DEPARTMENT OF NATURAL RESOURCES

Forest Regulation Division
1111 Washington St. SE
Olympia, WA 98504-7041

360 -
lila.westreich@DNR.WA.GOV
WWW.DNR.WA.GOV

M E M O R A N D U M

DATE: 10 August 2022

TO: Forest Practices Board

FROM: Lila Westreich, Compliance Monitoring Program Manager

SUBJECT: Compliance Monitoring Program 2020-2021 Biennium Report

Attached is the 2020-2021 Forest Regulation Compliance Monitoring biennium report, including data analysis, interpretation, and trend analysis of eight standard sample prescriptions and a periodic sample. All data was collected during the 2020 and 2021 spring field season at sites across Washington State. Trend analysis was conducted to understand how 2020-2021 compliance rates fit with the previous ten years of data analysis, from 2010-2021.

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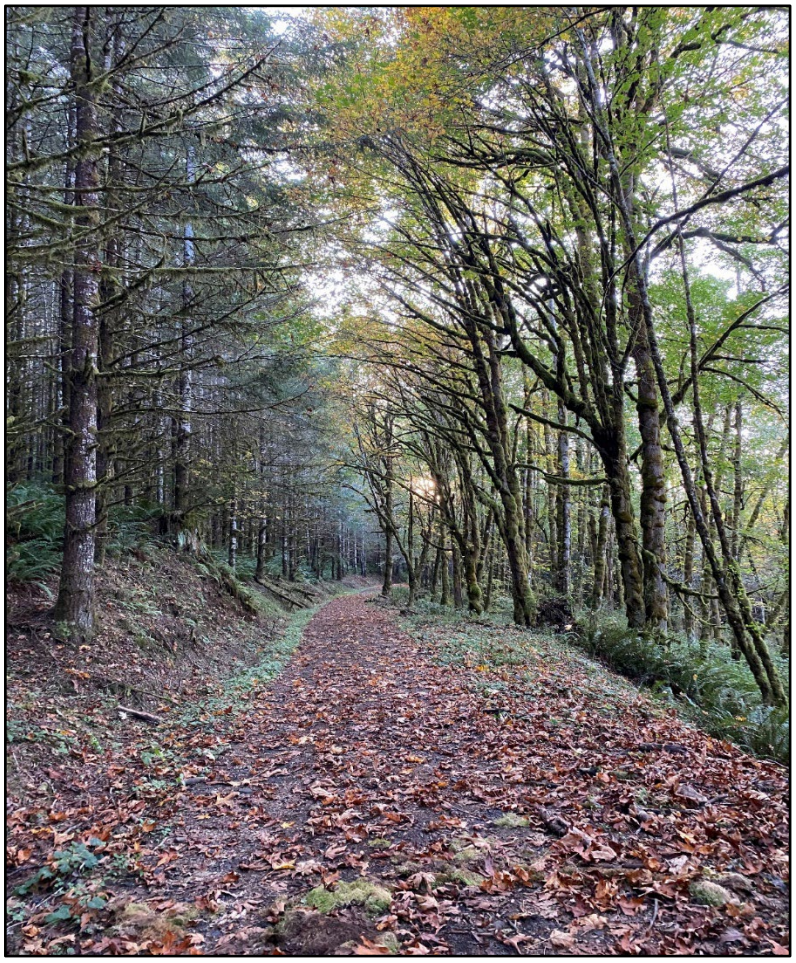


2020-2021 Biennium Forest Regulation Compliance Monitoring Report

August 2022

Lila Westreich
Compliance Monitoring Program Manager
Forest Regulation Division
Washington State Department of Natural Resources

Alice Shelly
Kleinschmidt R2 Consulting.

Contents

1. Executive Summary

The Forest Regulation Compliance Monitoring Program (CMP) is a key component of the Washington State Department of Natural Resources (DNR) within the Forest Regulation Division. Monitoring provides feedback to the Forest Practices Program about the pattern of on-the-ground compliance with forest practices rules and areas with a need for training, guidance, or clarification. The CMP informs the FP Program by providing an objective assessment of rule compliance (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. Forest practices rule compliance is prioritized for evaluation based on which rules are considered to have the greatest potential adverse impact on public resources, which include water, fish, wildlife, and capital improvements of the state and its political subdivisions (defined in RCW 76.09.020(25)). The evaluated rule groupings pertain to riparian and wetland areas and to road construction and maintenance.

Sampling Methodology and Prescription Sizes
For monitoring and appropriate statistical sampling, individual FP rules are grouped into categories of similar rules called "prescriptions." Forest Practice Applications (FPAs) are randomly selected from the total population of FPAs until the required number of prescriptions has been met – ensuring that the sample population for data collection is a randomly selected subset of the total number of FPAs expiring in the previous year. In each prescription, all applicable rules are assessed for compliance as part of data collection. FP rules that are monitored annually are referred to as the Standard Sample.

Prescription Type	WAC rule(s)	Standard Sample Assessed	Total FPAs population
Riparian protection: Desired Future Condition Option 1 (DFC1)	WAC 222-16-031, 222-30-021	16	68
Riparian protection: Desired Future Condition Option 2 (DFC2)	WAC 222-16-031, 222-30-021	13	292
Riparian protection: No Inner Zone Harvest (NIZH)	WAC 222-16-031, 222-30-021 and 022	15	1,484
Riparian protection: Non-Fish Bearing Perennial Waters (Np)	WAC 222-16-031, 222-30-021 and 022	33	1,780
Riparian protection: Non-Fish Bearing Seasonal Waters (Ns)	WAC 222-16-031, 222-30-021 and 022	24	1,855
Wetland protection: type A and B Wetlands	WAC 222-16-031, 222-30-020[6] and [7] and WAC 222-24-015	39	439
Wetland protection: Forested Wetlands	WAC 222-16-031, 222-30-020[6] and [7] and WAC 222-24-015	15	600
Road construction, maintenance, and abandonment	WAC 222-24	13	2,790

Haul Routes for sediment delivery	WAC 222-24	21	NA

The CMP assesses the alignment of water and wetland typing documented on specific FPAs with actual observations and measurements taken at the study site within the footprint of applicable FPAs (WAC 222-16-031 & WAC 222-16-035). The physical parameters (for example, stream width, stream gradient, etc.) are recorded for all waters and wetlands on site to make this comparison. Additional samples are included periodically to ensure non-standard sample rule groups are evaluated correctly such as unstable slopes and Forest Practices hydraulics project (currently on hold due to aerial herbicide pilot study in 2022-2023 biennium). For this report, the CMP conducted the first potentially unstable slopes for the standard sample to evaluate compliance with the FPAs for 2021, following an initial unstable slopes pilot study in 2019. Due to the relatively small size of the unstable slopes sample, this periodic sample is collected in odd years. The next sample will be collected in 2023. The outcome based on the two years of data collection will be provided in the 22-23 Biennial Report.

Study Design

The CMP modified the 2014-2015 compliance study design to increase precision in statistical estimates for each prescription type observed. The study design divides the number of sampled rules found to be compliant during field review by the number of total sampled rules within each prescription type, resulting in an average compliance rate. This approach increases statistical precision in results, and provides more information to help determine the individual rules with deviation associated with rule interpretation and implementation. The improved precision increases our ability to observe changes in compliance rates over time. The study design creates flexibility for future sampling to add or remove different prescription types from the sample as needed, while still providing the desired confidence intervals for each prescription type. Trend analysis is also included in this report, to assess how compliance ratings have changed over time and predict future compliance ratings based on linear regression analysis.

Findings

There have been statistically discernable increases in compliance since 2010 for some prescriptions and, equally notable, no significant decreases in rates of compliance with FP rules for any prescriptions. The 2020-2021 rule prescription compliance rates range from 88-98%, indicating generally high compliance with the grouped forest practices rules selected for monitoring. The highest compliance rate was found within the Roads and Haul Routes prescriptions (98%), and the lowest was in Type A and B Wetlands (88%). Further discussion of low compliance rates is available in this report in Section 4.2. Further exploration of indeterminate reasoning is available just below the results table. It should be noted that these results are bundled together to show all rules assessed in all prescriptions in all field reviews.

Prescription Type	Rules with Deviation	Compliant Rules	Evaluated Rules	Compliance Percentage
RMZ — Type Np Prescriptions	8	102	110	92.7%
RMZ — Type Ns Prescriptions	1	26	27	96.3%

RMZ — Type S or F No Inner Zone Harvest	3	74	77	96.1%
Forested Wetlands	1	27	28	96.4%
Type A and B Wetlands	12	88	100	88%
Western WA RMZ — Type S or F Inner Zone Harvest DFC1	10	116	126	92.1%
Western WA RMZ — Type S or F Inner Zone Harvest DFC2	2	91	93	97.8%
Roads	2.5	169	171	98.8%
Haul Routes*	NA	76.2 miles	77.4 miles	98.4%

*The haul route prescription does not use the same rule count as other prescriptions, rather in mileage of sediment compliance. More details can be found in the Haul Route Analysis further on in this report.

Water Typing

During the 2020-2021 biennium, the CMP visited 155 riparian-related sites involving typed water or wetlands for data collection. The individual compliance rate of each riparian-related site, including Type S or F No Inner Zone Harvest, Type Np and Ns prescriptions, Desired Future Condition prescriptions, and forested and non-forested wetlands can be found in the table above. Additional relevant data and results for water and wetland typing are located in Section 4.

Unstable Slopes

The Unstable Slopes FPA compliance sample was implemented in fall 2019 and repeated in 2021. The Unstable Slopes Sample resulted in a compliance rate in 2021 of 96%, with 72 rules found to be compliant out of 75 assessed rules across 25 prescriptions. Additional relevant data and results for unstable slopes are located in Section 8.

Trend Analysis

Compliance has been increasing in Western Washington riparian management zone DFC1 and DFC2 prescriptions, as well as for NIZH prescriptions, with estimated average compliance rates increasing from 0.6-0.9% per year over the 2020-2021 biennium (these results are based on compliance percentages from each year). No significant trends were observed for Np, Ns, Forested wetland or A/B wetland prescriptions. For the Roads prescriptions, trend analysis revealed 100% compliance rates for 7 out of the 12 previous years (2010-2021), with compliance rising from 93-99.8% in the past five years. Compliance with A and B wetlands has been more variable over the past 10 year sampling period (2010-2021). Additional insight and results for trend analysis can be found in Section 7.

Program Response to the Covid-19 Pandemic

Due to health and safety concerns as part of DNRs response to the Covid-19 pandemic the CMP was unable to perform standard sample field data collection until July 2020. As a result of the pandemic and the 2020 wildfire season, which had an early start and lasted longer than typical for the region, the scheduled fall 2020 Unstable Slopes study was postponed until fall 2021. The scheduled fall 2021 Forest Regulation Hydraulic Project study was postponed based on new hiring, training, and transitions within the CoMo program; the study will resume once CoMo

staff have completed current obligations and have available time to conduct fall sampling, expected in 2024 (Unstable Slopes will occur in 2023). The 2020-2021 biennial standard sample data collection was successfully completed on-time in 2021.

Recommendations for Changes within the Forest Regulation Program Based on CMP Results

An important goal of the CMP is to identify gaps in rule compliance and to try to understand why they may exist relative to administrative or operational implementation. This helps the Forest Regulation program develop training and education activities aimed at improving the rate of on-the-ground rule compliance in future forest activities. The following are some recent and on-going program adjustments aimed at addressing issues identified through compliance monitoring results:

- A recommendation in the WAC (Chapter 222-30) in reference to painting outer zone trees to reduce harvest would assist proponents in meeting this rule requirement.
- Training that focuses on wetland typing and how to implement applicable rules is recommended to address the underclassification of F water as wetlands. Additionally, clarification of wetland typing in the applicable WACs may also be needed to reduce confusion about how to distinguish F typed water from wetlands.
- Forest Practices Board Manual modifications and trainings for type A and B wetland identification are in development for expanding the range of information available to landowners and foresters in typing wetlands correctly.

2. Introduction

Photo by: Garren Andrews

Compliance monitoring is a component of the Washington State Forest Regulation Program. Section 2 gives a brief history about the genesis and development of the Compliance Monitoring Program (CMP), and explains key factors and concepts regarding compliance monitoring and the forest practices rules that are monitored.

2.1 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 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. Components that provide systematic feedback and facilitate change when needed have been intentionally designed and incorporated into the FP Program, which 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 include the Forest Practices Application Review System (FPARS) and FPA enforcement. Utilizing a well-defined, scientifically-informed process, the Forest Practice Board is authorized to adopt new FP rules, modify existing ones, and adopt technical guidance (in a "Board Manual") to help practitioners understand how to implement the rules. When the Board does that, the FP Program is responsible to ensure that the rules are followed in on-the-ground practice.

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, based upon best available science. When content from that report was enacted into law and the Board adopted rules in 2001 to implement it, compliance monitoring for forest practices became a legal requirement.

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 conducted 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: 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. 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 changes that have been proposed from CMP feedback.

2.2 Compliance Monitoring Program

Program Staffing
The DNR Forest Regulation assistant division manager for operations is responsible for the Compliance Monitoring Program. The DNR program staff includes a full-time program manager and a full-time field coordinator, along with funded participation for the equivalent of a 0.65 full-time staff person from the Washington State Department of Ecology. Tribal representatives and other Forest Regulation staff provide additional assistance.

Reports
Field sampling of completed FPAs occurs annually, and findings are presented in a biennial report as required by WAC 222-08-160(4). This report is a biennial CMP report and is based on samples conducted during the 2020 and 2021 field seasons. The data have been combined to produce the desired precision for statistical estimates and resultant comprehensive findings, conclusions, and recommendations in this biennial report.

Forest Practices Activities and Prescriptions
All forest practices activities such as timber harvest and forest road construction are subject to FP rules. Prescriptions are groupings of similar rules that apply to a forest practices activity, or prescription type. FP rules are divided and grouped by like topic/application for monitoring purposes.

Example: Forest practices activities such as road construction and timber harvest are evaluated based on the methods to implement a particular activity. Timber harvest in the riparian management zone has multiple models for desired future conditions (DFC) (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.”

These prescription types allow the CMP program to estimate compliance with specific rule groups rather than an overall forest practices compliance rate. This provides CMP with 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 is interested in developing new prescriptions to sample as forest practices adapts and evolves, and as interest in certain questions about compliance rates arise. CMP proposes new prescriptions for sampling, collaborates with stakeholders, and estimates the number of samples required for statistical precision of prescription compliance rates. Once pilot data has been collected and analyzed to increase efficiency and effectiveness of sampling procedure, this number of samples is then visited by the compliance monitoring field team for each of the FP rule prescription types, including the new types, over the course of the biennium.

Compliance
Each FPA is observed for compliance with two 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 finds that a deviation on an FPA can occur in one of the following three 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 they will leave an RMZ along the entire 1,000-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 can still be 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 activity has deviated from FP rules but complies with what the landowner stated on the FPA.
3) *The conditions on the ground deviate from both the FP rules and the FPA.*

The main role of the CMP is to determine on-the-ground compliance with FP rules (rule compliance). Understanding a deviation from what was noted in the FPA, or “FPA compliance,” will help DNR determine what improvements should be made in FPA forms, FPA application instructions, or in other methods of landowner outreach and education. Knowledge of the type of and potential cause for deviation helps to inform the efforts of the Forest Practices Program to improve understanding of the rule to influence rule compliance.

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 (it focuses on two landowner groups: small and large forest landowners).
- Focus on individual regions and compliance specific to that region (it focuses on statewide rule and FPA compliance).
- Tracking rule violations. When field reviewers encounter rule violations, the appropriate DNR regional staff is notified for further review.
- Modification of water types. Field reviewers’ record observed differences between water type documentation on FPAs and physical channel features.

2.3 Forest Practices Rules

Considered broadly, FP rules provide protection for many riparian and upland species and their forest habitat, as well as water quality protection. Currently, compliance monitoring focuses on

rules that protect habitat for aquatic and riparian species. Certain FP rule groupings are sampled yearly for statistical analysis of rule compliance statewide. These include:

- Riparian rules — Western Washington and Eastern Washington RMZ rules (WAC 222-16-031, 222-30-021 and 022)
- Road construction and maintenance rules (WAC 222-24)
- Wetland rules (WAC 222-16-031, 222-30-020[6] and [7]; and WAC 222-24-015)
- Haul routes (WAC 222-24) for sediment delivery

Available funding and associated staffing levels constrain the CMP's ability to monitor with statistical precision all FP rules that might affect the habitat of aquatic, riparian, and upland species. The CMP therefore prioritizes rule sampling based on the potential to adversely impact public resources.

Trend Analysis

For 2010-2021 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 (specifically, 2010-2015 data). If compliance for a particular rule was not assessed in accordance with current protocols, or was incomplete or was un-convertible, the rule was not included in the trend analysis dataset. Data are 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.

Additional sampling

Other FP rule groups are sampled as part of new prescriptions proposed for analysis, such as the Forest Practices Hydraulics Project (FPHP), unstable slopes, and Aerial Chemical Herbicide Application (proposed by the legislature for pilot study and potential inclusion into the standard sample). These samples are considered periodic Standard Samples. These other FP rule groups govern activities used less often than the rules sampled in the Standard Sample. The smaller population size and larger variance estimate usually leads to the CMP sampling a higher proportion of the total periodic sample population than is sampled in the (yearly) Standard Samples.

During the 2021 sampling period, unstable slope rules were sampled for FPA compliance. Unstable slopes will be sampled again in 2023 and reported on in the 2022-2023 biennial report.

3. 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 Regulation Compliance Monitoring Program Design and Compliance Monitoring Protocols*. More on sample selection and strategy procedures can be found in Appendix A. Section 3 explains key design and methodology concepts used in the Compliance Monitoring Program.

3.1 Population and Sample Selection

The population is the set of approved forest practices applications (FPAs) that had completed forest practices activities and expired between April 1, 2019, and March 31, 2021. Each FPA states all of the forest practices activities that the landowner is authorized 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 contains the prescriptions being evaluated.

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.

Average compliance for a prescription (for all rules it includes) across FPAs is calculated by the CMP instead of the proportion of completely compliant FPAs (all rule groups combined). Data is collected from samples for each individual prescription on an FPA. Sampled prescriptions are then grouped according to the sets of relevant rules they include. The prescription types include:

- Roads
- No Inner Zone Harvest (NIZH)
- Desired Future Condition Option 1 (DFC1)
- Desired Future Condition Option 2 (DFC2)
- Non-Fish-Bearing Perennial Waters (Np)
- Non-Fish-Bearing Seasonal Waters (Ns)
- Type A and B Wetlands (Non-forested wetlands)
- Forested Wetlands
- Unstable Slopes

3.2 Field Review and Data Collection

The compliance monitoring field team uses field observations and measurements. These 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 (BFW), among others. The following are examples of types of field observations and field measurements:

Riparian Harvest

- Observations:
    - Presence of alluvial fans, headwall seeps, and springs
    - Location of uppermost point of perennial flow
    - Presence of unstable slopes
- Measurements:
    - Bank full width (BFW) —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. Measured for Type S, F, and N waters, except where the waters obviously exceed or are below a threshold width (i.e., under or over 10 feet in Western Washington; under or over 15 feet in Eastern Washington).
    - Stream length — measured using a hip chain. The length is used to determine the stationing for BFW measurements and RMZ width measurements.
    - RMZ /WMZ widths — RMZ and WMZ widths (there are one to three zones within the RMZ) 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 on the CMP Roads Field Form. The questions address observed site conditions based on the required management practices in the FP rules (WAC 222-24-010, 020, 030, and 040). Haul routes are assessed in two ways: observation of fulfillment of road rule requirements, and professional judgment from CMP participants. Observations are used to rate sediment delivery levels resulting from each haul route. Haul Route compliance is calculated by distance. Compliance rate is calculated as the distance compliant divided by the distance sampled.

3.3 Compliance Assessment and Ratings

Compliance with individual rules is given binary (0 or 1) determination; the prescription compliance is the sum of compliant determinations divided by the sum of all compliance determinations made across all FPAs sampled for that prescription type.

Example: If a prescription has 17 rules that apply (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 Independent Scientific Peer Review (ISPR), this average compliance rate is then adjusted for potential bias using a jackknife estimation process (see Appendix for further explanation). In some cases, the bias adjustment has been large enough to change the compliance rate by up to one percentage point (e.g., 86% is adjusted to 87%).

Haul Routes
Haul routes are not sampled in proportion to regional population sizes. A stratified mean ratio compliance estimate is 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 based on statistical precision. Historically, sampling has not been done in a random manner, so there is potential for bias in the final estimate (however, sampling is based on previously randomly selected samples). Limiting potential conclusions based on statistical analysis of the Haul Route prescription is recommended. Conclusions could then be attributed in error to a phenomenon rather than to the method of sampling. The inclusion of the Haul Route prescription will be addressed over the next biennium.

Compliant/Deviation Determination
Compliance percentages published in CMP reports do not necessarily represent the complete picture of compliance with FP rules because of varying levels of compliance that are difficult to quantify. The compliance terminology was clarified to improve recognition and response to this issue. In the past, 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 portray the fact that while a prescription as a whole may deviate from FP rules, several of the FP rules that comprise a prescription may still be compliant.

For example, DFC2 prescription (leaving trees closest to Type S or F water in Western Washington) is not a single FP rule but a grouping of several rules. Some 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 within the DFC2 sample that deviated from compliance on at least one of the FP rules included in the prescription type.

It is important 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 the relevant rule required.

Compliance Ratings and Definitions

When assessing and rating compliance, the first step is to assess if the forest practice is Compliant or a Deviation. If the assessment cannot be made based on the data available it is labeled as Indeterminate. After this step, the reasons for deviation are applied. The options are shown below:

Compliance Assessment:	Exceeds Rule Requirement	Compliant	Deviation	Indeterminate
Deviation Assessment Reasoning	Layout	Operational	Administrative	

Compliant Rating Determinations

The Compliant rating means that an activity meets the requirements of the individual FP rule related 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 and that FP activities must comply with the FP Act and rules.

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, landowner/applicant provided more protection than required by FP rules.

*Deviation Rating Determinations**
The deviation rating is for an activity that does not meet the requirements of the individual FP rule. In order to gauge the magnitude of the deviation and where DNR might focus education and training efforts to improve compliance, the compliance monitoring field team uses professional judgment to examine deviations. Please note that these deviation ratings employ professional judgment and should not be used to excuse activities that violate FP rules or approved FPAs. A rating of Indeterminate means that the rule may be out of compliance, but the compliance monitoring field team cannot determine the deviation or another issue has prevented a compliance assessment from being determined. This is different from the lack of making a call as to why a deviation has occurred, which is covered below.

Deviation Reasons Determinations
The Deviation reason assessment is made by the field team as 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 attributing the impact of deviation observed in the field to a likely cause or contributing factor:

- 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.
    - A road cross drain is located such that increases sediment delivery.
- 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.
    - Erosion control measures not included on newly constructed road segments.
- 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.
    - Incomplete shade documentation.
    - Incorrect overstory species input into Desired Future Condition Worksheet.

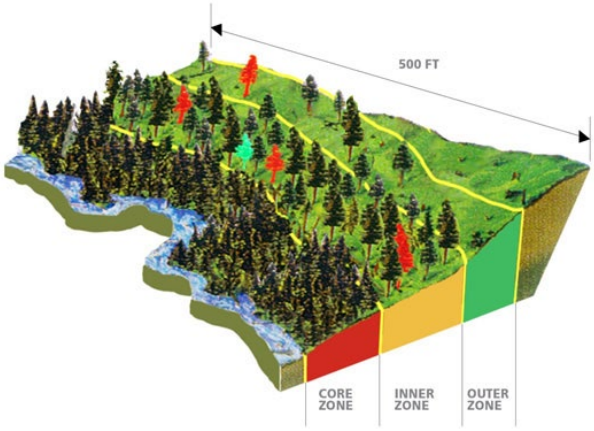
Note: Deviation ratings and reason determinations are not assessed for field form questions on the correct identification of site characteristics that determine which rules apply (i.e. water type, site class, and dominant overstory tree species). These data points are also not recorded when the field 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 the overall prescriptions are assessed as a Deviation. The examples show the process of assigning ratings to the deviation.*

Figure 1. Inner Zone Harvest with Deviation Rated as Low

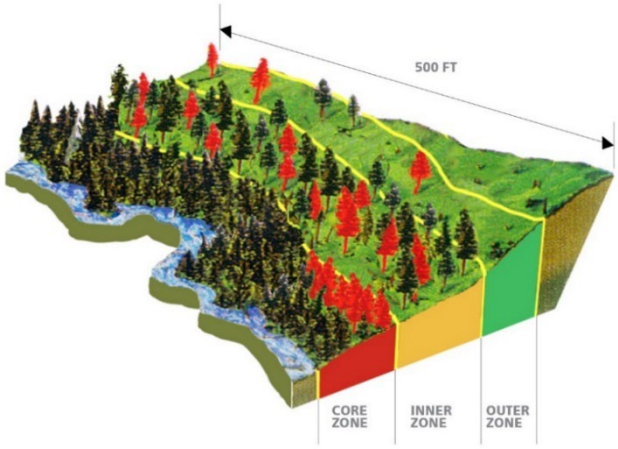
Figure 1 illustrates a riparian harvest adjacent to Type F water assessed as a Deviation and rated as Low. In this example, the landowner/applicant followed multiple FP rules by typing the waters accurately; measuring the stream width correctly; correctly measuring the core, inner, and outer zone widths;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

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 one tree per 500 feet was taken out of the outer zone, three 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).

Figure 2. Inner Zone Harvest with Deviation Rated as High



In contrast, Figure 2 illustrates an example of inner zone harvest assessed as a Deviation and rated as High. 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 three 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.

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

*It should be noted that during data collection under previous Compliance Monitoring Program managers and field coordinators, a ‘rating system’ of high, medium, and low were applied to each deviation. Due to a lack of basis for this determination, a lack of connection for those qualifiers back to individual forest practices rules, and the possibility of under or overrepresentation of a deviation, this system has been paused for the 2020-2021 biennium. The CMP manager plans to resume these ratings once a system has been established to understand the impact of these ratings in the program’s understanding of rule compliance.

3.4 Evaluation of Rule Compliance

The CMP utilizes cluster sampling. There are two levels of sampling units: the prescriptions and the rule application. The prescriptions are clusters of rule applications. In the previous method, only one assessment was made for each prescription per FPA, so the FPAs were all clusters of size 0 or 1. 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 maximum total number of rules under one instance of that given prescription), so the FPAs are treated as clusters.

The *average* compliance for a prescription or rule group among FPAs is an estimate rather than the proportion of completely compliant activities among FPAs. As noted in the sampling procedure (Appendix A), 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 constituent rules for the given prescription type are part of the population (from a random sample). See Appendix A for an in-depth description and detail on average compliance calculations.

3.5 Compliance Monitoring Challenges

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 sample averages vary depending on where measurements are taken. It is unlikely that the compliance monitoring field team can duplicate the exact same 10 measurements made along a stream reach for calculating stream width as were measured by a landowner when preparing their FPA. 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 distance to edge of bank full width; 2) buffer widths and lengths or floors within RMZs 3) bank full width of N and F/S waters. When a landowner's average potential error is within 5% of the compliance monitoring field team's finding for the rule requirements, 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.

Seasonal Effects on Water Typing Between Np/Ns
Seasonal conditions can impact the CMP's ability to accurately determine water typing between Ns and Np stream segments. In the spring, when FPA-typed Ns segments have observed water flow it is difficult to differentiate between seasonal and perennial water types. The CMP field team researches forester field notes, landowner-provided documentation, vegetative indicators, and uses professional judgement to make typing decisions. When there is not enough information

to make an accurate decision, CMP field team marks the typing as Indeterminate. If new information becomes available at a later date, the CMP may review the indeterminate decision.

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 good example of FP rules conflicting with on-site conditions is when a stream reach has rule-defined characteristics of both a Type Np water and a Type F water, absent an approved water type modification form. Type Np waters are defined as perennial non-fish habitat waters. Type F waters are defined as having a gradient equal to or less than 20% (along with other criteria omitted here for the purposes of the example). When a stream reach (> 500') meets the physical criteria for a Type F water, but also lies upstream of a portion of a stream reach that has a gradient greater than 20%, the water is considered Type F based on the physical characteristics defined in WAC 222-16-031. The only *exception* is when an approved Water Type Modification Form (WTMF) or supporting Interdisciplinary Team (ID Team) documentation exists and has resulted in a change of the water type.

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

FP rules are intended to protect aquatic resources and related habitat adjacent to typed waters and wetlands when subject to forest practices jurisdiction. Riparian and wetland areas provide valuable habitat and protect water quality. The area adjacent to Types S, F, or Np waters is a riparian management zone (RMZ), where trees are retained to provide functions required by aquatic and riparian species, maintain water quality, and provide protection from disturbance. A wetland management zone (WMZ) is the area located around the perimeter of a wetland habitat. Trees are retained to provide functions required by wetland species, maintain water quality, and provide shade, nutrients and protection from disturbance. Both types of buffers provide for bank stability, recruitment of woody debris, leaf litter fall, sediment filtering and shade.

An equipment limitation zone established in rule (ELZ) protects Type Np and Ns waters. The ELZ is a 30-foot-wide zone adjacent to Type Np and Ns waters. There are limitations on equipment use within the ELZ, and mitigation measures are required if other activities expose soil on more than 10% of the zone. The rule protection measures that guide timber harvest options within RMZs depend on the water type, the width of the stream, and the site (soil productivity) class. Wetland protection depends on the type and size of the wetland.

Sections 4.1 through 4.4 provide 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

Sampling for shade compliance began during the 2018-2019 biennium. Compliance was measured through review of the provided shade documentation attached to the approved FPA. For sufficient documentation, the proponent had determined that shade would adequately be maintained from timber harvest. Shade documentation was assessed only for those prescriptions where it would be applicable and required by the landowner on the FPA.

Statewide Water Type Observations

The CMP focuses on consistency and accuracy of water and wetland type information on FPAs. The width and length of riparian buffers required under FP rules are included in the different rules surrounding water and wetland types.

In the FP rules, water and wetlands are classified in specific categories, or "types," based on several factors (WAC 222-16-030, 031, and 035).

Water type and wetland type classification is a basic step of determining what rules apply to forest practice activities adjacent to typed water. Specific rules apply to specific water and wetland types because different water and wetland types fulfill unique and cumulative functions for aquatic and riparian species and water quality. Waters and wetlands of the state were initially classified by type using local knowledge and aerial photo imagery and were symbolized on water type maps. Today, the public can find information about the water or wetland type assigned to a particular water on the Forest Practices Application Review System (FPARS) mapping site. Because many of the typing labels on waters and wetlands depicted on DNR water type maps were originally created without a field visit, the maps sometimes display incorrect water or wetland types or miss streams altogether and must be field verified by landowners as a condition of FPA approval.

FP Rules for Water Type

WAC 222-16-031 defines four types of streams (S, F, Np, and Ns) and WAC 222-16-035 defines three types of wetlands (forested and, non-forested type A [including bogs >0.25 acre], and non-forested type B). The four stream types are classified in order based on stream function and level of protection required for the stream.

- Type S waters (highest level/most protective): "Shorelines" of the state as designated by the Department of Ecology.
- Type F waters (next highest level/protection): "Fish" use, specifically defined human uses, or both.
- Type Np waters (next lowest level/protection): Non-fish-bearing waters that have a perennial flow of water *during a normal rainfall year* and intermittent dry portions of the perennial channel downstream from perennial reaches.

- Type Ns waters (lowest level/protection): 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 and Wetland Types

Based on field observations, the CMP sometimes observes physical characteristics do not align with those submitted on maps with the FPA, and described in rule for the stated water type. These will be determined non-compliant. The only *exception* to water typing determinations based on physical stream characteristics is when an approved Water Type Modification Form (WTMF) or supporting Interdisciplinary Team (ID Team) documentation exists and has resulted in a permanent change of the water type. Landowners may use existing DNR water type maps as a starting point for information as they prepare their FPA.

To submit a completed application to DNR, the proponent must verify water and wetland types located within the areas proposed for forest practices activities on the FPA. Correct water and wetland typing is required. When a stream segment or wetland is incorrectly underclassified, inadequate riparian protection measures may result and may negatively affect public resources. If a stream segment or wetland is overclassified, unnecessary protection may be provided, to the detriment of the proponent's objectives for the forest practice activity.

Water and wetland type verification means the on-site 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.

Proponents may propose changes to DNR water type maps when field observations (including protocol surveys) verify that the water or wetland type on the water type map is incorrect and/or if a water or wetland 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 or wetland type indicated on the DNR water type map, an individual submits a Water Type Modification Form (WTMF) to DNR. The Water Type Modification Form goes through a concurrence review 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. The information collected is not comprehensive enough to determine all water types and depends 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 Supplemental Water Information Form (SWIF) is developed specifically for recording potential water or wetland type and other water-related discrepancies. A SWIF is completed when the compliance monitoring field team identifies possible inconsistencies between on-the-ground measurements and observations and what is described in the FPA. This information is reported in the compliance monitoring report. If a rule violation occurred because of the water or wetland type inaccuracy observed (i.e., the riparian protection buffer width or length was inadequate), then the information relating to the violation is sent to the appropriate DNR region for regulatory follow up. The SWIFs are used to obtain a sense of both the overall magnitude of possible water and wetland typing discrepancies on the landscape and the potential incorrect implementation of riparian buffers.

The compliance monitoring field team does not do formal water typing (e.g., fish protocol surveys) to update water types. Water and wetland typing has a defined process beyond the scope of the compliance review. Landowners are responsible to ensure that the water and the wetland types on the FPA have been field-validated.

Findings for Statewide Water and Wetland Types

Water and wetland 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 or wetland 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 shows a Type Np water that after observation is found to have Type F physical characteristics (without WTMF/protocol survey documentation) or observed fish.
- Overclassified — Physical characteristics show that the water or wetland should have been typed on the FPA and protected on the ground at a lower level of the water-typing scale.
    - For example, the FPA inaccurately shows a Type Ns water that after observation is found to be a non-typed water.
- Indeterminate — Waters or wetlands 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. 2020-2021 Water and Wetland Typing Observation Information

Water Type on FPA	# Waters and Wetlands in Standard Sample	# Waters and Wetlands Recorded on SWIF	SWIF** # Waters and Wetlands Underclassified	SWIF # Waters and Wetlands Overclassified	SWIF # Waters and Wetlands Indeterminate
F or S	45	0	*	0	0
Np	34	1	0	0	1
Ns	31	8	1	0	7
Type A Wetlands	20	13	5	8	0
Type B Wetlands	19	5	4	1	0
Forested Wetlands	15	1	1	0	0
Total	164	28	11	9	8

*Compliance monitoring field protocols stipulate that F or S waters are not to be evaluated for underclassification, as there is no higher water classification.
**SWIF = Supplemental Water Information Form.

Water and wetland typing observations from 2020 and 2021
Of the 164 sampled waters and wetlands in 2020 and 2021, SWIFs were completed for 28 samples due to water and wetland typing discrepancies.

Eleven samples were underclassified, resulting in an underclassification rate of approximately 7%. No approved Water Type Modification forms (protocol surveys) were contained within the paper records for the FPAs with underclassified waters. Of the eleven underclassified segments, three type B wetlands and five type A wetlands were observed to be associated with fish waters.

- The underclassification of the eight wetland segments was a result of misclassification of a fish stream as a type A or B wetland on the approved FPA. All eight wetlands still provided adequate resource protection as appropriate for fish streams, resulting in these situations being deemed Administrative. Administrative deviations typically exist due to paperwork errors during the FPA approval process, and approval errors by DNR.
- One type B wetland was determined to be type A wetland. The wetland was observed to have over 0.5 acres of open water, meeting the criteria for type A wetlands.
- One Forested Wetland was determined to be underclassified. A channel with flowing water was observed coming into and out of the wetland, as well as flow observed within the wetland, resulting in the field team determining the wetland to be an Np, with no supporting water type modification form or Interdisciplinary Team documentation to support lower order wetland typing, resulting in the underclassification of the sampled segments.
- One Ns stream was determined to be an Np stream by the CMP field team. Flow was observed within the channel during late July. There was no supporting water type

modification form or Interdisciplinary Team documentation to support lower order stream typing, resulting in the underclassification of the sampled stream segment.

Nine samples were overclassified, resulting in an over-classification rate of 5%.

- Seven type A wetlands were determined to be a type B wetlands, and measured to be smaller in area than reported on the FPA.
- One type A and one type B wetland were determined to be Forested Wetlands because on-site measurements indicated that there was greater than 30% crown closure and the wetland did not meet bog characteristics.

Eight samples (5%) were indeterminate.

- Water flow was observed in seven Ns stream segments during site visits in March and April. A determination could not be made about the potential for perennial flow within the segment during the drier time of the year.
- One Np stream segment was too steep to safely traverse and measure, and so a typing determination could not be made.

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

Section 4.2 provides two summary tables: Table 6 lists the RMZ, WMZ, and ELZ prescriptions sampled in 2020 and 2021; Table 7 shows statewide results for compliance with RMZ and WMZ FP rules. The data and findings for each prescription are discussed in Section 4.3 (Western Washington RMZs) and Section 4.4 (Statewide RMZs, WMZs, and ELZs).

Table 6. RMZ, WMZ, and ELZ Prescriptions Sampled in 2020-2021

Western WA	Eastern WA	Statewide
RMZ — DFC Option 1, Thinning from Below RMZ — DFC Option 2, Leaving Trees Closest to Water	RMZ – Inner Zone Harvest, Thinning from Below (not currently sampled)	WMZ — Wetlands RMZ — No Inner Zone Harvest ELZ — Type Ns & Np Activities RMZ — Type Np

Each prescription has a specific 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. Rule prescriptions for Type F and N waters can differ between Eastern and Western Washington. However, samples were not separated by Eastern and Western Washington. Wetland rules are the same for Eastern and Western Washington.

Table 7. 2020-2021 Compliance with FP Rules for Riparian, Wetlands and Roads Prescriptions

		DFC1	DFC2	NIZH	Statewide Np	Ns	AB Wetlands	Forested Wetlands	Roads
Small Forest Landowners*	# Compliant Rules	0	13	15	16	3	22	3	0.0
	# Rules with Deviation	0	1	0	3	0	3	0	0.00
	% of Sample Compliant	NA	92.9%	100%	84.2%	100%	88.0%	100%	NA
	Unbiased Compliance Estimate	NA	92.9%	100%	84.5%	100%	88.8%	100%	NA
	Prescriptions Assessed	0	2	3	7	3	12	2	0
Industrial Landowners	# Compliant Rules	116	78	59	86	23	66	24	169
	# Rules with Deviation	10	1	3	5	1	9	1	2.47
	% of Sample Compliant	92.1%	98.7%	95.2%	94.5%	95.8%	88.0%	96.0%	98.6%
	Unbiased Compliance Estimate	92.1%	98.7%	95.2%	94.5%	95.9%	88.2%	96.2%	98.5%
	Prescriptions Assessed	16	11	12	26	21	27	13	13
All Landowners	# Compliant Rules	116	91	74	102	26	88	27	169
	# Rules with Deviation	10	2	3	8	1	12	1	2.47
	% of Sample Compliant	92.1%	97.8%	96.1%	92.7%	96.3%	88.0%	96.4%	98.6%
	Unbiased Compliance Estimate	92.1%	97.9%	96.1%	92.8%	96.3%	88.2%	96.6%	98.5%
	95% LCL	88.3%	94.7%	90.1%	88.1%	88.7%	80.1%	89.0%	96.2%
	95% UCL	95.9%	100%	100%	97.4%	100%	96.2%	100%	100%
	Prescriptions Assessed	16	13	15	33	24	39	15	13

***** The relatively small number of small forest landowner FPAs in Table 7 reflects the small proportion of total small forest landowner FPAs within the total population of all FPAs that included the prescriptions that were assessed. The CMP cautions readers about drawing conclusions from the small forest landowner results shown in Table 7 due to the very small sample size and associated smaller statistical precision of this group.

4.1 Western Washington RMZs

Western WA Type S and F Waters

Section 4.1 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 and outer zone widths) the same as stated on the FPA? If not, does it affect the inner and outer zone widths?

In addition to common questions relevant to all Type S and F 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.

Western WA Type S and F Waters — DFC1, Thinning from Below
Desired Future Condition Option 1 is available for a landowner to use on their FPA if DFC growth modeling results project that the combined core and inner zone stand is on a developmental trajectory to meet the DFC requirement for 325 square feet of basal area per acre at an age of 140 years. If so, then harvest of projected surplus is allowed from within the inner zone. The smallest diameter trees can be harvested, followed by progressively larger trees until the surplus basal area limit has been reached (this form of treatment is referred to as “thinning from below”). A minimum of the 57 largest conifer trees per acre must be left in the *inner zone*. A minimum of 20 trees per acre must be retained in the *outer zone,* with exceptions under certain circumstances. The leave trees in the outer zone may be

dispersed evenly or clumped around sensitive features such as seeps, springs, and forested wetlands. Starting in 2018, as harvest is allowed within 75' of bank full width, the team evaluates documentation of shade requirements to determine rule compliance (WAC 222-30-040).

This tree selection process is used to establish a forest environment providing the opportunity for increased growth rate of leave trees in the inner zone. This is expected to provide the desired large wood, fish habitat, and water quality requirements in a reduced amount of time. The widths of the inner zone and outer zone vary depending on bank full width and site class.

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 because of the number of requirements that must be met. This harvest strategy occurred on an estimated 68 FPAs in the 2020-2021 population.

Table 8. 2020-2021 Compliance Ratings for Western WA Type S and F Waters — DFC1, Thinning from Below

Rule	WAC reference	FPAs Compliant	FPAs Deviation	FPAs Indeterminate	FPAs Total	% Compliant	% Deviation
Overstory Tree Species match DFC worksheet	222-30-021(ii)(B)(I)	15	1	0	16	94%	6%
Site Class	222-16-010	16	0	0	16	100%	0
Stream Size/typing	222-16-031(2)(3)	16	0	0	16	100%	0
No harvest in Core Zone	222-30-021(a)	15	0	1	16	94%	0
Inner Zone meets diameter leave tree requirements	222-30-021(ii)(B)(I)	12	3	1	16	75%	6%
Largest 57 TPA* left in Inner Zone	222-30-021(ii)(B)(I)	15	0	1	16	94%	0
If harvest planned within 75ft. of BFW/CMZ was shade documentation included?	222-30-040	11	4	0	16	69%	25%
CMZ present but not recorded on FPA	222-30-020(13)	2	0	0	2	100%	0
Correct # Outer Zone leave trees	222-30-021(iii)(c)	12	2	1	16	75%	13%

*TPA = trees per acre.
The total number of rules sampled and analyzed was 126; 116 were found to be compliant for the DFC1 prescription sample, and 10 were a Deviation, resulting in a 92.1% compliance rate (Table 7).

For compliance assessment, a total of 16 randomly selected samples were used for on-the-ground data collection. A total of 10 rule violations were found across the 126 total compliance questions answered. Indeterminate calls are listed in table format below.

Rule	WAC reference	FPAs Indeterminate	Reason
No harvest in Core Zone	222-30-021(a)	1	Notes dictate that entire unit was "unmanageable" and "unsafe" due to blowdown, no data could be collected safely to determine rule compliance. No apparent resource issue in all inspected areas. Tree counts were noted to be "on track to be compliant if we were to walk the rest."
Inner Zone meets diameter leave tree requirements	222-30-021(ii)(B)(I)	1	Same reason as above.
Largest 57 TPA* left in Inner Zone	222-30-021(ii)(B)(I)	1	Same reason as above.
Correct # Outer Zone leave trees	222-30-021(iii)(c)	1	Same reason as above.

Western WA Type S and F Waters — DFC2, Leaving Trees Closest to the Water
Desired Future Condition Option 2 can be used only within either:

- RMZs upon productivity site classes I, II, and III along waters that are ≤10 feet wide; and,
- RMZs growing on site classes I and II that are adjacent to waters >10 feet wide.

For this option, DFC growth modeling is used to determine if there is a projected available surplus basal area that would allow partial harvest to occur within 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. For site classes I, II, and III on waters ≤ 10 feet, a 30-foot no-harvest area extends outward from the outer edge of the core zone. For site classes I and II on waters >10 feet, a 50-foot no-harvest extension begins at the outer edge of the core zone. Twenty trees per acre must be retained after harvest in the outer zone, with certain exceptions. 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 easier to implement compared to DFC Option 1 and is applied more frequently. This harvest strategy occurred on an estimated 292 FPAs in the 2020-2021 population.

Table 9. 2020-2021 Compliance Ratings for Type S and F Waters in Western WA — DFC2, Leaving Trees Closest to the Water

Rule	WAC reference	Assessed FPAs Compliant	Assessed FPAs Deviation	Assessed FPAs Indeterminate	Assessed FPAs Total	Percent Compliant	Percent Deviation
Overstory Tree Species match DFC worksheet	(222-30-021(ii)(B)(I))	13	0	0	13	100%	0

Site Class	(222-16-010)	13	0	0	13	100%	0
Stream Size/ typing	(222-16-031(2)(3))	13	0	0	13	100%	0
No harvest in Core Zone	222-30-021(a)	13	0	0	13	100%	0
No harvest in Inner Zone Floor	(222-30-021(ii)(B)(II)	13	0	0	13	100%	0
20 conifer TPA in outer portion of Inner Zone	(222-30-021(ii)(B)(II))	13	0	0	13	100%	0
CMZ present but not recorded on FPA	222-30-020(13)	2	0	0	2	100%	0
Correct # Outer Zone leave trees	(222-30-021(iii)(c))	11	2	0	13	85%	13%

The total number of rules sampled and analyzed was 93; 91 were found to be compliant for the DFC2 prescription sample, and 2 were a Deviation, resulting in a 97.8% compliance rate (Table 7). For compliance assessment, a total of 13 randomly selected samples were used for on-the-ground data collection. A total of 2 rule violations were found across the 13 samples. Compliant and Deviation totals for each rule are outlined above (Table 9). No indeterminate calls were made for DFC2 prescriptions in the 2020-2021 biennium.

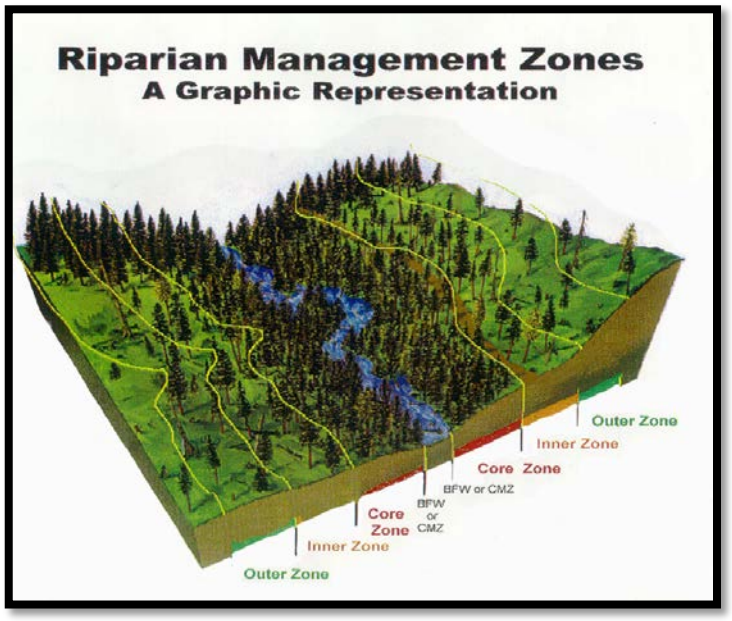
4.2 Statewide RMZs, WMZs, and ELZs

Statewide Typed Waters

Protection measures adjacent to typed water include protecting channel migration zones (CMZs), establishing riparian management zones (RMZs) along the full length of fish-bearing waters and along portion of the lengths of perennial non-fish-bearing waters, retaining no-harvest buffers adjacent to sensitive sites, and establishing equipment limitation zones (ELZs) in which equipment use is restricted in areas closest to 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 (Figure 3).

In Western Washington, timber harvest or road construction is prohibited from the 50-foot core zone on fish-bearing waters (zone closest to the water). Exceptions are for construction and maintenance of road crossings and for creation and use of yarding corridors used for timber extraction. The inner zone (middle zone, not including core zone) ranges from 10 to 100 feet, depending on the 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), generally 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 closest to steams where equipment use is limited to minimize ground and soil disturbance. The ELZ protects stream bank integrity and helps minimize sediment delivery to non-fish-bearing waters.

Riparian management includes retention of buffer areas of leave trees and other vegetation to maintain critical riparian functions (such as shade), contribution of large woody debris, streambank stability, sediment filtering, and litter leaf fall. In Eastern Washington, management is designed to mimic local disturbance regimes (such as wildfire) in a way that protects riparian function conditions and maintains general forest health. RMZ requirements are based on some combination of site productivity (site class), stream size, timber habitat type, basal area, and shade requirements. The no-harvest core zone along type S and F waters is 30 feet. Forest practices adjacent to Types S and F waters 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.

Statewide Type S and F Waters — No Inner Zone Harvest

For the No Inner Zone Harvest (NIZH) option, DFC results might show that existing stands in the combined core and inner zone do not meet stand requirements in Western Washington and therefore, inner zone harvest cannot take place, or sometimes the landowners elect not to harvest in the inner zone for operational or other reasons. Where harvest was permitted within 75’ of BFW, documentation that shade requirements were met was evaluated for rule compliance beginning in 2018. No Inner Zone Harvest is the most frequently selected harvest strategy adjacent to fish-bearing waters. This harvest strategy occurred on an estimated 1,484 FPAs in the 2020-2021 population.

Table 10. 2020-2021 Compliance Ratings for Statewide Type S and F Waters — No Inner Zone Harvest

Rule	WAC reference	FPAs Compliant	FPAs Deviation	FPAs Indeterminate	FPAs Total	% Compliant	% Deviation
Stream Size/typing	(222-16-031(2)(3))	15	0	0	15	100%	0
Site Class	(222-16-010)	15	0	0	15	100%	0
No harvest in Core Zone	(222-30-021(a))	15	0	0	15	100%	0
No harvest in Inner Zone	(222-30-021(b))	14	1	0	15	93%	7%

Correct # Outer Zone leave trees	(222-30-021(iii)(c))	12	2	0	14	86%	14%
Observed CMZ not noted in FPA	(222-30-020(13))	2	0	0	2	100%	0
Appropriate shade doc included?	(222-30-040)	1	0	0	1	100%	0

The total number of rules sampled and analyzed was 77; 74 were found to be compliant for the NIZH prescription sample, and 3 were a Deviation, resulting in a 96.1% compliance rate (Table 7). For compliance assessment, a total of 15 randomly selected samples were used for on-the-ground data collection.

Statewide Type Np Waters

Type Np waters and sensitive sites contribute to the quality of water and fish habitat in downstream Type S 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 (two-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 56-foot buffers. These include headwater springs or the uppermost point of perennial flow; the intersection of two or more Type Np waters; perennially saturated side-slope seeps; perennially saturated headwall seeps; and alluvial fans. No harvest is allowed within alluvial fans. 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% of the soil within the ELZ.

In Eastern Washington, within 50 horizontal feet of the outer edge of bankfull width of an Np, the landowner must identify on the FPA either a partial-cut or clear-cut strategy for each unit to be harvested. For partial-cut and clear-cut strategies, basal area requirements must be met that are specified for the timber habitat type. For clear-cut strategies, a two-sided 50-foot no-harvest buffer along the stream reach must be left that is equal in total length to the clear-cut portion and no more than 30% of the stream's total length, and must meet the upper end of basal area requirements for the respective timber habitat type (WAC 222-30-022(2)(b)(i)&(ii)).

On-Site Review for Statewide Type Np Waters

Questions 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 1,780 FPAs having one or more Np waters within their harvest boundaries.

Table 11. 2020-2021 Compliance Ratings for Statewide Type Np Waters

Rule	WAC reference	Assessed FPAs Compliant	Assessed FPAs Deviation	Assessed FPAs Indeterminate	Assessed FPAs Total	Percent Compliant	Percent Deviation
Np Stream Size/typing	(222-16-031(4))	32	0	1	33	97%	0
Is ≤ 10% of ELZ exposed?	(222-30-021(2)(a))	0	0	0	0	NA	NA
Appropriate Length of 50 foot buffer	(222-30-021(2)(b)(vii))	24	0	1	25	96%	0
No harvest within required 50 foot buffer	(222-30-021(2)(b)(i))	25	6	0	31	81%	19%
No harvest 50 feet from headwall seeps & springs	(222-30-021(2)(b)(ii)(iii))	4	0	1	5	80%	25%
56ft PIP/UMPPF* & Confluence buffer	(222-30-021(2)(b)(iv)(v))	18	2	0	20	90%	10%
No harvest on Alluvial fans	(222-30-021(2)(b)(vi)	0	0	0	0	NA	NA

*Perennial Initiation Point & Upper Most Point of Perennial Flow

The total number of rules sampled and analyzed was 110; 102 were found to be compliant for the Np waters prescription sample, and 8 were a Deviation, resulting in a 92.7% compliance rate (Table 7). For compliance assessment, a total of 33 randomly selected samples were used for data collection. Indeterminate calls are explained in detail below.

Rule	WAC reference	Assessed FPAs Indeterminate	Reason
Np Stream Size/typing	(222-16-031(4))	1	Team could not safely get all the way to the stream for documentation.

Appropriate Length of 50 foot buffer	(222-30-021(2)(b)(vii))	1	Required no cut length was 110 ft., roughly 5 stumps within 50 ft. along entire length of unit, no length of uncut 110 ft. anywhere in the area. Cannot dictate compliance due to lack of knowledge about entire length of Np stream.
No harvest 50 feet from headwall seeps & springs	(222-30-021(2)(b)(ii)(iii))	1	Could not see slopes to verify compliance.

Statewide Type Ns Waters

Buffers are not required for Type Ns waters. There is a 30-foot ELZ, and mitigation measures are required if more than 10% of the soil in the ELZ is exposed. Forest practices in proximity to Type Ns waters are common. This harvest strategy occurred on an estimated 1,855 FPAs in the 2020-2021 population.

Table 12. 2020-2021 Compliance Ratings for Statewide Type Ns Waters

Rule	WAC reference	FPAs Compliant	FPAs Deviation	FPAs Indeterminate	FPAs Total	% Compliant	% Deviation
Ns Stream Size/typing	(222-16-031(5))	23	1	7	31	74%	3%
If GTE 10% disturbance to ELZ, was there mitigation	(222-30-021(2)(a))	3	0	1	4	75%	0

The total number of rules sampled and analyzed was 27; 26 were found to be compliant for the Ns waters prescription sample, and 1 was a Deviation, resulting in a 96.3% compliance rate (Table 7). For compliance assessment, a total of 24 randomly selected samples were used for on-the-ground data collection. A total of 1 rule violation was found across the 24 samples. Indeterminate calls are explained in detail below.

Rule WAC reference	FPAs Indeterminate	Reason
Ns Stream Size/typing (222-16-031(5))	7	Ample perennial vegetation, some flow, not enough evidence to make a call.
		Stream had flow, vegetative indicators of perennial streams. Too tough to say in April, very low volume system.
		Stream had flow and perennial indicators but the group felt it was inconclusive based on the amount of flow/gradient.
		Ns from PIP of Np connection looked dry and sparse for about 250ft, but the group found perennial vegetation and flowing water up above, resembling the actual PIP

		Skunk cabbage indicates high water table. Flow observed 4/27/21. However it's very possible that the stream goes dry in the low flow time of year.
		Based on findings we can assume Ns call was correct but technically there was flow. Could not determine typing in full confidence.
		There was flow the day of sampling, but stream could very well go dry in the late season
Is ≤ 10% of ELZ exposed (222-30-021(2)(a))	1	Call based on exposed soil, notes unclear on reasoning or connection to previous indeterminate calls.

Statewide Wetland Management Zones

Forest practices wetland rules are very nearly 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 five acres have a minimum 50-foot WMZ width, and an average 100-foot WMZ width;
- Type A Wetlands of 0.5 to 5 acres and Type B wetlands greater than 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;
- 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 acres or larger. There are no leave tree requirements or WMZs 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 cannot be used within the minimum WMZ width without written approval from DNR.

On-Site Review for Statewide Wetlands

Protection requirements for wetlands depend on the size and type of wetland. The information collected by the compliance monitoring field team varied 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 and 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 WMZ is greater than or less than 10% of the total harvest unit footprint (if >10%, leave tree requirements are reduced),

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 three acres within the harvest unit) are delineated correctly and shown on the activity map by the landowner/applicant.

Statewide type A and B WMZs

Type A and B Wetlands are estimated to occur on 439 FPAs statewide in the 2020-2021 population.

Table 13. 2020-2021 Compliance Ratings for Statewide type A and B WMZs

Rule	WAC reference	FPAs Compliant	FPAs Deviation	FPAs Indeterminate	FPAs Total	% Compliant	% Deviation
Wetlands type & size	(222-16-035(1)(a)&(b))	30	9	0	39	77%	23%
Variable buffer width appropriate	(222-30-020(8)(a))	21	1	1	23	91%	4%
Openings less than 100’ wide	(222-30-020(8)(d))	2	1	0	3	67%	33%
Openings less than 200’ wide	(222-30-020(8)(d))	1	0	0	1	100%	0
Leave trees species represent pre-harvest	(222-30-020(6))	11	0	0	11	100%	0
Ground based in min WMZ had approval	(222-30-020(8)(e))	2	1	0	3	67%	33%
Where WMZ-RMZ overlap was best protection used	(222-30-020(8))	3	0	0	3	100%	0
38 TPA > 6in WW (4in EW)	(222-30-020 (8)(b)(f*))	0	0	0	0	NA	NA
13 TPA > 12in,where they exist	(222-30-020 (8)(b)(f*))	0	0	0	0	NA	NA
75 TPA > 6in, where they exist	(222-30-020(8)(b))	6	0	0	6	100%	0
25 TPA > 12in, where they exist	(222-30-020(8)(b))	6	0	0	6	100%	0
3 TPA > 20in, where they exist	(222-30-020 (8)(b)(f*))	0	0	0	0	NA	NA

The total number of rules sampled and analyzed was 100; 88 were found to be compliant for type A and B wetland prescription sample, and 12 were a Deviation, resulting in an 88% compliance rate (Table 7). For compliance assessment, a total of 39 randomly selected samples were used for on-the-ground data collection. A total of 12 rule violations were found across the 39 samples. Indeterminate calls are explained in detail below.

Rule	WAC reference	FPAs Indeterminate	Reason
Variable buffer width appropriate	(222-30-020(8)(a))	1	Notes dictate that multiple questions were raised during site visit; rule was noted as unclear for harvest operations, trees were harvested within minimum 25 ft. buffer, but it was apparent there would be enough trees to meet the 75 trees per acre rule with respect to size classes. Group in the field was unsure if harvest was allowed within minimum buffer. (Note from CMP Manager 2022: no changes were made to this finding, due to a lack of historical knowledge of this field visit; however, it was likely that this call should have been changed a compliant call in the field based on the Forest Practices rules on WMZ buffers).

Statewide Forested Wetlands

An estimated 600 FPAs statewide contained Forested Wetlands in the 2020-2021 sample population.

Table 14. 2020-2021 Compliance Ratings for Statewide Forested Wetlands

Rule	WAC reference	FPAs Compliant	FPAs Deviation	FPAs Indeterminate	FPAs Total	% Compliant	% Deviation
Wetlands type & size consistent	(222-06-035(2))	14	1	0	15	93%	7%
If harvest occurred, was low impact used	(222-30-020(7))	8	0	0	8	100%	0
If greater than 3 acres, was wetland mapped	(222-16-036(3))	5	0	0	5	100%	0

The total number of rules sampled and analyzed was 28; 27 were found to be compliant for the forested wetland prescription sample, and 1 was a Deviation, resulting in a 96.4% compliance rate (Table 7). For compliance assessment, a total of 15 randomly selected samples were used for on-the-ground data collection. A total of one rule violation was found across the 15 samples.

5. Forest Practices Rule Compliance for Roads and Haul Routes

Section 5 provides rule and on-site review descriptions and compliance monitoring findings regarding the Standard Sample for roads and haul routes statewide.

A well-designed, located, constructed, and maintained forest road system is essential to both forest management and protection of public resources and public safety. Washington state forest practices rules – which include riparian practices, road construction, maintenance, and abandonment, and best management practices – are among the most stringent in the country. The 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

Correct implementation of Forest Practices rules accomplishes these goals by 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)

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

FP Rules for Statewide Roads and Haul Routes-Rules Applied

The following are rules for road construction, landing construction, Type F and N water road crossings, road abandonment, and haul routes.

Forest Road Construction
Road rules require specific standards for road location, design, and construction. The Roads Field Form (described in the on-site review section below) is written to gather the information needed to assess compliance for forest roads.

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 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/wetlands 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 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. When a landowner chooses to abandon a forest road, specific standards delineated in the rules must be followed (additional technical guidance in Board Manual Chapter Section 3). 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 closure point at the time of abandonment, and water crossing structures must be removed (WAC 222-24-052[3]).

Haul Routes
The 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 and the level of sediment delivery.

On-site Review for Statewide Roads and Haul Routes

To determine road compliance, CMP field team visited FPA sites where forest road construction, landing construction, Type N water road crossings, abandoned roads, and haul routes are present. The field team used the Roads Field Form and the Haul Route Field Form to record information while on site. The field team does not confirm water typing 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 Roads Field Form is used to record observation-based data related to forest road construction, landing construction, Type N water road crossings, and abandoned roads. The initial series of questions on the 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 some of the 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 Haul Route Field Form is used 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 15), and the cause of the noncompliance (Table 16). 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 15).

Table 15. 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. (Table 16)

Table 16. 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 un-stabilized 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

Roads Findings
Road construction or abandonment occurred on an estimated 2,790 FPAs in the 2020-2021 sample. The resulting Roads prescription sample size was 13 and a total of 171 rules were evaluated.

Table 17. FP Rule Compliance for 2020-2021 Road Activities

Statewide Road Activities for 2020-2021		
All Landowner Types	**Status of Compliance**	**Road Activities Rule Compliance**
	# of Rules Sampled	171
	# Compliant Rules	169
	# with Deviation	2.5*
	Compliance %	98.8%
	95% Confidence Interval	CI (96, 100)

For roads prescriptions, compliance with a single rule on an 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 percentage or ratio (a number between 0 and 1).

Of the 171 rules sampled, 169 were compliant for the Roads prescription sample, resulting in a 98.8% compliance rate. Field observations resulted in 10 Deviation road segments:

- One Deviation observation to the rule that roads with potential to deliver sediment are out sloped, crowned, and ditched with appropriate drainage structures.
- Three Deviation observations to the rule that diversion structures must be placed in relation to streams or wetlands so as to divert most flow to forest floor.
- One Deviation observation to the rule that alterations to stream bank, bed, and bank vegetation limited to that necessary of the construction of the project.
- Two Deviation observations to the rule that road must be out sloped, water barred, or otherwise left in condition suitable for erosion control and to maintain water movement within wetlands and natural drainages.
- Two Deviation observations to the rule that ditches must be left in suitable condition to reduce erosion.
- One Deviation observation to the rule that crossing and fill on all typed waters was removed (except where dept. determines otherwise).

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. If the entire route was 5 miles long or less, the entire road was observed. If the entire route was over 5 miles, 10 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 were recorded (Table 19). The CMP 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 18. 2020-2021 Haul Route Compliance Summary

Compliant		Deviation		
99% (97, 100) CI*		1.4% (0, 3.2)		
No Delivery	**De Minimis**	**Low**	**Medium**	**High**
98%	0.39%	0.47%	0.44%	0.50%

*CI is confidence interval at the 95% confidence level

Table 19. 2020-2021 Haul Route Deviation by Cause

Primary Cause	Miles	% of Deviation
Other*	0.70	56%
Contaminated ditchwater	0.20	16%
Inadequate water crossing structures	0.15	12%
Ruts/inadequate crown	0.05	4%
Haul on native surface or inadequate rock	0.05	4%
Faulty cross drainage	0.05	4%
Obstructed or bermed ditch line	0.05	4%

*The "other" category is comprised of non-point source sediment delivery and blocked drainage structures.

A total of 21 samples were assessed for haul route compliance. For 76.19 miles of the 77.44 miles of haul routes evaluated, no delivery or de minimis sediment delivery was observed, resulting in a compliance rate of 98%. The primary contributing factor was "other;" for 2020, all deviations were considered "other."

6. Potentially Unstable Slopes

The potentially unstable slopes periodic sample 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 the population of FPAs assessed through this study. The design objective was to evaluate how well on-the-ground results related to avoiding or mitigating potential adverse impacts from forest practices on RILs were carried out compared to what was required by the subject FPA. The unstable slopes study was designed to evaluate overall FPA compliance, as opposed to individual rule compliance. Thus, the unstable slopes prescription was comprised of "FPA compliance only" questions. This focus differs from typical compliance monitoring analyses but was necessary because of the absence of rules metrics that are measurable in the field within the rule identified landform prescription type.

The population sampled for unstable slopes consisted of FPAs containing RILs or that had such features reported as being immediately adjacent to the forest practice. As defined in WAC 222-16-50(d)(i), RILs include inner gorges, convergent headwalls, bedrock hollows, toes of deep-seated landslides, groundwater 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. 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 to determine that all FP activities have been completed, based on the random order assigned.

The Forest Regulation Science Team consists of regulatory licensed engineering geologists ("qualified experts" per WAC 222-10-030(5) 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, or FPAs where forest practices activities had not been completed, were removed from the sample population. 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, or other LEG-certified collaborator from another government entity (WAC 222-10-030(5)) when answering the following questions related to FPA RIL compliance. The DNR qualified expert (or LEG-certified collaborator) is a licensed engineering geologist and also meets the qualified expert status with 3 years of field experience. For the 2020-2021 biennium, ECY contributed LEG experience.

- Did the landowner identify all potentially rule identified unstable features in/around the harvest/activity area?
- Did the landowner apply mitigation for all potentially rule identified unstable features as identified on their FPA?
- Did NO harvest occur within the no harvest mitigation area associated with potentially rule identified unstable features?
- Due to potential data redundancy, the question "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?" was eliminated.

A **Yes/No** or **N/A** determination was applied for questions that 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 **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).

Findings for Unstable Slopes Study

In the 2021 Unstable Slopes sample, there was a total population of 811 FPAs. The resulting sample size was 25, and a total of 75 rules were evaluated (Table 20).

Table 20. 2021 Statewide Unstable Slopes Periodic Study Compliance Results

Unstable Slopes Categories	Results
Sample Size	25
Rules Compliant	72
Rules Deviant	3
Total Rules Assessed	75
Compliance Percentage	96%

Field observations from 2021 included for three deviation observations.

- One deviation was due to a potentially unstable area not identified on the FPA.
- One deviation was due to a RIL (Rule Identified Landform) that had not been identified on the proponent's FPA. A toe of deep-seated landslide was observed by the Forest Regulation QE.
- One deviation observed by the Forest Regulation QE found that four boundary trees along an inner gorge with tree roots within the gorge were cut, and the loss of root strength had potential to destabilize the slope.

7. Forest Practices Rule Trend Analysis

Compliance surrounding FPAs 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 track trends in prescription and individual rule compliance. Sample size for each year is determined based on achieving a specific precision level (+/- 6%, 95% Confidence Interval) for average compliance with a set of rules (a prescription) over a two-year period. Because the population of FPAs available in any given year is finite and variable, and variance estimates vary, the estimated sample size necessary to achieve a specific precision level also varies by year. Differing priorities, compliance estimation methods, and natural variability have caused differences in precision levels through time. In addition, methods for determining compliance with some individual rules have changed since 2006. While these differences create challenges for evaluating trends through time, this report includes an analysis aimed at seeking to discern statistically meaningful patterns of changes in compliance rates over time.

Methods

For the 2010-2021 dataset, rule compliance was carefully tracked to ensure that compliance determination was consistently applied. Data collected prior to changes to analysis was back-corrected to be able to be used for newer analysis procedures where applicable. The compliance data from 2006-2009 have not yet been matched to current rules, although these data may be included in future reports. Results have been reviewed to ensure consistent application of compliance determinations across the dataset.

Data removed from the trend analysis dataset include:

- data not collected in accordance with current field protocols
- rules no longer included in compliance estimates
- current rules for which longer term results were not available

Data for the remaining rules were combined and compared through time within each corresponding prescription type. The 2014-21 results were calculated using the jackknifed form of the ratio estimator. Differences in compliance estimates used for trends versus reported annual compliance are due to the reduction in data used for trends as discussed above. Trends in average compliance with prescriptions and individual rule compliance for this subset are tracked to maintain long term consistency with current methods. Trend results are reported below for the 2010-2021 period, and also for the reduced time period 2014-2021. This more recent time period reflects the time since the last major program changes in 2014.

Linear regression analysis was used to estimate overall linear trends in average compliance through time. Because of the varying precision levels among years, the regression assumption of homogeneous variance in average compliance was not satisfied. Generally, higher sample sizes (i.e., number of rules assessed in a given year) 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 was employed to correct for the non-homogeneous variance (where the average compliance is weighted by the inverse of the estimated mean standard error of compliance for each year). The result is that years with better (more precise) 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 (Wald t-tests) were reported, as well as 90% confidence intervals for linear regression coefficients for the weighted regression. The relative weights used for weighted linear regression were used to size the points in the regression plots (for example larger points were weighted heavier in the regression based on variance estimates).

In summary, a higher proportion of the population sampled (that is more rules per FPA) in any given year reduces the variance and more heavily weights that point in the regression analysis. Slope estimates (that is average change in compliance per year) are given for weighted regressions with p-values for significance tests, and a 90% confidence interval for the weighted regression slope. Since no individual rules are measured or tracked for Haul Routes, trend analysis was not conducted for the Haul Route prescription type.

Results

There is evidence of increasing compliance trends in Western Washington riparian management zone DFC1 and DFC2 prescriptions, and for statewide NIZH prescriptions, with estimated average increases in compliance rates from 0.6 to 0.8% per year over the 2010-2021time period (Figure 4). If results for the four years prior to program changes in 2014 are removed, the trends are less apparent and not statistically significant, leaving no evidence of consistent increase or decrease in compliance for the 2014-2021time period for any prescription.

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 98% over the course of the evaluation period. As a result of increasing prescription compliance rates, significant weighted regression trend results ($p = 0.039$) were observed for the DFC1 prescription type. A year over year increase of 0.82% (0.20-1.4%) for the overall prescription compliance rate was observed (Figure 4). Note that the increase in compliance occurred mainly in the 2010-2014 time period, and there is no evidence of trends in compliance rates over the 2014-2021 period ($p = 0.90$).

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 89% to 100% over the course of the evaluation period. As a result of the increasing prescription compliance rate, significant trend results ($p = 0.0079$) were observed for the DFC2 prescription (Figure 4). A year over year increase of 0.63% (0.26 – 1.0%) for the overall prescription compliance rate was observed (Figure 5). Note that the increase in compliance occurred mainly in the 2010-2014 time period, and there is no evidence of trends in compliance rates over the 2014-2021 period ($p=0.94$).

No Inner Zone Harvest

Trend analysis results for the NIZH prescription type revealed relatively consistently increasing compliance rates for the prescription, and the associated rules from year to year. Prescription compliance rates varied from 88% to 100% over the course of the evaluation period. As a result of the increasing prescription compliance rate, significant trend results ($p = 0.0025$) were observed for the weighted NIZH prescription. A year-over-year increase of 0.82% (0.45, 1.2%) in the overall prescription compliance rate was observed (Figure 4). Note that the increase in compliance over the 2014-2021 period is similar to the full 2010-2021 trend for NIZH prescriptions, but this trend is not statistically significant ($p=0.24$).

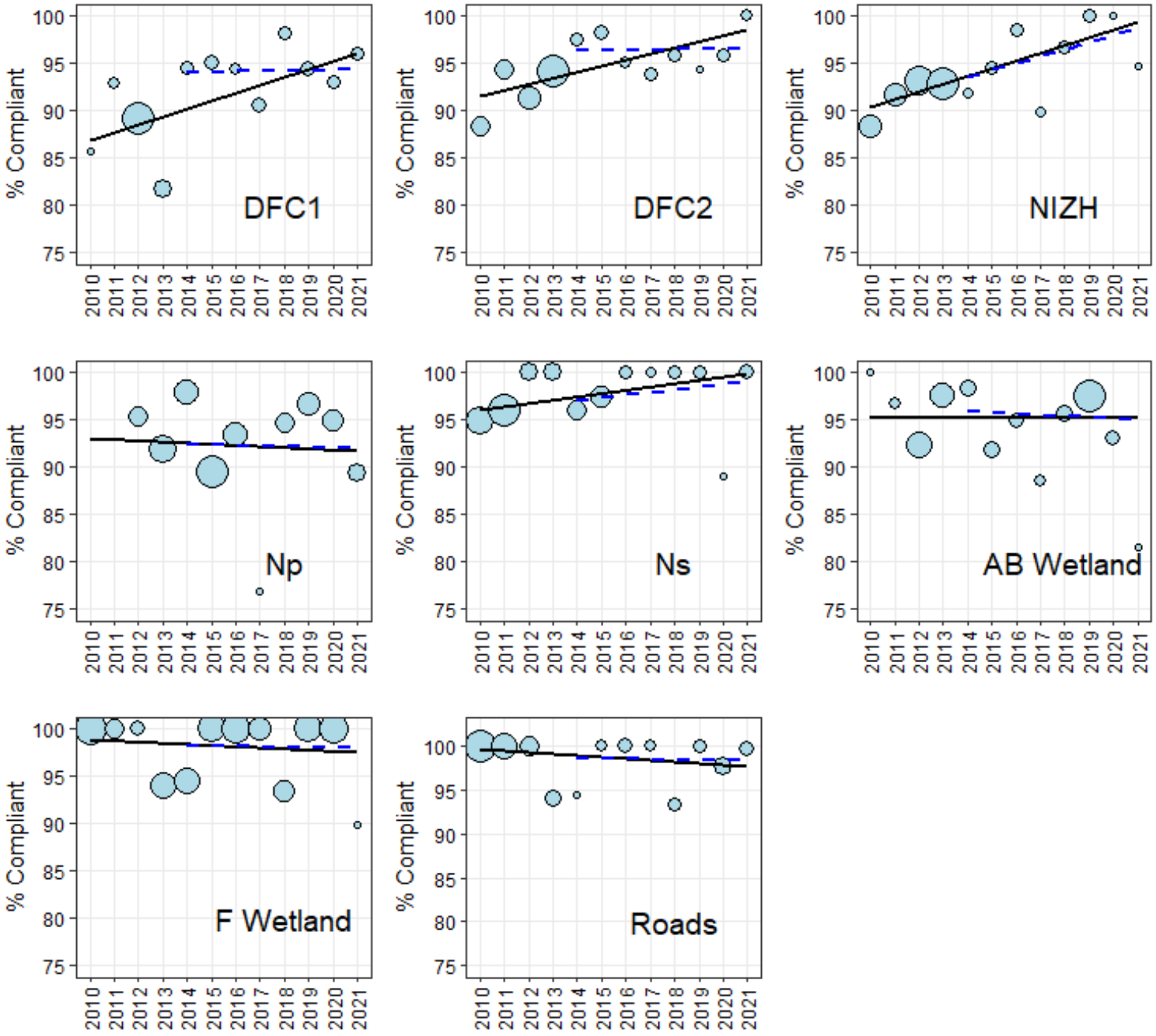


Figure 4. Annual rule compliance for eight prescriptions with a weighted linear regression overlaid for 2010-2021 (black line) and for 2014-2021 (blue dashed line). The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

Non-Fish-Bearing Perennial Waters

Np data collected from 2010 and 2011 were excluded from current trend analysis results because of data conversion issues (data were collected in such a way that they could not be converted to current analysis methods of individual rule compliance assessment; in some instances, a "yes" answer on previous data forms did not necessarily equate to a compliant, and vice versa for "no" answers and deviations). 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. No significant trend ($p = 0.81$) was observed for the Np prescription type (Figure 4).

Non-fish Bearing Seasonal Waters
Trend analysis results for the Ns prescription type revealed increasing compliance rates for the prescription. Prescription compliance rates varied from 89% to 100% over the course of the evaluation period. No significant trend results ($p = 0.12$) were observed for the Ns prescription type (Figure 4).

A and B Wetlands
Trend analysis results for the A and 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 82% to 100% over the course of the evaluation period. No significant trend results ($p = 0.96$) were detected for the weighted A and B Wetlands prescription type (Figure 4).

Forested Wetlands
Trend analysis results for the Forested Wetlands prescription type revealed 100% compliance rates for the prescription, and the associated FP rules, in 8 out of 12 years from 2010 to 2021, with compliance rates varying from 90% to 95% in the remaining 4 years. No significant trend results ($p = 0.70$) were observed for the Forested Wetlands prescription type (Figure 4).

Roads
Due to the large number of individual rules that comprise the Roads prescription (42), only prescription compliance is visually represented in the report. Trend analysis results for the Roads prescription type revealed 100% compliance rates for the prescription in 7 out of 12 years from 2010 to 2021, with compliance rates varying from 93% to 99.8% in the remaining 5 years. No significant trend ($p = 0.26$) was observed for the Roads prescription type (Figure 4).

Discussion
There have been statistically discernable linear or monotonic increases in compliance since 2010 for some prescriptions and, equally notable, no significant decreases in rates of compliance with FP rules. Compliance rates for both DFC1 and DFC2 prescriptions have increased since 2010. The increase was most apparent in the first five years (2010-2015), and the compliance rates for both prescriptions are relatively stable near 95% in the past eight years. The NIZH prescription has had a stable increase in compliance since 2010 and is now close to 100%. The Np prescription has variable compliance but seems stable at about 93% (except for the low in 2017). Compliance with Ns rules has been at 100% for five out of six recent years, although it was less than 90% in 2020. Compliance with roads and wetlands rules appears to be stable with an average compliance about 98% for roads and forested wetlands and 95% for A and B type wetlands, although compliance was lower for both wetland prescription types in 2021. Compliance with A and B wetlands rules has been more variable across years.

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

8. Forest Practices Application Compliance

Overall FPA compliance generally mirrors FP rule compliance on individual FPAs; however, occasionally one may be compliant while the other is not. Sometimes the FPA is compliant with rules but deviates from the landowner's stated protections on the FPA – what the landowner proposed and committed to. The CMP records FPA Deviation observations. Future prescription samples sizes are not based on FPA compliance variance estimates, and cluster size (Table 20).

Table 21. 2020-2021 Comparison of Rule and FPA Percentage Compliance

	RMZ Prescription	Rule Percentage Compliant	FPA Percentage Compliant
Statewide	No Inner Zone Harvest	96.1%	91.5%
	Type Np Prescriptions	92.7%	88.6%
	Type Ns Prescriptions	96.3%	100%
	Type A and B Wetlands	88%	93.8%
	Forested Wetlands	96.4%	100%
	Roads	98.6%	98.6%
Western WA	Inner Zone Harvest DFC1	92.1%	88.5%
	Inner Zone Harvest DFC2	97.8%	96.2%

Table 22. 2020-2021 Comparison between FPA and Rule Compliance, Deviation, and Indeterminate Assessments

	RMZ Prescription	Rule Prescriptions	FPA Prescriptions	Rules Deviation	FPA Deviation	Rules Indeterminate	FPA Indeterminate
State-wide	No Inner Zone Harvest	15	15	3	4	0	0
	Np Water	33	31	8	9	2	1
	Ns Water	24	2	1	0	8	1
	A/B Wetlands	39	25	12	4	1	0
	Forested Wetlands	15	11	1	0	0	0
	Roads	13	13	2.47	9	0	0
W WA	Inner Zone Harvest DFC1	16	16	10	9	4	4
	Inner Zone Harvest DFC2	13	13	2	2	0	0

Findings for FPA/FP Rule Compliance Differences

The CMP notes observed differences between FP rule compliance and FPA compliance. FPA compliance focuses on terms of the approved FPA. There are few differences between FP rule compliance rates and rates of compliance with an FPA for the 2020-2021 sample. An example of a discrepancy between FPA compliance and rule compliance include the following:

- Treatment of a segment as a small type F water resource, when the resource was actually a large type F water resource by CMP staff, meaning that the required buffer extends further than anticipated on the FPA. In this case, the FPA is compliant, but not rule compliant.

- Underreporting of resource such as Np or Ns stream, thereby under-protecting the resource with no-cut buffer. This situation would be compliant with the FPA and what was proposed on the FPA, but not with the rules.

9. Report Discussion and Proposed Changes

The 2020-2021 rule prescription compliance rates range from 88-98%, demonstrating a wider range of the values determined for compliance with WAC rules than in previous years. This wider range of values corresponds to less statistical confidence by the CMP in ability of the standard sample to express the variation seen in the larger population of prescriptions.

Riparian and Wetland Compliance Proportioned across the Population

Tables that describe 2020-2021 riparian and wetland findings are in Sections 4 for individual prescription types. Table 23 summarizes the number of FPAs assessed as part of the standard sample during 2020-2021 in the field by CMP staff, in comparison to the total estimated FPAs in the population for that prescription. For example, 16 field samples were collected for DFC1 prescription out of a total of 68 estimated prescriptions across the state for 2020-2021. The methodology and statistical analysis used for the CMP to estimate rule compliance across an entire population using a smaller sample is unable to determine *overall* compliance for multiple prescriptions. Since population sizes vary so widely, rule compliance can only be estimated in this report for individual prescriptions (DFC1, DFC2, NIZH, etc.) and not an overall rate for *all* fish-bearing waters across the state.

Table 23. 2020-2021 Estimated FPA Sample and FPA Population Sizes

Prescription Type	Standard Sample Assessed	Total FPA population
Riparian protection: Desired Future Condition Option 1 (DFC1)	16	68
Riparian protection: Desired Future Condition Option 2 (DFC2)	13	292
Riparian protection: No Inner Zone Harvest (NIZH)	15	1,484
Riparian protection: Non-Fish Bearing Perennial Waters (Np)	33	1,780
Riparian protection: Non-Fish Bearing Seasonal Waters (Ns)	24	1,855
Wetland protection: type A and B Wetlands	39	439
Wetland protection: Forested Wetlands	15	600
Road construction, maintenance, and abandonment	13	2,790
Haul Routes* for sediment delivery	21	NA

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

Introduction of Jackknife Compliance Rate Estimator

The ratio estimator used prior to the 2016-17 biennia was biased due to high variance estimates, but the bias was disregarded, and assumed to be small. The biased ratio estimator is no longer used by the Compliance Monitoring Program. To correct for potential bias and reduce variance, the jackknife estimator was introduced and applied during the 2016-17 biennium onward and used to calculate future sample sizes.

Compliance Monitoring Program Challenges and Recommended Changes for 2020-2021

Program Response to the Covid-19 Pandemic

Due to health and safety concerns as part of DNR's response to the Covid-19 Pandemic, the CMP was unable to perform standard sample field data collection until July 2020. As a result of the pandemic and 2020 wildfire season, which started early and ran longer than is typical for the region, the scheduled

Fall 2020 Unstable Slopes study was postponed until Fall 2021. The scheduled Fall 2021 Forest Regulation Hydraulic Project study was postponed until Fall 2022. The 2020-2021 biennial standard sample data collection was successfully completed on-time in 2021.

Type A/B Wetland Typing and Compliance Rates

The overall compliance rate for Type A/B Wetlands fell from the target 90%+ compliance rate to 88% compliance rate in the 2020-2021 biennium. Overall, wetland typing for A, B, and Forested Wetlands was below the 90% compliance benchmark sought by the Forest Regulation Division. Typing discrepancies occurred in 18/39 sampled FPAs. This is in part due to underclassification of wetlands that were associated with F typed waters. WAC rule (WAC 222-30-020(8)) dictates that when a wetland management zone and a riparian management zone overlap, "the requirement which best protects public resources shall apply." Given the opportunity for this statement to be open to interpretation, it is recommended by the CMP that the language be clarified to encompass the goal of the requirement: the requirement with higher protection of natural resources would apply. This would mitigate underclassification of wetlands. In all, eight wetlands, 3 B wetlands and 5 A wetlands were determined to be associated with F typed waters.

> Recommendations for Improvement: Training that focuses on wetland typing and how to implement applicable rules is recommended to address the underclassification of F water as wetlands. Additionally, clarification of wetland typing in the applicable WACs may also be needed to reduce confusion about how to appropriately identify fish water in wetland areas.

Representation of Complete Compliance

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

> Recommendations for Improvement: A recommendation in the board manual (Chapter 222-30) in reference to painting outer zone trees to reduce harvest would assist proponents in meeting this rule requirement.

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 three specific measurements: when determining 1) stream bank full 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 to be the same (that is, the CMP cannot tell a difference). 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-the-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.

Acknowledgements
The contributions of the following were critical to the completion of this report: the tribal staff and regional staff of the Washington state departments of Ecology, Fish and Wildlife, and Natural Resources who performed field reviews in good weather and bad, with special thanks to those who reviewed and entered data, including; Garren Andrews, Pete Grebowski, Chris Briggs, Chris Johnson, Wendy Neet, Jason Graham, Bob Penhale, and Brett Raunig. Also thanks to Donelle Mahan and Joseph Shramek who patiently reviewed various drafts. Finally, the Compliance Monitoring Program will always owe a debt of gratitude to Walt Obermeyer for all his hard work in helping guide the program.

10. Glossary

Bank full width (BFW)

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

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

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

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

Clear-cut. A harvest method in which the entire stand of trees is removed in one 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 bank full 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). 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 omitted from 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 use 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 and 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 harvests, are conducted.

Rule Identified Landforms (RILs). Inner Gorges, Convergent Headwalls, Bedrock Hollows, Toes of Deep-Seated Landslides, groundwater 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 that cumulatively indicate the presence of unstable slopes.

Seep. A moist or wet place where water reaches the earth's surface.

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.

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.

11. Appendix A: Sampling and Sample Size Estimation

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 individual prescriptions that occur as part of completed FPAs.

There are thousands of active (not expired) FPAs every year because the majority of FPAs have three years to be completed. Each FPA has an expiration date set based on date of approval. For this report, all active FPAs were available to be selected by setting sample dates for FPAs that expire between April 1 of the preceding year and March 31 of the sample year. This timeframe increases the likelihood that the forest practices operations are complete before the primary compliance monitoring sampling months (February through November), and the compliance monitoring field team is given the opportunity to visit the site before the FPA expires.

To make random selection of FPAs from the sampling population, the FPAs are assigned a random number as a decimal fraction between 0 and 1 and are ordered from the smallest to the largest number. The methodology involves reviewing the FPAs in this randomized 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 random number given, and categorized by region. Division staff review FPAs in the order assigned for monitored activities that are completed. Region staff assess if the activities identified in the FPA have been completed. FPAs that do not include monitored activities and FPAs that are not complete are deleted from the population. Sample sizes are determined based on proportion to region population size for each prescription type.

For each riparian prescription, the population to be sampled consists of FPAs that include that prescription. This makes up the sample FPA population. In some cases, a single FPA contains several of the same riparian prescription type. When this happens, one prescription implementation is randomly selected for assessment. Table 1 lists the Standard Sample prescriptions monitored in 2020 and 2021.

For roads prescriptions, compliance with a single rule on an 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 percentage or ratio (a number between 0 and 1).

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, not 0 or 1, for that road rule on that FPA. The remaining analysis is the same as riparian prescriptions.

Sample Size and Confidence Values
Standard Sample

In the biennial compliance monitoring design employed by the CMP, the Standard Sample uses a significance level of 95% (alpha=0.05). The CMP set a desired half-width of the 95% confidence interval (CI) at 6%. A 95% CI at +/– 6% means: if the sample was repeated 20 times, one would expect the population mean (hypothetical perfect 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 using an assumption that the observed variance in compliance rates and average number of applicable rules within each prescription will be similar to historical observations. Current sample sizes were based on 9 years of data (2010-2018) prior to 2020 sampling, and 10 years of data (2010-2019) for 2021 sampling. Estimates for population variance are updated after each biennium. Increases in these estimates will lead to increased sample sizes in the following year. The population may also influence sample size, as infrequent prescriptions may require fewer samples to achieve similar historic observations. For more information on determining sample sizes, refer to the Appendix. The current two-year approach assumes that there is no change in compliance between the two years, so that no bias is introduced by having unbalanced population sampling.

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 FPA 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 approval 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 longer sampled), No Inner Zone Harvest, Non-fish Bearing Perennial Waters, Non-Fish-Bearing Seasonal Waters, type A and 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:

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

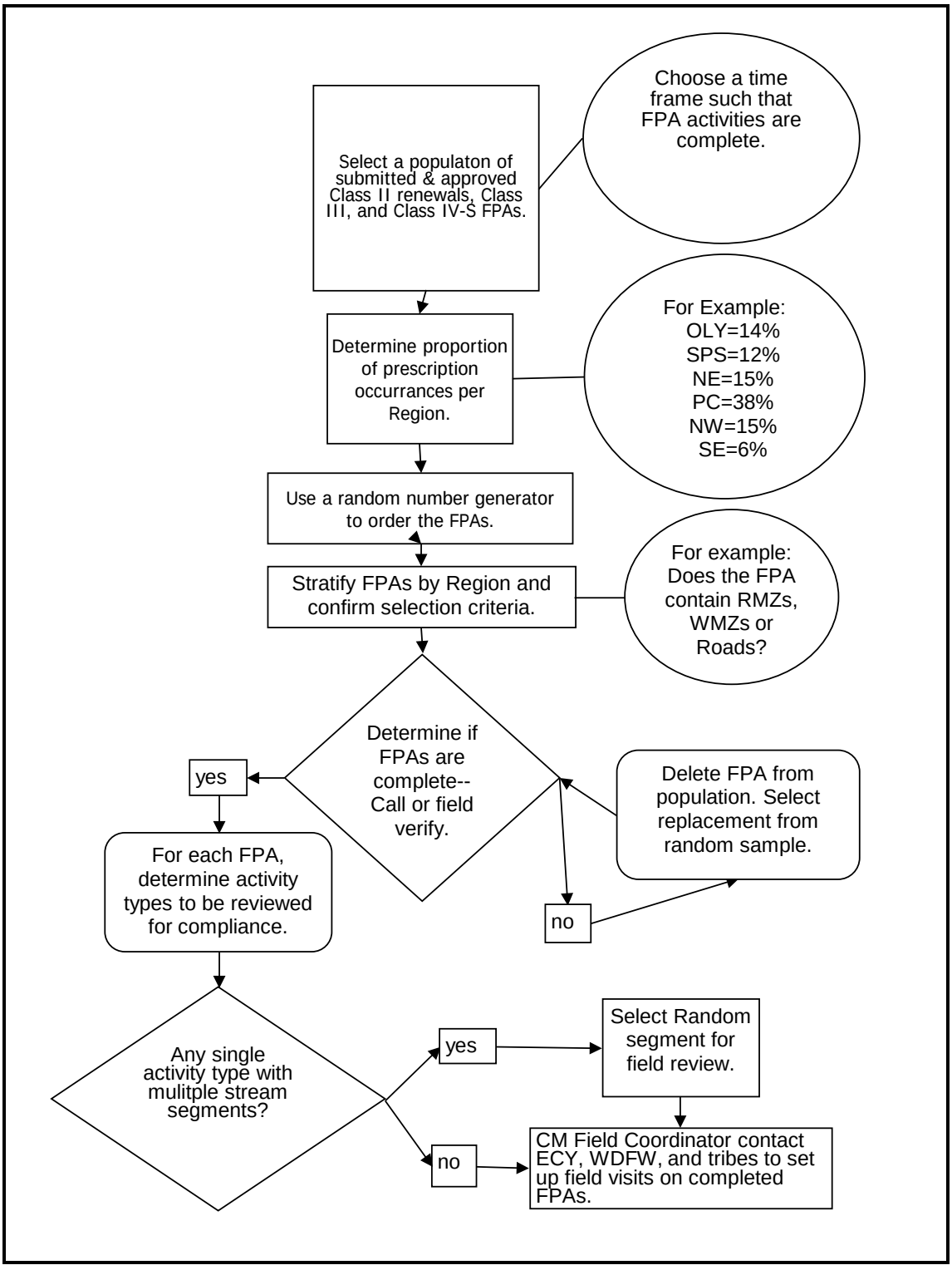
F_1 = the total number of FPAs approved in Year 1,
f_1 = the number of FPAs evaluated for membership in the population ("opened") in Year 1, and
n_1 = the number of FPAs opened that contained completed activities in Year 1.

The finite population correction factor (FPCF):

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

The figure below displays a flow chart that illustrates how activities are selected for field assessment.

Figure 1. 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 two-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 ith FPA in the sample, and y_i is the number of rules that were complied with on the ith FPA.

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

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

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

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

and N is the estimated population size for the prescription.

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: 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 ith FPA in the sample, and y_i is the number of rules complied with on the ith FPA.

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

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

where $t_{.025,(n-1)}$ is the 97.5th 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 FPA 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 2016-17 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:

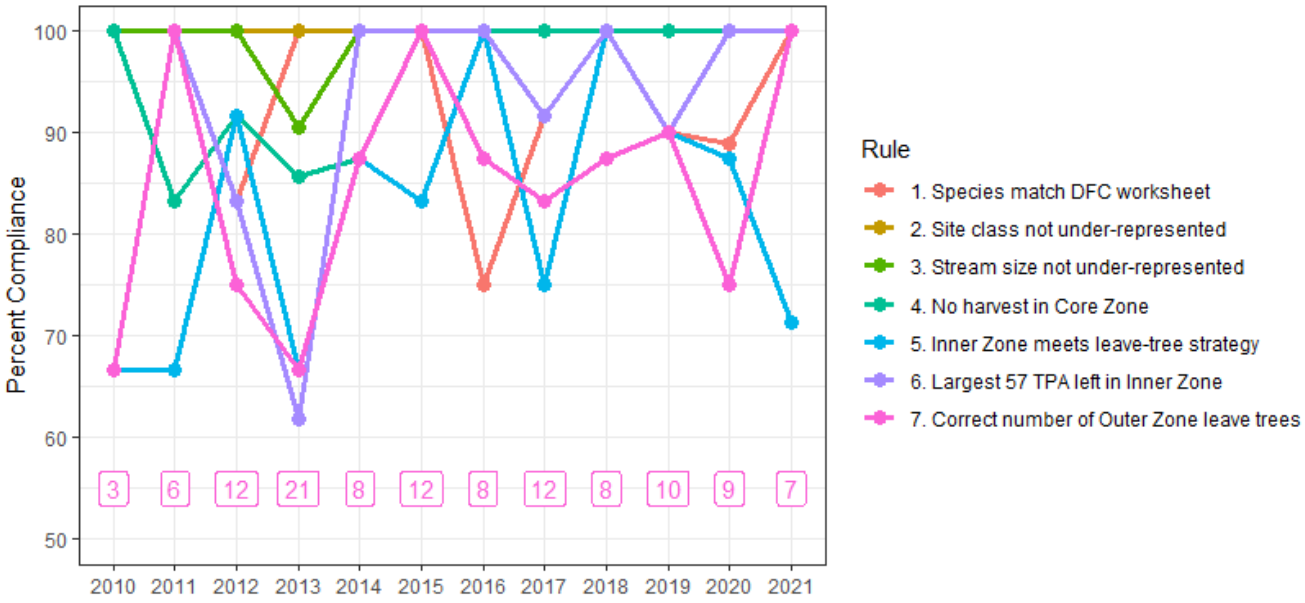
$$\widehat{R_{JK}} \pm t_{.025,(n-1)} \cdot \widehat{SE(R_{JK})},$$

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 $\widehat{N}$.

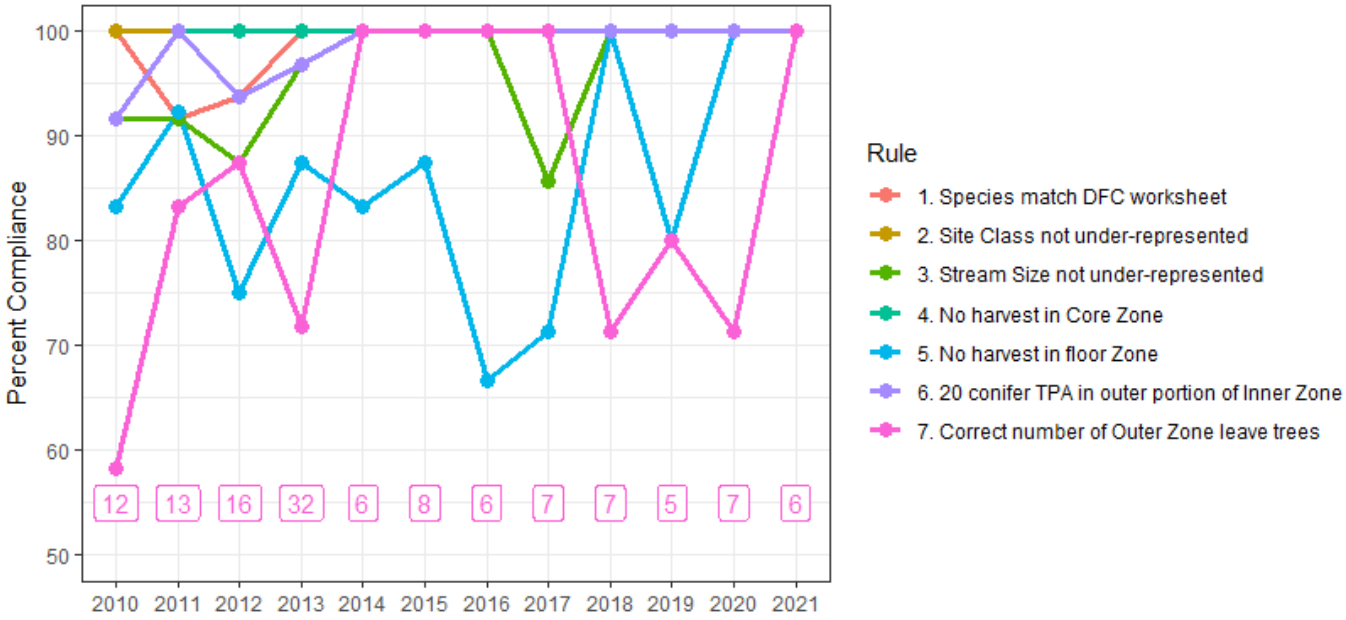
12. Appendix B: Trends of Individual Rules

Note: Numbers in boxes at the bottom of each plot are the number of FPAs reviewed for the prescription type in each year.

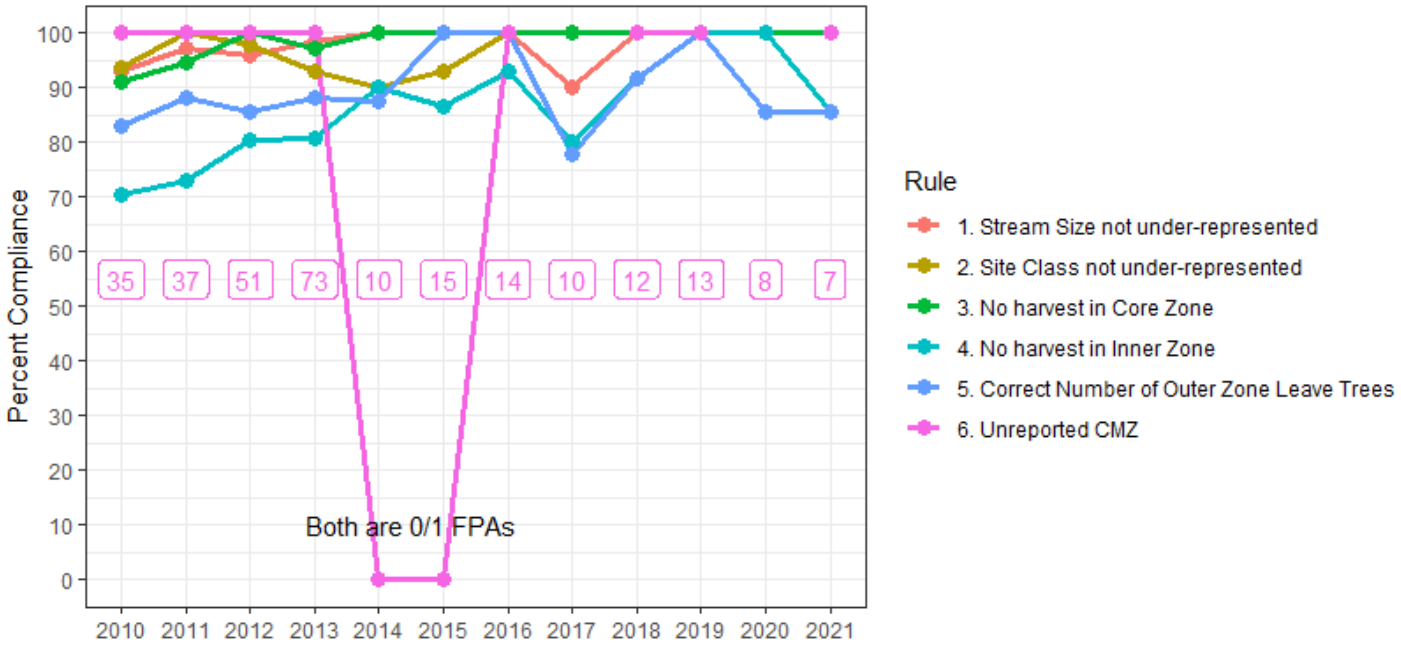
Desired Future Condition 1



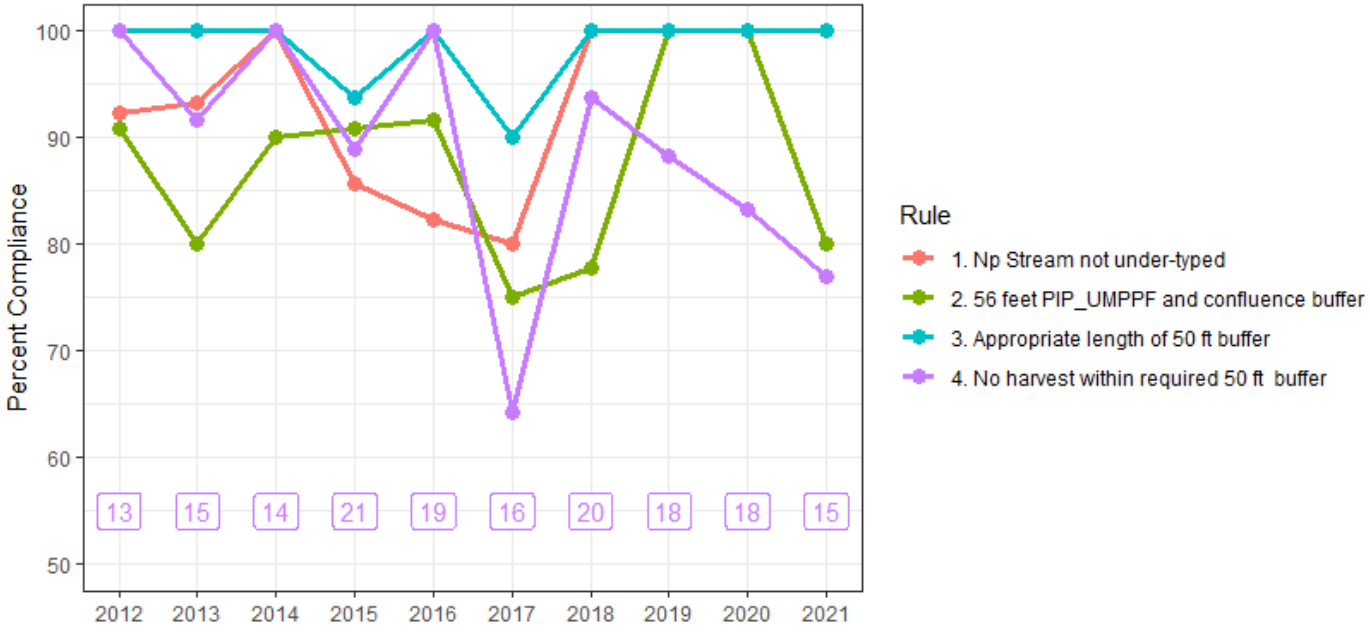
Desired Future Condition 2



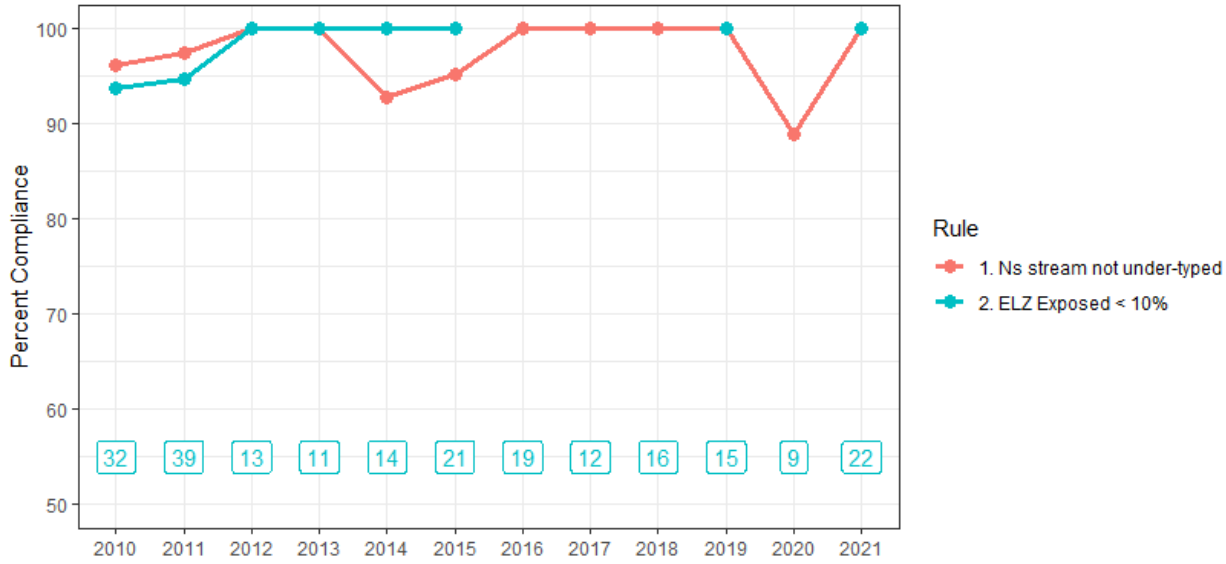
No Inner Zone Harvest



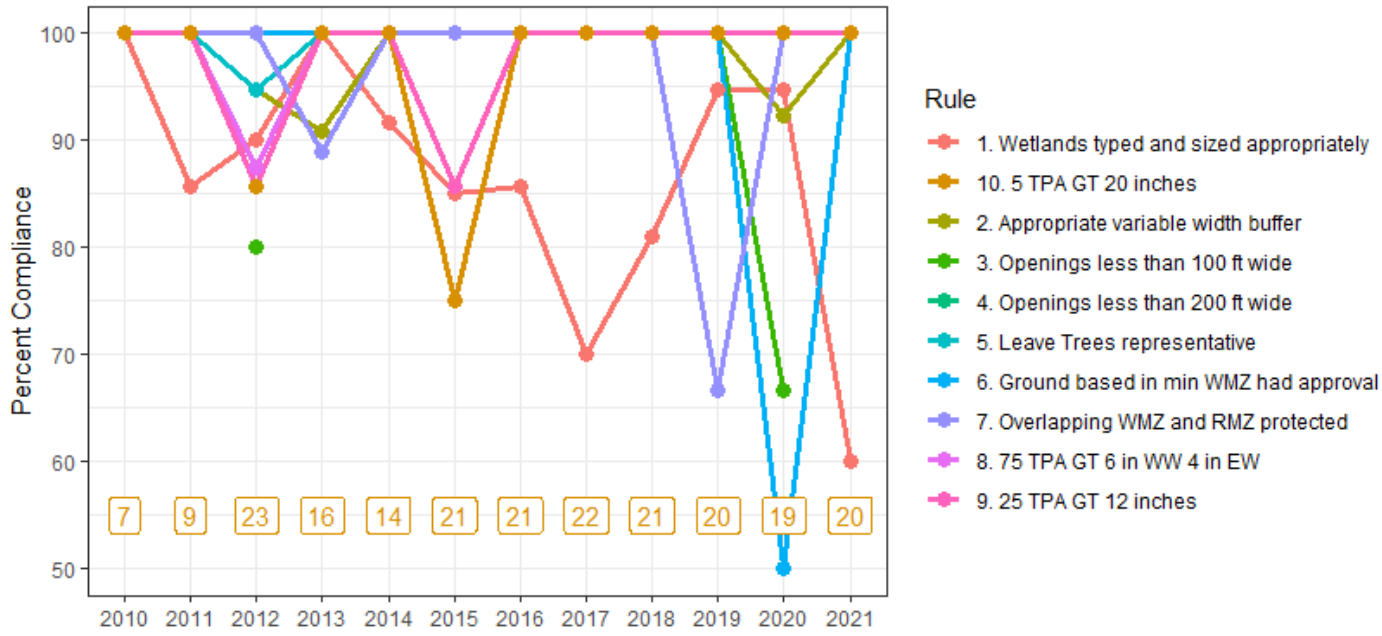
Non-Fish Bearing Perennial Waters



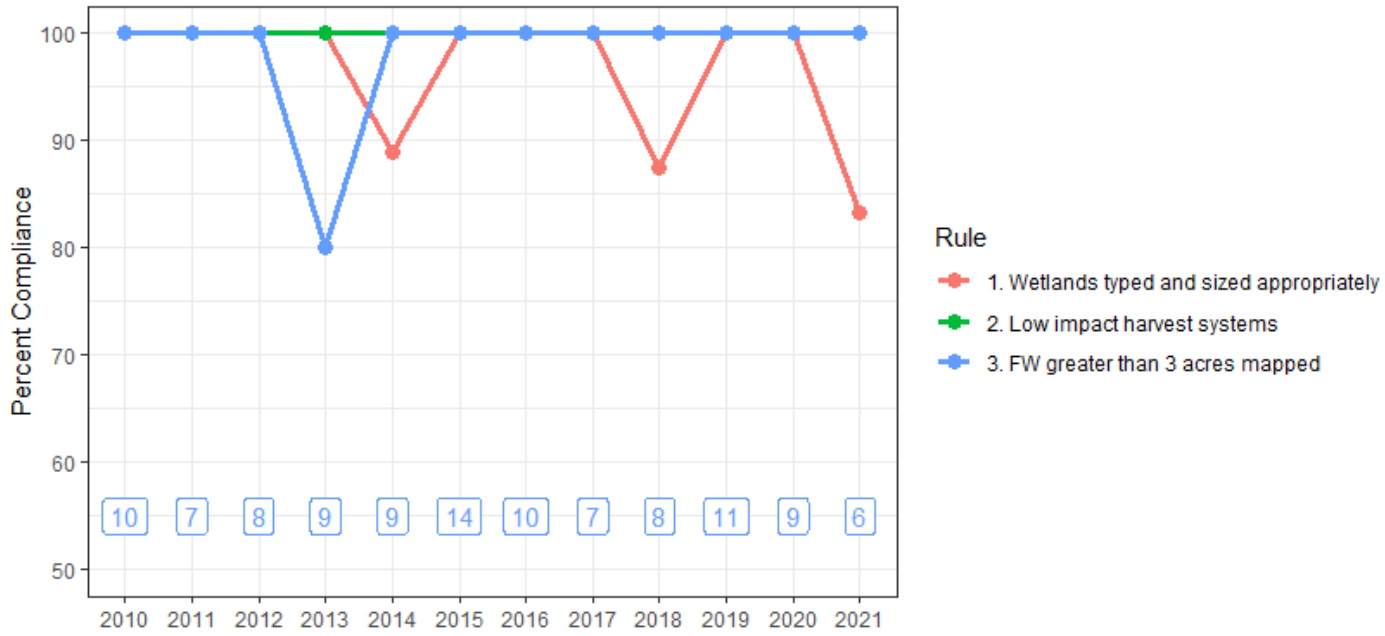
Non-Fish Bearing Seasonal Waters



A and B Wetlands



Forested Wetlands



13. Appendix C: 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 Regulation 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. Reviewers were selected by the associate editor in consultation with the managing editor of ISPR. In addition to reviewing the document, the Review Team met with the managing editor 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 were 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 12 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 Deviation 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
        i. 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 containing the technical details of the sample selection procedure be included in the biennial report. The expansion of the statistical methods appendix improves the reproducibility of the study and improves understanding of the sampling selection and data analysis process. The updated Appendix Cetails 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 requires 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

14. Appendix D: Technical Report on Jackknife Estimation Revisions and Trend Analysis, a Comparison between the 2014-15 and 2016-17 Biennia

Introduction

The 2014-2015 Forest Regulation 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 and subsequent Biennial Reports. 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 2014-15 and 2016-17 biennia, and an assessment of linear trends in compliance through time.

Methods

2016-2017 Biennium

Prior to the 2016-17 biennium, 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 ith FPA in the sample, and y_i is the number of rules complied with on the ith 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 97.5th 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):

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

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

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

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

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

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 Deviation: 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 the 2016-17 biennium, the method for estimating compliance and uncertainty around the compliance estimate was changed to the jackknife method, a 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 affected 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, precision levels vary every year 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 practices 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 downward 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 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 and 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

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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 Land-owners	# 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 Land-owners	# 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 Land-owners	# 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 and 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 and 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	

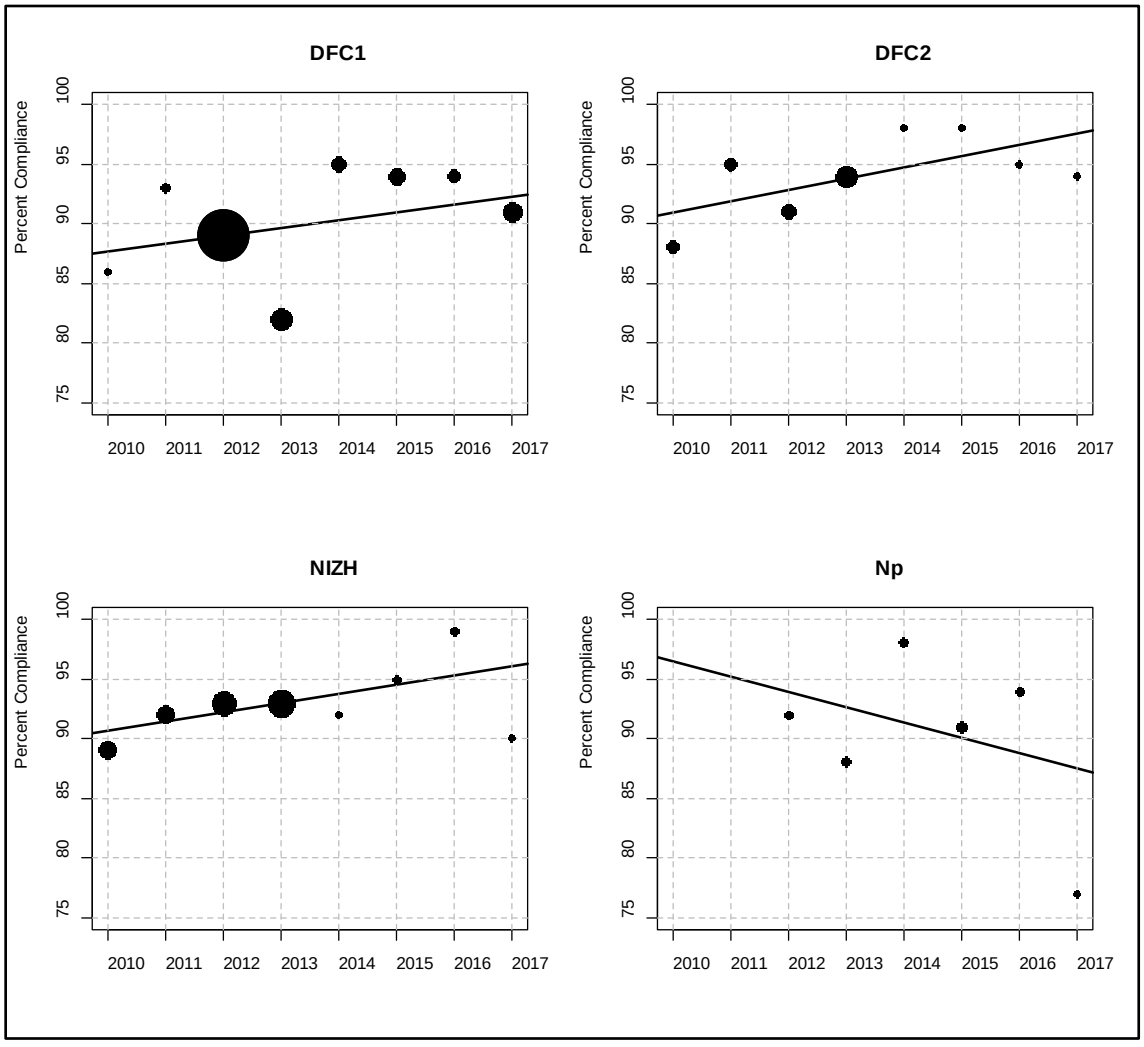

Figure 1. Annual rule compliance for four prescriptions with weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

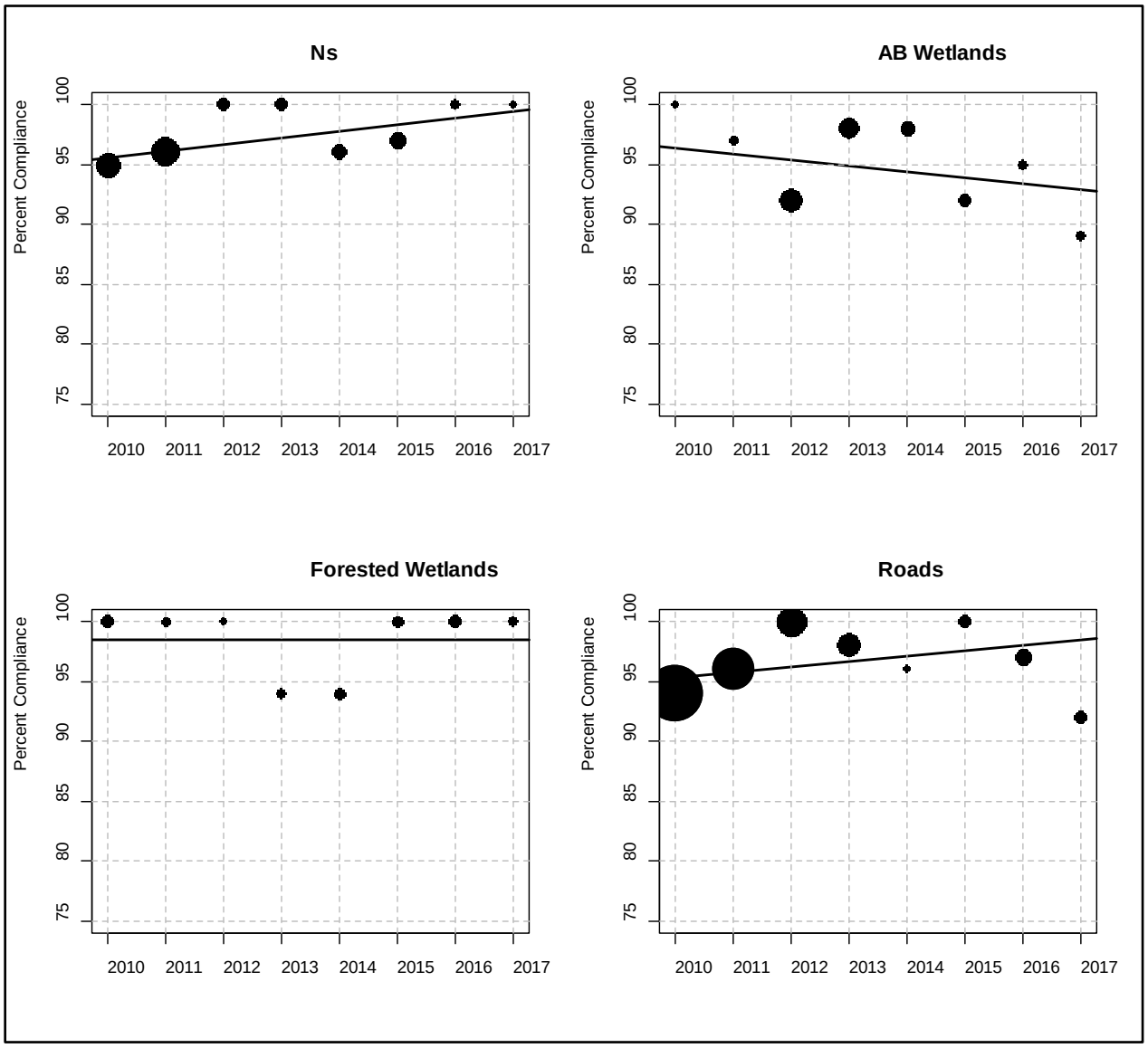

Figure 2. Annual rule compliance for four prescriptions with weighted linear regression line overlaid. The point sizes reflect the relative weights given to each point in the regression based on variance differences among years.

15. References

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