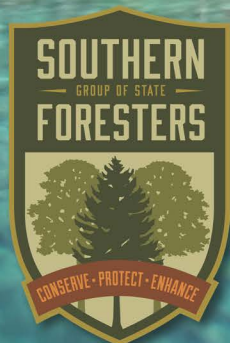


Silviculture Best Management Practices

Implementation Monitoring Framework
for Southern State Forestry Agencies (2024 revision)



WATER RESOURCES
COMMITTEE

Preface

The 1972 amendment to the Federal Water Pollution Control Act, commonly known as the Clean Water Act, recognized nonpoint source pollution and called on states to develop and implement water quality management plans (Clean Water Act, 1972). Since then, state forestry agencies, the U.S. Forest Service, state water quality agencies and the U.S. Environmental Protection Agency (EPA) have been working together to identify potential silviculture-related sources of nonpoint source pollution and develop recommendations that minimize these risks.

In the southern states, a traditional regulatory approach was initially proposed to address silviculture-related water pollution. However, after further analysis and consultation with the forestry community, the EPA and most states generally agreed that a non-regulatory approach using outreach strategies would prevent or reduce pollution problems before land management activities occurred. The result was an education-based approach having three basic components:

1. Identification, development and revision of Best Management Practices (BMPs) to protect water quality during forestry operations.
2. Widespread education/training of forestry practitioners and forest landowners to facilitate the implementation of BMPs.
3. Routine monitoring of forestry operations to determine the level of BMP implementation.

By the 1990's, all 13 southern states had developed initial, EPA-approved, silviculture BMPs, and were implementing BMP education programs which included training sessions for forestry practitioners, loggers, landowners and land managers. At this point, however, several of the southern states had not yet developed routine BMP monitoring procedures to assess implementation levels. In addition, there was no standard or model procedure under which to conduct monitoring. As a result, states with monitoring programs were using differing methods to measure and report levels of BMP implementation. Consequently, monitoring results were met with varying degrees of acceptance by regulatory agencies and the scientific community. Inconsistency among states with respect to statistical design, reproducibility and general objectivity were cited as concerns.

In response to these concerns, the Southern Group of State Foresters (SGSF) appointed a BMP Monitoring Task Force (see Appendix A) in 1996 to develop a consistent approach to BMP monitoring for the region. The goal was to produce a BMP monitoring framework that was technically defensible, and which would employ practical procedures to allow for statistical comparison among the states. The resulting framework was titled *Silviculture Best Management Practices Implementation Monitoring: A Framework for State Forestry Agencies* (BMP Monitoring Task Force [SGSF], 1997). In 1999, SGSF formally endorsed the monitoring framework with adoption by SGSF member states being voluntary.

In the fall of 2001, the Water Resources Committee (WRC) became a formal committee of SGSF. The WRC charter calls for the appointment of one primary representative from each of the SGSF member states to the committee. It also establishes regular reviews of member states' BMP programs, the periodic review and revision of the implementation monitoring framework, and the

development of regional training to assist member states in all aspects of their BMP programs. Since initially developing BMPs, most states have periodically revised their BMPs to keep current with changing information and technology. In addition, SGSF encouraged those states which had not yet adopted the monitoring framework to do so.

In March 2002, a subcommittee of the BMP Monitoring Task Force (see Appendix A) reconvened and completed a revision of the original monitoring framework (BMP Monitoring Task Force [SGSF], 2002). The revision expanded the list of recommended practices to be evaluated, and increased the recommended monitoring frequency from every two years to every three years.

The first round of state program reviews began in September of 2003. The overarching purpose of the visits was to share program experiences among state BMP experts, learn from other states' experiences, recommend changes or improvements where necessary, and improve overall program performance and delivery. Subsequently, between September 2003 and March 2006, a small group of WRC members conducted on-site reviews of each BMP program in all 13 member states.

In June 2007, a second revision to the monitoring framework was produced, this time by the WRC (SGSF, 2007). Changes were made to the Risk Assessment section and a table of contents and appendix were added. The new appendix included the *Statistical Guide for BMP Implementation Monitoring* (Simpson et al., 2006) and supplemental information on significant water quality risk indicators.

Between July 2007 and February 2012, a follow-up review of each of the 13 states' BMP programs was conducted. Initial review recommendations were discussed, and new recommendations were provided. In 2016, the document titled *Silvicultural Best Management Practices Program Review and Technical Assistance Guidelines* (SGSF, 2016) was developed to serve as a basis for all future state program reviews. The third round of state reviews began in late 2016 and was completed in early 2023, with plans for a fourth round in development. Results for each review phase were reported to SGSF.

Additionally, in 2008, the WRC began compiling a regional BMP implementation monitoring report for the states which were following the monitoring framework. The initial report was published in June 2008 and included data from 1997-2007 for 11 member states. Although the two remaining states did conduct monitoring during this timeframe, the data was not included since the monitoring was not in conformance with the framework protocol (Water Resource Committee [SGSF], 2008). Following this publication, an expectation was established by the WRC that all member states would follow the protocol in the monitoring framework and a regional report would be compiled every 5 to 7 years. Subsequently, regional reports were published in September 2012 and May 2019. The *2012 Southern Region Report* covered 2007-2012 and the *2018 Southern Region Report* covered 2012-2018. As of the *2012 Southern Region Report*, all 13 member states in the continental U.S. had monitoring programs which were following the protocols in the monitoring framework (SGSF, 2012; SGSF, 2019). In recent years, due to funding issues and reductions in staffing, a few of the member states have had difficulties either maintaining their implementation monitoring programs or following all the parameters set out in the monitoring framework.

In June 2022, another revision effort to the monitoring framework was initiated. This document is the result of that effort.

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Introduction

Silviculture Best Management Practices (BMPs) are management recommendations which have been shown to prevent, reduce or minimize nonpoint source pollution from entering nearby water resources. Silviculture BMPs are collaboratively developed, assessed and revised within each state to tailor recommendations to the state's unique geography, natural resources and economic considerations by utilizing input received from a variety of stakeholders. Although there are some minor differences in how BMPs are written and presented among states, the result is a series of recommendations that maintain water quality during ongoing silviculture operations.

This document should serve as the framework for Silviculture BMP implementation monitoring by the state forestry agencies which are members of the Southern Group of State Foresters. Widespread utilization of this document within the southern region has led to improved consistency among states in the specific aspects of BMP monitoring listed below. In addition, the recommendations for each specific aspect are core elements of a credible BMP implementation evaluation and reporting process.

Considerations Used to Develop BMP Implementation Monitoring Criteria

1. Monitoring Frequency

1) *Issue:*

How frequently should BMP implementation monitoring be conducted and reported?

1) *Alternatives Considered:*

Annual; Every 2 Years; Every 3 Years; Continual Monitoring

1) *Recommendation:*

Statewide implementation monitoring should be conducted and reported a minimum of every three years.

1) *Rationale:*

Due to the large number of forestry operations conducted annually in the South, a large sample size is necessary to achieve statistical reliability. The logistics of locating, visiting and evaluating this large number of sites means annual monitoring and reporting is often impractical. Furthermore, there are no significant advantages provided by annual monitoring and reporting to justify the additional burden.

Monitoring and reporting on at least a three-year basis is more logistically achievable and is consistent with typical 319 funding cycles for the states utilizing these federal grants. In addition, monitoring at this frequency is considered sufficient to allow for visual observations of on-site problems and timely corrective action.

2. Site Selection

2) *Issue:*

What characteristics should a forestry site/operation exhibit in order to qualify as a BMP implementation monitoring site?

2) *Alternatives Considered:*

- 2a) Minimum/No Minimum Area
- 2b) Presence/Absence of Surface Water on Site
- 2c) Time Since Treatment
- 2d) Site Selection Methodology
- 2e) Sample Size

2a) Minimum/No Minimum Area

2a) *Recommendation:*

No minimum area is required, but a site must be part of a normal, ongoing silvicultural operation (i.e. not in the process of conversion to another land use).

2a) *Rationale:*

Since forestry operations occur on tracts of all sizes, and BMPs apply regardless of acres involved, all forestry operations should be eligible for monitoring. However, operations which include timber harvesting as part of a change in land use should be disqualified regardless of the size of the operation. Such activities do not accurately reflect normal silvicultural operations.

2b) Presence/Absence of Surface Water on Site

2b) *Recommendation:*

The presence of surface water features is not necessary for a site to be eligible for BMP implementation monitoring. However, states should record whether a surface water feature was present on the assessed tract.

2b) *Rationale:*

BMP implementation in most states is not contingent upon the presence of surface water on-site. However, any states with proximity restrictions related to BMP implementation should select monitoring sites using appropriate criteria. Recording surface water presence enables states to assess which tracts could pose a risk to water quality.

2c) Time Since Treatment

2c) *Recommendation:*

The most recent silviculture activity(ies) on a site to which BMPs apply must not have been completed more than two years prior to implementation monitoring.

2c) *Rationale:*

Forestry operations that were completed more than two years prior to being monitored are increasingly difficult to evaluate because of rapid regrowth of vegetation and more difficult access. Likewise, evidence of erosion and sedimentation becomes less visible over time, as does the opportunity to correct such problems without "re-disturbing" sensitive areas. Conversely, an interval of less than two years can be difficult to accomplish in states which do not have silviculture activity notification requirements and/or limited staff. However, it is acknowledged that monitoring conducted as soon as possible after an activity is completed will be most beneficial for limiting any water quality issues which may have resulted from the silviculture activity.

2d) Site Selection Methodology

2d) *Recommendation:*

Sites for implementation monitoring may be located using aerial reconnaissance, severance tax records, notification logs, satellite imagery or other available sources of information. In addition, the sample population should accurately reflect the silvicultural operations conducted within the state. For example, an estimate of the number of harvests within each county or physiographic region could be used to assign a weighted number of sampled tracts per county or region (i.e., allow more samples to be taken in areas with a higher concentration of silvicultural operations). It

is essential to achieve a random, stratified random or randomized cluster statistical design to obtain an unbiased sample.

2d) *Rationale:*

Several data sources can provide the information necessary to select a random sample of silviculture operations. However, it is important that the sample population accurately reflect actual conditions in a given state and areas with higher silviculture use be sampled accordingly.

2e) Sample Size

2e) *Recommendation:*

The sample size should be sufficient to achieve an estimate of implementation that is + 5% within the 95% confidence interval. The minimum sample size needed should be determined using the survey design procedure given in the *Statistical Guide for BMP Implementation Monitoring* (Simpson et al., 2006) found in Appendix B.

2e) *Rationale:*

To maximize the validity and credibility of the monitoring results, the number of sites evaluated for BMP implementation should be calculated to provide minimum error ($\pm 5\%$) and high confidence (95%). This can be accomplished by following the statistical procedures outlined in the Simpson et al., 2006 document.

3. Practices to be Evaluated

3) *Issue:*

Which categories of practices should be evaluated for BMP implementation monitoring?

3) *Alternatives Considered:*

Harvesting, Site Preparation (mechanical, chemical, and prescribed burning), Forest Roads, Stream Crossings, Streamside Management Zones, Firebreaks, Forest Chemical Application (fertilization and herbicides)

3) *Recommendation:*

All of the above alternatives should be evaluated.

3) *Rationale:*

These BMP categories contain all practices that are generally associated with operational silviculture in the South.

4. Basis for Practice Evaluation and Reporting

4) *Issue:*

On what basis should BMPs be evaluated and reported?

4) *Alternatives Considered:*

Individual Practices, Categories of Practices, Overall Site

4) *Recommendation:*

Evaluation and reporting should include all three levels of BMPs listed above.

4) *Rationale:*

Evaluation of BMPs at the practice level provides the basic measure of on-site BMP implementation. This level of information also allows for comparison of a specific practice among all monitoring sites and against any other site variables. Such comparisons are useful for identifying the variables most often associated with non-implementation.

In addition, by evaluating categories of practices, monitoring can provide broader conclusions about BMP implementation for stream crossings, forest roads, etc. Also, this information can identify training needs for forestry agency personnel, and education needs for forestry practitioners.

It is also important for water quality agencies, forest landowners and other stakeholders to understand the overall/cumulative level of BMP implementation on each individual forestry operation. Overall site compliance is the traditional measure of BMP implementation on forestry operations and is a key indicator of program success to demonstrate the effectiveness of the non-regulatory approach to controlling silviculture-related nonpoint source pollution.

5. Scoring Methodology

5) *Issue:*

How should BMP implementation monitoring be scored?

5) *Alternatives Considered:*

Pass/Fail, Graduated Scale, Percent Correct Implementation, Yes/No

5) *Recommendation:*

An individual practice should be scored as “Yes” when applied as specified in the state's BMP Manual. If a particular practice is not applicable, this should be noted as well. Any significant deviation from practice specifications should result in a “No” answer for BMP implementation. Categories and overall scores should be expressed as a simple percentage of all applicable practices. For example, if 100 practices were applicable but only 90 were actually implemented correctly, then the score would be 90% for that category or site, as the case may be.

5) *Rationale:*

Evaluating whether or not BMPs have been properly implemented and their applicability to specific site conditions yields the most objective and reproducible method of implementation monitoring. While some subjective judgment will always be necessary in questionable situations, objectivity can be maximized by training. In addition, subjectivity and confusion

can be minimized by avoiding practice evaluations based on graduated scales for partial implementation or arbitrary "Pass/Fail" declarations. Simple "Yes/No" scoring of BMPs also facilitates the calculation, summarization and reporting of category and overall implementation levels on a percentage basis.

6. Risk Assessment

6) *Issue:*

How should the risk to water quality resulting from failure to implement BMPs be evaluated and documented?

6) *Alternatives Considered:*

No Evaluation of Risk, Risk Evaluated and Significant Risk Noted

6) *Recommendation:*

The risk to water quality should be evaluated and significant risk documented. Significant risk may be attributed to non-implementation for a specific BMP, category of BMPs or the overall operation. The field evaluation of significant risk should be based on **existing** on-the-ground conditions resulting from failure to correctly implement BMPs which if left unmitigated will likely result in an adverse change in the chemical, physical or biological condition of a waterbody. Such a change may or may not violate water quality standards.

Significant risk should also be considered as a situation or set of conditions that can be remedied or otherwise mitigated. Additionally, if a failure to implement BMPs results in any ancillary risks not associated with water quality (e.g., site productivity, road usability or other site values), those should not be designated a "significant risk" within the context of BMP implementation monitoring. Significant risk should be directly and exclusively related to water quality impairment.

Upon designating a significant risk associated with a soil erosion concern, states may consider the option of estimating soil erosion using the Universal Soil Loss Equation as adapted for forestry (USLE-Forest - see Appendix C). This model estimates the amount of soil movement within a defined area but does not estimate sedimentation (Dissmeyer & Foster, 1984). Such estimates coupled with research findings would provide more comprehensive information which would enable others to understand the magnitude of the risks.

Key site conditions often associated with significant risk include, but are not limited to, steep topography and highly erodible soils. Forestry operations conducted under one or more of these conditions without proper implementation of certain BMPs may have a high potential to pose a significant risk to water quality. Examples of forestry activities where significant risks have been identified include heavy equipment operation in close proximity to surface waters and stream crossings, logging slash disposal and intensive mechanical site preparation. A comprehensive list of on-site indicators often associated with a significant risk to water quality are given in Appendix D.

6) *Rationale:*

Documenting the occurrence of significant risk serves a number of useful and practical purposes. First, risk assessment lends credibility and integrity to the BMP monitoring process by recognizing that high risk conditions can occur, and that prevention and/or restoration is a high priority for state forestry agencies. Second, routine documentation of significant risk will determine whether such instances are the exception rather than the rule, and that a lack of BMPs during a silviculture operation may not necessarily equate to or result in a water quality problem. This is particularly important as it relates to BMP effectiveness monitoring (Dissmeyer, 1994). Finally, providing forest landowners with an objective risk assessment is a valuable public service which not only protects the environment, but can also protect the landowner and/or operator from what might otherwise result in enforcement proceedings or other personal liability.

7. Follow-up Actions

7) *Issue:*

What specific actions should states take following BMP implementation monitoring?

7) *Alternatives Considered:*

No Follow-up, Courtesy Copies of Monitoring Results, Personal Visit, Referral to Regulatory Agency (where necessary)

7) *Recommendation:*

Landowners who have participated in BMP implementation monitoring should be provided a copy and explanation of the monitoring results. In addition, participating landowners should receive recommendations for any remedial actions deemed necessary by the field observer. In cases where a significant risk has been identified, state forestry personnel should attempt to schedule a follow-up site visit with the landowner in order to ensure that recommendations were understood and implemented satisfactorily.

7) *Rationale:*

Follow-up activities with landowners and/or loggers serve as a useful educational opportunity, as well as a demonstration of cooperation and courtesy. The BMP monitoring data provides an excellent focal point for reviewing the performance of an operator and the responsibilities of the landowner in terms of water quality and site protection. Remedial or other actions can also be recommended at this time, as can commendation for a job well done.

Where a significant risk has been identified in the monitoring process, an on-site follow-up can help ensure the landowner/operator is aware of the seriousness of the situation and is advised of remedial actions. Potential consequences of inaction can also be explained and discussed at that time and should include environmental impacts as well as possible enforcement actions or other liabilities. This effort can provide the basis for fulfilling the responsibilities of the state forestry agency and provide the landowner with the information from which to make an informed decision.

Conclusion

This BMP Implementation Monitoring Framework is designed to achieve analytical consistency among the SGSF member states by creating a methodology which is statistically sound, objective and technically defensible. SGSF recommends all member states follow these protocols. This will allow for the comparison of monitoring results among member states and compilation of periodic regional reports. By comparing monitoring data, states can better identify regional trends in BMP implementation and, if needed, address areas needing improvement through training, demonstration and information exchange.

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Glossary

Implementation Monitoring – The process used to determine the proper application of BMPs according to the specifications in individual state BMP manuals.

Risk Assessment – The process and criteria used to identify a significant risk to the chemical physical or biological integrity of water quality.

Significant Risk – An existing on-the-ground condition resulting from failure to correctly implement BMPs, that if left unmitigated will likely result in an adverse change in the chemical, physical or biological condition of a waterbody. Such a change may or may not violate water quality standards.

Appendix A: BMP Monitoring Task Force

1996-1998 Task Force Members

Jeff Vowell – Chairman, Florida Division of Forestry
Frank Green, Georgia Forestry Commission
Tim Adams, South Carolina Forestry Commission
Daryll Jones, South Carolina Forestry Commission
Robin Bible, Tennessee Division of Forestry
Sam Austin, Virginia Department of Forestry
Matt Poirot, Virginia Department of Forestry
Gary Cole, Alabama Forestry Commission
Burl Carraway, Texas Forest Service
Mike Sampson, Mississippi Forestry Commission
John Greis, U.S. Forest Service
David Hoge, U.S. Forest Service
Bruce Prud'homme, U.S. Forest Service
Rob Olszewski, Plum Creek Timber Company
Jim Shepard, National Council of the Paper Industry for Air and Stream Improvement

2002 Task Force Subcommittee Members

Jeff Vowell – Chairman, Florida Division of Forestry
Frank Green, Georgia Forestry Commission
Daryll Jones, South Carolina Forestry Commission
Matt Poirot, Virginia Department of Forestry
Gary Cole, Alabama Forestry Commission
Burl Carraway, Texas Forest Service
Mike Sampson, Mississippi Forestry Commission
John Greis, U.S. Forest Service
David Hoge, U.S. Forest Service
Bruce Prud'homme, U.S. Forest Service

Appendix B: Statistical Guide for BMP Implementation Monitoring

Statistical Guide for BMP Implementation Monitoring



SOUTHERN GROUP
OF STATE FORESTERS

Southern Group of State Foresters
Water Resources Committee

October 2006

Statistical Guide for BMP Implementation Monitoring

by

Hughes Simpson, Texas BMP Coordinator
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Southern Group of State Foresters
Water Resources Committee

October 2006

Statistical Guide for BMP Implementation Monitoring
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Introduction

Implementation monitoring is the process used to determine the proper application of Best Management Practices (BMPs) according to the specifications in individual state BMP Manuals. In 1999, the Southern Group of State Foresters (SGSF) endorsed a monitoring framework designed to provide regional guidelines for monitoring BMP implementation so that consistency and reliability of southern state efforts would be maximized. The framework calls for evaluations to be conducted on randomly selected forestry operations and to result in data that is statistically valid.

Field evaluations consist of answering “yes”, “no”, or “not applicable” to questions regarding proper implementation of specific BMPs. These are typically broken down into several activity categories (roads, trails, stream crossings, etc.). Each question represents a specific BMP (“yes” means the BMP was implemented correctly and “no” means it was not). If a BMP listed on the evaluation form was not applicable to that site, “not applicable” is recorded. Additionally, the presence of a significant risk to water quality is noted for each question if, due to a lack of or malfunction of a BMP, water quality has been impacted or is clearly threatened. To determine the implementation rate, the total number of “yes” answers is summed and then divided by the total number of applicable answers (yes / yes + no) to determine the total BMP Implementation rate, expressed as a percent, for the site.

After combining all results, BMP implementation may be reported for the state, regions of the state, landowner types, forestry activities, river basins or watersheds, and BMP groups or other categories of interest for reporting purposes. Strengths (BMPs along streams) and weaknesses (BMPs on roads) are generally identified from the results.

In 2004, a task force of the SGSF Water Resources committee was formed to develop this statistical guide to assist the southern state forestry agencies with BMP implementation monitoring design and reporting. Included with this guide is an [Excel spreadsheet](#)¹ created to help states determine how many sites are needed to conduct a statistically reliable survey, calculate the margin of error for each BMP evaluated and reported, and analyze statistical trends in BMP implementation.

Major elements in the design of a statistically valid BMP implementation survey include:

- sampling intensity (total number of sites needed for the survey)
- methodology of choosing sites
- how to ensure randomness of the samples
- stratification of field sites (# of samples per county, landowner type, etc.) so that sound conclusions can be drawn from each.

Key calculations for the analysis of a BMP implementation survey will include:

- determining statistical significance of BMP trends
- confidence intervals and margin of error

¹ 2006_BMP_Monitoring_Statistical_Guide_Spreadsheet.xls

Survey Design

Determining the Sample Size or Number of Sites to Evaluate

$$n = \frac{4p(100 - p)}{m^2}$$

Where n = the number of sites to evaluate
 p = the estimated overall percent implementation in the state
 m = the margin of error (5%)

Notes:

- p must be estimated because it is unknown (% implementation from the most recent round of monitoring may be used)
- The closer the estimated value of p is to 100, the lower the value of n will be.
- n is highest when p is estimated to be 50%.
- m is the margin of error associated with the estimate of p . There is .95 (95%) probability that the sample taken will produce an estimate which differs from p by a value of m

Example:

$$n = \frac{4p(100 - p)}{m^2}$$

Where p (overall BMP implementation) is estimated at 80%

$$n = \frac{4(80) * (100 - 80)}{5^2}$$

$$n = \frac{6400}{25}$$

$$n = 256$$

Using the spreadsheet¹

The spreadsheet is set up so that all that must be entered is the estimated value of p (Est. % BMP Impl). It will then automatically calculate the number of sites to evaluate based on an embedded formula and a margin of error equal to 5% (as recommended by the SGSF framework).

¹ 2006_BMP_Monitoring_Statistical_Guide_Spreadsheet.xls

*** These equations calculate the minimum number of sites necessary to evaluate. Increasing the sample size will yield an even more accurate estimate of BMP implementation. A minimum of 100 sites is recommended.**

Data Storage

BMP implementation monitoring data can be stored in a number of different formats. The easiest is an Access database consisting of the individual state's BMP monitoring form (checklist), data tables, queries, and reports. Site evaluations can then be entered directly into the database in a user-friendly format. Queries and filters can be created to display the "target" data (i.e. implementation scores for tracts in which a professional forester was involved) for export to the *Statistical Guidebook Spreadsheet*¹. Reports can provide a quick glance at the results of the survey (i.e. % implementation by county). GIS programs can import data for geographical representation and further analysis. A sample database is available for states to customize to fit their needs.

Site Selection

BMP field sites may be selected in a number of ways: aerial reconnaissance, severance tax records, timber deeds, drive-bys etc. To avoid bias, it is important that personnel involved in the site selection process do not contact consulting foresters, industry foresters, or large landowners to provide a list of recent harvesting operations. This could bias samples to the "good" sites. Of equal importance is to avoid selecting sites thought to be either "good" or "bad". The SGSF framework calls for sites to be no older than 2 years after the most recent treatment activity.

Ensuring Randomness

Ensuring randomness is critical in any type of sampling. One way to help achieve randomness is to identify twice as many sites as are needed for the survey, and use a random number generator to identify specific sites to monitor.

Stratification of Field Sites by Ownership, Watershed, or Other Factors

Stratifying the monitoring sites based on important characteristics such as ownership type, watershed, or physiographic region, can add substantial value to the survey's results. It is important that the sample taken be reflective of the actual conditions. There are two ways to accomplish this:

- Take a truly random sample from the population (this will solve the stratification but is extremely difficult).
- Intentionally select sample sites based on their stratum

Forest Inventory and Analysis (FIA) data may be used to estimate the number of sites undergoing forestry operations by landowner type. This percentage can then be used to estimate the number of monitoring sites each landowner group should comprise.

¹ 2006_BMP_Monitoring_Statistical_Guide_Spreadsheet.xls

Data Analysis**Margin of Error**

The margin of error expresses the maximum likely difference observed between the sample mean and the true population mean with 95% probability. It is an important statistical calculation and can be performed for an individual BMP evaluation question (i.e. SMZ width). The following formula is used to perform this calculation:

$$m = 2\sqrt{\frac{P(100-P)}{n}}$$

Where m = margin of error for a single BMP
 P = the percent implementation for a single BMP
 n = the number of sites on which the BMP were evaluated

Notes:

- If the actual value of P is larger than the estimated value of P , then the actual margin of error will be smaller than m .
- This equation is not valid for a subset of all possible sites (i.e. calculating margin of error from the % BMP implementation for NIPF landowners.)
- For a BMP that is not applicable to all sites, the actual margin of error will be larger than m .
- Estimating the average % BMP implementation across all possible sites for a group of BMPs and then using this number of sites will produce a margin of error that is smaller than m .
- If the value of P is 100%, the margin of error is not zero. No calculation can be made.

Example:

$$m = 2\sqrt{\frac{P(100-P)}{n}}$$

Where P (% BMP impl. for adequate SMZ width) was evaluated to be 89% on 125 sites

$$m = 2\sqrt{\frac{89(100-89)}{125}}$$

$$m = 2\sqrt{\frac{979}{125}}$$

$$m = 2\sqrt{7.832}$$

$$m = 5.597$$

Using the spreadsheet¹

The spreadsheet is designed to calculate the margin of error for a single BMP. All that must be entered is the % implementation for a single BMP (% for single BMP) and the number of sites on which that BMP was evaluated (# of sites).

95% Confidence Interval

The 95% confidence interval is a tool that statisticians use to demonstrate their confidence in the measured mean of a sample. It provides a range for which they are 95% confident (i.e. 19 times out of 20) that the actual mean will be found within that range. To calculate the 95% confidence interval, you must also calculate the mean, variance, standard deviation, standard error, and margin of error.

Example:

Let's calculate the 95% confidence interval for the following sample:

95%, 80%, 88%, 100%, 77%

First calculate the mean.

$$\frac{95+80+88+100+77}{5} = \frac{440}{5} = 88\%$$

Then calculate the variance.

Step 1: $USS = 95^2 + 80^2 + 88^2 + 100^2 + 77^2 = 39,098$

Step 2: $SUM = 95 + 80 + 88 + 100 + 77 = 440$

Step 3: $CF = 440^2/5 = 193,600/5 = 38,720$

Step 4: $CSS = 39,098 - 38,720 = 378$

Step 5: $DF = 5 - 1 = 4$

Step 6: $Variance = 378 / 4 = 94.5$

Next calculate the standard deviation.

Std dev. = $\sqrt{variance} = \sqrt{94.5} = 9.721$

After that, calculate the standard error.

Std. error = $(Std\ dev. / \sqrt{number\ of\ sites}) = 9.721 / \sqrt{5} = 4.347$

Next, calculate the margin of error.

Margin of Error = $2(Std.\ error) = 2(4.347) = 8.695$

Finally, use the margin of error to calculate the 95% confidence interval.

95% Confidence interval = $Mean \pm Margin\ of\ Error = (79.305, 96.695)$

¹ 2006_BMP_Monitoring_Statistical_Guide_Spreadsheet.xls

Using the Spreadsheet¹

The spreadsheet is set up so that all that must be entered is the individual tract scores (Indiv. % Impl) and the total number of sites (# of sites). The spreadsheet automatically calculates the mean, variance, standard deviation, standard error, margin of error, and the 95% confidence interval (low and high ends).

BMP Trend Analysis

Analyzing trends or patterns in BMP implementation can be useful to target areas or ownership types for concentrated educational efforts (i.e. additional logger training workshops). Commonly reported trends include higher BMP implementation rates when professional foresters are used, the landowner is familiar with BMPs, and the logger has attended BMP training.

In order to determine trends in BMP implementation, several statistical analyses should be performed. First, a parametric two sample t-test is conducted because of the large sample size. This percentage data must undergo an arcsine square root transformation prior to analysis. Percentage data must be transformed because they are not normally distributed, which invalidates the normality assumption of the parametric test. A non-parametric test (Wilcoxon) may also be performed to add greater statistical validity.

To determine statistical significance, the resulting *P* value was compared to the level of significance. The *P* value is the probability of observing a value of the test statistic as contradictory (or more) to the null hypothesis as the computed value of the test statistic. In these tests, a 0.05 (5%) level of significance was used. For the two implementation ratings to be significantly different, the *P* value must be lower than the level of significance.

Using the spreadsheet¹

The spreadsheet is set up so that all you have to do is enter the individual scores for the tracts that answered “yes” to the particular trend question and likewise for those that answered “no” in the respective column. It will then perform the arcsine square root transformation and conduct a parametric two sample t-test on the new data, based on a level of significance of .05. This value will be used to determine whether the difference in implementation scores for that particular trend is statistically significant. This classification is noted by the answer “TRUE” found under the Stat. Diff column.

****The arcsine square root transformation was conducted so that Microsoft Excel could perform the analysis. More robust tests (non-parametric tests like the Wilcoxon) may be conducted to add greater statistical validity. These tests are not included in basic Microsoft Excel programs but can be found in programs like *JMP*, *SAS*, or *Statistica*.**

¹ 2006_BMP_Monitoring_Statistical_Guide_Spreadsheet.xls

Area Weighting BMP Implementation Data

Results are typically reported giving equal weight to all sites (i.e. a 20 acre tract counts the same as a 450 acre tract when compiling all data). Statistically, tracts could also be weighted based on their acreage, i.e. larger tracts would have a greater influence on the total % BMP implementation than the smaller tracts. This analysis can be performed to provide information on how the practices are impacting the total landscape. Both methods are useful in reporting BMP implementation rates, though the SGSF framework does not call for area-weighting. The following formula may be used to perform this calculation.

$$AW \% = \Sigma (((\text{indiv } A / \text{Total } A) * 100)) * \% \text{ Impl})$$

Where **AW %** = area weighted BMP implementation %
A = area (acres)
% Impl = individual tract % BMP implementation

Example:

For this example, let's use 5 individual tract scores and their respective size:

95% - 100 acres, 80% - 35 acres, 88% - 70 acres, 100% - 275 acres, 77% - 20 acres

Equal weighted % BMP Implementation = Sum of scores divided by number of sites

$$\frac{95+80+88+100+77}{5} = \frac{440}{5} = \mathbf{88\%}$$

Area weighted % BMP implementation = Sum of scores proportional to tract size

<i>% BMP Impl</i>	<i>Tract Size</i>	<i>% of Total</i>	<i>AW %</i>
95	100	20	19
80	35	7	5.6
88	70	14	12.3
100	275	55	55
77	20	4	3.1
Total	500	100	95

$$= \mathbf{95\%}$$

% of Total = Tract Size / Total Size

*AW % = % of Total * % BMP Implementation for each individual tract*

Area Weighted % BMP Implementation = Sum of individual AW %

Using the spreadsheet¹

The spreadsheet is set up so that all that must be entered are the individual percent BMP implementation rates and their respective tract sizes in acres. It will then automatically weight the BMP implementation scores based on the tract size.

Reporting

Using the statistical procedures contained in this guide, BMP Implementation data can be reported in the following ways:

- Overall % BMP implementation for the state
- % BMP implementation by landowner group
- % BMP implementation by BMP category
- Area weighted % BMP implementation

¹ 2006_BMP_Monitoring_Statistical_Guide_Spreadsheet.xls

Appendix C: Universal Soil Loss Equation - Forest

The BMP implementation monitoring conducted by the southern states provides a qualitative (yes/no) evaluation of practices known to protect water quality on silvicultural operations. Results of these monitoring efforts are communicated as a surrogate, demonstrating protection against sedimentation and other nonpoint source pollutants. However, there are challenges in communicating these data in a way that will resonate with audiences who are unfamiliar with forestry and/or are attempting to understand the variances in sediment contribution made by different land uses. The Universal Soil Loss Equation as adapted for forests (USLE-Forest) by Dissmeyer and Foster (1984) provides a quantitative methodology to predict the amount of soil erosion that can occur on forestlands. Using the USLE-Forest on site conditions which have been identified as a significant risk to water quality will provide a quantitative measurement which can give further context to the extent sedimentation may be occurring because of silvicultural operations and, in doing so, may improve the understanding of these audiences.

$$A=R*K*LS*CP$$

The USLE-Forest model has six components that are multiplied together to estimate soil loss (A) in tons per acre per year (Wischmeier and Smith 1978). Collectively these components consider a variety of soil, site and vegetation characteristics which contribute to erosion or deposition. The six components are:

- A rainfall and runoff factor (R),
- A soil erodibility factor (K)
- A slope-length factor (L)
- A slope-steepness factor (S)
- A cover and management factor (C)
- A support practice factor (P).

It should be noted that on-site erosion does not necessarily equate to delivery of sediment to a waterbody.

A detailed description of how to estimate soil erosion using the USLE-Forest is provided in Dissmeyer and Foster, 1984. The methodology was transposed into a digital format using ESRI Survey123 by the North Carolina Forest Service. It was designed to prompt users to enter site information using the USLE-Forest table look-ups and figures needed to estimate soil loss. Once the components are entered, the workflow is programmed to calculate the estimated soil loss (Lang et al., 2022). A copy of the Survey123 file is available by contacting the Water Resources Branch of the North Carolina Forest Service.

Appendix D: On-Site Indicators of Significant Risk

Significant Water Quality Risk Indicators

Significant Risk is classified as an existing, on-the-ground condition, resulting from failure to correctly implement BMPs, which if left unmitigated will likely result in an adverse change in the chemical, physical or biological condition of a waterbody. Such a change may or may not violate water quality standards.

On-Site Indicators of Significant Risk to Water Quality

The conditions listed below are often associated with significant water quality risks. They should be viewed as “red flag” warnings that the chemical, physical, and/or biological quality of adjacent waterbodies will likely be threatened if not mitigated.

- Temporary stream crossings remain in channel following operation.
- Stream crossings and approaches not stabilized.
- Logging debris in waterbody affecting or obstructing flow.
- Evidence of excessive sediment entering waterbody from adjacent treated area.
- Canopy completely or almost completely removed from the SMZ on a perennial waterbody.
- Evidence of heavy equipment operation in the stream channel.
- Waterbody banks compromised by equipment and/or skidding activities.
- Water diversion devices are absent or severely compromised on roads or skid trails where runoff is likely to enter a waterbody.
- Ruts or other excessive physical damage to soils and groundcover within the SMZ.
- Fill material in a stream crossing without providing an adequate means for conveyance of flow.
- Unstabilized fireline tied directly into a waterbody.
- Oil, chemicals, batteries or other hazardous materials leaking or remaining on site following the operation.
- Road or skid trail too steep or so poorly located that stabilization is improbable.
- Excessive defoliation of riparian vegetation caused by herbicide application.