Re-evaluating Forest Harvesting BMP efficiencies for the Chesapeake Bay Program's Watershed Model

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Summary:

The Timber Harvest Task Force was convened by the Forestry Workgroup and Land Use Workgroup and is evaluating opportunities to improve the modeling of the water quality impacts of forest harvesting in the Phase 7 Watershed Model. We conducted an initial evaluation of the literature and consulted experts to determine if there was a need to re-evaluate: 1. The loading rates of harvested forests, 2. The nutrient and sediment removal efficiencies of forest harvesting BMPs, and 3. The credit duration of forest harvesting BMPs. Based on our research, we determined that there is insufficient research to support modifying the loading rates of harvested forests, but **we recommend changes to the efficiency rate and credit duration for the Forest Harvesting Practices BMP.**

Introduction:

The Chesapeake Bay Program is currently updating its modeling and analysis tools, including the Chesapeake Assessment Scenario Tool (CAST), which is a publicly available model of the Chesapeake Bay watershed used to estimate changes in long-term nutrient and sediment loads due to changes in point sources, land use, and land management. Harvested forest is one land use type modeled in CAST. With the implementation of forest harvesting BMPs, harvest managers can prevent significant soil erosion, reducing the total sediment and nutrient loads in waterways that could otherwise result from an unsustainable harvest. These BMPs include practices that are implemented to minimize impacts during forest harvest, as well as practices to minimize water quality impacts following the harvest. These BMPs are described in the USDA-NRCS National Handbook of Conservation Practices and include, but are not limited to, Forest Trails and Landings (655) and Forest Slash Treatment (384). The Bay Program uses BMP "efficiencies" to quantify the percentage of a pollutant that is removed when a BMP is applied.

The Bay Program's Forestry Workgroup (FWG) provides expertise to the partnership on forestry-related issues, including timber harvesting. To best advise the Forestry Workgroup on their recommendations for Phase 7 of the watershed model, we conducted a literature review of materials related to the water quality impacts of forest harvesting and timber harvest BMPs and consulted forest harvest experts. During this literature review, we searched for information

relevant to the base loading rates of harvested forests, the efficiency rate for timber harvest BMPs, as well as the credit duration for forest harvesting BMPs.

Current Base Loads and Efficiencies:

Between 2006-2007, the University of Maryland led a project to review and refine effectiveness estimates for forest harvesting BMPs implemented and reported within the Chesapeake Bay Watershed (CBW). As a part of this project, Pamela Edwards (USDA Forest Service) and Karl Williard (Southern Illinois University) were asked to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. Edwards and Williard examined three studies that contained data of timber harvest with and without BMPs from comparable plots to calculate an efficiency rate of the BMPs. Edwards and Williard averaged the efficiency rates from these studies to form a recommended average efficiency rate for CAST. These rates were discounted by 20% to develop a conservative estimate, with the estimate for TN being discounted further, as there was only one study that specifically addressed TN efficiency.

They recommended that the Effectiveness Estimates be set to a conservative **60% for total suspended solids (TSS), 50% for total nitrogen (TN), and 60% for total phosphorus (TP).** These recommendations were formally adopted in the 2009 report "Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed (Page 300 – 342)", by Dr. Thomas Simpson and Sarah Weammert. Forest harvesting BMPs were assigned a credit duration of one year, so these efficiencies are applied to loading rates for a duration of one year. This information can also be found in the Chesapeake Bay Program's Quick Reference Guide for Best Management Practices (Page 162 – 163).

Research Methodology:

We conducted a literature review of materials related to forest harvesting and sediment, nitrogen, and phosphorus loads. We examined relevant studies published within the last 15 years, between 2009 - 2024. We examined studies that took place either in full or partially within the Chesapeake Bay Watershed and neighboring states, as well as eastern mixed deciduous and pine forests. In addition, we consulted with several experts, who assisted in guiding our research. These include Dr. C. Rhett Jackson from the University of Georgia, Dr. Michael Aust from the University of Virginia Tech, and Moriah Van Voorhis from the North Carolina Forest Service, who we want to thank for their assistance. Rodney Newlin from the Virginia Department of Forestry and Andrew Vinson from the Virginia Department of Forestry were also consulted and assisted in the drafting of this report.

Results: Literature Review Summary

In conducting our literature review, we were unable to find any published literature that evaluated the effects of harvest with BMPs compared with harvests without BMPs in the field.

In most cases, BMP efficiencies were estimated based on a modeled No-BMP scenario. In one case (Dangle et al., 2019), only total loads with BMPs were reported, with no indication of an efficiency estimate. In this case, we averaged the reported loads in this study, and compared them with the average of the No-BMP scenarios from the older studies referenced in the 2009 report to determine an estimated efficiency rate. In some cases, a range of efficiencies for a variety of forest harvest BMPs were given, including skid trails, stream crossings, streamside management zones, and others. In addition, the harvests that were evaluated were often categorized as BMP-, BMP-standard, and BMP+, to denote the different levels of BMP implementation. In these cases, we used the average efficiency rate given. Data on the nutrient and sediments loads and concentrations from each study reviewed is included in Appendix A.

Literature that reported efficiency rates and base loads also reported similar loads over multiple years of BMP usage.

Sediment:

There was insufficient literature to reevaluate base TSS loading rates of harvested forests in the absence of BMPs.

Based on the literature, we found an average 85% efficiency rate for BMP sediment retention. This represents a 18% difference from the previously reported average reported in the 2009 report, and a 25% difference from the CAST efficiency rate. This percentage does not include studies where impacts to sediment were not statistically significant. Some of the literature reviewed found that when forest harvest BMPs were utilized, the impacts of harvest on sediment loads were not statistically significant. As a result, they were unable to calculate a reliable efficiency rate. In these cases, we report in the findings column the words they used to describe their results.

Table 1. Forest Harvest Impacts on TSS (with BMPs)

Reference	Efficiency
Hawks, Bolding et al., 2022	64%
Hawks, Aust, et al., 2022	83%
Lakel et al., 2009	97%
A.J. Lang et al., 2022[+]	88.20%
Dangle et al., 2019*	100.00%
Cristan et al., 2019[+]	75.6%
Witt et al., 2016	“Low impact”
Maine FS, 2021	“No measurable difference”
Average	85%
Edwards & Willard Average	67%
Current CAST efficiency	60%

*The study's efficiency numbers were estimated through comparing reported BMP loads to reported No-BMP loads in other studies with comparable geography.

+The study reported a range of BMP efficiencies for different environments, which was then averaged out to calculate an average efficiency.

Nitrogen:

There was insufficient literature to reevaluate base TN loading rates of harvested forests in the absence of BMPs.

The literature reviewed found that when forest harvest BMPs were utilized, the impacts of harvest on TN were not statistically significant. As a result, they were unable to calculate a reliable efficiency rate. In these cases, we report in the findings column the words they used to describe their results.

Table 2. Forest Harvest Impacts on TN (with BMPs)	
Reference	Findings
DaSilva et al., 2012	"No significant increase"
Marchman et al., 2013	"Statistically insignificant"
Boggs et al., 2015	"No significant increase"
Witt et al., 2016	"Low impact"
Edwards & Williard Average	51%
Current CAST efficiency	50%

Phosphorus:

There was insufficient literature to reevaluate base TP loading rates of harvested forests in the absence of BMPs.

The literature reviewed found that when forest harvest BMPs were utilized, the changes in TP were not statistically significant. As a result, they were unable to calculate a reliably efficiency rate. In these cases, we report in the findings column the words they used to describe their results.

Table 3. Forest Harvest Impacts on TP (with BMPs)	
Reference	Findings
Boggs et al., 2015	"No significant increase"
DaSilva et al., 2012	"No significant increase"
Marchman et al., 2013	"Statistically insignificant"
Edwards & Williard Average	72%
Current CAST efficiency	60%

Results: Expert Consultation

When reaching out to experts, they acknowledged that there have not been many new timber harvest BMP research and studies published, and that most BMPs are comparable to BMPs done pre-2000. They also uniformly expressed that the current BMP efficiencies in CAST were not representative of BMP efficiencies. They suggested that BMPs captured over 95% of sediments, that phosphorus loads were highly associated with sediment loads and thus similar, and that very little nitrogen was entering waterways with proper BMP usage. This supports the findings from the literature showing that harvests do not generate significant increases in nutrient loads when BMPs are utilized.

We also consulted Rodney Newlin and Andrew Vinson from the Virginia Department of Forestry. They reported that they perform a BMP audit on 240 randomly selected harvests each year. These audits report when there is a significant risk (SR), which is defined as a harvest where the lack of a BMP is causing or likely to cause pollution, and when there is active sedimentation (AS) occurring. Looking at the last 10 years of their BMP audit reports (2013 – 2023), there was an average of no SR for 98.3% of their audits, and no AS for 99.3% of their audits. Given this high percentage and the high sample size, they supported that BMPs capture >95% of sediments. In addition, Newlin and Vinson reported that BMPs are designed to handle 10-year storm events if they are properly installed and not altered by someone.

Recommendations:

There was insufficient literature looking at base loads of harvested forests without forest harvest BMPs. **We do not recommend changing the base loads of harvested forests.**

The literature and expert consultation suggest that the current efficiency rates for forest harvesting BMPs could be increased, while still remaining conservative. For TSS, there is consensus from both the literature and from the experts that the efficiency rates in CAST are underreporting BMP effectiveness. We determined an average of >85% efficiency in reducing sediment loads with BMP implementation based on the available literature. However, experts reported that the efficiency rate is likely >95%. Currently, CAST reports a 60% efficiency rate for TSS. **Given this information, we recommend changing the efficiency rate for TSS to 85%.**

For TN, the literature reported that with BMP implementation, there were minimal impacts in TN loads after forest harvests. This was supported by the experts interviewed, who advised that very little nitrogen enters waterways with BMP implementation. Currently, CAST reports a 50% efficiency rate for TN. **Given this information, we recommend changing the efficiency rate for TN to 90%.**

For TP, the literature reported that with BMP implementation, there were minimal impacts in TP loads after forest harvests. This was supported by the experts interviewed, who advised that phosphorus loads and efficiencies were highly correlated with sediment loads, and thus are similarly low. Currently, CAST reports a 60% efficiency rate for TP. **We recommend changing the efficiency rate for TP 85%.**

There was evidence that efficiencies are maintained throughout multiple years after BMP implementation, both from the literature and from experts. **We recommend changing the credit duration to three years** to align with the full post-harvest time period for which the land loads as a harvested forest in the model**.**

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