document protocol surveys on water type modification forms 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 water 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 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 be an untyped water.

- 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. 2016-2017 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** | 57 | 1 | * | 1 | 0 |
| **Ns** | 31 | 5 | 1 | 4 | 0 |
| **Np** | 35 | 6 | 6 | 0 | 0 |
| **Type A Wetlands** | 14 | 5 | 2 | 2 | 1 |
| **Type B Wetlands** | 29 | 12 | 5 | 5 | 2 |
| **Forested Wetlands** | 17 | 0 | 0 | 0 | 0 |
| **Total** | 183 | 29 | 14 | 12 | 3 |

*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 2016 and 2017:

Of the 183 sampled waters in 2016 and 2017, 29 samples called for SWIFs due to water typing discrepancies.
Fourteen samples were underclassified, resulting in an underclassification rate of roughly 8%. No approved Water Type Modification forms (protocol surveys) were contained within the paper records for the FPAs with underclassified waters. Of the 14 underclassified segments, fish were observed in one of the sampled segments, the other 13 non-compliant segments met fish physical characteristics with no supporting water type modification form or Interdisciplinary Team documentation to support lower order hierarchal water typing, resulting in the underclassification of the respective sampled segments. Of those, 7 were wetlands, where either fish presence was observed or the waters were associated with F waters. Six Np waters and 1 Ns water met fish habitat physical characteristics.
Ten samples were overclassified, resulting in an overclassification rate of 5%. Four Ns waters were determined to be wet swales or channels with no connectivity to higher order waters. Two type A wetlands were determined to be type B wetlands, and were measured to be smaller in area than what was reported on their respective FPAs. Of the 5 overclassified type B wetlands; 3 were determined to be forested wetlands, and 2 were determined to be non-typed wetlands. A large F

water was determined to be overclassified after bankfull width measurements revealed that the segment was a small F water.

Three samples were indeterminate. All 3 of the indeterminate observations were for A and B wetlands. The field team were unable determine the acreage of a Type A wetland at low water. An A wetland was unable to be located after debris flows post wildfire destroyed the selected wetland. Additionally, a B wetland could not be adequately delineated (Table 3).

## 6.2 Statewide Summary for FP Rule Compliance for RMZs, WMZs, and ELZs

Section 6.2 provides 2 summary tables: Table 4 lists the RMZ, WMZ, and ELZ prescriptions sampled in 2016 and 2017; Table 5 shows statewide results for compliance with RMZ and WMZ FP rules. The data and findings for each prescription are discussed in Section 6.3 and 6.4 (Western Washington RMZs) and Section 6.5 (Statewide RMZs, WMZs, and ELZs).

**Table 4. RMZ, WMZ, and ELZ Prescriptions Sampled in 2016 & 2017**

| Western WA | Eastern WA | Statewide |
|---|---|---|
| RMZ — Option 1, Thinning from Below<br>RMZ — Option 2, Leaving Trees Closest to Water | RMZ – Inner Zone Harvest, Thinning from Below | WMZ — Wetlands<br>RMZ — No Inner Zone Harvest<br>ELZ — Type Ns & Np Activities<br>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 for the individual rules that comprise the prescription. FP rule prescriptions for Type F and N waters can have different rules 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. 2016-2017 Compliance with FP Rules for Riparian, Wetlands and Roads Prescriptions**

| | | Western WA | | Statewide | | | | | | Eastern WA |
|---|---|---|---|---|---|---|---|---|---|---|
| | Status of Compliance | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Ns Activities | Type A&B Wetlands | Forested Wetlands | Roads | Inner Zone Harvest |
| | | | | | | | | | | |
| Small Forest Landowners | # Compliant Rules | 4 | n/a | 13 | 6 | 0 | 19 | 6 | 27.5 | 12 |
| | # with Deviation | 3 | n/a | 1 | 3 | 0 | 1 | 0 | 4.5 | 2 |
| | % of Sample Compliant | 57% | n/a | 93% | 74% | n/a | 96% | 100% | 82% | 86% |
| | Prescriptions Assessed | 1 | 0 | 3 | 4 | 0 | 9 | 3 | 3 | 2 |
| | | | | | | | | | | |
| Large Forest Landowners | # Compliant Rules | 124 | 86 | 99 | 90 | 26 | 82 | 28 | 98 | 37 |
| | # with Deviation | 8 | 5 | 5 | 12 | 0 | 8 | 0 | 2.0 | 0 |
| | % of Sample Compliant | 94% | 95% | 95% | 86% | 100% | 91% | 100% | 98% | 100% |
| | Prescriptions Assessed | 19 | 13 | 21 | 31 | 26 | 34 | 14 | 12 | 5 |
| | | | | | | | | | | |
| All Landowners | # Compliant | 128 | 86 | 112 | 96 | 31 | 101 | 34 | 125.5 | 49 |
| | # with Deviation | 11 | 5 | 6 | 15 | 0 | 9 | 0 | 6.5 | 2 |
| | % of Sample Compliant | 92% | 95% | 95% | 87%* | 100% | 92% | 100% | 95% | 96% |
| | Confidence Interval | (87, 97) | (89, 100) | (90, 99) | (79, 94) | n/a | (87, 97) | n/a | (88, 100) | n/a |
| | Prescriptions Assessed | 20 | 13 | 24 | 35 | 31 | 43 | 17 | 15 | 7 |

* Jackknife biased corrected, see appendix D

## 6.3 Western Washington RMZs

### 6.3.1 Western WA Type S and F Waters

Section 6.3.1 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 affect the inner zone width?

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.

#### *6.3.1.1 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 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 faster. The widths of the inner zone and outer zone vary depending on the bankfull width of the water 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 at breast height (DBH) must be retained in the outer zone. The leave trees in the outer zone may be dispersed evenly 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 2016-17 sample, 20 FPAs were selected for review with DFC1 chosen as the harvest option from a total population of 86 FPAs. The resulting DFC1 prescription sample size was 20, and a total of 139 rules were evaluated.

**Table 6. 2016-17 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 | High | No Assessed Deviation Rating | Indeterminate |
| DFC1 (%) | 5% | 92% | 2% | 1% | 2% | 3% | 1% |
| DFC1 (Rule Count) | 7 | 128 | 3 | 1 | 3 | 4 | 1 |

Sample size = 20

One hundred thirty one of the sampled 139 rules were compliant for the DFC1 prescription sample, resulting in a 92% compliance rate +/- 5%. Of the 20 sites sampled, 12 were 100% compliant and 8 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2016 and 2017 accounted for 11 non-compliance determinations across 8 sample sites. There were 3 non-compliant determinations for incorrect dominant overstory tree species. Douglas-fir was selected as the dominant overstory tree species per the DFC worksheet, however, Western Hemlock was observed as the dominant overstory tree species at all 3 sites. The reason for non-compliance was determined to be administrative for all 3 non-compliant determinations. No deviation severity rating is assigned for non-compliant site characteristic rules.

A single non-compliant determination was recorded for an incorrect stream size. The CMP field team calculated BFW exceeded 10 feet; the segment was recorded as a small type F water in the FPA. The

reason for non-compliance was determined to be administrative, and deviation severity ratings are not assigned for non-compliant site characteristic rules.

There were 3 non-compliant determinations for observation of harvest of trees larger than allowed by the selected DFC harvest strategy. For 2 of the non-compliant determinations the reason for non-compliance was determined to be layout, resulting in a low deviation rating for both determinations. The third non-compliant determination was a result of the 6 largest required leave trees missing from the final inner zone tally. The CMP field team could not make a final determination between administrative or layout as the reason for non-compliance. A high deviation rating was assessed for the non-compliant observation.

A single non-compliant determination was recorded for less than the required 57 residual trees per acre remaining in the inner zone. The CMP field team could not make a final determination between administrative or layout as the reason for non-compliance. A high deviation rating was assessed for the non-compliant observation.

There were 3 non-compliant determinations for the outer zone retaining less than 20 trees per acre per rules. The reason for non-compliance was determined to be layout for all 3 non-compliant observations. One non-compliant observation was assessed a low deviation rating for 1 missing outer zone leave tree. One non-compliant observation was assessed a moderate deviation rating for 11 missing outer zone leave trees. One non-compliant observation had no observed outer zone leave trees, resulting in a high deviation rating. (See table 6.)

Exceeds ratings were assigned  where extra  Outer Zone leave trees were observed for 7 samples.

#### *6.3.1.2 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 along waters that are less than or equal to 10 feet wide and to RMZs in site classes I and II for waters greater than 10 feet wide. For this option, DFC growth modeling results show an available surplus basal area that allows 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 water. 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 water and the site class. For site classes I, II, and III on waters 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 waters 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 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 less complex to implement and is selected more frequently by proponents than DFC1. In the 2016-17 sample, 13 DFC2 prescriptions were sampled from an estimated population of 331. A total of 91 rules were evaluated.

**Table 7. 2016-17 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 | High | No Assessed Deviation Rating | Indeterminate |
| DFC2 (%) | 9% | 95% | 1% | 1% | 0% | 2% | 1% |
| DFC2 (Rule Count) | 8 | 86 | 1 | 1 | 0 | 2 | 1 |

Sample size = 13

Eighty-six of the sampled 91 rules were compliant for the DFC2 prescription, resulting in a 95% compliance rate +/- 5.5%. Of the 13 sites sampled, 9 were 100% compliant and 4 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2016 and 2017 accounted for 5 non-compliance rule determinations. A single non-compliant determination was recorded for an incorrect stream size. The CMP field team calculated BFW exceeded 10feet; the segment was recorded as a small type F water in the FPA. The reason for non-compliance was determined to be layout, and deviation severity ratings are not assigned for non-compliant site characteristic rules.

There were 4 non-compliance determinations for observed harvest within the no-cut inner zone floor. The reason for non-compliance was determined to be layout for 3 of the non-compliant observations. The reason for the fourth non-compliant determination was determined to be operational. For each of the 4 non-compliant rule determinations a different deviation rating was assessed. For one of the non-compliant determinations, a low deviation rating was assessed for 3 cut-stumps in the inner zone floor. The second non-compliant determination was assessed a moderate deviation rating for 12 cut-stumps in the inner zone floor. The third non-compliance determination the deviation rating was indeterminate. The fourth non-compliant determination was not assessed a deviation rating. (Table 7.)

Exceeds ratings were assessed for leaving more than the required number of inner zone floor leave trees in 5 samples. Additionally, exceeds ratings were assessed for excess outer zone leave trees in 3 samples.

# 6.4 Eastern Washington RMZs

## 6.4.1 Eastern WA Type S and F Waters

Section 6.4.1 addresses Type S and F riparian prescriptions: Eastern Washington Inner Zone Harvest, thinning from below.

**On-site Review for Eastern WA Type S and F Waters**

During the compliance monitoring field review, there are questions on the Eastern 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 water width (variable in determining inner zone width) the same as stated on the FPA? If not, does it affect the inner zone width?

In addition to common questions relevant to all Type S and F water riparian prescriptions, specific Eastern Washington Inner Zone Harvest riparian prescription questions were evaluated for the unique rules that comprise the prescription type.

### *6.4.1.1 Eastern WA Type S and F Waters — EWaIZH, Thinning from Below*

Eastern Washington Inner zone harvest is permitted if the calculated inner zone basal area per acre exceeds the basal area requirement for the requisite site index, elevation, and timber habitat type. Inner zone leave tree and basal area requirements are segregated by site index (low, medium, and high), elevation (below 2,500', 2,500'-5,000', and above 5,000'), and timber habitat type (Ponderosa pine, Mixed conifer, and High elevation). For the high elevation timber habitat type, Western Washington type S and F rules apply. When harvest is allowed because the calculations project more basal area is available than required 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 selective harvest 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 faster. The widths of the inner zone and outer zone vary depending on the bankfull width of the water and the site class. 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 or clumped around sensitive features such as seeps, springs, and forested wetlands.

**Findings for Eastern WA Type S and F Waters — Inner Zone Harvest, Thinning from below**

Eastern Washington Inner Zone Harvests are infrequently implemented. As a result, the Compliance Monitoring Program conducted a census study on Eastern Washington Inner Zone Harvests. In the 2016-17 census, all 7 identified EWaIZH prescriptions were evaluated. A total of 51 rules were evaluated.

**Table 8. 2016-17 Compliance Ratings for Type S and F Waters in Eastern WA — Inner Zone Harvest, Thinning from below**

| RMZ Prescription | FP Rule Compliance Ratings | | | | | | |
|---|---|---|---|---|---|---|---|
| | Compliant Ratings | | Deviation Ratings | | | | |
| | Exceeds (part of Compliant) | Compliant | Low | Moderate | High | No Assessed Deviation Rating | Indeterminate |
| EWaIZH (%) | 8% | 96% | 0% | 0% | 0% | 4% | 0% |
| EWaIZH (Rule Count) | 4 | 49 | 0 | 0 | 0 | 2 | 0 |

Census Population = 7

Field observations from 2016 and 2017 accounted for 2 non-compliance rule determinations. Both non-compliant determinations were recorded for incorrect site class. The CMP field team did not assess a reason for non-compliance or assign a deviation rating.

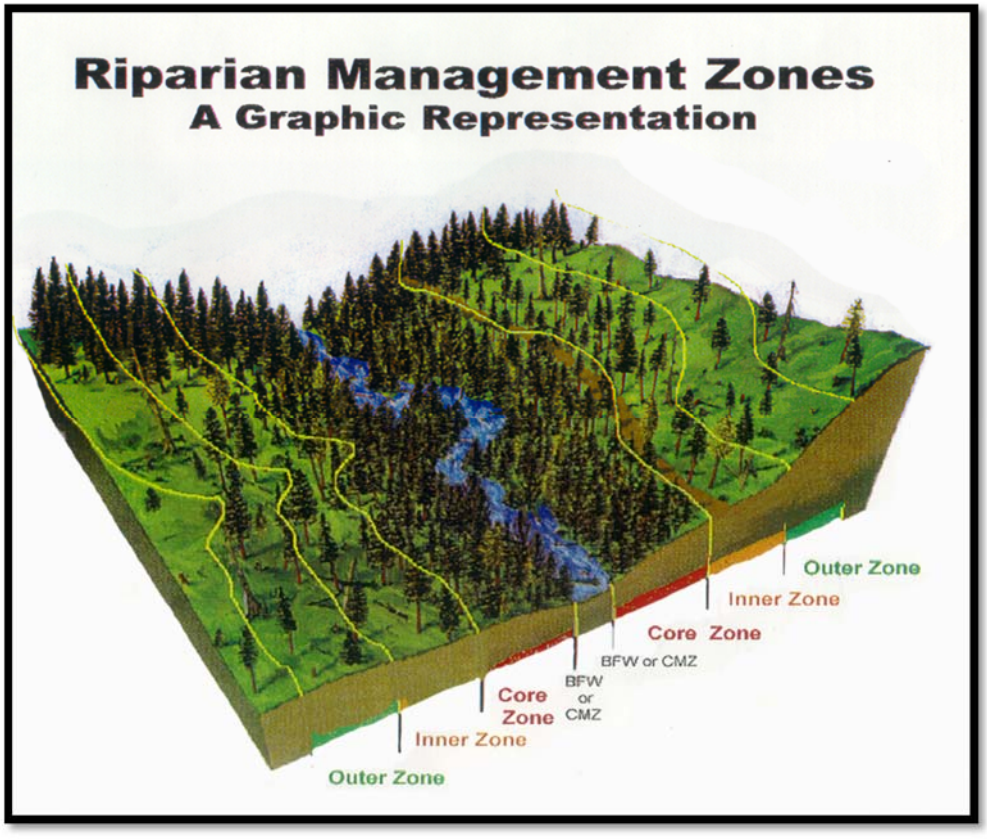
## 6.5 Statewide RMZs, WMZs, and ELZs

### 6.5.1 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 waters 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 water 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 water is based on the DNR site class map, timber habitat type, basal area, and shade requirements needed to protect the water. 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.

#### *6.5.1.1 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 1408 FPAs in the 2016-17 population. The resulting NIZH prescription sample size was 24, and a total of 118 rules were evaluated.

**Table 9. 2016-17 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% | 95% | 3% | 2% | 0% | 1% | 0% |
| No Inner Zone Harvest (Rule Count) | 9 | 112 | 3 | 2 | 0 | 1 | 0 |

Sample size = 24

One hundred twelve of the sampled 118 rules were compliant for the NIZH prescription sample, resulting in a 95% compliance rate +/- 5%. Of the 24 sites sampled, 19 were 100% compliant and 8 showed deviation from at least 1 FP rule in the prescription type.

A single non-compliant determination was recorded for an incorrect stream size. The CMP field team calculated BFW exceeded 10', the segment was recorded as a small type F water in the FPA. The

reason for non-compliance was determined to be administrative, and deviation severity ratings are not assigned for non-compliant site characteristic rules.

Three non-compliant determinations were recorded for observed harvest within the no-cut inner zone. The reason for all 3 non-compliant observations was determined to be layout. A deviation rating of low was assessed for 2 non-compliant observations as a result of 8, and 13 observed cut stumps, respectively. A deviation rating of moderate was assessed for the third non-compliant observation as a result of 16 cut-stumps observed within the no-cut inner zone.

Two non-compliant determinations were recorded for observed less than 20 trees per acre remaining in the outer zone. For the first determination, 3 required outer zone leave trees were missing resulting in a deviation rating of moderate and the reason for non-compliance was determined to be layout. For the second non-compliance determination for less than 20 trees per acre in the outer zone a deviation rating of low was assessed, and the reason for non-compliance was determined to be layout. (Table 9.)

Exceeds ratings were assessed for excess outer zone leave trees on 9 samples. Additional outer zone leave trees were remaining beyond what was required by rule.

#### *6.5.1.2 Statewide Type Np Waters*

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

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

In western Washington, the total distance of the 50-foot buffer required along a Type Np water varies and depends on the length of the Type Np water from the confluence with the Type S or F water. Buffers on both sides of the water (2-sided buffers) must protect at least 50% of a Type Np water's length. 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 waters 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 water, 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 clearcut 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 waters 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 waters differ from those for Type S and F fish-bearing waters. 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 water segment?

**Findings for Statewide Type Np Waters**

Type Np waters were commonly encountered with an estimated 1776 FPAs having 1 or more Np waters within their harvest boundaries. The resulting Np prescription sample size was 35, and a total of 111 rules were evaluated.

**Table 10. 2016-17 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 (%) | 1% | 87%* | 5% | 0% | 0% | 9% | 0% |
| Np Water (Rule Count) | 1 | 96 | 6 | 0 | 0 | 10 | 0 |

Sample size = 35
* Jackknife biased corrected, see appendix D

Ninety-six of the sampled 111 rules were compliant for the Type Np prescription sample, resulting in an 87% compliance rate +/- 8%. Of the 35 sites sampled, 26 were 100% compliant and 9 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2016 and 2017 accounted for 15 non-compliance determinations.

Six non-compliant determinations were recorded for incorrect water type. Fish were observed in one of the sampled segments, the other 5 non-compliant segments 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, and no deviation rating is assessed for non-compliant site characteristic rules.

One non-compliant determination was recorded for inadequate no-cut buffer length. The sample segment was missing 125’ of required no-cut buffer. The reason for non-compliance was determined to be administrative as a result of an incorrectly identified F/N break. A deviation rating was unable to be determined for the non-compliant observation.

Five non-compliant determinations were recorded for observed harvest within the 50-foot no-cut harvest buffer. The reason for non-compliance for 3 of the observations was operational, while layout was determined to be the reason for non-compliance for the other 2 observations. A deviation rating of low was assessed for 3 of the observations; no deviation rating was able to be determined for the other 2 observations.

Three non-compliant determinations were recorded for observed harvest within the 56-foot Upper Most Point of Perennial Flow no-cut buffer. For 2 of the observations the reason for non-compliance was determined to be layout. For the third observation, the reason for non-compliance was determined to be operational. All three sampled segments were assessed a deviation rating of low. (Table 10.)

#### *6.5.1.3 Statewide Type Ns Waters*

Buffers are not required for Type Ns waters. 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 1,868 FPAs in the statewide population for the 2016-17 sample. The resulting Ns prescription sample size was 31, and a total of 31 rules were evaluated.

**Table 11. 2016-17 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% | 100% | 0% | 0% | 0% | 0% | 0% |
| Ns Water (Rule Count) | 0 | 31 | 0 | 0 | 0 | 0 | 0 |

Sample size = 31

All 31 of the sampled rules were compliant for the Ns prescription sample, resulting in a 100% compliance rate. There were zero observations of rule non-compliance for the Ns prescription type. However, only one rule is consistently evaluated as part of the Ns prescription type. (Table 11.)

### 6.5.2 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 Wetlands of 0.5 to 5 acres have a minimum 25-foot WMZ width and an average 50-foot WMZ width. Type B Wetlands of 0.5 to 5 acres have a minimum 25-foot WMZ width, and Type B Wetlands less than 0.5 acre along with Forested Wetlands require no WMZ. Leave trees are required (by size and number) within the WMZ. Bogs, both forested and non-forested, are treated as Type A wetlands when

they are 0.25 acre or larger. There are no leave tree requirements for the Forested Wetlands prescription. 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, 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.

### *6.5.2.1 Statewide Type A&B WMZs*

**Findings for Type A&B WMZs Statewide**

Type A&B Wetlands are estimated to occur on 313 FPAs statewide in the 2016-17 population. The resulting Type A&B Wetlands prescription sample size was 43 and a total of 110 rules were evaluated.

**Table 12. 2016-17 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 (%) | 2% | 92% | 0% | 0% | 0% | 8% | 0% |
| Type A&B (Rule Count) | 2 | 101 | 0 | 0 | 0 | 9 | 0 |

Sample Size = 43

One hundred one of the sampled 110 rules were compliant for the Type A&B WMZ sample, resulting in a 92% compliance rate +/- 5%. Of the 43 sites sampled, 34 were 100% compliant and 9 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2016 and 2017 resulted in 9 non-compliance determinations. All were for incorrectly typed and sized A and B wetlands. Seven typed B wetland segments were determined to be associated with type F waters. Two typed A wetland segments were determined to be associated with type F waters. Non-compliance on 3 of the sampled segments was determined to be administrative; no reason for non-compliance was determined for the other 6 segments. No deviation rating is assessed for non-compliant site characteristic rules. (Table 12)

#### *6.5.2.2 Statewide Forested Wetlands*

**Findings for Statewide Forested Wetlands**

Approximately 463 FPAs statewide contained Forested Wetlands in the 2016-17 sample population. The resulting Forested Wetlands prescription sample size was 17 and a total of 34 rules were evaluated.

**Table 13. 2016-17 Compliance Ratings for Statewide Forested Wetlands**

| Wetland Prescription | FP Rule Compliance Ratings | | | | | | |
|---|---|---|---|---|---|---|---|
| | Compliant Ratings | | Deviation Ratings | | | | |
| | Exceeds (Part of Compliant) | Compliant | Low | Moderate | High | No Assessed Deviation Rating | Indeterminate |
| Forested (%) | 0% | 100% | 0% | 0% | 0% | 0% | 0% |
| Forested (Rule Count) | 0 | 34 | 0 | 0 | 0 | 0 | 0 |

Sample size = 34

All 31 sampled rules were compliant for the Forested Wetlands sample, resulting in a 100% compliance rate. There were zero observations of rule non-compliance for the Forested wetland prescription type. (Table 13.)

# 7. Forest Practices Rule Compliance for Roads and Haul Routes

Section 7 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 as well as public safety. 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 water crossings.

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

- Road construction
- Landing construction
- Type N water 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 water 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 water 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 water or the 100-year flood level of any typed water (WAC 222-24-035).

*Type 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 water 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 on site. The compliance monitoring field team does not confirm water tying during road assessments. 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 water 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. Water crossing questions helped guide systematic water 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 water 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 14), and the cause of the noncompliance (Table 15).

There are 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 14.)

**Table 14. 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 15.)

**Table 15. 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 1349 FPAs in the 2016-17 sample. The resulting Roads prescription sample size was 15 and a total of 132 rules were evaluated.

**Table 16. FP Rule Compliance for 2016-2017 Road Activities**

| Statewide Road Activities for 2016 & 2017 | | |
|---|---|---|
| | **Status of Compliance** | **Road Activities Rule Compliance** |
| **All Landowner Types** | # of Rules Sampled | 132 |
| | # Compliant Rules | 125.5 |
| | # with Deviation | 6.5 |
| | Compliance % | 95% |
| | 95% Confidence Interval | CI (88, 100) |

Sample size = 15

One hundred twenty five point five of the sampled 132 rules were compliant for the Roads prescription sample, resulting in a 95% compliance rate +/- 6%. Of the 15 sites sampled, 13 were 100% compliant and 2 showed deviation from at least 1 FP rule in the prescription type.

Field observations from 2016 and 2017 accounted for 6.5 non-compliance determinations across 2 sites. Two non-compliant observations were recorded for failure to stabilize disturbed soils during road construction. The reason for non-compliance was determined to be operational, and deviation rating of low was assessed for both observations.

A single non-compliant observation was recorded for inadequate drainage structures installed on a road with potential to deliver sediment to an adjacent type N water. The reason for non-compliance was determined to be operational, and a deviation rating of low was assessed for the observation.

A single non-compliant observation was recorded for failure to install rock armoring on a water crossing inlet. The CMP field team did not make a final determination between layout/operational as the reason for non-compliance. A deviation rating of low was assessed for the observation.

A single non-compliant determination was recorded for an installed culvert less than 24 inches in diameter on an Np typed water. The CMP field team did not determine the reason for non-compliance, and the assessed deviation rating was low.

A single non-compliant observation was recorded for an inadequate catch basin for an installed culvert. The reason for non-compliance was determined to be operational, and a deviation rating of low was assessed for the observation.

A non-compliant observation was recorded for a water bar that was impeding ditch line flow. Two separate road segments had the same rule evaluated on the FPA; at the second segment, the rule was

observed to be compliant. For the non-compliant observation, no reason for non-compliance was determined, and deviation rating of low was assessed. (Table 16.)

*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 route 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 Table 17) were recorded. The compliance monitoring field team recorded compliance information for haul routes in general and 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 17. Haul Route Compliance Summary**

| Compliant | | Deviation | | |
|---|---|---|---|---|
| 92% (75, 100) CI* | | 8.0% (0, 28) CI | | |
| **No Delivery** | **De Minimis** | **Low** | **Medium** | **High** |
| 89% | 2.7% | 4.1% | 1.9% | 2.1% |

*CI is confidence interval at the 95% confidence level

**Table 18. Haul Route Deviation by Cause**

| Primary Cause | % Deviation with This Primary Cause |
|---|---|
| Inadequate water crossing structures | 19% |
| Cutslope failure | 5% |
| Other (described in comments) | 29% |
| Faulty cross drainage | 14% |
| Stream or Spring Intercepted | 5% |
| Rutting/inadequate crown | 5% |
| Sediment from stream adjacent parallel road | 5% |
| Wetland intercepted water | 5% |
| Water channeled to eroding slopes | 10% |

For 26.1 miles of the 28.2 miles of haul routes evaluated, no delivery or de minimus sediment delivery were observed, resulting in a compliance rate of 92% (Table 17). The 29% or 0.6 miles that aggregates

the “other” category is comprised of non-point-source sediment delivery and blocked drainage structures as the largest primary cause of sediment delivery (Table 18). Inadequate water crossing structures accounted for 19% or 0.4 miles of the observed deviation mileage. Faulty cross drainage accounted for 14% or 0.3 miles of the deviation mileage. Water channeled on to eroding slopes accounted for 10% or 0.2 miles of the observed deviation mileage. All other primary cause categories accounted for 0.1 miles of deviation each, respectively. For efficiency, haul routes were observed on FPAs that had been selected for one of the standard sampled prescriptions.

# 8. 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. To accomplish this, data from before 2014 have been converted to be consistent with current analytical protocols.

The sample size for each year is set based on accomplishing a specific 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 sample size 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 have changed since 2006. While these differences create challenges in evaluating trends through time, this report includes an analysis aimed at seeking to discern statistically-meaningful patterns of changes in compliance rates measured over time.

**Methods**

For the 2010-2017 dataset, rule compliance was carefully tracked to make sure that the compliance determination was consistently applied in all years. Results were reviewed to ensure consistent application of compliance determinations across the dataset. Where data were not collected in accordance with current field protocols, were incomplete, or rules are no longer included in compliance estimates, the data were removed from the trend analysis dataset. Data for rules were combined and compared through time within each corresponding prescription type. The 2016-17 results used for trend analysis were calculated using the jackknifed form of the ratio estimator. Trends in average compliance with prescriptions and individual rule compliance are tracked to maintain consistency with current methods.

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 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 $\alpha = 0.10$. Residuals from regressions were 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.

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 95% 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 DFC1 prescription type. (Figure 4.)

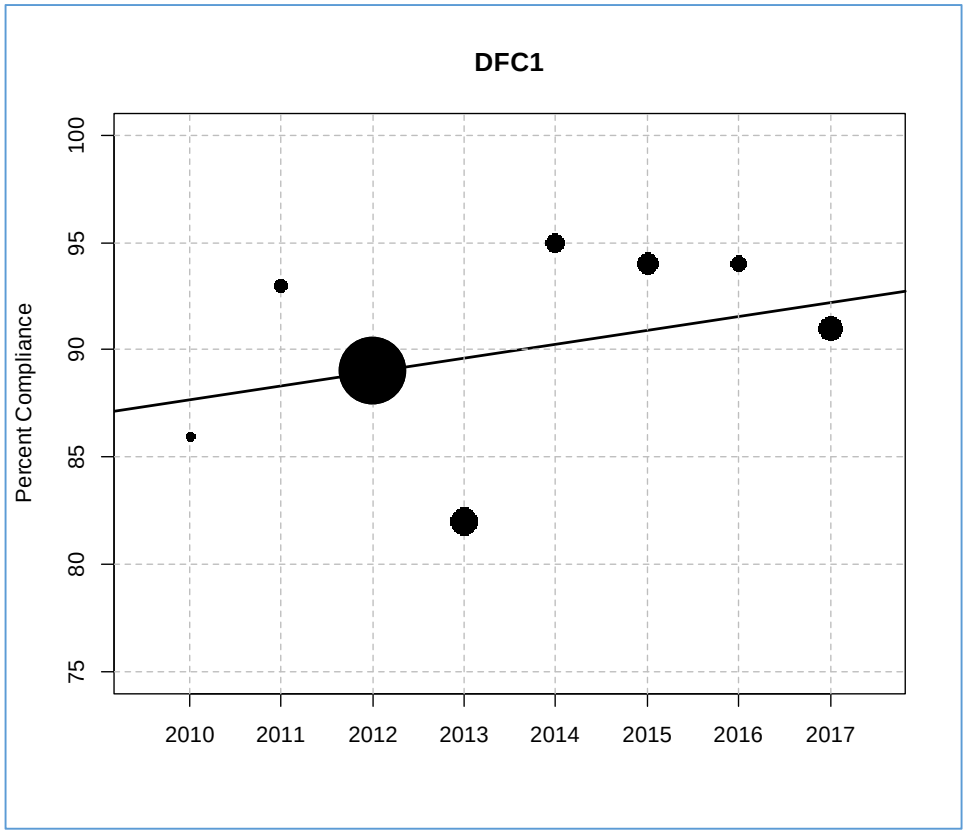



**Figure 4**. Annual rule compliance for the DFC1 prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*Desired Future Condition 2*

Trend analysis results for the DFC2 prescription type showed increasing 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 increasing prescription compliance rate, significant trend results (weighted $p = 0.094$) were observed for the weighted DFC2 prescription. A year over year increase of 0.94% for the overall prescription compliance rate was observed. (Figure 5.)

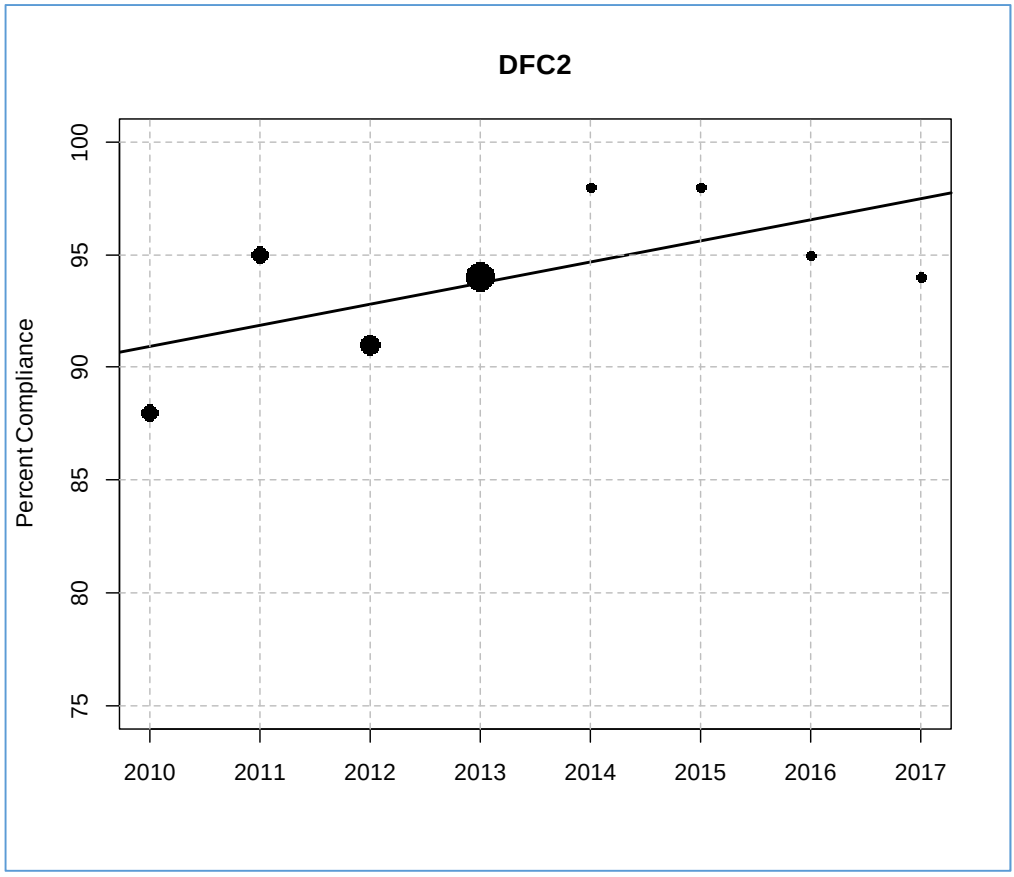



**Figure 5.** Annual rule compliance for the DFC2 prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*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 99% over the course of the evaluation period. As a result of the increasing prescription compliance rate, significant trend results (weighted $p = 0.099$) were observed for the weighted NIZH prescription. A year over year increase of 0.77% of the overall prescription compliance rate was observed. (Figure 6.)

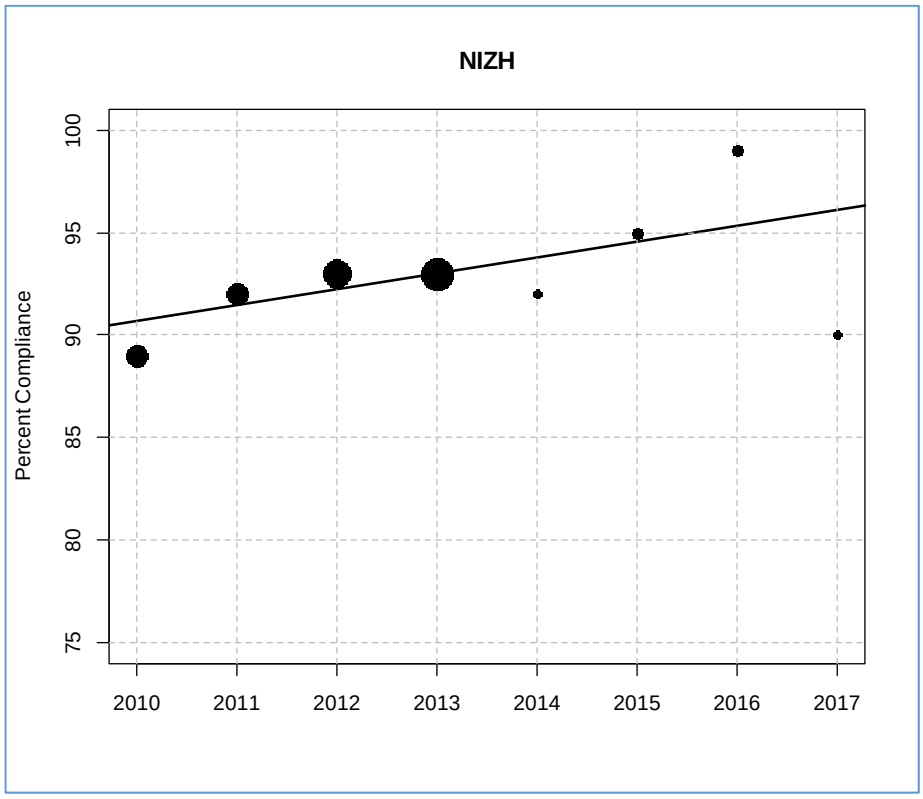



**Figure 6.** Annual rule compliance for the NIZH prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*Non-fish Bearing Perennial Waters*

As a result of data conversion 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 77% to 98% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.50$) were observed for the weighted Np prescription type. (Figure 7.)

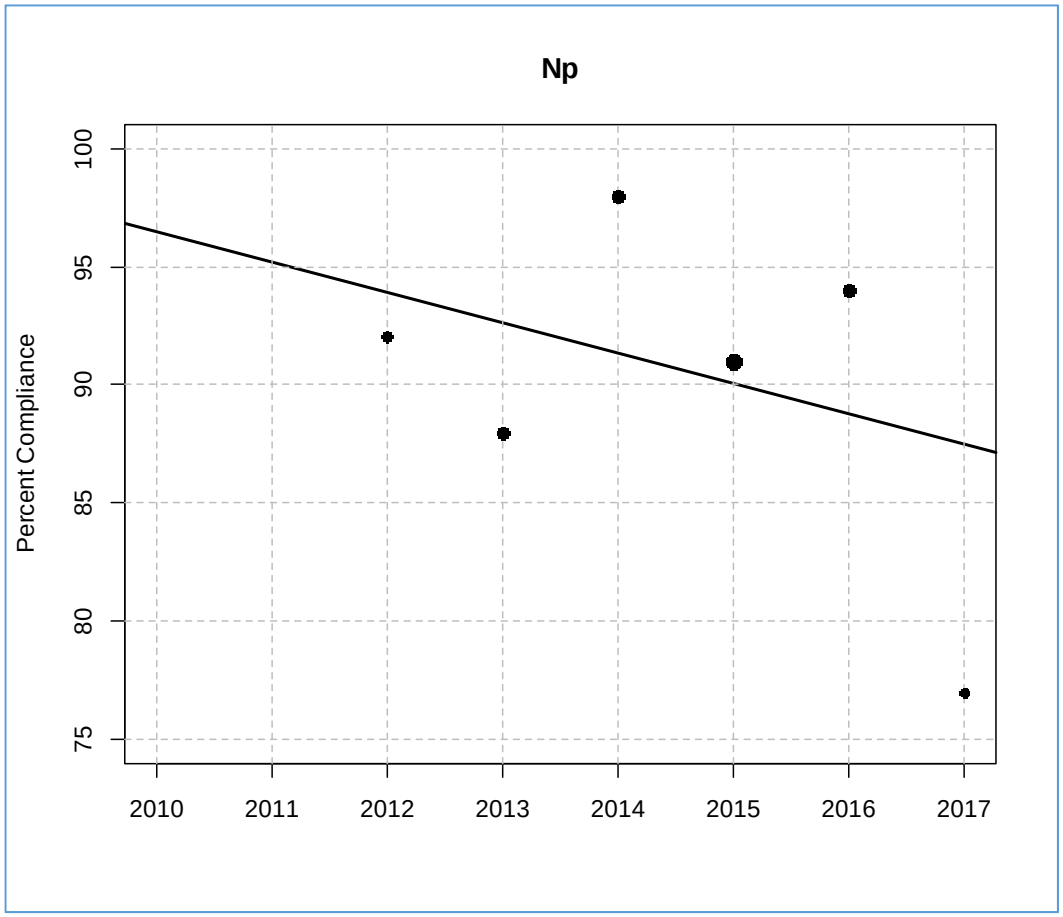



**Figure 7.** Annual rule compliance for the Np prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*Non-fish Bearing Seasonal Waters*

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 recently increasing compliance rates significant trend results (weighted $p$ = 0.10) were observed for the weighted Ns prescription type. A year-to-year increase of 0.55% of the overall prescription compliance rate was observed. (Figure 8.)

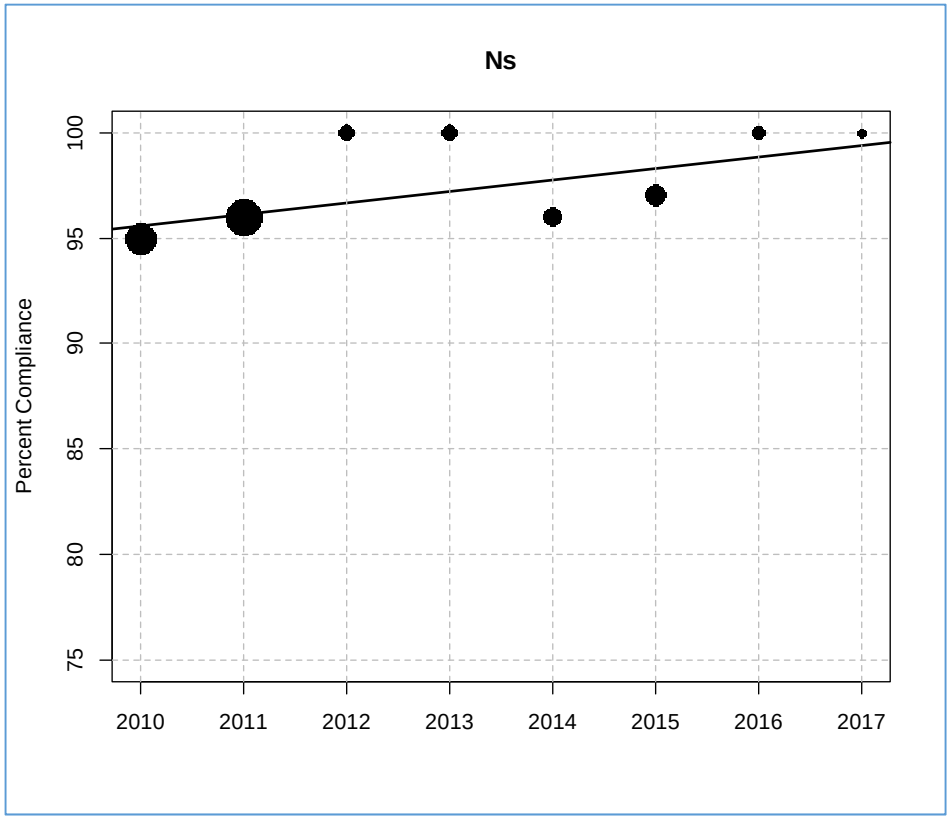



**Figure 8.** Annual rule compliance for the Ns prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*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 89% to 100% over the course of the evaluation period. As a result of the oscillating prescription compliance rate no significant trend results (weighted $p = 0.54$) were detected for the weighted A & B Wetlands prescription type. (Figure 9.)

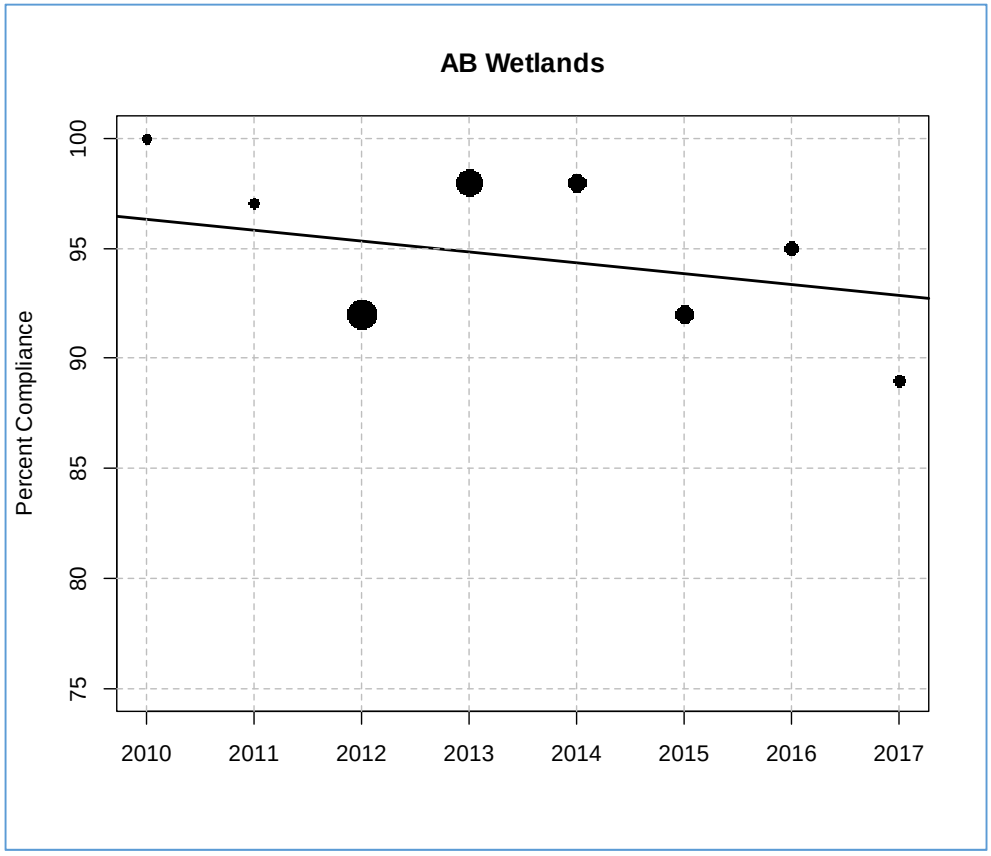



**Figure 9.** Annual rule compliance for the A&B Wetlands prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*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 $p = 0.99$) were observed for the weighted Forested Wetlands prescription type. A flat trend line for prescription compliance was observed. (Figure 10.)

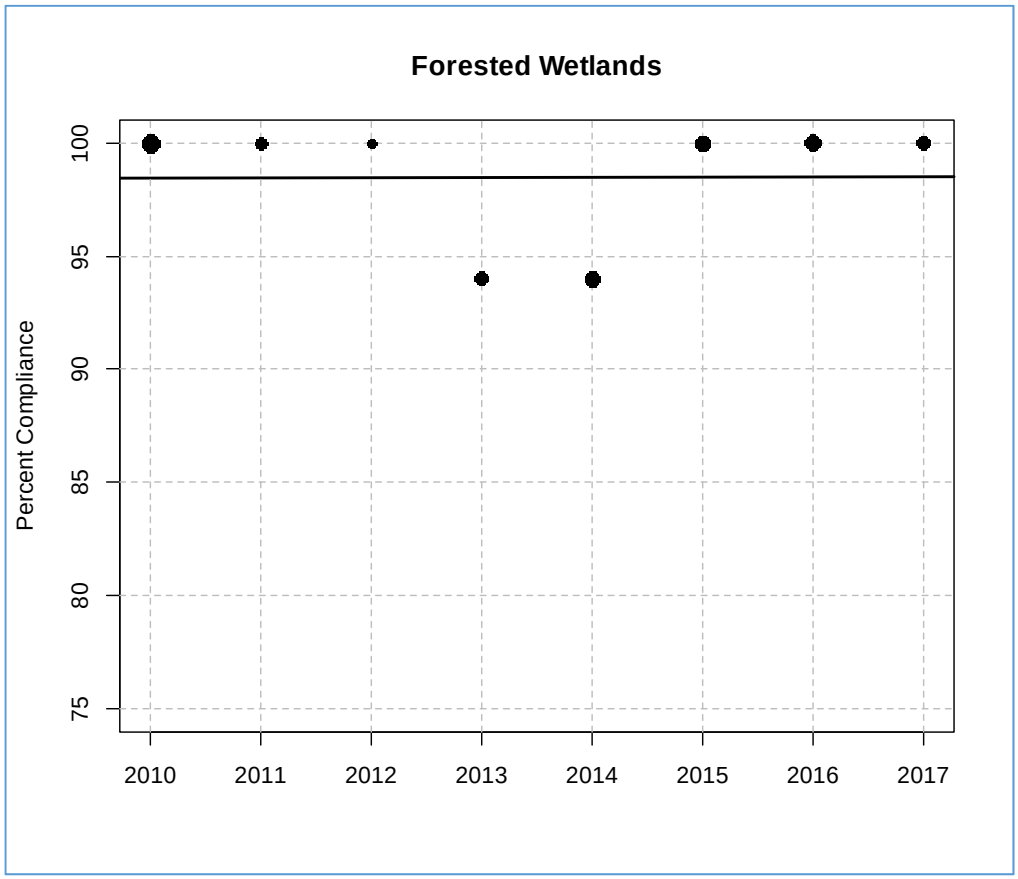



**Figure 10.** Annual rule compliance for the Forested Wetlands prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

*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 showed oscillating prescription compliance, and varying compliance for individual rules from year to year. Prescription compliance rates varied from 92% to 100% over the course of the evaluation period. No significant trend results for weighted regression analysis ($p = 0.34$) rate were observed for the Roads prescription type. (Figure 11.)

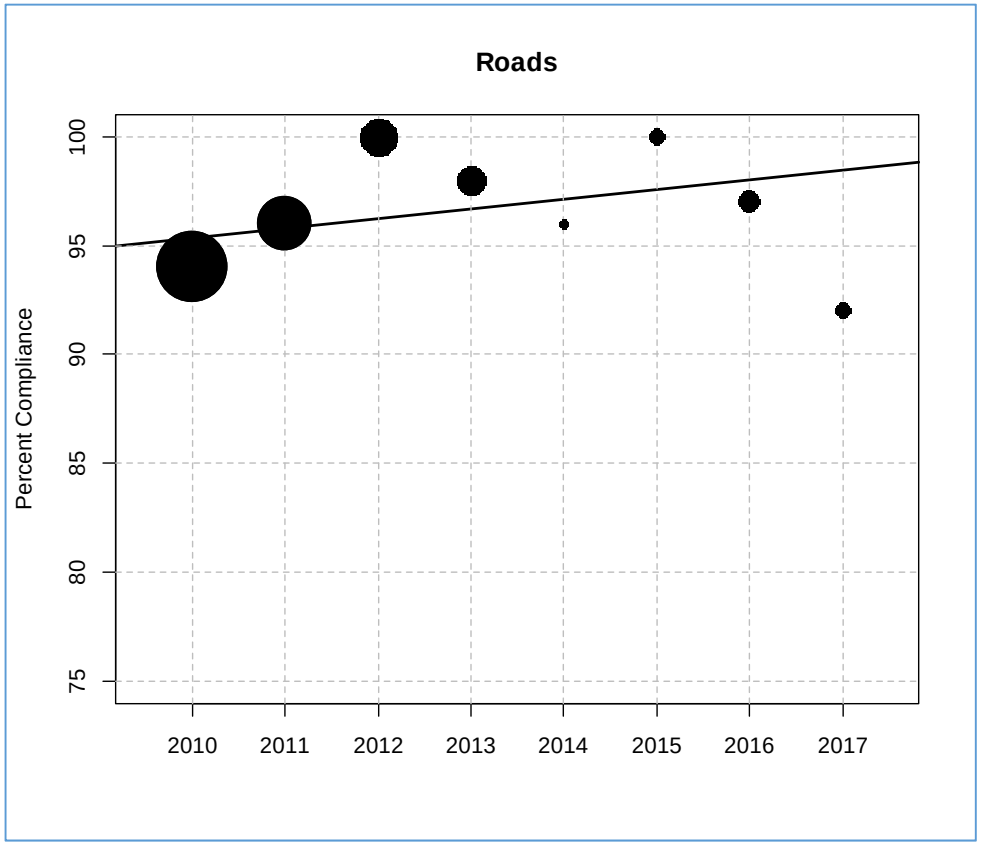



**Figure 11.** Annual rule compliance for the Roads prescription with a weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

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

# 9. Forest Practices Application Compliance

Section 9 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. Future prescription samples sizes are not based on FPA compliance variance estimates, and cluster size. (Table 19.)

**Table 19. 2016-17 Compliance with FPAs for Riparian and Wetland Prescriptions**

| | | Western WA | | Statewide | | | | | | Eastern WA |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Status of Compliance** | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Ns Activities | Type A&B Wetlands | Forested Wetlands | Roads | IZH (census) |
| **Small Forest Landowners** | # Compliant Rules | 1 | n/a | 8 | 8 | n/a | 16 | 3 | 27.5 | 5 |
| | # with Deviation | 3 | n/a | 0 | 3 | n/a | 0 | 0 | 4.5 | 0 |
| | % of Sample Compliant | 25% | n/a | 100% | 74% | n/a | 100% | 100% | 82% | 100% |
| | Confidence Interval | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | Prescriptions Assessed | 1 | 0 | 3 | 5 | n/a | 5 | 2 | 3 | 1 |
| **Large Forest Landowners** | # Compliant Rules | 75 | 50 | 57 | 70 | n/a | 74 | 14 | 98 | 30 |
| | # with Deviation | 3 | 3 | 5 | 8 | n/a | 2 | 0 | 2.0 | 1 |
| | % of Sample Compliant | 96% | 94% | 92% | 90% | n/a | 97% | 100% | 98% | 97% |
| | Confidence Interval | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | Prescriptions Assessed | 19 | 13 | 21 | 30 | n/a | 24 | 12 | 11 | 6 |
| **All Landowners** | # Compliant Rules | 76 | 50 | 65 | 78 | n/a | 90 | 17 | 125.5 | 35 |
| | # with Deviation | 6 | 3 | 5 | 11 | n/a | 2 | 0 | 6.5 | 1 |
| | % of Sample Compliant | 93% | 94% | 93% | 88% | n/a | 98% | 100% | 95% | 97% |
| | Confidence Interval | (85, 100) | (88, 100) | (86, 100) | (80, 96) | n/a | (85, 100) | n/a | (87, 100) | n/a |
| | Prescriptions Assessed | 20 | 13 | 24 | 35 | n/a | 29 | 14 | 14 | 7 |

Note: No rules within Ns prescription type are evaluated for FPA compliance.

**Table 20. 2016-2017 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 | 24 | 24 | 0 | 0 | 0 | 0 |
| | RMZ — Type Np Prescriptions | 35 | 30 | 2 | 1 | 0 | 2 |
| | ELZ - Type Ns Prescriptions | 31 | 31 | 0 | 0 | 0 | 0 |
| | WMZ — Type A&B Wetlands | 43 | 40 | 1 | 0 | 0 | 2 |
| | Forested Wetlands | 17 | 17 | 0 | 0 | 0 | 0 |
| | Roads | 14 | 14 | 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 | 13 | 13 | 0 | 1 | 0 | 0 |
| **Eastern WA** | RMZ – Type S or F Inner Zone Harvest EWaIZ (census) | 7 | 6 | 1 | 0 | 0 | 0 |

**Findings for FPA/FP Rule Compliance Differences**

There are few differences between FPA compliance and FP rule compliance for the 2016-2017 sample. Differences were found in the DFC1, DFC2, EWaIZH, Type Np waters, and Type A&B Wetlands prescription samples. (Table 20.)

2016 and 2017 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 the Rule/FPA compliant, where the proponent incorrectly identified and treated the segment as a small type F water, but it was determined to be a large type F water by the CMP field staff. The outer zone had a sufficient number of leave trees per the FPA. However, with a large F water the outer zone extended into the harvested area, leaving the outer zone 11 leave trees short of satisfying the requirements of the rule.

Within the DFC option 2 prescription, the difference occurred as a deviation from the Rule/FPA compliant, where the proponent incorrectly identified and treated the segment as a small type F water, but it was determined to be a large type F water by the CMP field staff. After re-running the DFC software with the correct stream size, it was revealed the no-cut inner zone floor was wider than the previously selected strategy. With harvest observed within the no-cut portion of the inner zone floor the requirements for rule were not met.

Within the Eastern Washington Inner Zone Harvest prescription, the difference occurred as a deviation from the FPA/Rule compliant, where the proponent reported a longer stream length than was measured by the CMP field team for the sampled segment. Resulting, in fewer than the required 21 largest trees per acre remaining in the inner zone per the proponent's stream length measurements. However, using the shorter segment length reported by the CMP field team the requirements of rule were met.

Within the Np prescription, 5 samples deviated from the FPA, Rule, or were indeterminate. For the first sample, the proponent reported a longer 50-foot no-cut buffer than was required. Harvest was observed within the proponent's no-cut buffer. However, no harvest was observed within the required no-cut buffer by rule. The sample was compliant with the rule but deviated from the FPA. For the second sample, the proponent underreported the required length of the 50 foot no cut buffer. Per CMP field team stream length measurements, the proponent needed an additional 125 feet of no-cut buffer. The sample was compliant with the FPA but deviated from the requirement of the rule. For the third sample, because of the underreported 50-foot no-cut buffer length, harvest occurred within the required 50-foot no-cut buffer. The sample was complaint with the FPA but deviated from the requirement of the rule. For the fourth sample, the proponent over reported the required 50 foot no-cut buffer length. The CMP field team observed harvest within 50 feet of the water in the additional no-cut buffer. The sample was compliant with the rule but deviated from the FPA. For the fifth sample, the proponent treated the water as an Np but it was determined to be an F by the CMP field staff. Region FP staff received neither a Water Type Modification Form nor related Interdisciplinary Team documentation noting a water type change. During the compliance monitoring field visit, the water met the criteria of a Type F water (> 2' wide and < 16% gradient), and fish were visually observed. The sample was determined to be compliant with the wording on the FPA, and non-compliant with the rule.

Within the Type A&B Wetlands prescription, 3 samples deviated from either rule or application compliance. For the first sample, the proponent declared that the selected wetland was Type A. However, during the compliance monitoring field review, it was determined that the wetland was a Type B wetland, resulting in an incorrect no-cut buffer width per the FPA. The sample was determined to be compliant with the rule but deviated from the FPA. For the second sample, the CMP field team was unable to determine the appropriate water type. Resulting, in an indeterminate rule assessment for the no-cut buffer with. The sample was determined to be compliant with the FPA but indeterminate for the rule. For the third sample, because of the CMP field team being unable to determine water type, the appropriate number of leave trees per acre was indeterminate. The sample was determined to be compliant with the FPA but indeterminate for the rule.

# 10. Potentially Unstable Slopes Emphasis Study

The potentially unstable slopes emphasis study was developed in accordance with governance of the program to evaluate compliance with forest practices rules and the FPA. Forest Practices Applications (FPA) containing potentially unstable rule identified landforms (RILs) were assessed for the unstable slopes emphasis study. The design objective was to evaluate how well on-ground results related to avoiding and/or mitigating potential adverse impacts from forest practices on RILs were carried out compared to what was required by the subject FPA. The focus of the unstable slopes emphasis study was to evaluate overall FPA compliance as opposed to individual rule compliance. Thus, the unstable slopes prescription was comprised of FPA compliance only questions. This change of focus from typical compliance monitoring analyses was due to the lack of field measurable rules within the rule identified landform prescription type.

The population sampled for Unstable Slopes consisted of FPAs containing RILs or had them immediately adjacent. As defined in WAC 222-16-50(d)(i)), RILs include Inner Gorges, Convergent Headwalls, Bedrock Hollows, Toes of Deep-seated Landslides, ground water recharge areas for glacial deep-seated landslides, outer edges of meander bends along valley walls or high terraces of an unconfined meandering stream, and any areas containing landforms indicating the presence of potential slope instability which cumulatively indicate the presence of unstable slopes. Initial screening of FPAs eligible for sampling consisted of those with a checked 'Unstable Slopes' box located under the Resource Review section on the 'Office Checklist Page 1'. Following initial screening, FPAs that contained RILs or had RILs bounded out of the FPA footprint were assigned a randomly generated number. Compliance Monitoring and Science Team staff reviewed these FPAs for completeness, based on the random order assigned. The Science Team consists of forest practices regulatory licensed engineering geologists (Qualified Expert) who evaluate landowner proposals and provide advice to FP foresters who make decisions about FPA approval or disapproval. FPAs that did not contain the RIL prescription, and/or FPAs where forest practices harvest or road construction activities had not been completed, were removed from the sample population. In some cases, the FPA contained multiple instances of the Unstable Slopes prescription type. If multiple occurrences of the same prescription type are contained on a single FPA, only one occurrence is selected, at random, and assessed through a CMP field review.

To qualify overall FPA compliance for unstable slopes prescriptions, yes/no determinations were produced by a DNR Qualified Expert (WAC 222-10-030(5)) when answering the following questions related to FPA RIL compliance:

- Did the landowner identify all potentially rule identified unstable landforms in/around the harvest area?
- Did the landowner apply mitigation for all potentially unstable rule identified landforms as identified on their FPA (Question 31)?
- Did harvest occur within the no harvest mitigation area associated with potentially rule identified unstable landforms?

- If a Geotechnical memo, letter or report prepared by a QE was submitted as part of the FPA, was the mitigation, as identified in their report, implemented by the landowner?

A **Yes/No** or **N/A** determination was assessed for each individual question that makes up the Unstable Slopes prescription. These questions were answered during the Qualified Expert's field assessment, following a complete and thorough office review of the selected FPA. Questions were determined to be **compliant** when the QE confirmed all applicable rule identified landforms had been identified by the proponent and the completed harvest was observed to have correctly followed the approved FPA (for FPA compliance).

The **Exceeds** rating was not utilized.

The **deviation from compliance** determination means that implementation of the avoidance/mitigation actions in the approved FPA were not followed. As with the compliant determination, this determination was made for each individual question included in the Unstable Slopes prescription sample. If an answer to a question illustrated a deviation from compliance, then the proponent either did not identify all applicable rule identified landforms, or did not execute the stipulations stated in the FPA (for FPA non-compliance).

Deviation ratings (Low, Moderate, and High) were not utilized for the Unstable Slopes sample.

**Findings for Unstable Slopes Emphasis Study**

In the 2017 Unstable Slopes sample, 43 FPAs were selected for review from a total population of 978 FPAs. Three samples had no answerable questions and were excluded from analysis. The resulting sample size was 40, and a total of 119 questions were evaluated (Table 21).

**Table 21. 2017 Statewide Unstable Slopes Emphasis Study Compliance Results**

| **Unstable Slopes** | |
|---|---|
| **Sample Size** | **40** |
| **Mean Cluster Size** | **3.0** |
| **Questions Evaluated** | **119** |
| **Questions 'yes'** | **109** |
| **Mean 'yes'** | **91.6%** |
| **95% Confidence Interval** | **(85%, 98%)** |

One hundred nine of the sampled 119 questions were answered 'yes' for the Unstable Slopes prescription sample, resulting in a 92% compliance rate +/- 6.5%. Of the 40 sites sampled, 34 had 'yes' answers for all questions and 6 had 'no' answers for at least 1 question in the prescription type.

Field observations from 2017 included for 10 deviation observations.

- Four deviations were recorded for identifying all potentially rule identified unstable landforms in or around the harvest area.
- Two deviations were observed where avoidance/mitigation was not applied for all potentially rule identified unstable landforms.

- Four deviations were observed where harvest occurred within the no harvest mitigation area associated with potentially unstable rule identified landforms.
- No deviations were observed where a Geotechnical memo, letter or report prepared by a QE was submitted as part of the FPA, were the landowner, as identified in their report, did not implement the mitigation.

# 11. Report Discussion

The 2016-17 rule prescription compliance rates range from 87-100%, indicating high compliance with forest practice rules. The uncertainty bounds maintain the half-width 95% confidence interval target of +/-6% except for the Np prescription, which had lower compliance and higher variance than expected based on historic estimates. The Np sample size, relative to the expected population size, will be adjusted for the next biennia to reflect these disparities. Note that the jackknife-based confidence intervals are not symmetric. In addition, sample size estimates will continue to be determined using conventional ratio variance estimates.

**Riparian and Wetland Compliance Proportioned across the Population**

Tables that describe 2016-2017 riparian and wetland findings are in Sections 6.2, 6.3, 6.4, and 6.5 for individual prescription types. Section 6 also provides estimates of the population sizes for each prescription type. Table 22 (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 waters.

**Table 22. 2016-17 Estimated Population Size and Associated FP Rule Compliance**

| Prescription Type | Estimated Population of FPAs with the Prescription | Compliance Percentage |
|---|---|---|
| RMZ — Type Np Prescriptions | 1,776 | 87% |
| RMZ — Type Ns Prescriptions | 1,868 | 100% |
| RMZ — Type S or F No Inner Zone Harvest | 1,408 | 95% |
| Forested Wetlands | 463 | 100% |
| Type A&B Wetlands | 313 | 92% |
| Western WA RMZ — Type S or F Inner Zone Harvest DFC2 | 331 | 95% |
| Western WA RMZ — Type S or F Inner Zone Harvest DFC1 | 86 | 92% |
| Roads | 1,349 | 95% |
| Haul Routes | NA* | 92% |

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

**Comparison between Ratio Estimates and Jackknife Estimates**

The ratio estimator used for the previous biennia (2014-15) is a biased estimator, but the bias has been disregarded in previous biennia, and assumed very small. The jackknife estimates were compared to the biased ratio estimates for the past three biennia to evaluate the consequences that using the biased estimator may have had on interpretation of compliance results in the past.

The differences are generally negligible. The maximum difference in average compliance for the 2016-2017 biennium is a 0.22% reduction in compliance for roads, paired with a similar 0.16% increase in compliance for A&B Wetlands. For A&B Wetlands, average compliance using the jackknife estimator is 91.98%, whereas average compliance with the biased estimator would be 91.82%. The confidence intervals for the A&B Wetlands prescription shifted by a similar amount, indicating that the bias in the standard error estimate was minimal. The confidence interval is slightly (0.007%) narrower. For the roads prescription, the jackknife estimate is 94.85%, versus 95.08% for the biased estimator. The upper confidence interval is at 100% for both methods, but the lower confidence interval is lower by 0.8% for the jackknife interval, indicating the small downward bias in the original standard error estimate. Additional information and analysis concerning ISPR is located in Appendix D.

**Table 23. Comparison of 2016-2017 rule compliance and confidence intervals using the standard ratio estimate method applied in previous biennia compared to the current jackknife method.**

| | | Western Washington | | Statewide | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Ns Activities | Type A & B Wetlands | Forested Wetlands | Roads |
| Prescriptions Assessed | | 20 | 13 | 24 | 35 | 31 | 43 | 17 | 15 |
| # Rules Compliant[1] | | 128 | 86 | 112 | 96 | 31 | 101 | 34 | 125.5 |
| # Rules with Deviation[1] | | 11 | 5 | 6 | 15 | 0 | 9 | 0 | 6.50 |
| Standard Ratio Compliance Estimate | | 92.086% | 94.505% | 94.915% | 86.49% | 100% | 91.82% | 100% | 95.08% |
| 90% Confidence Interval | Lower Bound | 87.17% | 89.00% | 90.40% | 78.84% | n/a | 86.50% | n/a | 88.30% |
| | Upper Bound | 97.00% | 100% | 99.43% | 94.13% | n/a | 97.14% | n/a | 100% |
| Jackknife Compliance Estimate | | 92.093% | 94.507% | 94.913% | 86.60% | 100% | 91.98% | 100% | 94.85% |
| 90% Confidence Interval | Lower Bound | 87.18% | 89.00% | 90.40% | 78.95% | n/a | 86.66% | n/a | 87.51% |
| | Upper Bound | 97.01% | 100% | 99.43% | 94.25% | n/a | 97.30% | n/a | 100% |
| Jackknife - Standard Ratio Compliance | | 0.0069% | 0.0016% | -0.0025% | 0.1100% | 0% | 0.1590% | 0% | -0.2231% |
| Jackknife Half-width of CI - Standard Ratio Half-width of CI | | 0.0013% | 0.0013% | 0.0030% | 0.0044% | n/a | -0.0034% | n/a | 0.5652% |

## Compliance Monitoring Program Challenges

*Representation of Complete Compliance*

The expectation is for landowners to follow all FP rules. 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 DFC prescriptions, if there were too few outer zone trees, there were often also more tree than required left 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.

*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 to better resolve questions associated with the variability in the natural environment.

*Compliance vs. Resource Protection*

The CMP study design has been developed to determine the how well actual on-ground results comply with specific sampled Forest Practices rules. The CMP does not evaluate effectiveness of the rules, nor the adequacy of the resource protection provided by the proponent's implementation of the Forest Practices rules.

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

Several rule and Board Manual updates are currently in process because of the 2014-2015 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 and 2018 Forest Practices Board work plan. Rule and Board Manual clarifications were presented at the May 2015 and 2016 Forest Practices Board meeting. As a direct result of Compliance Monitoring fieldwork, options are being considered to update the Forest Practices Application form and/or instructions for Wetland Management Zones to accurately reflect rule interpretation. The updated FPA form will be available July 16th 2018.

# 13. Glossary

**Bankfull width (BFW).**

a) **For waters** — the measurement of the lateral extent of the water surface elevation perpendicular to the channel at bankfull depth. In cases where multiple channels exist, bankfull 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. The crowns of dominant trees crowd one or more sides of a co-dominant tree.

**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 waters.

**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 class III or IV forest practice. Class III and IV forest practices have a higher potential to impact a public resource than does a 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.

**Jackknife analysis.** A resampling technique for variance and bias estimation. Each observation is systematically left out of the dataset and the ratio estimate is recalculated, then the mean is determined from the recalculations.

**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 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 Water, Non-Fish Bearing Seasonal Water, 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 water, where trees are left to provide protection from disturbance when forest practices activities such as timber harvest are conducted.

**Rule Identified Landforms (RILs).** Inner Gorges, Convergent Headwalls, Bedrock Hollows, Toes of Deep-seated Landslides, ground water recharge areas for glacial deep-seated landslides, outer edges of meander bends along valley walls or high terraces of an unconfined meandering stream, and any areas containing landforms indicating the presence of potential slope instability which cumulatively indicate the presence of unstable slopes

**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 waters 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 water crossings where the alignment of the road continues to parallel the stream for more than 250 feet on either side of the water. 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 (UMPPF).** 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.

# 14. Appendix A: Sampling and Sample Size Estimation

## SAMPLING STRATEGY

### *Quantitative objectives*

The primary quantitative objective of the Compliance Monitoring Program is to estimate the statewide average compliance of forest practices activities with applicable forest practices rules within each biennium, with an error rate of +/-6%. A secondary objective is to compare changes in compliance through time.

### *Population description*

The population designated for sampling consists of the total number of each prescription type identified on forest practices applications that have completed forest practices activities and expire April 1, through March 31 of the following year. The program uses these dates as the timeframe for each successive year of compliance monitoring. This consistent annual sampling period ensures that no FPAs are excluded from selection due to submittal date.

FPAs for annual field assessments include *completed* Class II, Class III, and Class IV-Special and Class IV –General non-conversion FPAs expiring within a one-year period that contain a monitored standard prescription. Each application states all the forest practices activities that the landowner intends to implement. This information allows the compliance monitoring field team to locate forest practices applications (FPAs) that list the particular FP rule prescriptions being sampled in a given year. Sample selections for each prescription type are produced from the FPAs that contain the prescriptions being monitored that year.

Desired Future Condition Option 1, Desired Future Condition Option 2, Eastern Washington Inner Zone Harvest, No Inner Zone Harvest, Non-fish Bearing Perennial Waters, Non-fish Bearing Seasonal Waters, Type A & B Wetlands, Forested Wetlands, Roads, and Haul Routes comprise the annual standard sample prescriptions. The overall prescription population size is often not known, but can be estimated based on the number of FPAs that were reviewed and were found to be part of the population containing the given prescription. The CMP estimates N for an individual prescription as follows:

$$\widehat{N} = \frac{n_1 \times F_1}{f_1},$$

where
$F_1$ = the total number of FPAs approved in Year 1,
$f_1$ = the number of FPAs evaluated for membership in the population ("opened") in Year 1, and
$n_1$ = the number of FPAs opened that contained completed activities in Year 1.

The finite population correction factor (FPCF):

$$1 - \frac{n}{\hat{N}}.$$

***Sample Selection methods***

Each FPA is assigned an expiration date upon approval. There are thousands of active (not yet expired) FPAs every year, because the majority of FPAs have 3 years in which to be completed. Populations are grouped by prescriptions (DFC1, DFC2, NIZH, etc.) that have been identified by 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.

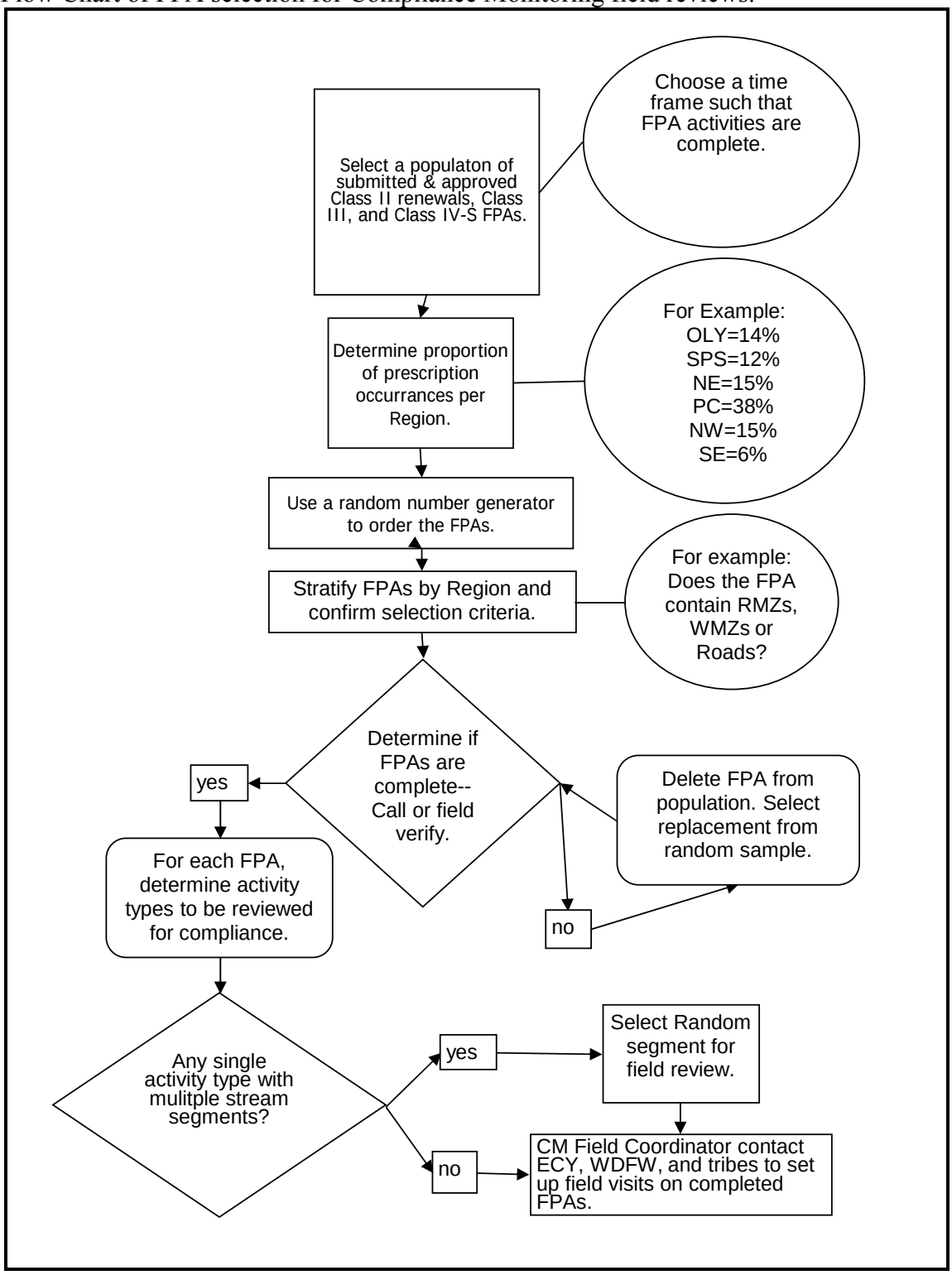
To ensure all active completed FPAs have an opportunity to be selected, the populations to be sampled are FPAs that expire between April 1 of the preceding year and March 31 of the sampling year. The April 1 to March 31 window improves the likelihood that the forest practices operations will be completed prior to the primary compliance monitoring sampling months, February through November, and that the compliance monitoring field team attempts to conduct data collection before the FPA expires.

To ensure a random selection of FPAs from the sampling population, FPAs 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 consists of reviewing the FPAs in this random order. Each FPA is reviewed to determine the sample FP rule prescription types, which can be sampled. This selection process continues through the ordered list of FPAs until the target sample size is reached for each sampled prescription type.

All FPAs in the population are ordered by the assigned generated random number and categorized by region. FPAs that do not contain monitored activities and FPAs that are not complete are removed from the population. Sample sizes are applied in proportion to statewide population size for each prescription type.

For each riparian prescription, the population to be sampled consists of FPAs containing 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. If multiple instances of the same prescription type are contained on a single FPA, one instance is randomly selected and assessed for the purposes of Compliance Monitoring field reviews.
The figure below displays a flow chart that illustrates how activities are selected for field assessment.

Figure Flow Chart of FPA selection for Compliance Monitoring field reviews.



***Sample size and allocation***

The stated objective is to estimate compliance for each prescription with a precision of +/- 6% with a 95% confidence interval. We use data from previous biennia for each prescription to estimate compliance variance, the average number of rules among FPAs, and the expected population sizes (overall and within each region). Because these population values can vary widely among biennia, it is important to update the estimates after one year of sampling for the biennium is completed. This 2-year approach assumes that there is no change in compliance between the two years, so that no bias is introduced by having unbalanced sampling among the two years.

The estimated population values for variance, cluster size, and population size are used to estimate the sample sizes required to attain a width of +/- 6% for a 95% confidence interval using an iterative process based on a t-distribution confidence interval on average prescription compliance:

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

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

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

and $N$ is the estimated population size for the prescription.

***Compliance and Variance Calculation Methods***

In previous biennia, the average compliance was calculated according to the rules of estimation for cluster samples (See, for example, Cochran, 1977; Schaeffer et al., 1990). The mean compliance for a prescription was estimated by the ratio of the number of compliant rules divided by the total number of rules sampled across all FPAs in the prescription:

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

where $n$ is the number of FPAs sampled for the prescription, $x_i$ is the number of rules applied on the $i$th FPA in the sample, and $y_i$ is the number of rules complied with on the $i$th FPA.

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

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

where

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

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

and $N$ is the estimated population size for the prescription (i.e., total number of FPAs containing the prescription).

The ISPR review found that this was a proper statistical estimation process. However, the review drew attention to the bias on the order of 1/n that is present in the ratio estimator, and recommended that the jackknife estimation procedure described by Cochran (1977) and Gregoire (1984) be applied to help reduce or eliminate any potential bias in the estimates. Therefore, beginning with the 2016-2017 biennium, average compliance for each prescription is now estimated using a jackknife ratio estimator and associated confidence interval, as recommended by the ISPR review. For the jackknife estimator, each FPA was removed from the prescription sample in turn, and a ratio estimate of compliance was estimated on this reduced sample ($\widehat{R_{-J}}$). The jackknife estimator for average compliance in a finite population is (Cochran, 1977, eqn 6.82):

$$\widehat{R_{JK}} = w \cdot \hat{R} - (w-1) \cdot \widehat{R_{\_}}$$

where

$w = n\left[1 - \frac{(n-1)}{N}\right]$ is a finite population correction factor, and

$\widehat{R_{\_}}$ is the average of the *n* quantities $\widehat{R_{-J}}$.

An estimate of variance is also given by Cochran (1977, eqn 6.86):

$$var(\widehat{R_{JK}}) = \left(1 - \frac{n}{N}\right) \cdot \frac{(n-1)}{n} \cdot \sum_{j=1}^{n} \left(\widehat{R_{-J}} - \widehat{R_{\_}}\right)^2$$

$$var(\widehat{R_{JK}}) = \left(1 - \frac{n}{N}\right) \cdot \frac{(n-1)^2}{n} \cdot var(\widehat{R_{-J}})$$

$$\widehat{SE(R_{JK})} = \sqrt{var(\widehat{R_{JK}})}$$

An approximate 95 percent confidence interval for the jackknife estimate was then formed as follows:

$$\widehat{R_{JK}} \pm t_{.025,(n-1)} \cdot \widehat{SE(R_{JK})},$$

where $t_{.025,(n-1)}$ is the 97.5$^{th}$ percentile of the student-*t* distribution with *(n-1)* degrees of freedom, and *N* in the formulas above is replaced by $\widehat{N}$.

# 15. Appendix B: 2016-2017 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) | CMZ not recorded on FPA 222-30-020(13) | Correct # Outer Zone leave trees (222-30-021(iii)(c)) |
|---|---|---|---|---|---|---|---|---|
| Compliance | 17 | 19 | 19 | 20 | 16 | 19 | 1 | 17 |
| Assessed | 20 | 19 | 20 | 20 | 19 | 20 | 1 | 20 |
| % compliant | 85% | 100% | 95% | 100% | 84% | 95% | 100% | 85% |
| 95% CI | (65, 91) | (84, 100) | (77, 95) | (85, 100) | (63, 91) | (77, 95) | (8, 100) | (65, 91) |

### Desired Future Condition Option 2

| DFC2 (n=13) | 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)) | CMZ not recorded on FPA 222-30-020(13) | Correct # Outer Zone leave trees (222-30-021(iii)(c)) |
|---|---|---|---|---|---|---|---|---|
| Compliance | 12 | 13 | 12 | 13 | 9 | 13 | 1 | 13 |
| Assessed | 12 | 13 | 13 | 13 | 13 | 13 | 1 | 13 |
| % compliant | 100% | 100% | 92% | 100% | 69% | 100% | 100% | 100% |
| 95% CI | (74, 100) | (76, 100) | (64, 100) | (76, 100) | (39, 91) | (76, 100) | (3, 100) | (76, 100) |

### No Inner Zone Harvest

| NIZH (n=24) | 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)) | Observed CMZ 222-30-020(13) |
|---|---|---|---|---|---|---|
| Compliance | 23 | 24 | 24 | 21 | 19 | 1 |
| Assessed | 24 | 24 | 24 | 24 | 21 | 1 |
| % compliant | 96% | 100% | 100% | 88% | 90% | 100% |
| 95% CI | (79, 100) | (86, 100) | (86, 100) | (68, 97) | (70, 99) | (3, 100) |

## Non-Fish Bearing Perennial Waters

| 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/UMPPF & Confluence buffer (222-30-021(2)(b)(iv)(v)) | No harvest on Alluvial fans |
|---|---|---|---|---|---|---|---|
| Compliance | 26 | 5 | 23 | 21 | 3 | 17 | 1 |
| Assessed | 32 | 6 | 24 | 25 | 3 | 20 | 1 |
| % compliant | 81% | 83% | 96% | 84% | 100% | 85% | 100% |
| 95% CI | (64, 93) | (36, 100) | (79, 100) | (64, 95) | (30, 100) | (62, 97) | (3, 100) |

## Non-Fish Bearing Seasonal Waters

| Ns (n=31) | Ns stream size (222-16-031(5)) | Is ≤ 10% of ELZ exposed (222-30-021(2)(a)) |
|---|---|---|
| Compliance | 31 | 0 |
| Assessed | 31 | 0 |
| % compliant | 100% | N/A |
| 95% CI | (89, 100) | N/A |

## Forested Wetlands

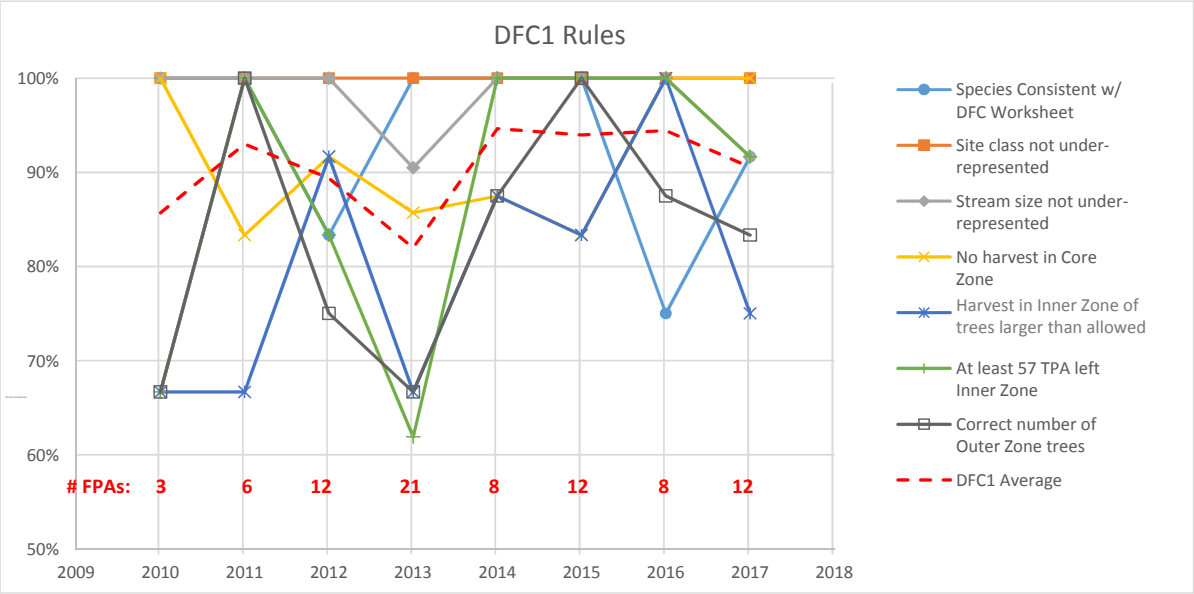
| Forested Wetlands (n=17) | Wetlands type & size consistent (222-06-035(2)) | If harvest occurred, low impact used (222-30-020(7)) | If greater than 3 acres, was it mapped (222-16-036(3)) |
|---|---|---|---|
| Compliance | 17 | 11 | 6 |
| Assessed | 17 | 11 | 5 |
| % compliant | 100% | 100% | 100% |
| 95% CI | (81, 100) | (72, 100) | (55, 100) |

## A & B Wetlands

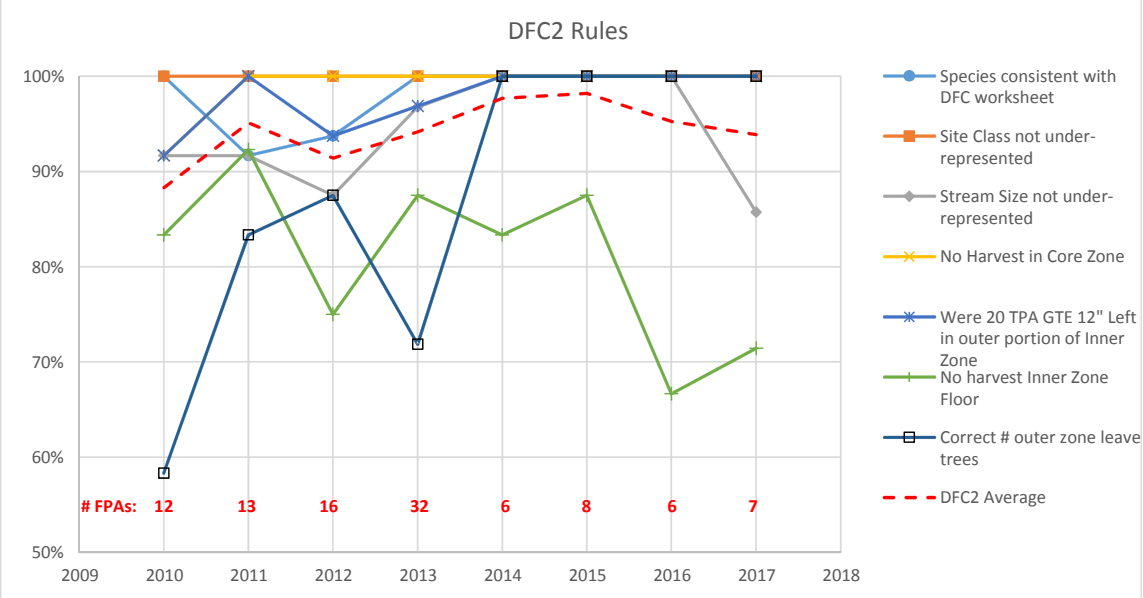
| A&B Wetlands (n=43) | Wetlands type & size (222-16-035(1)(a) &(b)) | Variable buffer width appropriate (222-30-020(8)(a)) | Openings less than 100' wide (222-30-020(8)(d) | Openings less than 200' wide | Leave trees species represent pre-harvest (222-30-020(6)) | Ground based in min WMZ had approval (222-30-020(8)(e)) | WMZ-RMZ overlap-best protection used (222-30-020(8) | 38 TPA GT 6in WW (4in EW) (222-30-020(8)(b)) | 13 TPA GT 12in,where they exist (222-30-020(8)(b)) | 75 TPA GT 6in, where they exist | 25 TPA GT 12in, where they exist | 3 TPA GT 20in, where they exist | 5 TPA GT 20in, where they exist (222-30-020(8)(b)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Compliance | 32 | 21 | 1 | 1 | 19 | 2 | 5 | 1 | 1 | 6 | 6 | 1 | 5 |
| Assessed | 41 | 21 | 1 | 1 | 19 | 2 | 5 | 1 | 1 | 6 | 6 | 1 | 5 |
| % compliant | 78% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 95% CI | (63, 89) | (85, 100) | (6, 100) | (6, 100) | (83, 100) | (20, 100) | (51, 100) | (6, 100) | (6, 100) | (57, 100) | (57, 100) | (6, 100) | (51, 100) |

# 16. Appendix C: Trends of Individual Rules

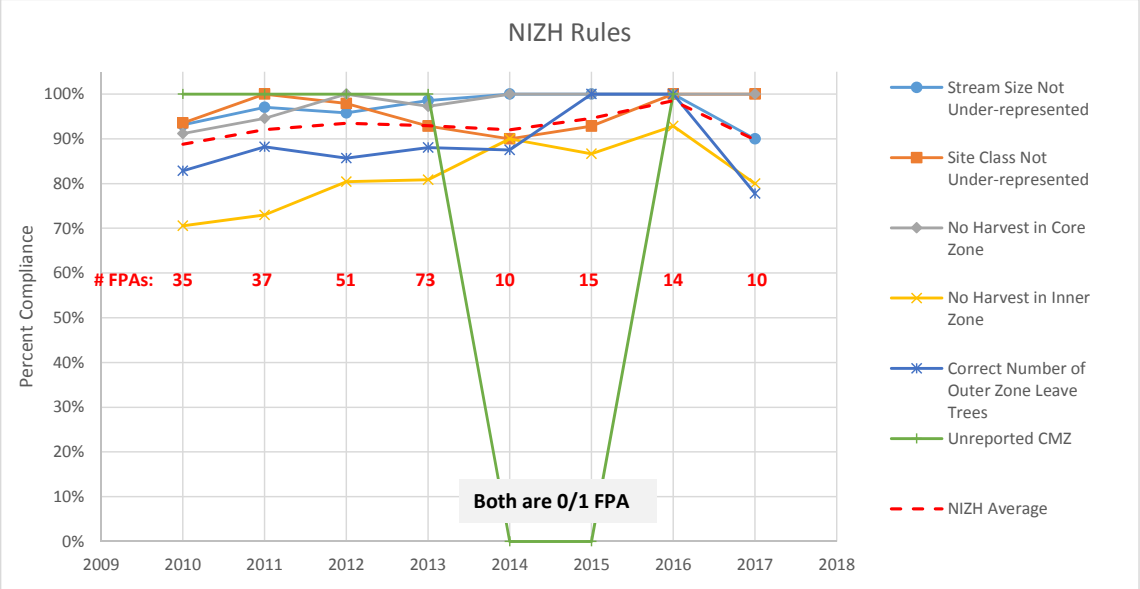
## Desired Future Condition 1



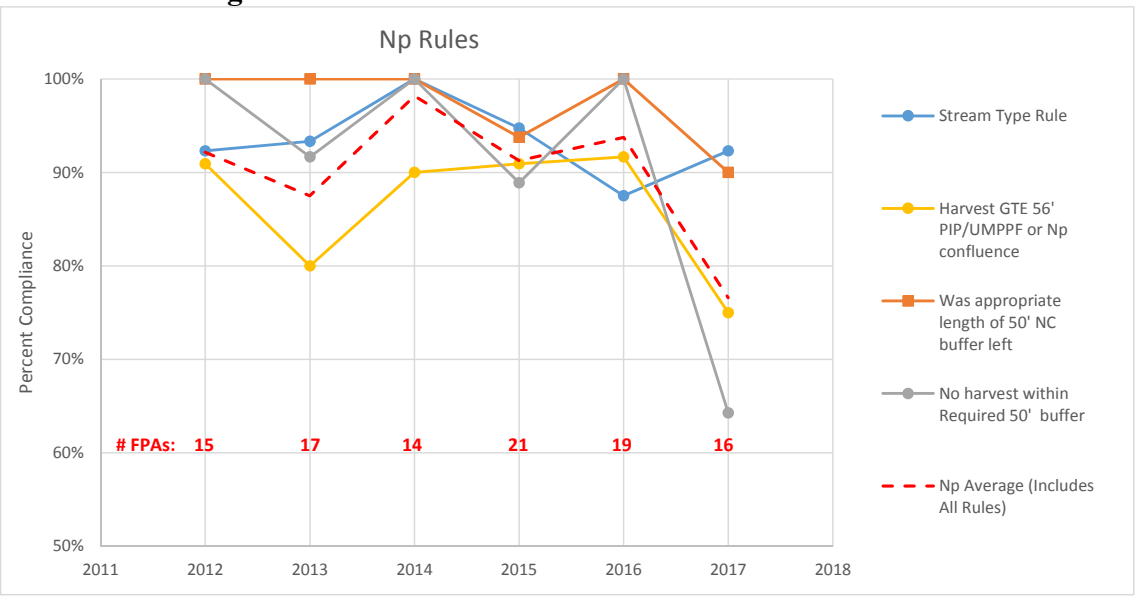

## Desired Future Condition 2



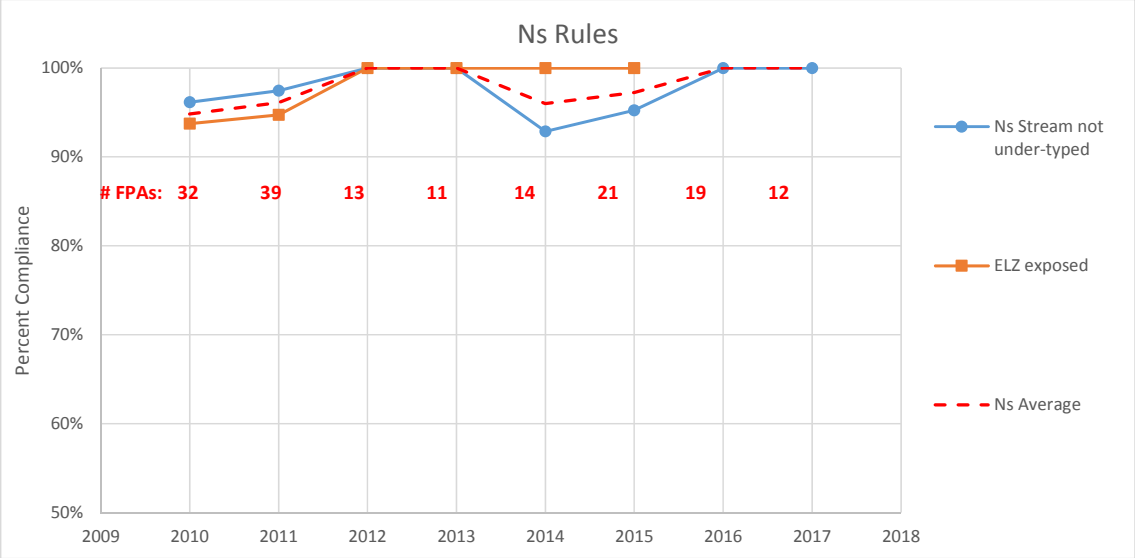
## No Inner Zone Harvest



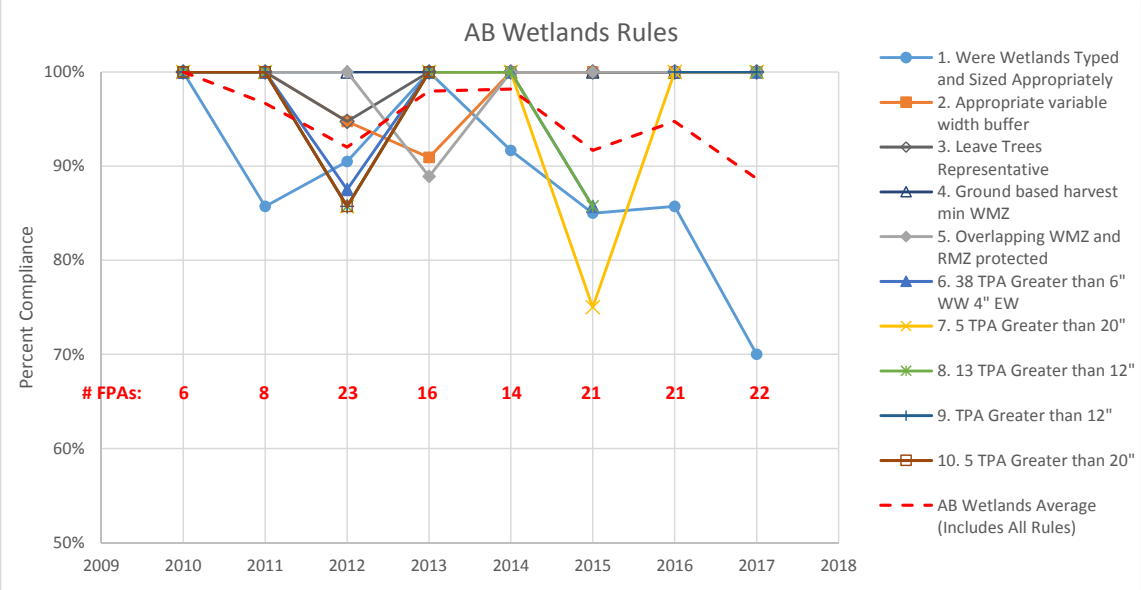

## Non-Fish Bearing Perennial Waters



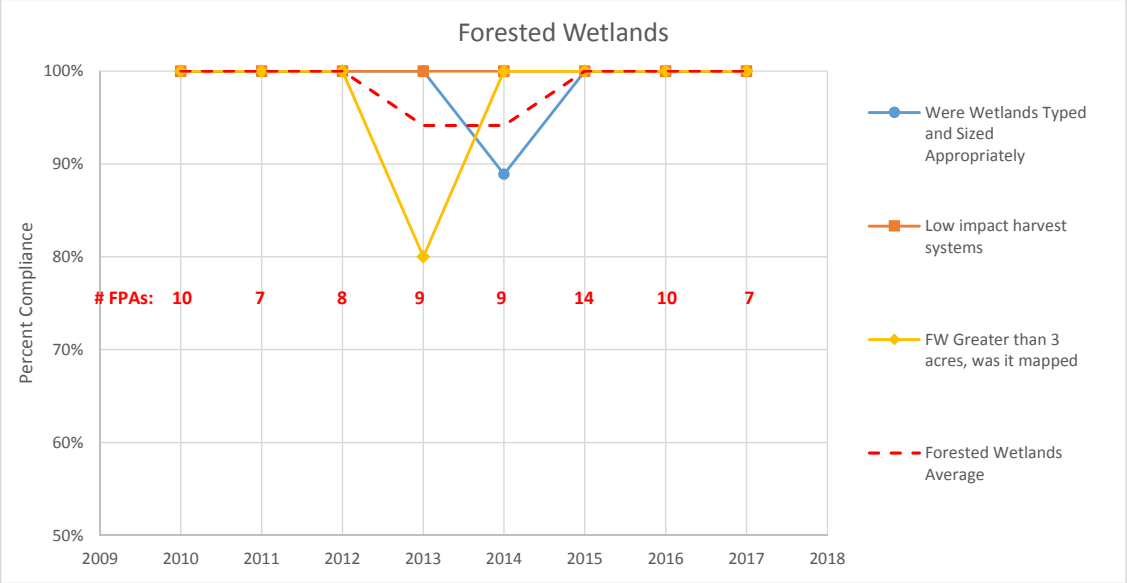
## Non-Fish Bearing Seasonal Waters




## A & B Wetlands



## Forested Wetlands



# 17. Appendix D: Technical Report on Jackknife Estimation Revisions and Trend Analysis

## INTRODUCTION

The 2014-2015 Forest Practices Compliance Monitoring Biennial Report was reviewed by an Independent Scientific Peer Review (ISPR) Panel from the University of Washington in 2017. One recommendation from the ISPR was to alter the method for estimating the biennial compliance statistic and the uncertainty around that estimate to correct for the known bias present in a ratio estimator. The recommendation was to use a jackknife estimator rather than the conventional estimator of a ratio. The jackknife estimator was therefore used to estimate compliance for the 2016-2017 Biennial Report. This technical appendix provides the details of the methods revisions, including a summary of the compliance results, a comparison between compliance using the previous method and the new method for the past two biennia, and an assessment of linear trends in compliance through time.

## METHODS

### *2016-2017 BIENNIUM*

In previous biennia, the average compliance was calculated according to the rules of estimation for cluster samples (See, for example, Cochran, 1977; Schaeffer et al., 1990). The mean compliance for a prescription was estimated by the ratio of the number of compliant rules divided by the total number of rules sampled across all FPAs in the prescription:

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

where $n$ is the number of FPAs sampled for the prescription, $x_i$ is the number of rules applied on the $i$th FPA in the sample, and $y_i$ is the number of rules complied with on the $i$th FPA.

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

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

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

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

*N* is the estimated population size for the prescription (i.e., total number of FPAs containing the prescription).

The ISPR review found that this was a proper statistical estimation process. However, the review drew attention to the bias on the order of 1/n that is present in the ratio estimator, and recommended that the jackknife estimation procedure described by Cochran (1977) and Gregoire (1984) be applied to help reduce or eliminate any potential bias in the estimates. Therefore, beginning with the 2016-2017 biennium, average compliance for each prescription is now estimated using a jackknife ratio estimator and associated confidence interval, as recommended by the ISPR review. For the jackknife estimator, each FPA was removed from the prescription sample in turn, and a ratio estimate of compliance was estimated on this reduced sample ($\widehat{R_{-J}}$). The jackknife estimator for average compliance in a finite population is (Cochran, 1977, eqn 6.82):

$$\widehat{R_{JK}} = w \cdot \hat{R} - (w-1) \cdot \widehat{R_{-}}$$

where

$w = n\left[1 - \frac{(n-1)}{N}\right]$ is a finite population correction factor, and

$\widehat{R_{-}}$ is the average of the *n* quantities $\widehat{R_{-J}}$.

An estimate of variance is also given by Cochran (1977, eqn 6.86):

$$var(\widehat{R_{JK}}) = \left(1 - \frac{n}{N}\right) \cdot \frac{(n-1)}{n} \cdot \sum_{j=1}^{n} \left(\widehat{R_{-J}} - \widehat{R_{-}}\right)^2$$

$$var(\widehat{R_{JK}}) = \left(1 - \frac{n}{N}\right) \cdot \frac{(n-1)^2}{n} \cdot var(\widehat{R_{-J}})$$

$$\widehat{SE(R_{JK})} = \sqrt{var(\widehat{R_{JK}})}$$

An approximate 95 percent confidence interval for the jackknife estimate was then formed as follows:

$$\widehat{R_{JK}} \pm t_{.025,(n-1)} \cdot \widehat{SE(R_{JK})},$$

where $t_{.025,(n-1)}$ is the 97.5th percentile of the student-*t* distribution with *(n-1)* degrees of freedom, and *N* in the formulas above is replaced by $\widehat{N}$.

***COMPARISON BETWEEN RATIO ESTIMATES AND JACKKNIFE ESTIMATES***

The ratio estimator used for previous biennia is a biased estimator, but has been ignored in previous biennia, and assumed to be very small. We compare the jackknife estimates to the biased ratio estimates for the past three biennia to evaluate the consequences that using the biased estimator may have had on interpretation of compliance results in the past.

***COMPLIANCE TRENDS***

FPA compliance has been monitored since 2006. In that time, there have been multiple changes (documented elsewhere) to the methods for monitoring compliance. The current compliance monitoring methods include tracking compliance with individual rules within prescriptions, while sampling the rule applications in clusters (FPAs) for convenience of sampling. The sample size for each year is set based on maintaining a set precision level 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 or samples necessary to reach a given 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 cause some difficulty in estimating trends through time. However, the rules that have been consistently monitored since 2010 can be and have been compared through time in this report. The compliance data from 2006-2009 have not yet been matched to current rules, although these data may be included in future reports.

For the 2010-2017 data, each rule was reviewed to make sure that the compliance determination was consistently applied in all years. For example, in the earlier time periods, some rules did not have a possibility of being recorded as non-compliant: if they existed on the application, then they were compliant. Rules such as this are not currently included in the rule compliance estimates for prescriptions, and were therefore not included in the trend analysis. In addition, the label or compliance question for some rules may have changed over time, potentially causing inconsistencies in the application of compliance determination. These issues were carefully considered and resolved before the final set of rules to be tested for trend was selected for each prescription.

For this biennium, 2016-2017, the method for estimating compliance and uncertainty around the compliance estimate has been changed to the jackknife method, to less biased estimator. The comparison between the jackknife estimates and the conventional ratio estimates for 2016-17 and

2014-15 compliance showed minor differences. The trends in compliance are therefore unlikely to be impacted by the choice of estimator. The jackknife estimators have been applied for annual compliance estimates for 2014-2017 at this point, and previous years with the conventional estimators.

Linear least-squares regression can be used to estimate general trends in average compliance through time. However, there are varying precision levels among years due to differences in sample sizes (proportion of population sampled) and in average cluster size (number of rules per FPA). In this case, the linear regression assumption of homogeneous variance is violated, which can cause biased estimates of trend. To adjust for this bias, we use weighted regression analysis, with the result in each year weighted by a relative variance estimate. In this way, years with more precise estimates of average compliance receive more weight in the regression, which compensates statistically for unequal variances. The trend estimates and significance level for both unweighted and weighted linear regression are supplied, with a 90% confidence interval for the annual trend (slope) for the weighted regression. Residuals from regressions are tested for approximate normality using Shapiro-Wilks test with alpha = 0.05.

# RESULTS

### *2016-2017 BIENNIUM RESULTS*

The jackknife estimates of compliance with FPAs and with Rules are displayed in Tables 1 and 2, respectively. The prescription compliance rates range from 87-100% indicated high compliance with forest practice rules. The uncertainty bounds maintain the target +/-6% width with the exception of the Np prescription, which had lower compliance and higher variance than expected based on historic estimates. The sample size relative to the expected population size will be adjusted for the next biennia to reflect these differences. Note that the jackknife-based confidence intervals are not symmetric. Also, sample size estimates will continue to be based on conventional ratio variance estimates.

### *COMPARISON BETWEEN RATIO ESTIMATES AND JACKKNIFE ESTIMATES*

The standard ratio estimates and associated confidence intervals for rule compliance are compared for 2016-2017 biennium in Table 3, and for the 2014-2015 biennium in Table 4. The differences are generally very small. The maximum difference in average compliance for the 2016-2017 biennium is a 0.22% reduction in compliance for roads, paired with a similar 0.16% increase in compliance for AB Wetlands. For AB Wetlands, average compliance using the jackknife estimator is 91.98%, whereas average compliance with the biased estimator would be 91.82%. The confidence intervals for the AB Wetlands prescription are shifted up by a similar amount, indicating that the bias in the standard error estimate was minimal. The confidence interval is slightly (0.007%) narrower. For the roads prescription, the jackknife estimate is 94.85%, versus 95.08% for the biased estimator. The upper confidence interval is at 100% for both methods, but the lower confidence interval is lower by 0.8% for the jackknife interval, indicating the small downward bias in the original standard error estimate.

For the 2014-2015 biennium, the largest difference in compliance rate was for the roads rules, which had a compliance rate of 98.44% using the standard method, but a compliance rate of 98.54% using the jackknife method (a difference of 0.1%). The DFC2 prescription had the largest downwards shift, going from 98.00% to 97.99% using the jackknife estimator, a difference of -0.01%. The width of the confidence intervals grew or shrank by similar amounts depending on bias in the standard error estimates. The largest increase in confidence interval width was for AB Wetlands, which went from 10.47% wide to 10.61% wide, an increase of by 0.13%. In contrast, the confidence interval width for roads decreased by 0.19%.

#### *COMPLIANCE TRENDS*

Change in annual rule compliance through time is displayed in Figure 1 and Figure 2, and trend statistics are given in Table 5. The relative weights used for weighted linear regression were used to size the points in the regression plots – larger points were weighted heavier in the regression based on variance estimates. For example, a higher proportion of the population sampled or a larger cluster size (i.e., more rules per FPA) in any given year reduces the variance and results in a heavier weight for the regression analysis. Slope estimates (i.e., average change in compliance per year) are given for weighted and unweighted regressions with p-values for significance tests, and a 90% confidence interval for the weighted regression slope. There is some evidence for increasing trends in compliance for Western Washington DFC2 prescriptions, and statewide NIZH and Ns prescriptions, with estimated average increases from 0.5 to 1% per year. Note that the residuals from the forested wetlands weighed regression displayed non-normal characteristics (Shapiro-Wilks test p-value 0.00006), but no further tests were conducted due to the obvious lack of trend displayed in Figure 2.

## DISCUSSION

The compliance with Forest Practices rules and applications remains high for the 2016-2017 biennium. The change to the jackknife estimator for compliance and uncertainty around compliance estimates has resulted in minor changes that do not affect the interpretation of compliance for this program, either for this biennium or historically.

There are some apparent increases in compliance since 2010 for some prescriptions, and no apparent decreases. Several caveats to these conclusions are needed: first, these methods are only testing for linear trends, and second, the 2010-2013 data have not yet been adjusted for the jackknife estimation method. The jackknife adjustments to earlier biennia are unlikely to result in large changes, but the annual trends observed are also small.

**Table 1: 2016-2017 Compliance with Forest Practices Applications for Riparian and Wetland Harvest Prescriptions**

| | | Western Washington | | Statewide | | | | | Eastern WA |
|---|---|---|---|---|---|---|---|---|---|
| | **Status of Compliance** | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Type A & B Wetlands | Forested Wetland | Roads | IZH (Census) |
| | | | | | | | | | |
| **Small Forest Landowners** | # Compliant Rules | 1 | n/a | 8 | 8 | 16 | 3 | 27.5 | 5 |
| | # with Deviation | 3 | n/a | 0 | 3 | 0 | 0 | 4.5 | 0 |
| | % of Sample Compliant | 25% | n/a | 100% | 74% | 100% | 100% | 82% | 100% |
| | Prescriptions Assessed | 1 | 0 | 3 | 5 | 5 | 2 | 3 | 1 |
| | | | | | | | | | |
| **Industrial Landowners** | # Compliant Rules | 75 | 50 | 57 | 70 | 74 | 14 | 98 | 30 |
| | # with Deviation | 3 | 3 | 5 | 8 | 2 | 0 | 2.0 | 1 |
| | % of Sample Compliant | 96% | 94% | 92% | 90% | 97% | 100% | 98% | 97% |
| | Prescriptions Assessed | 19 | 13 | 21 | 30 | 24 | 12 | 11 | 6 |
| | | | | | | | | | |
| **All Landowners** | # Compliant[1] | 76 | 50 | 65 | 78 | 90 | 17 | 125.5 | 35 |
| | # with Deviation[1] | 6 | 3 | 5 | 11 | 2 | 0 | 6.5 | 1 |
| | % of Sample Compliant | 93% | 94% | 93% | 88% | 98% | 100% | 95% | 97% |
| | Confidence Interval | (85,100) | (88,100) | (86,100) | (80,96) | (95,100) | n/a | (87,100) | n/a |
| | Prescriptions Assessed | 20 | 13 | 24 | 35 | 29 | 14 | 14 | 7 |

**Table 2: 2016-2017 Compliance with Forest Practices Rules for Riparian and Wetland Harvest Prescriptions**

| | | Western Washington | | Statewide | | | | | | Eastern WA |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Status of Compliance** | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Ns Activities | Type A & B Wetlands | Forested Wetland | Roads | IZH (Census) |
| **Small Forest Landowners** | # Compliant Rules | 4 | n/a | 13 | 6 | 0 | 19 | 6 | 27.5 | 12 |
| | # with Deviation | 3 | n/a | 1 | 3 | 0 | 1 | 0 | 4.5 | 2 |
| | % of Sample Compliant | 57% | n/a | 93% | 74% | 0% | 96% | 100% | 82% | 86% |
| | Prescriptions Assessed | 1 | 0 | 3 | 4 | 0 | 9 | 3 | 3 | 2 |
| **Industrial Landowners** | # Compliant Rules | 124 | 86 | 99 | 90 | 26 | 82 | 28 | 98 | 37 |
| | # with Deviation | 8 | 5 | 5 | 12 | 0 | 8 | 0 | 2.0 | 0 |
| | % of Sample Compliant | 94% | 95% | 95% | 88% | 100% | 91% | 100% | 98% | 100% |
| | Prescriptions Assessed | 19 | 13 | 21 | 31 | 26 | 34 | 14 | 12 | 5 |
| **All Landowners** | # Compliant[1] | 128 | 86 | 112 | 96 | 31 | 101 | 34 | 125.5 | 49 |
| | # with Deviation[1] | 11 | 5 | 6 | 15 | 0 | 9 | 0 | 6.5 | 2 |
| | % of Sample Compliant | 92% | 95% | 95% | 87% | 100% | 92% | 100% | 95% | 96% |
| | Confidence Interval | (87,97) | (89,100) | (90,99) | (79,94) | n/a | (87,97) | n/a | (88,100) | n/a |
| | Prescriptions Assessed | 20 | 13 | 24 | 35 | 31 | 43 | 17 | 15 | 7 |

**Table 3. Comparison of 2016-2017 rule compliance and confidence intervals using the standard ratio estimate method applied in previous biennia compared to the current jackknife method.**

| | | Western Washington | | Statewide | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Ns Activities | Type A & B Wetlands | Forested Wetland | Roads |
| | | | | | | | | | |
| Prescriptions Assessed | | 20 | 13 | 24 | 35 | 31 | 43 | 17 | 15 |
| # Rules Compliant[1] | | 128 | 86 | 112 | 96 | 31 | 101 | 34 | 125.5 |
| # Rules with Deviation[1] | | 11 | 5 | 6 | 15 | 0 | 9 | 0 | 6.50 |
| Standard Ratio Compliance Estimate | | 92.086% | 94.505% | 94.915% | 86.49% | 100% | 91.82% | 100% | 95.08% |
| 90% Confidence Interval | Lower Bound | 87.17% | 89.00% | 90.40% | 78.84% | n/a | 86.50% | n/a | 88.30% |
| | Upper Bound | 97.00% | 100% | 99.43% | 94.13% | n/a | 97.14% | n/a | 100% |
| | | | | | | | | | |
| Jackknife Compliance Estimate | | 92.093% | 94.507% | 94.913% | 86.60% | 100% | 91.98% | 100% | 94.85% |
| 90% Confidence Interval | Lower Bound | 87.18% | 89.00% | 90.40% | 78.95% | n/a | 86.66% | n/a | 87.51% |
| | Upper Bound | 97.01% | 100% | 99.43% | 94.25% | n/a | 97.30% | n/a | 100% |
| | | | | | | | | | |
| Jackknife - Standard Ratio Compliance | | 0.0069% | 0.0016% | -0.0025% | 0.1100% | 0% | 0.1590% | 0% | -0.2231% |
| Jackknife Half-width of CI - Standard Ratio Half-width of CI | | 0.0013% | 0.0013% | 0.0030% | 0.0044% | n/a | -0.0034% | n/a | 0.5652% |
| | | | | | | | | | |

**Table 4. Comparison of 2014-2015 rule compliance and confidence intervals using the standard ratio estimate method applied in previous biennia compared to the current jackknife method.**

| | | Western Washington | | Statewide | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | DFC1 | DFC2 | No Inner Zone Harvest | Np Activities | Ns Activities | Type A & B Wetlands | Forested Wetland | Roads |
| Prescriptions Assessed | | 20 | 14 | 25 | 35 | 35 | 35 | 23 | 13 |
| # Rules Compliant | | 131 | 98 | 116 | 128 | 59 | 120 | 38 | 81.7 |
| # Rules with Deviation | | 8 | 2 | 8 | 8 | 2 | 7 | 1 | 1.29 |
| Standard Ratio Compliance Estimate | | 94.24% | 98.00% | 93.55% | 94.118% | 96.72% | 94.49% | 97.44% | 98.44% |
| 90% Confidence Interval | Lower Bound | 91.01% | 95.22% | 87.46% | 89.40% | 92.04% | 89.25% | 92.21% | 95.30% |
| | Upper Bound | 97.48% | 100% | 99.64% | 98.84% | 100.00% | 99.73% | 100.00% | 100.00% |
| Jackknife Compliance Estimate | | 94.25% | 97.99% | 93.54% | 94.122% | 96.77% | 94.55% | 97.49% | 98.54% |
| 90% Confidence Interval | Lower Bound | 91.02% | 95.21% | 87.45% | 89.38% | 92.13% | 89.24% | 92.35% | 95.49% |
| | Upper Bound | 97.48% | 100.0% | 99.64% | 98.86% | 100.00% | 99.85% | 100.00% | 100.00% |
| Jackknife - Standard Ratio Compliance | | 0.0029% | -0.0070% | -0.0053% | 0.0046% | 0.0443% | 0.0575% | 0.0555% | 0.0997% |
| Jackknife Width of CI - Standard Ratio Width of CI | | -0.0026% | 0.0156% | 0.0072% | 0.0444% | -0.0980% | 0.1330% | -0.1443% | -0.1868% |

**Table 5. Results of analysis of linear trend through time on rule compliance**

| | Estimate of Annual Change (% per year) | Unweighted Regression | Weighted Regression | 90% Confidence Interval on Slope of Weighted Regression |
|---|---|---|---|---|
| DFC1 | Estimate | 0.80% | 0.65% | (-0.078, 2.1) |
| | p-value | 0.29 | 0.41 | |
| DFC2 | Estimate | 0.76% | 0.94% | (0.022,1.8) |
| | p-value | 0.13 | 0.094 | |
| NIZH | Estimate | 0.50% | 0.77% | (0.004,1.5) |
| | p-value | 0.32 | 0.099 | |
| Np | Estimate | -1.8% | -1.3% | (-5.0, 2.4) |
| | p-value | 0.34 | 0.50 | |
| Ns | Estimate | 0.50% | 0.55% | (0.004,1.1) |
| | p-value | 0.15 | 0.102 | |
| A&B Wetlands | Estimate | -1.0% | -0.49% | (-1.95, 0.96) |
| | p-value | 0.08 | 0.54 | |
| Forested Wetlands | Estimate | 0.0% | 0.0078% | (-0.87, 0.88) |
| | p-value | 1.00 | 0.99 | |
| Roads | Estimate | -0.19% | 0.45% | (-0.39, 1.3) |
| | p-value | 0.70 | 0.34 | |

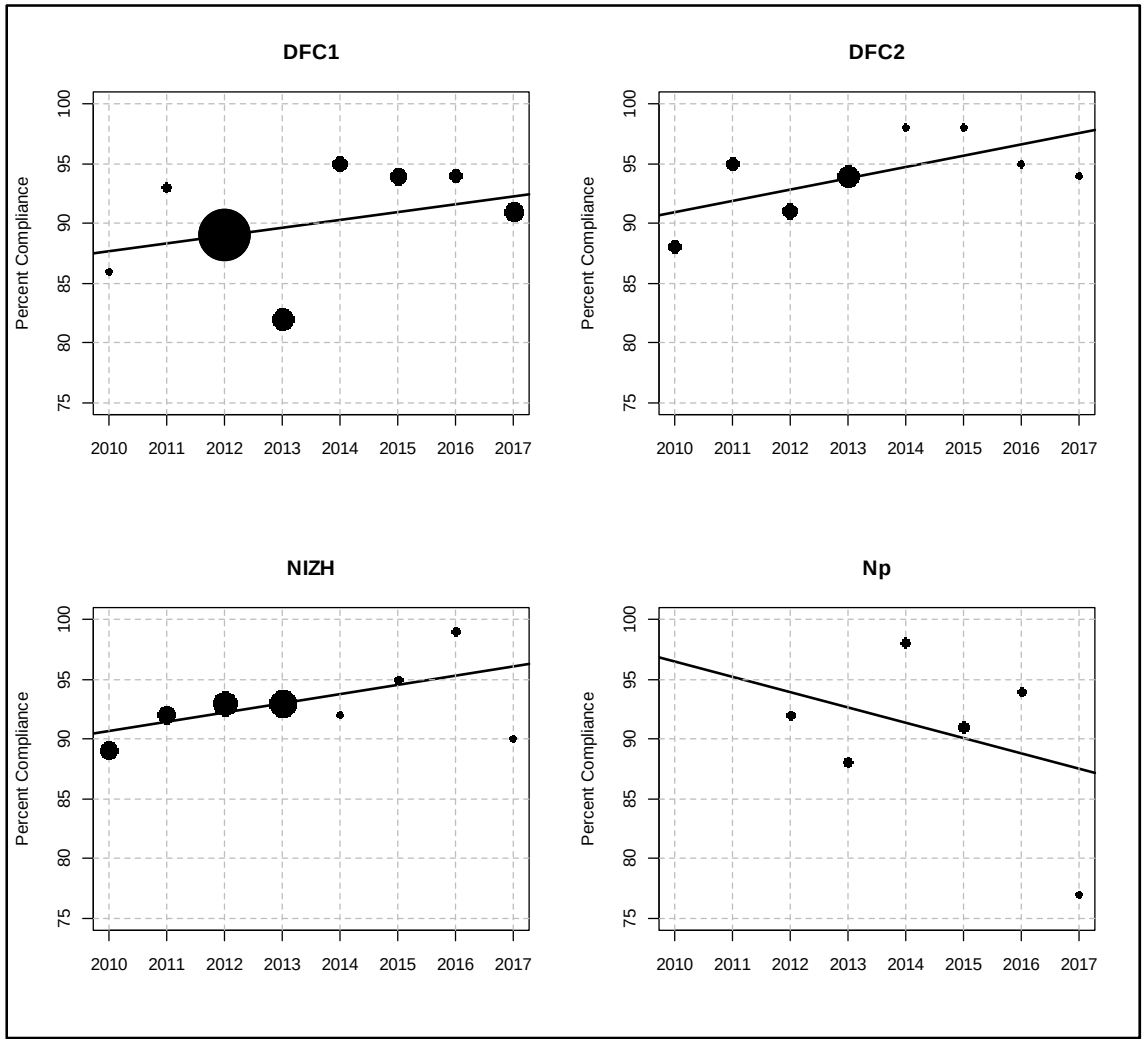



**Figure 1. Annual rule compliance for four prescriptions with weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.**

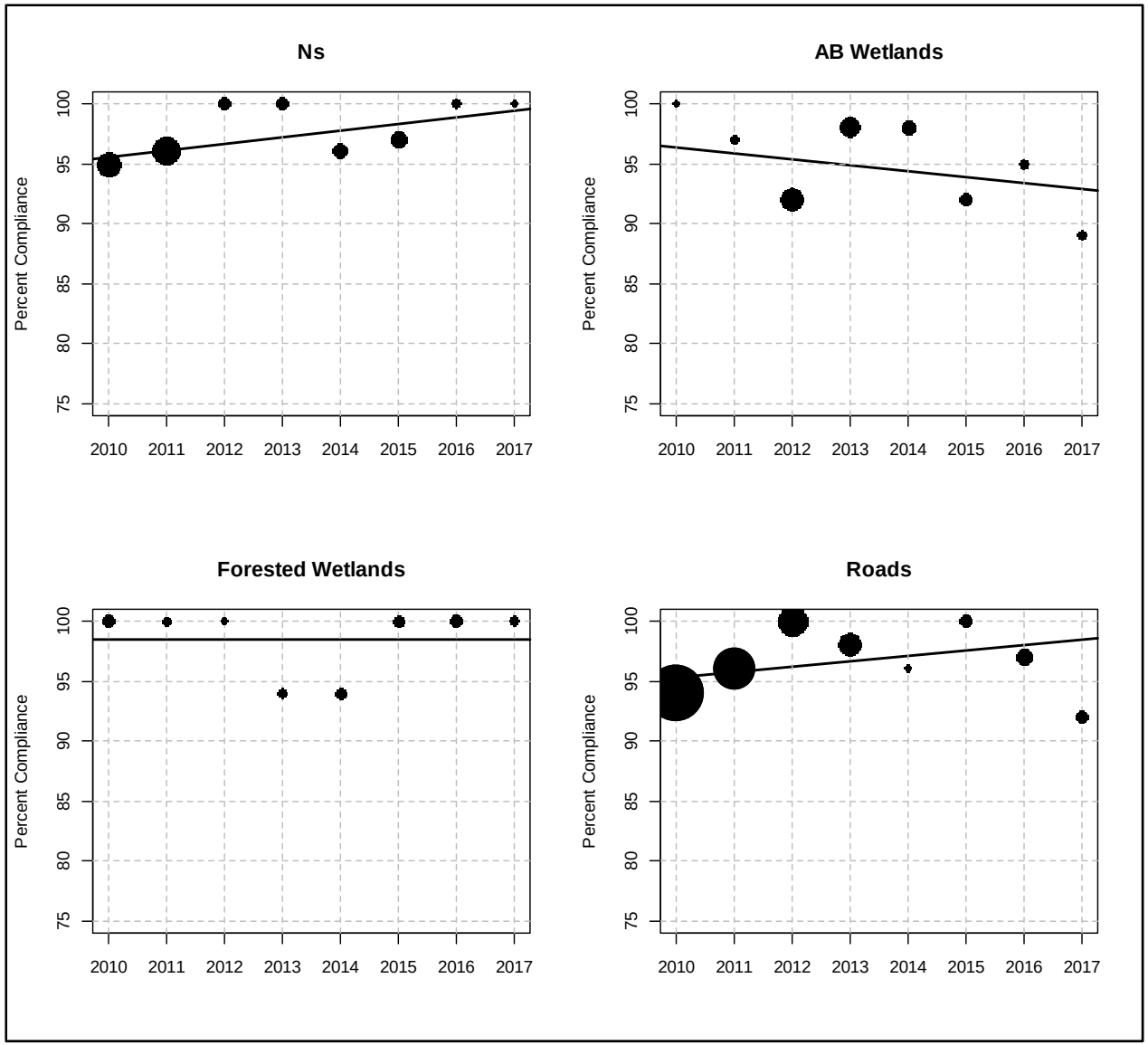



**Figure 2. Annual rule compliance for four prescriptions with weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.**

# 18. References

Cochran WG. 1977. Sampling techniques. New York: John Wiley & Sons.

Cochran WG. 1963. Sampling techniques. 2nd ed. New York: John Wiley & Sons.

Efron B. 1987. Better bootstrap confidence intervals. Journal of the American Statistical Association 82(397):171–85.

Gregoire TG. 1984. The jackknife: an introduction with application in forest data analysis. Canadian Journal of Forest Research 14(4): 493-97.

Scheaffer RL, Mendenhall W, Ott L. 1990. Elementary survey sampling. 4th ed. Boston: PWS-Kent.

Zar JH. 1996. Biostatistical analysis. 3rd ed. Upper Saddle River New Jersey.