Maine Forestry Best Management Practices Use and Effectiveness 2005-2009

Department of Conservation
Maine Forest Service
22 State House Station
Augusta, Maine 04333

Forest Policy and Management Division

December 2010

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Printed under Appropriation 010 04A 5440 512

Executive Summary

The Maine Forest Service (MFS) has worked closely with Maine's professional forestry community for many years to develop and refine forestry Best Management Practices (BMPs) to protect water quality. MFS BMPs stress a strong understanding of water quality protection principles needed to use the "toolbox" of BMP practices effectively. MFS prefers a flexible, voluntary BMP approach over prescriptive regulation. Voluntary BMPs based on water protection principles allow loggers to select efficient practices that result in the desired outcome; protection of water quality. For an outcome based BMP system to be successful, a strong training program must be in place as well as a monitoring system to ensure that BMPs are working on a statewide basis. MFS's key partners in training development and delivery have been Maine's Sustainable Forestry Initiative and the Certified Logging Professional and Qualified Logging Professional programs. This public-private partnership has advanced Maine's BMP educational efforts far beyond what they would be if they were solely a government effort.

Forestry operations do not have permitting requirements under the Clean Water Act because there is a "silvicultural exemption" given in that law, as long as best management practices (BMPs) are used to help control non-point source pollution. The MFS is statutorily responsible for the development of forestry BMPs 38 MRSA §410-J in Maine and has issued a BMP manual as required by EPA. As part of this mandate, MFS also monitors and reports on the use and effectiveness of BMPs on harvest operations across the state.

The MFS publishes reports on BMP use and effectiveness annually on its website, the current report looks at progress over the last five years. This report presents an analysis of data collected during the five-year period beginning in 2005 and ending in 2009. The objective of this ongoing effort is to assess the use and effectiveness of BMPs in Maine.

Data in this report was collected and analyzed using the "Best Management Practices Implementation Monitoring Protocol," an original project of the Northeastern Area Association of State Foresters' (NAASF) Water Resources Committee. This protocol assesses the overall effectiveness of the suite of BMPs used rather than monitoring the simple installation of prescribed, individual practices, which do not necessarily guarantee success in protecting water quality.[1] Having data collected using a consistent protocol over a five-year period from a total of 500 timber harvests allows for examination of trends in BMP effectiveness. It also allows for examination of data items that have too small a sample size to yield meaningful results in any one year.

MFS uses BMP monitoring to focus educational outreach efforts to loggers, foresters, and landowners and identify trends for targeting technical assistance.

[1] Welsch D., R. Ryder, T. Post. 2007. Best Management Practice (BMP) Manual –Field Guide: Monitoring, Implementation, And Effectiveness for Protection of Water Resources: U.S. Department of Agriculture, Forest Service, NA-FR-02-06, 129 pp.

Trainings include indoor and field sessions and hands on activities such as skidder bridge construction and bottomless culvert installation workshops. Since 2004 approximately 2500 loggers, foresters, and landowers have attend MFS sponsored BMP related classes and workshops and 10,000 copies of the BMP manual have been distributed.

As BMPs are voluntary measures to protect water quality, MFS does not use BMP monitoring to assess compliance with nor enforce laws and rules. When monitoring staff observe concerns or minor issues during BMP monitoring, MFS works closely with the landowner in a non-regulatory manner to seek corrective measures. Education and intervention usually result in quick corrective action, thereby avoiding lengthy regulatory processes that may prolong erosion problems and result in greater negative environmental impacts. Dealing with minor issues in this manner also increases landowner willingness to cooperate with the BMP monitoring process, resulting in a more comprehensive picture of BMP use.

Assessing the overall effectiveness of the suite of BMPs used rather than monitoring the installation of prescribed individual practices allows assessment of whether BMPs effectively protected water quality. For example, simply finding that waterbars were installed does not indicate whether they were effective in directing water into the filter area and keeping sediment out of the waterbody. This approach supports MFS's desire to pursue outcome-based forest policy, a science-based voluntary process that achieves mutually beneficial economic, environmental, and social outcomes in the state's forests. Outcome-based policies are an alternative to prescriptive regulation. They demonstrate measurable progress towards achieving statewide sustainability goals and allow landowners to use creativity and flexibility to achieve objectives, while providing for the conservation of public trust resources and the public values of forests.

MFS has conducted random, statewide monitoring of BMPs on timber harvesting operations since March 2000. MFS continues this monitoring effort as a part of regular field activities and expects to generate subsequent reports.
Key findings of this report include:

- **From 2005-2009 BMPs were effective in preventing sedimentation is 84% of cases.**
- **Sediment entering a waterbody has decreased from 17% of cases in 2005 to 10% in 2009.[2]**
- **Harvests that had BMPs assigned contractually to a logger or forester were more likely to prevent sediment from entering a waterbody.**
- **The percentage of stream crossing structures evaluated that span the stream has increased over the evaluation period. Structures that span the channel rather than constricting it are more likely to maintain**

[2] Note: Due to year to year differences in sampling intensity relative to the total number of harvests movement of percentages up or down by 5% or less between years is considered insignificant.

ecological stream function and permit the passage of fish and other organisms.

- **The number of sample units harvested by dragged wood systems such as grapple skidders has increased from 75% in 2005 to almost 90% in 2009.**
- **There was no evidence of chemical spills on 94% of harvests evaluated.**

Acknowledgements

MFS obtained landowner permission prior to conducting BMP surveys. Landowners, loggers, and foresters often accompany MFS field staff during site evaluations. With a 90% positive response to MFS survey requests, it is evident that Maine landowners are sincere about responsible timber harvesting practices that protect and enhance water quality. MFS is grateful to landowners for such a high rate of positive responses and active landowner participation, without which this comprehensive report would not be possible.

MFS also extends appreciation to Pat Sirois, Kirby Ellis, Andy Shultz, Ethel Wilkerson, Tim Post and Dick Morse, and staff from Massachusetts DC&R, UNH cooperative extension and New York City's Watershed Agricultural Council, who acted as quality control teams, assuring consistent application and interpretation of the monitoring protocol by MFS field staff.

Ethel Wilkerson of the Manomet Center for Conservation Sciences and David Welsch, Watershed Specialist, USDA Forest Service Northeastern Area State & Private Forestry (NA) reviewed the draft manuscript and provided many helpful comments.

Additional appreciation is expressed to David Welsch for assistance and training in running the standardized reporting system.

Absent significant changes in staffing levels or bureau priorities, MFS expects to continue BMP monitoring indefinitely and to report periodically on the most recent data utilizing the USDA Forest Service - Northeastern Area, Best Management Practices Protocol: Monitoring Implementation and Effectiveness for Protection of Water Resources.

Note: The data in this document were generated using the procedures outlined in the two volumes of the **Best Management Practices (BMP) Monitoring Manual: Implementation and Effectiveness for Protection of Water Resources**:
Field Guide (NA–FR–02–06) **Desk Reference** (NA–FR–02–07) Both documents were published by:
USDA Forest Service
Northeastern Area State and Private Forestry
11 Campus Boulevard, Suite 200
Newtown Square, PA 19073
Online versions are available at: http://na.fs.fed.us/watershed/bmp.shtm

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Introduction

The BMP protocol provides an efficient, economical, standardized, and repeatable BMP monitoring process that is automated from data gathering through the generation of a standard data summary. It uses commonly available software and inexpensive field data recording devices. It is compatible with existing state BMP programs and is available for use by forestry agencies, forest industry, and "green certification" programs.

More information, manuals, software programs, and training in the protocol procedures and report generation can be obtained from David Welsch of the NA Watershed Team, or Keith Kanoti, Water Resources Forester with the Forest Policy & Management Division of the Maine Forest Service.

Background

The BMP protocol project is a cooperative effort of the USDA Forest Service, and the NAASF–Water Resources Committee. The project originally was funded by grants from the USDA Forest Service and the U.S. Environmental Protection Agency (EPA).

The original concept and question sequence was developed by Roger Ryder and Tim Post of the Maine Forest Service in collaboration with David Welsch and Albert Todd of NA. The NA proposed the method to the NAASF and the EPA for development as a regional protocol.

State forestry agencies from Delaware, Indiana, Maine, Maryland, Massachusetts, New Hampshire, New York, Ohio, Pennsylvania, Vermont, Virginia, West Virginia, and Wisconsin; the New York City Watershed Agricultural Council Forestry Program; and the USDA Forest Service Northern Research Station and NA have collaborated in the development and testing of the BMP protocol.

A further discussion of the Maine Forest Service legislative mandate and BMP monitoring history can be found in the 2005 Maine Forestry Best Management Practices Use and Effectiveness: http://www.state.me.us/doc/mfs/pubs.htm.

Sampling

MFS selected a stratified random sample of harvest sites (Figure 1) from the MFS Forest Operations Notification database. To adequately represent different type of ownership (large investor and industrial as well as small family forest ownerships) the sample was stratified by harvest size, ownership size, and geographical area. At each sample site either one or two sample units (Figure 2) were chosen for evaluation. The information in this report was compiled using measurements from **500** sample units covering an estimated **81,589** acres. These sample units included **301** skid trail and haul road crossings for which **56,531** feet of approaches were evaluated. Individual numbers of sample units evaluated for each year were as follows **2005 n= 90, 2006 n=112, 2007 n=114, 2008 n=107, 2009 n=77[3].** 2009 was characterized by very poor market conditions and the reduced number of sample units evaluated reflects the fact that many landowners delayed harvesting until market conditions improved.

Each sample unit contains the potential for approximately 200 observations and includes a number of observations of some types of data. The data collection procedure and an explanation of delineating sample units is described in the U.S. Forest Service publication *Best Management Practices (BMP) Monitoring Manual—Field Guide: Implementation and Effectiveness for Protection of Water Resources* (NA–FR–02–06), which includes the question set and instructions for making and recording the observations. Diagrams and definitions are also included.

[3] Yearly sampling intensity ranged from 2.5% to 3.0% of all notified timber harvests.

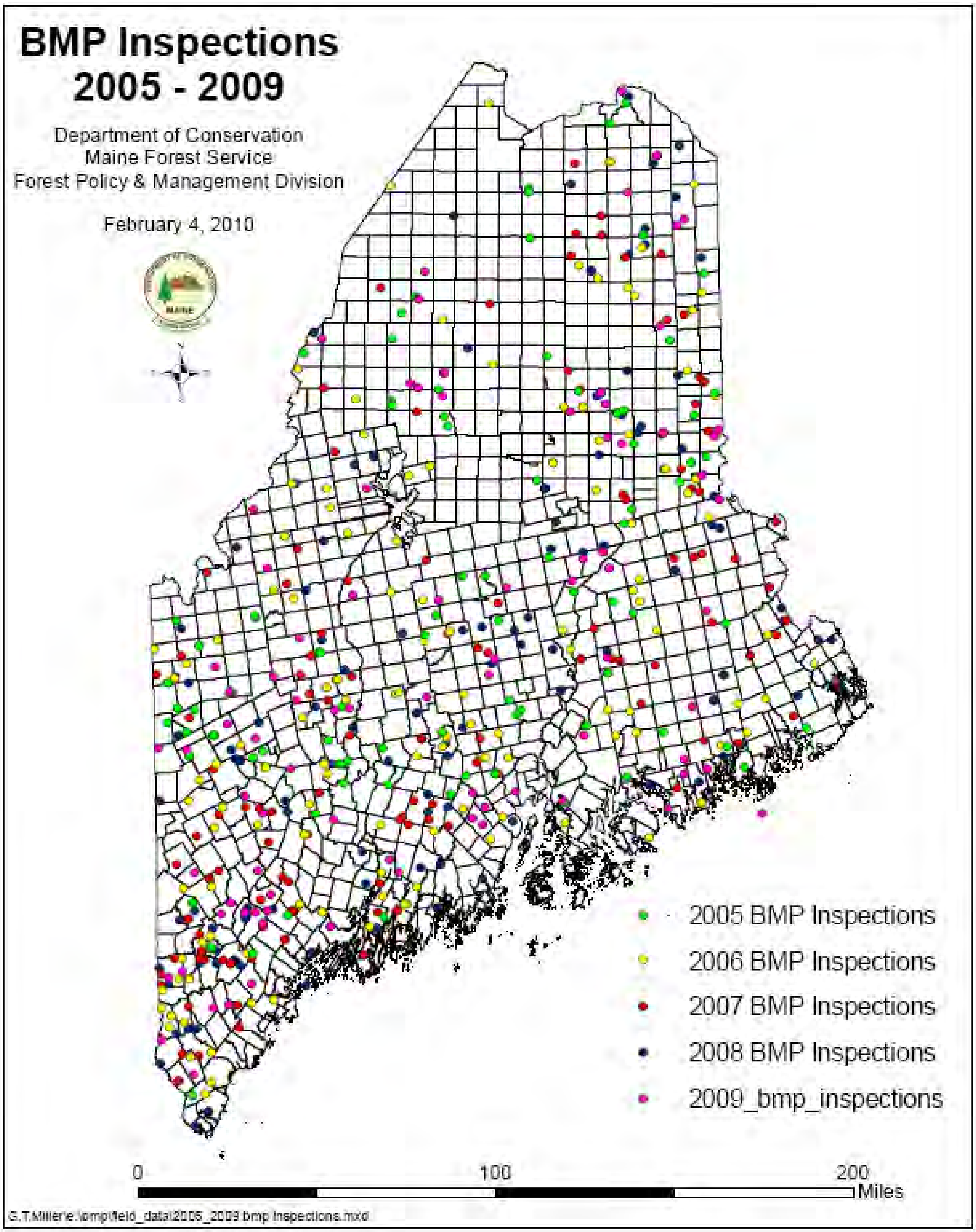

Figure 1 Locations of 2005-2009 BMP inspection sites.

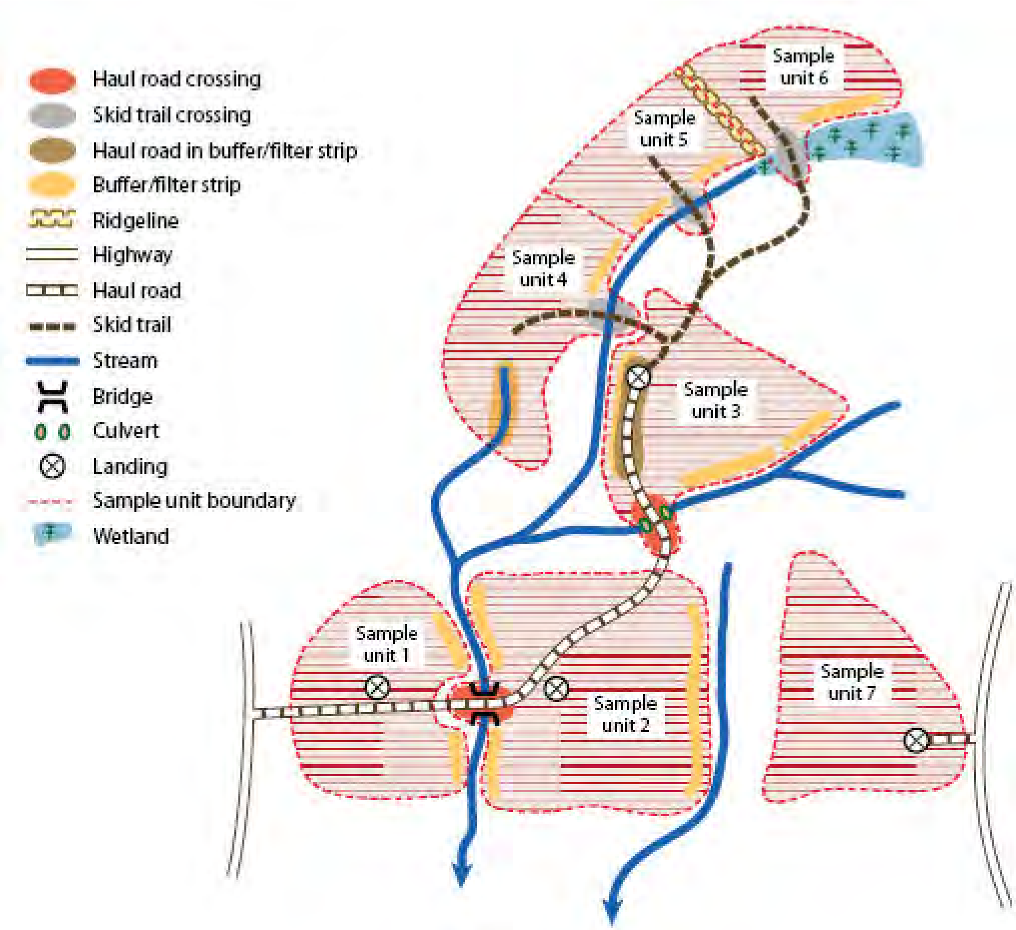

Figure 2 Typical Sample unit delineation. Sample units are delineated by timber cutting boundaries, ownership boundaries, and water body crossings, as shown in this plan view. One or two sample units are randomly chosen for assessment in the randomly selected harvest areas.

General Information

For each sample unit a set of general information questions pertaining to the sample unit as a whole were answered. These included ownership category, ownership size class, type of harvest system used and who was assigned responsibility for BMPs.

Harvest Systems Used

Ground based harvesting is by far the most common type of harvest system in Maine. **Ground based - dragged** harvesting systems involve the use of cable or grapple skidders, where trees are harvested individually or pre-bunched mechanically and dragged to the landing for further processing, sorting, and loading for off-site transport. Ground based - dragged harvests typically result in greater amounts of exposed soil compared to carried wood systems. 2005-2009 data appear to show that there has been an increase in the number of harvests using ground based dragged systems (Figure 3) relative to other harvesting systems.

In certain situations exposing mineral soil on a harvest is desirable for silvicultural proposes, such as the regeneration of trees species like eastern white pine that benefit from an exposed mineral soil seedbed. However, if not planned properly, mineral soil scarification can increase the risk of waterbody sedimentation. **Ground based - carried** harvesting systems generally result in less exposed soil and hence reduced environmental risk as trees typically are cut to length in the woods and then carried or forwarded to the landing for further processing, sorting, and loading for off-site transport.

MFS encourages operators to upgrade to carried wood systems by offering low interest loans through its Direct Link Loan program. This program, backed by the Maine Municipal Bond Bank, offers loans at reduced interest rates to logging contractors who purchase or upgrade equipment designed to minimize soil disturbance associated with timber harvesting.

When used properly carried wood systems (e.g. the forwarder seen on the right) can result in less soil disturbance vs. dragged wood systems (e.g. the cable skidder seen on the left). Regardless of the type of system used, operator skill and training are critical to good results.

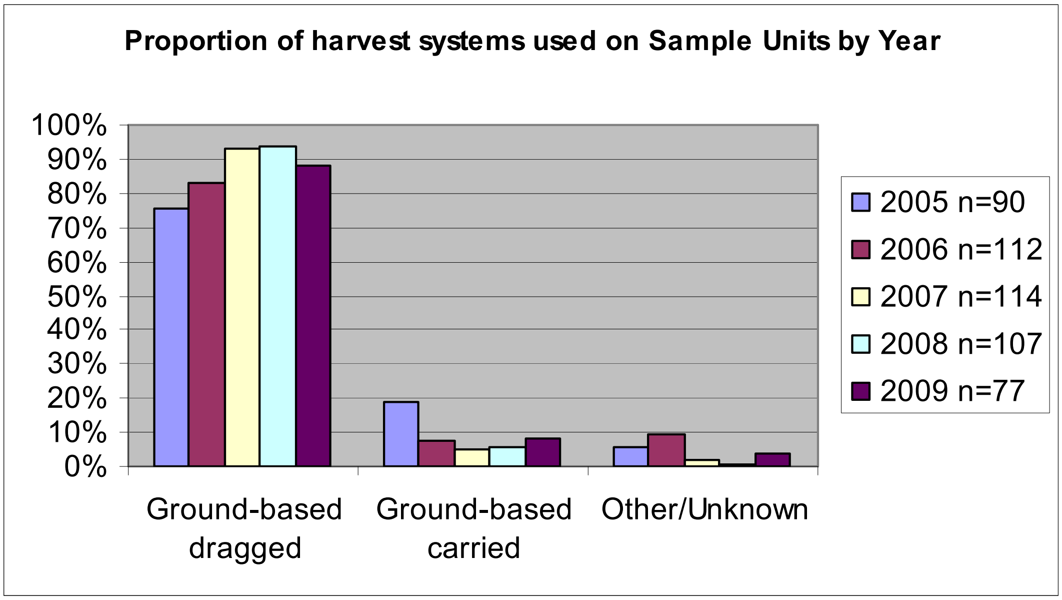

Figure 3 Harvest systems used on all harvested sample units by year . The unknown/other category includes harvest systems not typically used in Maine such as cable yarding sample sties and where the type of system used was not or could not be determined.

BMP Responsibility

BMPs are voluntary in Maine. However, mandatory BMPs may be resultant of contractual agreements between the landowner, logger, and forester or an enforcement action where remedial activities need to follow specific BMP practices to stabilize an erosion or sedimentation problem. BMPs also are mandatory under the third party forest and logger certification systems in Maine.

MFS recommends identifying by name the person responsible for BMP implementation in a written timber sale agreement that clearly explains landowner, logger, and forester expectations. BMP responsibility was assigned either in writing or orally in 80-90% of the cases where responsibility could be determined (Figure 4).

In previous individual year BMP reports it was difficult to make inferences about the effectiveness of assigning BMP responsibility due to small sample sizes. Combining the five years of data, we now can make more confident statements about the effectiveness of assigning BMPs. On sample units where stream crossings were present and BMPs were known to be contractually assigned, measurable sediment occurred 4% of the time when foresters were assigned responsibility for BMPs, 9% of the time when loggers were assigned, and 15% of the time when BMP responsibility was not assigned (Figure 5). Sample units that had BMPs contractually assigned were about twice as likely to have a surface water crossing compared to sites with no BMP responsibility assigned.

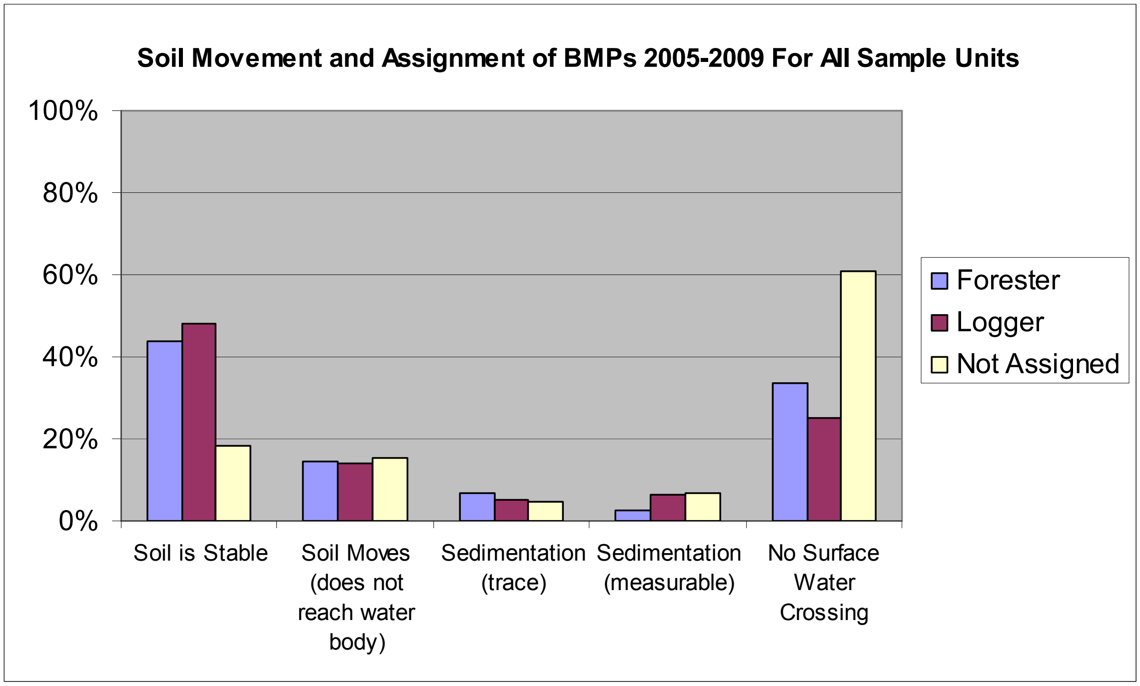

Figure 4 Assignment of BMP responsibility on all sample units.

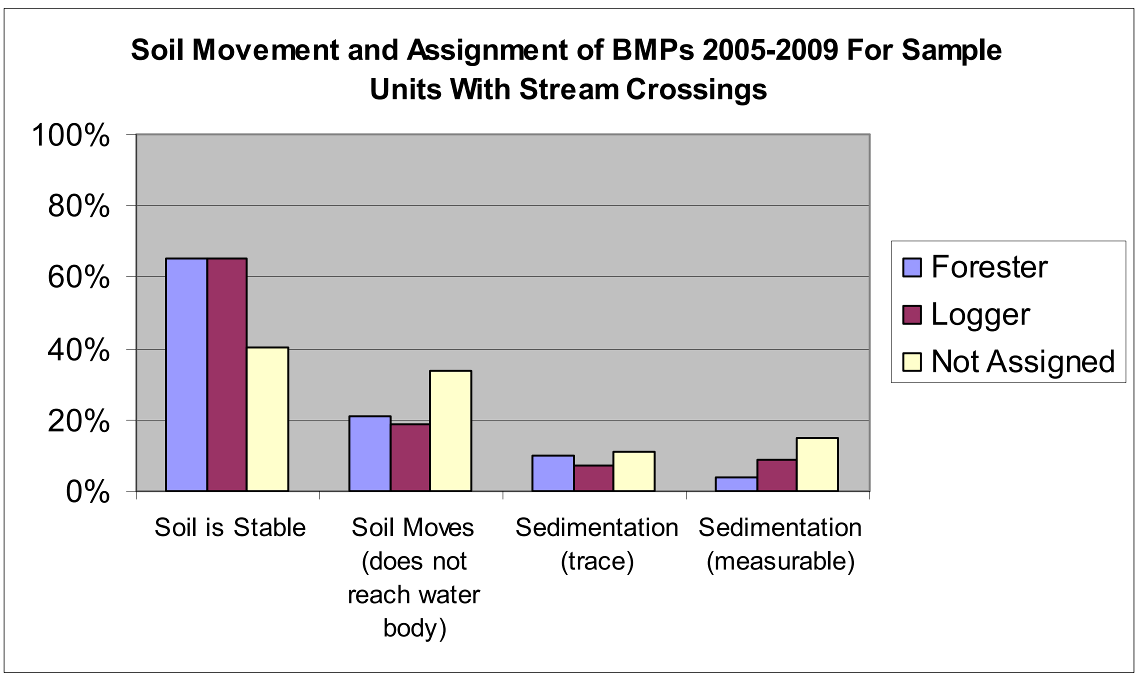

Figure 5 Assignment of BMPs on sample units with stream crossings.

Soil Movement, Sedimentation and Stabilization

Soil entering surface waterbodies can have many negative effects on water quality. Sedimentation can result in embeddedness of gravel substrates which degrades aquatic organism habitat, including spawning habitat for important fish species such as brook trout and Atlantic salmon; increases turbidity, and alters the chemical properties of rivers, streams, lakes and wetlands. BMPs are designed to be simple, cost effective measures that, when applied appropriately, stabilize soil and decrease or eliminate soil moment and sedimentation.

There are five opportunities to observe the occurrence of soil movement, soil sedimentation, or stabilization for each sample unit, four at the approaches and one at the crossing structure. Therefore, for the **500** sample units, there were **2500** opportunities to observe soil conditions.

Of the 2500 opportunities to observe soil conditions 14% showed sediment entering the waterbody. (Figure 6). **Monitoring data from individual years shows that rates of measurable sedimentation have consistently declined from 2005 to 2009 (Figure 7). Over the same period, the rate of trace sedimentation has remained relatively constant.**

Forty percent of the sample units did not have water crossings. **This is due either to the absence of water or the purposeful avoidance of stream crossings through pre-harvest planning.** In 2006 the protocol was modified to better account for stream crossings that were avoided by planning (On these sites harvesting took place on both sides of the waterbodies present and no waterbodies were crossed). From 2006 to 2009 4% of sample units with no water crossings had all stream crossings on the lot avoided by harvest planning. On-the-ground harvest layout can help identify sensitive areas, reduce skid trails, and avoid unnecessary stream crossings. On the remaining sites without water crossings, either no water was present on the lot or harvesting only took place on one side of the waterbodies. Deciding not to harvest on the far side of a waterbody may also be due to planning. There were also likely large harvests sampled where some stream crossings could be avoided by planning and others could not.

If we only consider sample units that had stream crossings from 2005 to 2009 23% of the observations showed sediment (either trace or measurable amounts) entering the water. This number has decreased over time from 28% in 2005 to 19% in 2009. Over this time period, measurable sediment has decreased from nearly 20% of observations to 8% while trace amounts have increased slightly from 8% to 11% (Figure 8).

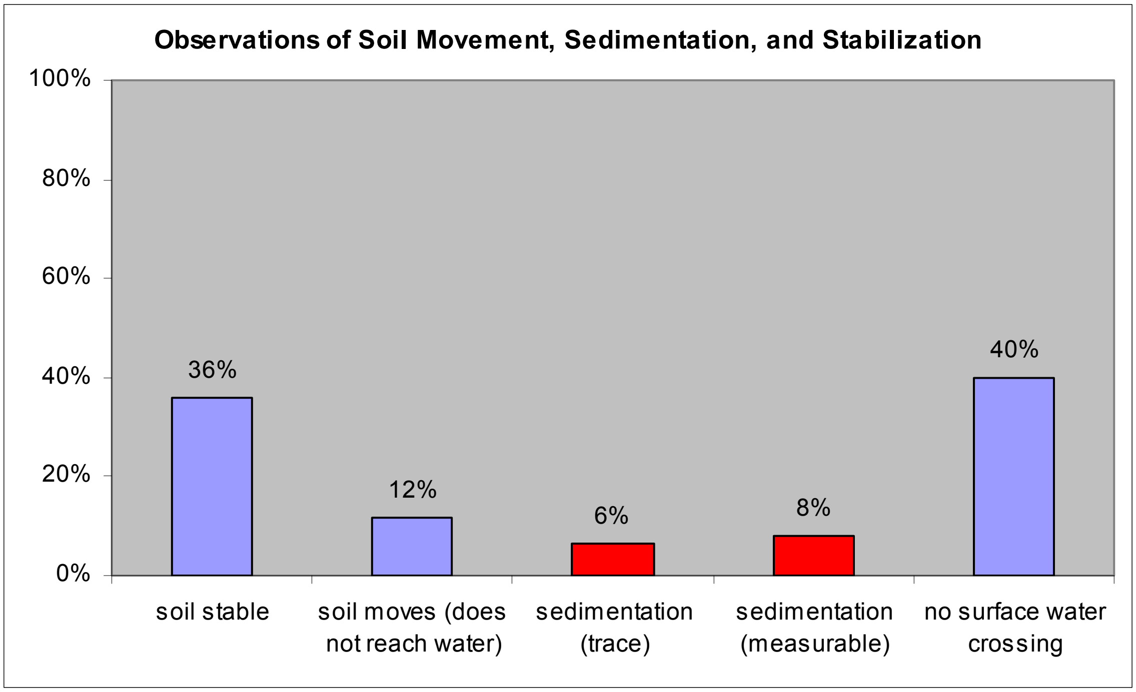

Figure 6 Observations of soil movement, sedimentation and stabilization for all sample units surveyed 2005-2009 n=2500.

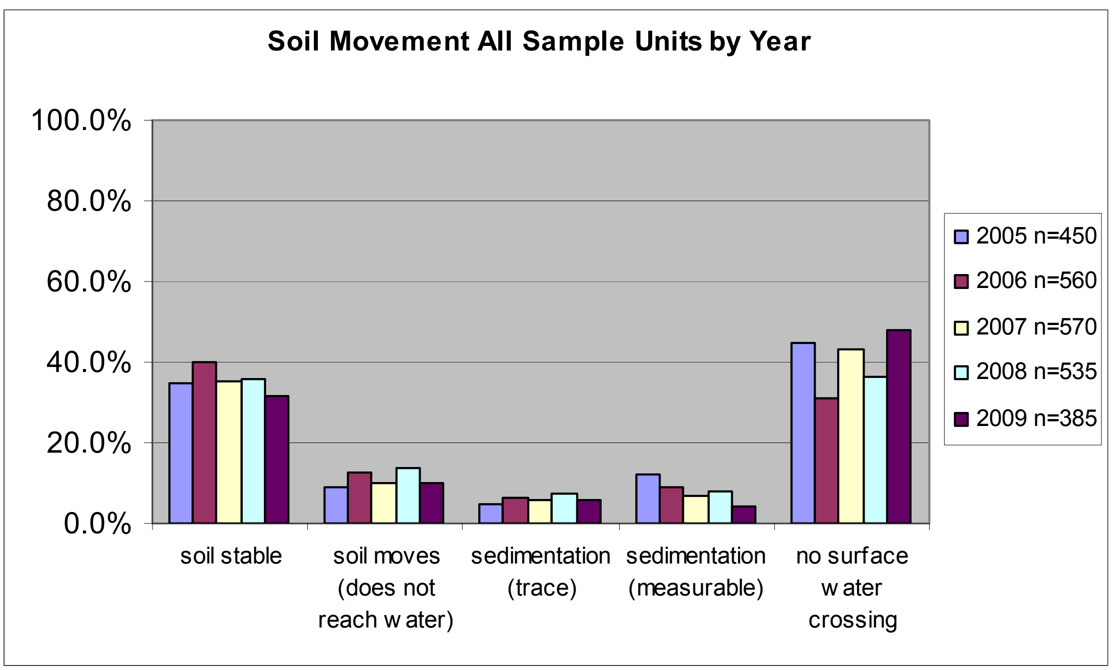

Figure 7 Observations of soil movement, sedimentation and stabilization for all sample units by year.

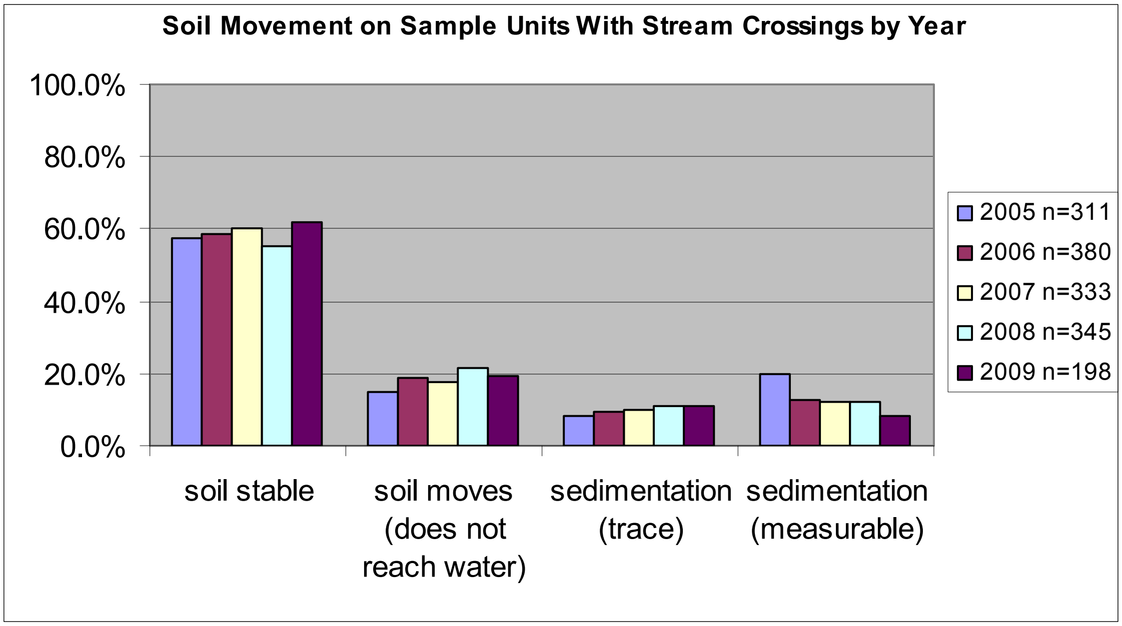

Figure 8 Observations of soil movement, sedimentation and stabilization for all sample units with stream crossings.

Sedimentation Associated with Water Crossings

Crossing Structure

Water crossings and their associated approaches have the greatest potential to negatively impact waterbodies during forest management operations. Improper design and/or maintenance of crossings can lead to sediment and hazardous materials being carried by equipment or runoff into waterbodies. In addition, crossings can modify water flow, disrupt the movement of aquatic organisms, cause upstream ponding, increase scouring or destabilize stream banks. The impacts of improperly designed, maintained or closed out crossings can be substantial and long lasting if corrective actions are not taken

In total MFS Staff evaluated **301** crossing structures. For the purposes of the protocol the crossing structure includes any portion of the road that lies within the bankfull width of the channel (See appendix A). Crossings were identified as either a haul road or skid trail. A haul road is a forest access system designed to transport harvested forest products on trucks to a location or facility for resale, sorting or processing into value added forest products. Skid trails are primarily used by skidders or forwarders (photo page 7) to primarily bring trees that have been harvested to a concentration point for further preparation for transport on a haul road or public transportation route. Staff evaluated **156** haul road crossings and **145** skid trail crossings.

Because water crossings have a high potential to negatively impact water quality, the BMP Protocol examines them in detail. ***Data reported in this section only contains information from only sites that had surface water crossings.*** By limiting the analysis to sites with water crossings, we are better able to understand the issues associated with these features.

Crossing Structure Types

Across all sample units culverts were the most common type of crossing structure encountered. Single culverts were by far the most common type of structure encountered on haul roads (Figure 9) while fords (both unimproved and pole and brush fords) and removed structures were the most common encountered on skid trails (Figure 10).

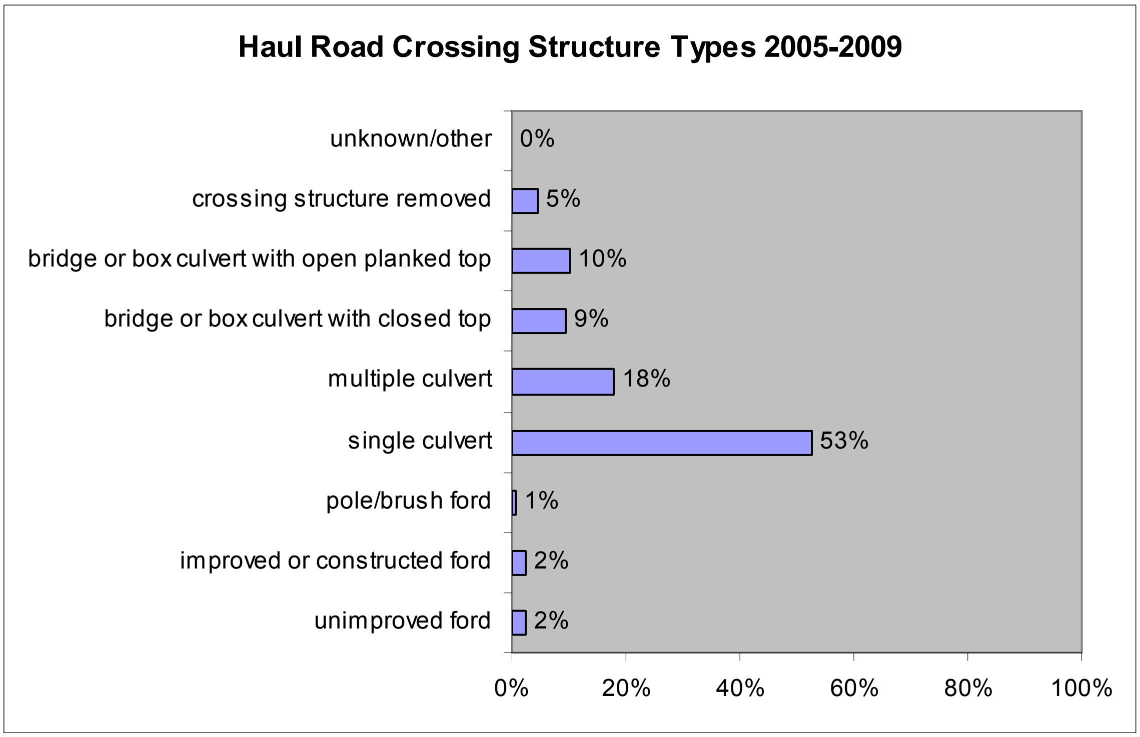

Figure 9 Crossing structure types for all haul road crossings surveyed 2005-2009 (n=156)

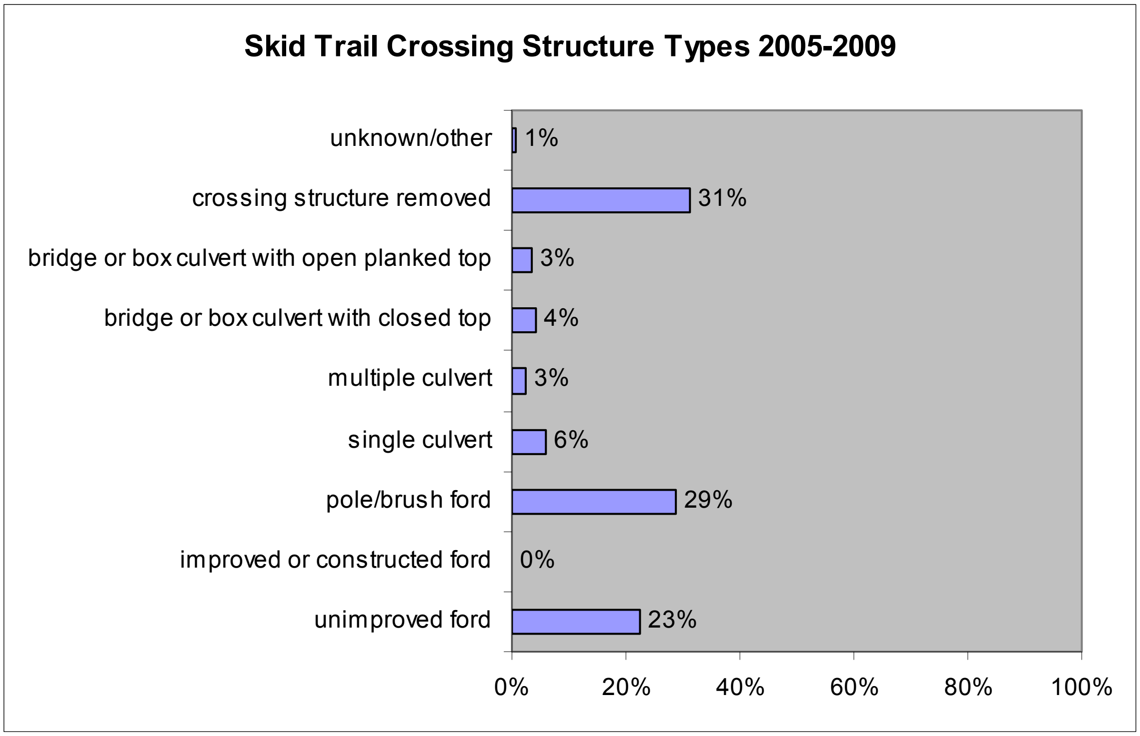

Figure 10 Crossing structure types for all skid trail crossings surveyed 2005-2009 (n=145)

Soil Stabilization and Sedimentation from the Crossing Structure

MFS observations of all waterbody crossings from 2005-2009 showed 51% were fully stabilized, while 49% had soil movement, which in many cases (41%) reached the waterbody. 13% of crossings had trace sedimentation and 28% had measurable sedimentation enter the waterbody (Figure 11). Measurable sedimentation is defined as $\geq$ 1 cubic foot of sediment below the bankfull elevation of the channel. Many times portions of a crossing structure must come in contact with the waterbody. It is extremely difficult to keep all soil from reaching the waterbody, but siltation and sedimentation can be minimized to the point that the biological activity of the associated waterbody is not affected.

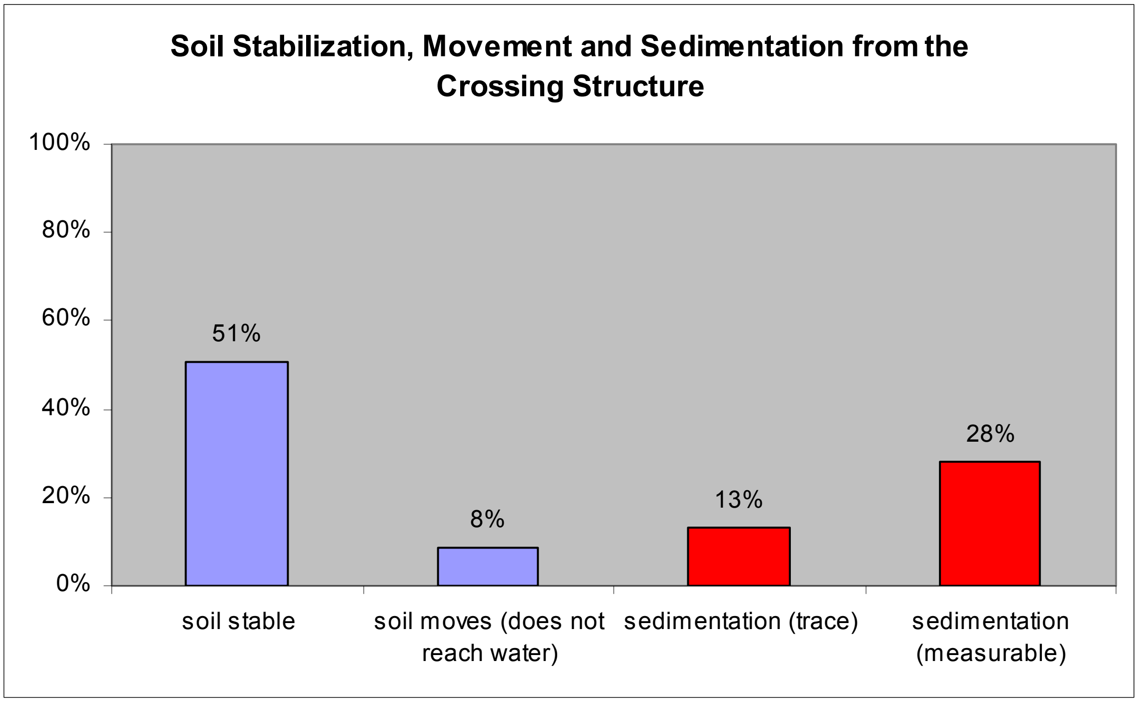

Figure 11 Soil stabilization movement and sedimentation for all crossings surveyed 2005 -2009 **(n=301)**

The amount of sediment entering the waterbody was quantified in 2005 and 2009 but not in 2006-2008. The average volume of sediment entering the water for crossings for which the data are available was 56 cubic feet. This average was skewed by two very large sedimentation events caused by structure failures. These events demonstrate the importance of proper crossing structure design and sizing since failure has the potential to lead to large sediment inputs. Because of the influence of these two events the median value of 3 cubic feet value is probably more useful in determining the impact of sedimentation occurring at "typical" crossings (Table 1).

Table 1 Sediment volumes entering the waterbody from the crossing structure for crossings evaluated in 2005 and 2009.

	Average	**Median**	**Maximum**
unimproved ford	4	2	9
improved or constructed ford	1920	1920	1920
pole/brush ford	5	1	23
single culvert	15	3	123
multiple culvert	18	6	87
bridge or box culvert with closed top	3	2	6
bridge or box culvert with open planked top	183	87	800
crossing structure removed	28	3	120
unknown other	0	0	0

In previous years reports, sedimentation originating from the crossing structure has been identified as a problem area. In response to this issue MFS and its partners including Maine SFI, Certified Logging Professional program, Qualified Logging Professional program, and the Northeast Master Logger Certification Program have targeted training to address the issue. Over 600 loggers, foresters and landowners have attended BMP related training sessions over the past two years. The MFS has also expanded its temporary skidder bridge loaner program so that four sets of steel skidder bridges and about 20 sets of wooden skidder bridges are available for loan to loggers across the state.

Looking at sedimentation rates from the crossing structure by year shows a trend of decreasing measurable sedimentation rates over time (Figure 12).

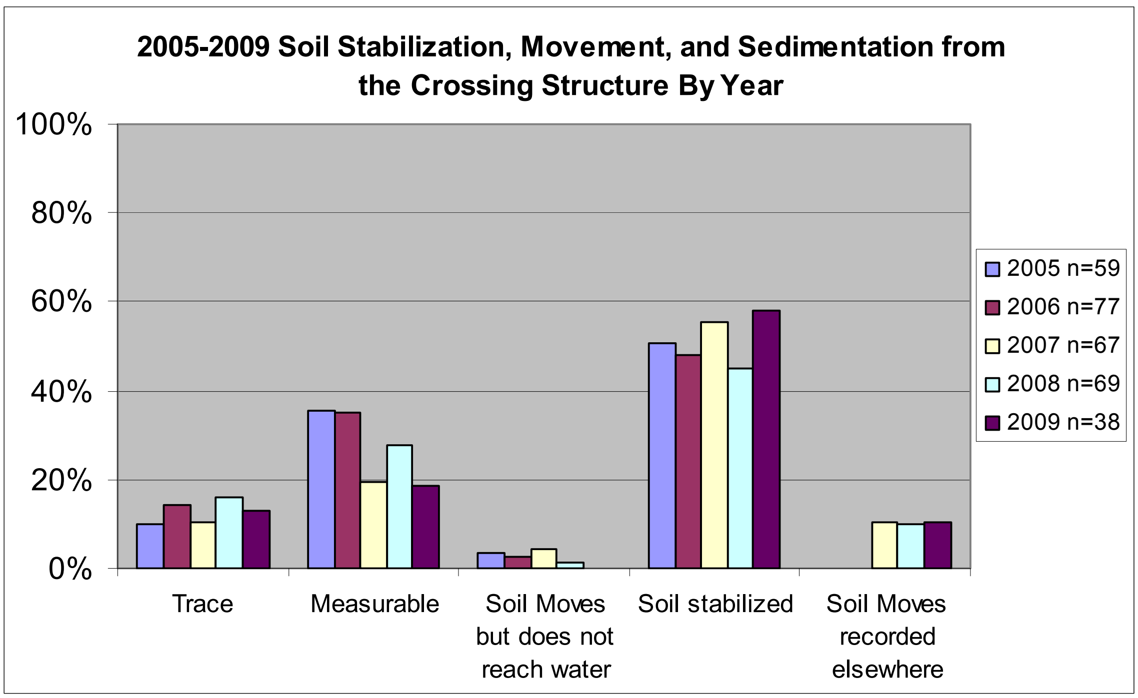

Figure 12 Soil stabilization movement and sedimentation from crossing structures.

The Maine Forest Service and the Maine Sustainable Forestry Initiative sponsored skidder bridge mat workshops are designed to reduce stream crossing sedimentation by teaching loggers how to construct and install temporary skidder bridges. This program also provides direct assistance by providing skidder bridges that are available as free loaners at host mills.

BMP Implementation at crossings

MFS supports voluntary, outcome based BMPs. The desired outcome when crossing a waterbody is to minimize the ecological impacts of the crossing on the waterbody in a cost effective manner that allows for a productive timber harvest. Minimizing sedimentation from crossings is a primary desired outcome. An examination of both application of BMPs when sedimentation occurred (i.e. the desired outcome may not have been fully achieved) and when the desired outcome was achieved (soil was stabilized) is instructive.

When sediment reached a waterbody at a crossing structure, the most common cause was the inadequate application of BMPs (47%) rather than a total lack of BMPs (19%) (Figure 13). Only 13% of sedimentation occurred on sites with properly implemented BMPs. This indicates that sites with No BMPs or inadequate BMPs have a much higher risk of sedimentation occurring than sites where BMPs are properly implemented.

Installation and closeout of crossings were the most common activities related to sedimentation from the crossing structure. Often times some sediment entering the waterbody during installation or closeout is unavoidable, but using proper

BMPs the amount of sediment entering the waterbody can be minimized. 20% of sedimentation was incidental to the installation or closeout and 30% was determined to be due to incorrect installation or closeout. (Figure 14) The number of sedimentation events related to incorrect installation or closeout points to an area to focus on in future educational efforts.

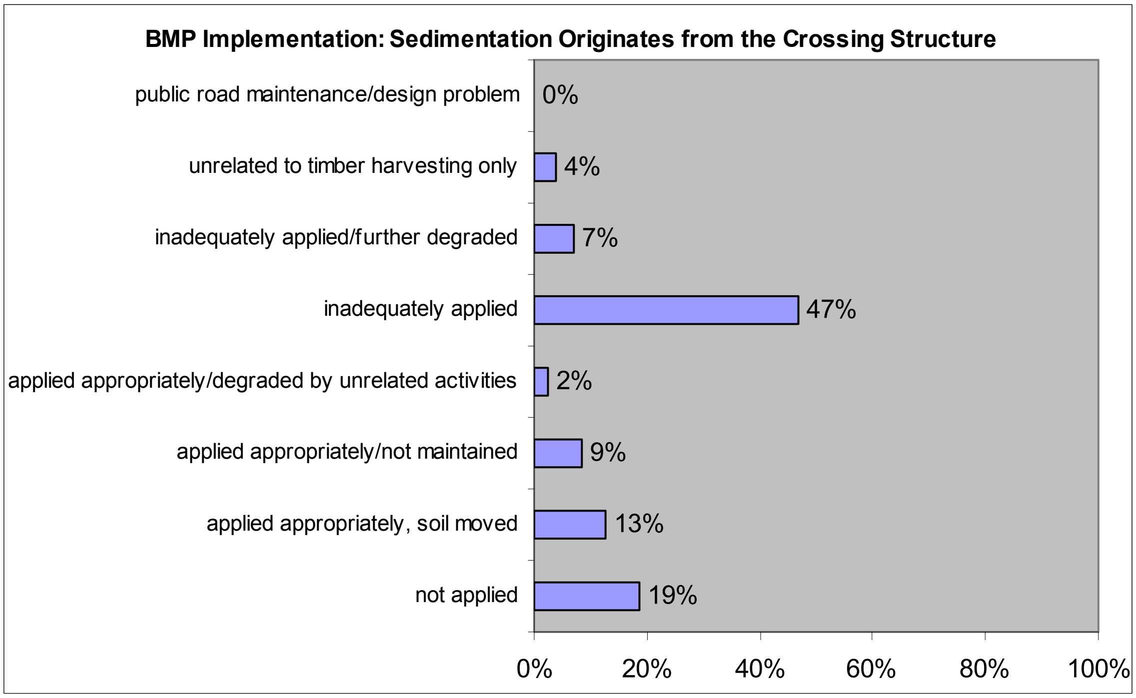

Figure 13 BMP application when sediment (both trace and measurable) originating from the crossing structure entered the waterbody 2005-2009. Only crossings that actually had sedimentation occur are shown (n=128).

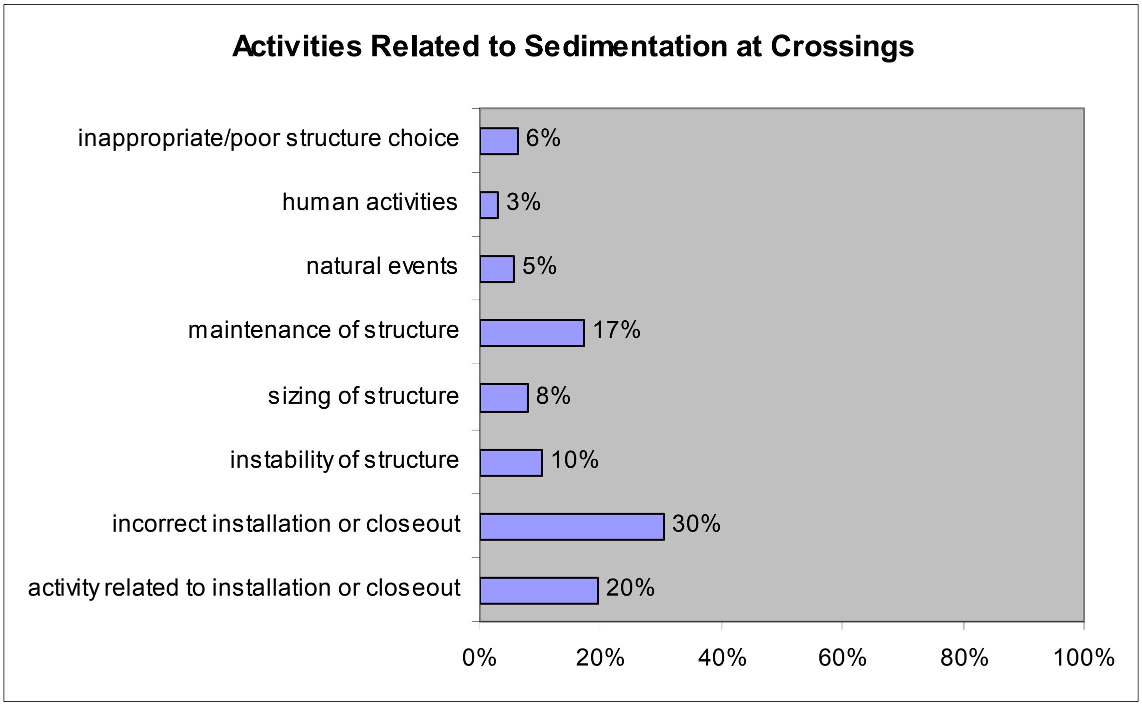

Figure 14 Specific activities related to sedimentation (both trace and measurable) at the crossing structure for crossings surveyed 2005-2009. Only crossings that actually had sedimentation occur are shown (n=128).

Crossings that did not have any sediment enter the waterbody achieved the desired outcome. This outcome was most often achieved by appropriate application of BMP principles (See Appendix B for a discussion of fundamental BMP principles) and practices (Figure 15). Proper planning also eliminated the need to install BMP practices in many cases. An example of planning is timing the harvest to occur when the ground is frozen. The fact that 27% of crossings (Figure 15) had stable soil with inadequately applied BMPs however is cause for concern, since these crossings may represent an increased risk to water quality in the future. Past reports have also identified inadequate application and lack of maintenance of BMPs as problem areas. Training efforts should continue to stress these areas.

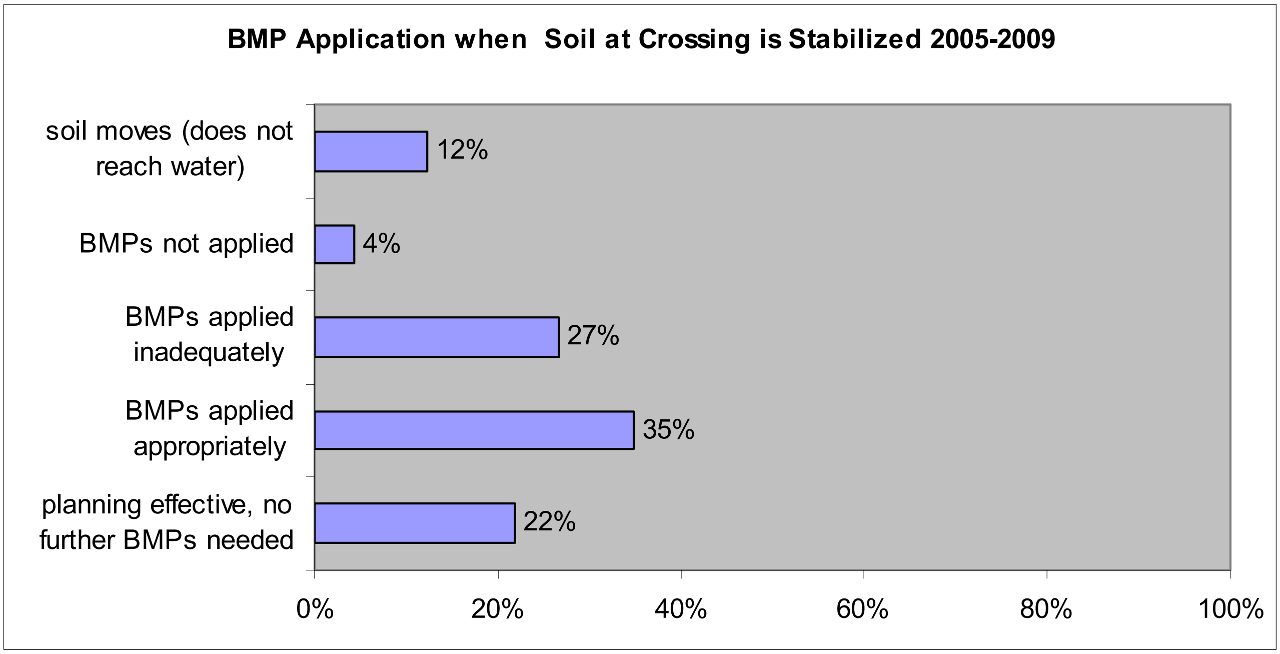

Figure 15 Soil stabilization at the crossing was most often due to appropriately applying BMPs or proper effective planning that eliminated the need for installing BMP practices (n=210).

Sedimentation and Structure Type

Some sedimentation occurred at all structure types. When measurable sedimentation was observed at the crossing, the structure present was most often a single culvert (Figure 16). However this does not indicate the relative risk of sedimentation occurring since single culverts were also the most commonly evaluated structure. To assess this risk, each structure type was analyzed separately to see how often sedimentation occurred for that type. This analysis indicated that **multiple culverts had the highest likelihood of being associated with measurable sedimentation and bridges had the lowest likelihood (Figure 17).** The fact that multiple culverts were most likely to be associated with measurable sedimentation is not surprising since fill material that must be placed between the culverts often is placed directly in the stream channel. Multiple culverts are often installed to increase the hydraulic capacity of the crossing without raising the profile of the road. In certain cases small bridges may be a viable alternative to multiple culverts where keeping the road profile low is important.

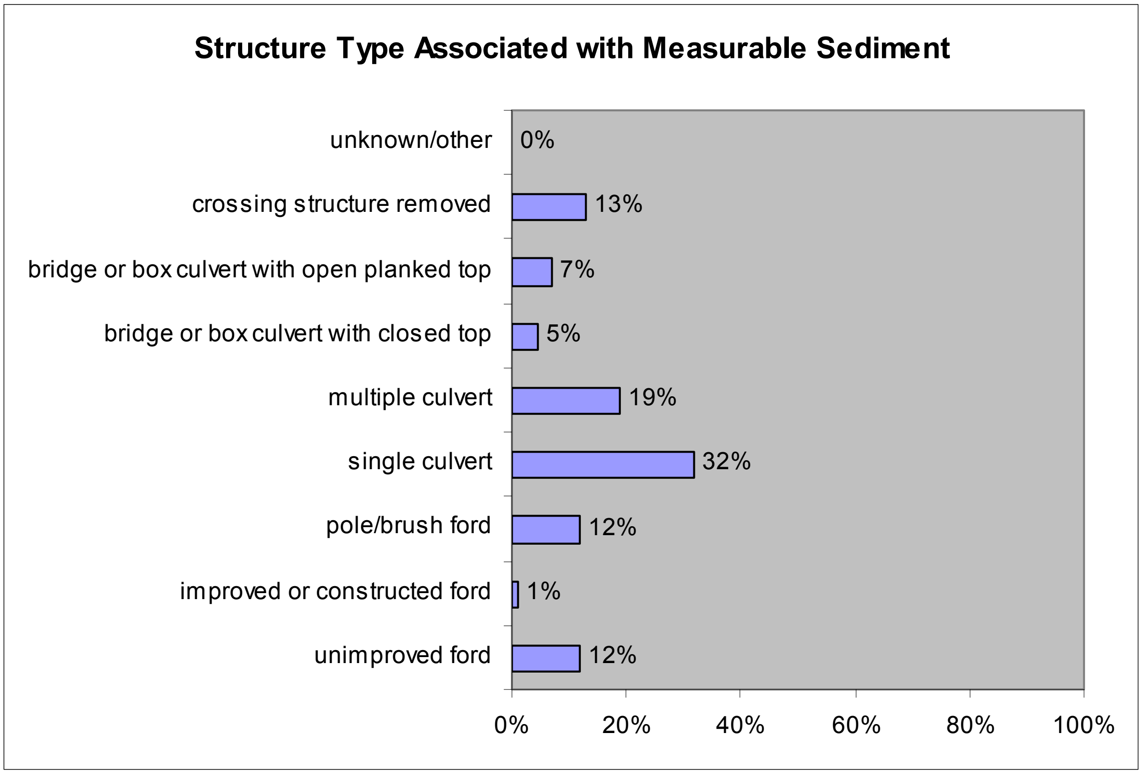

Figure 16 Structure type associated with measurable sedimentation n=85.

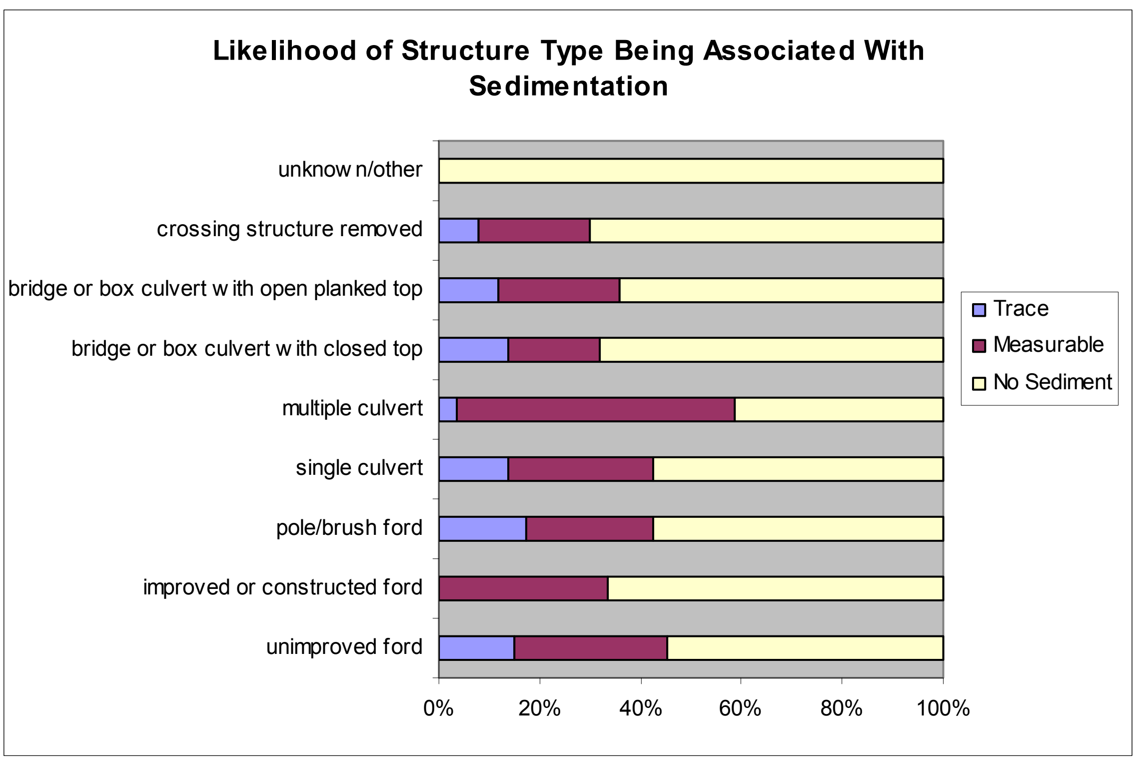

Figure 17 Likelihood of structure type being associated with sedimentation (unimproved ford n=33, improved ford n=3, pole/brush ford n=40, single culvert n=94, multiple culvert n=29 bridge closed top n=22, bridge open top n=25, structure removed n=50).

Approaches

Soil Stabilization and Sedimentation from the Approaches

During from 2005-2009 MFS Field Staff evaluated **56,531** feet of water crossing approaches. Each water crossing offered four opportunities to evaluate approaches: once inside the buffer and once outside the buffer on both sides of the crossing. On the sample units with crossings, there were a total of **1240** opportunities to evaluate soil conditions at the approaches.

In 81% of the cases no soil reached the water body from the approaches (Figure 18). **Measurable sedimentation reached the waterbody from the approaches in 16% of observations in 2005 and 6% in 2009. Trace sedimentation occurred in 8% of cases in 2005 and 11% of cases in 2009 (Figure 19).**

Analysis of the 19% of cases where sedimentation occurred from the approaches over the five year of monitoring indicates the majority of sedimentation was due to inadequate maintenance or inadequate installation of additional BMPs (Figure 20). Assessment of BMP application when sedimentation occurred indicates that in sedimentation was most often due to inadequate application of BMPs rather than BMPs not being applied (Figure 21). This reinforces the need for improved or increased education for loggers, machine operators and foresters on the importance of controlling water flow on roads and skid trails *throughout the operation.* These educational efforts should also stress the importance of adapting to changing site conditions and reinforcing or installing additional BMPs as needed.

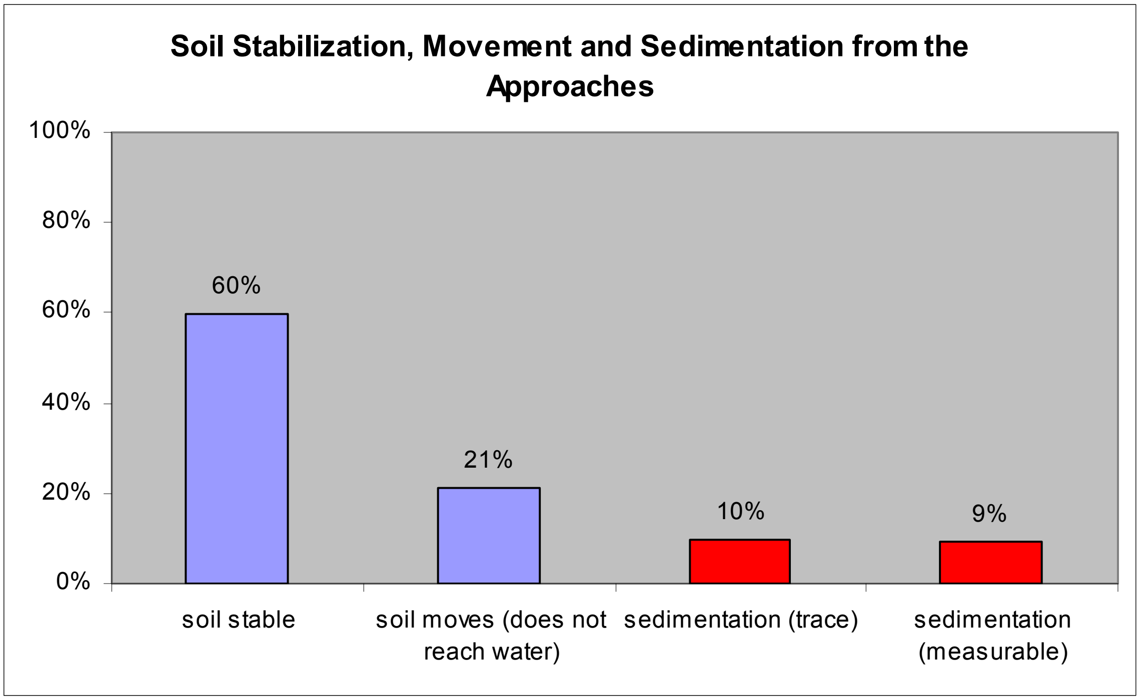

Figure 18 Soil stabilization, movement and sedimentation originating from the stream crossing approaches for all sample units with crossings (n=1240).

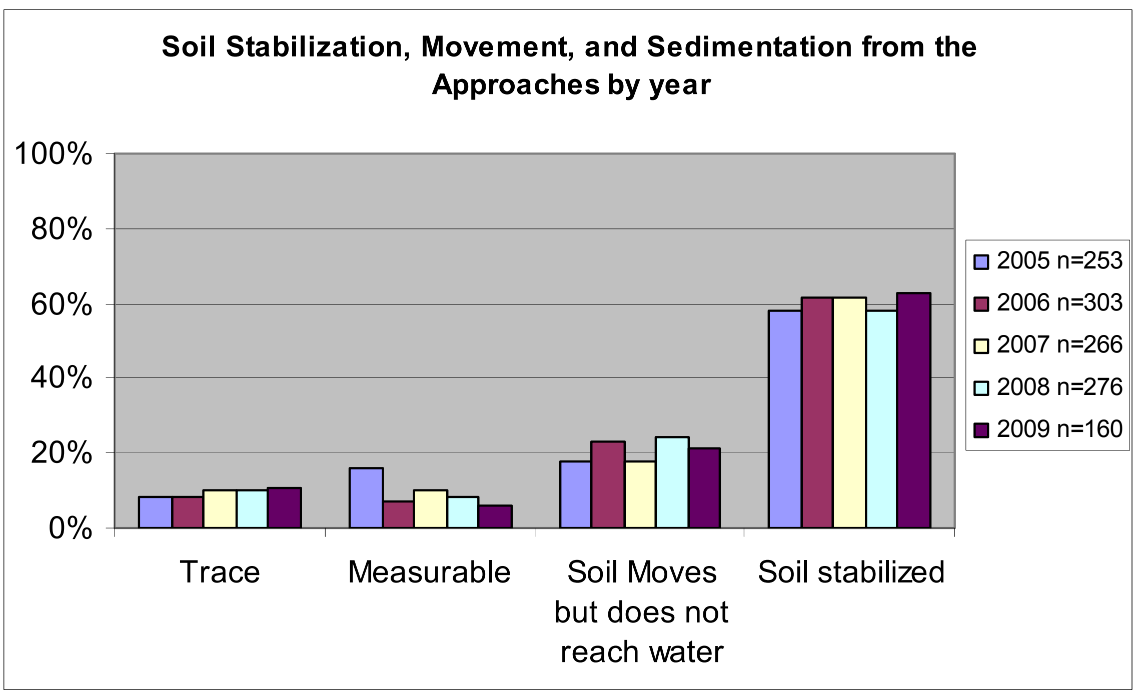

Figure 19 Soil stabilization, movement and sedimentation originating from the stream crossing approaches by year.

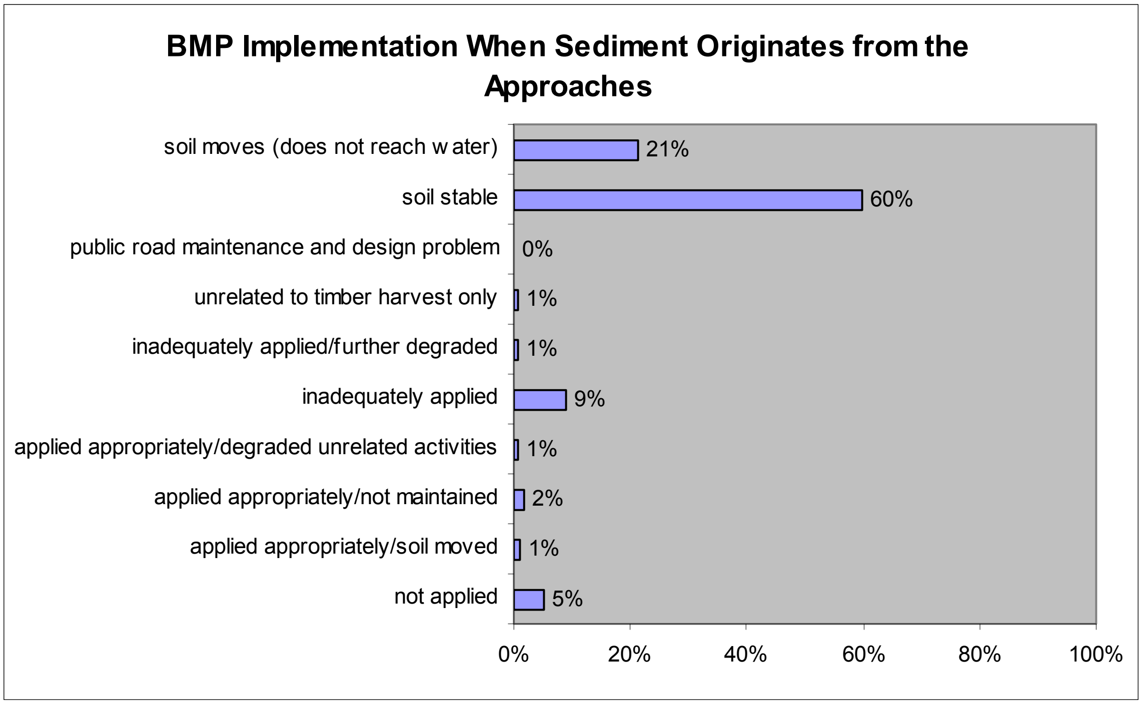

Figure 19 BMP implementation when sediment (both measurable and trace) reaches the waterbody from the approaches for all sample units with crossings (n=1240).

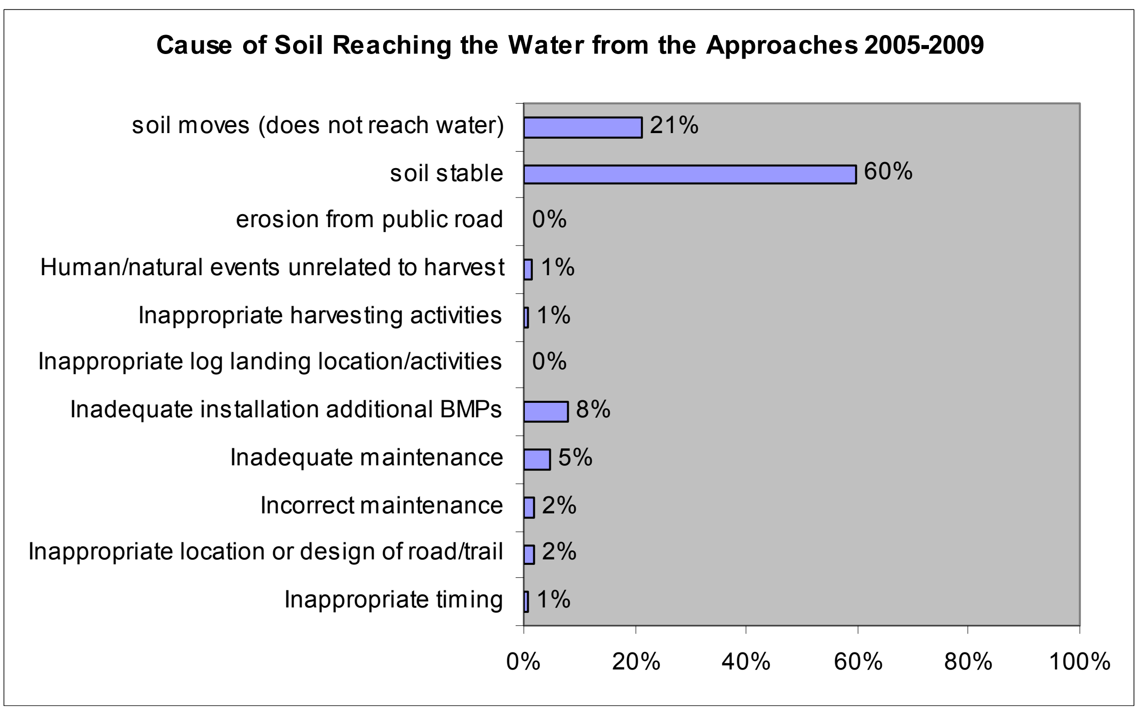

Figure 20 Cause of sediment (both trace and measurable) reaching the waterbody from the approaches for all sample units with crossings (n=1240).

Fish Passage

Stream crossings that prevent fish from passing under or through them can reduce the amount of stream habitat available, or the ability of some species to spawn. Permanent structures least likely to impede fish and macroinvertibrate passage are those in which the natural stream bottom is accessible and undisturbed such as bridges and bottomless arch culverts. Structures that span the natural bankfull channel are also less likely to present barriers than ones that constrict the channel. Whether a structure presents an actual barrier to fish passage depends on many factors including the species and size of the fish, stream flow levels and water temperature. Whether the crossings evaluated in the monitoring represent actual barriers is beyond the scope of the monitoring to determine.

Maine's Forestry BMPs make the following recommendations for designing stream crossings to reduce the likelihood of creating barriers to fish passage:

- Culverts and bridges should be at least as wide as the stream channel at normal high watermark
- Culverts should be embedded from 5-25% of their diameter into the stream substrate.
- A natural stream bottom should be retained or redevelop within the structure after installation.

Crossings structures that are in place for more than three months have a higher potential to interfere with the migratory patterns of aquatic organisms than one that are in place for shorter periods of time. About 2/3 of crossings evaluated were in place for more than 3 months and had fish and or macroinvertebrates present (Figure 22).


Stream crossing structures such as bridges and open bottom culverts that are open to the natural stream bottom are least likely to impede the passage of fish and other aquatic organisms. Sizing and embedding round culverts so material can collect in the bottom can minimize impacts to fish passage.

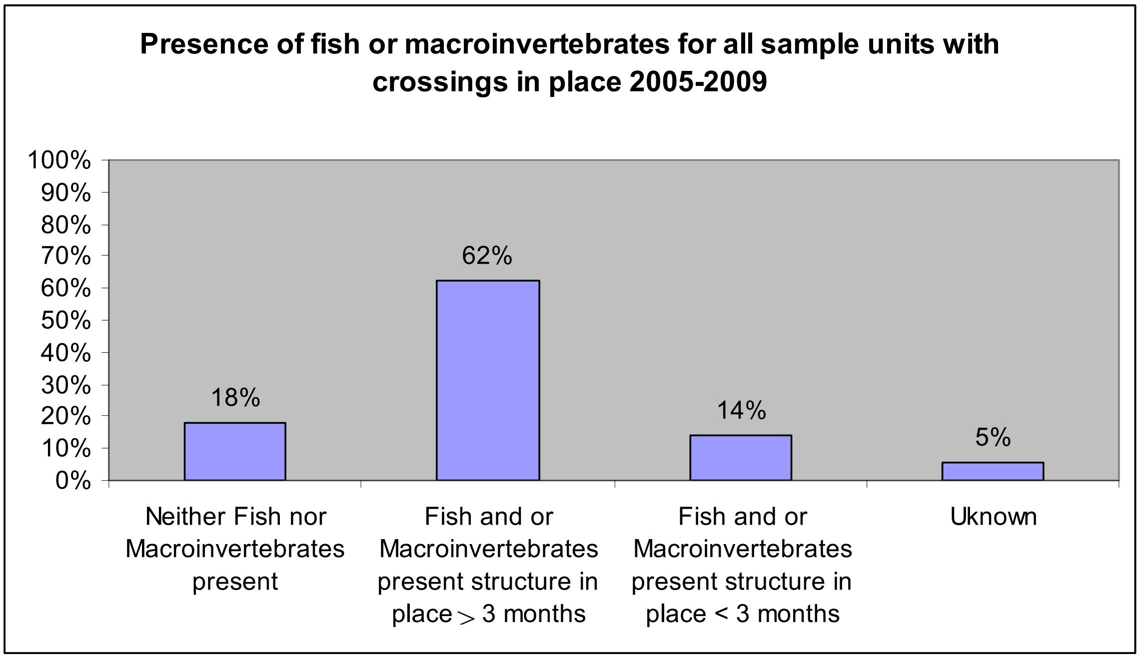

Figure 21 Presence of fish or macroinvertebrates for all sample units with a crossing structure in place.

Crossing structures with bottoms open to the natural substrate or closed bottom structures sized such that substrate can collect in the bottom are considered most likely to provide passage for fish and other aquatic organisms. Crossings with closed bottoms and no collected substrate and perched crossings are likely to create conditions that will prevent certain species and life stages from passing under certain flow conditions. 50% of structures had bottoms open to the stream bottom or continuous substrate (Note: Pole and brush fords are considered to have open bottoms since these structures are removed after use leaving a natural stream bottom. Spaces between the logs and brush may also permit passage when the structure is in place). The vast majority of closed bottom structures did not have continuous substrate or were perched (Figure 23).

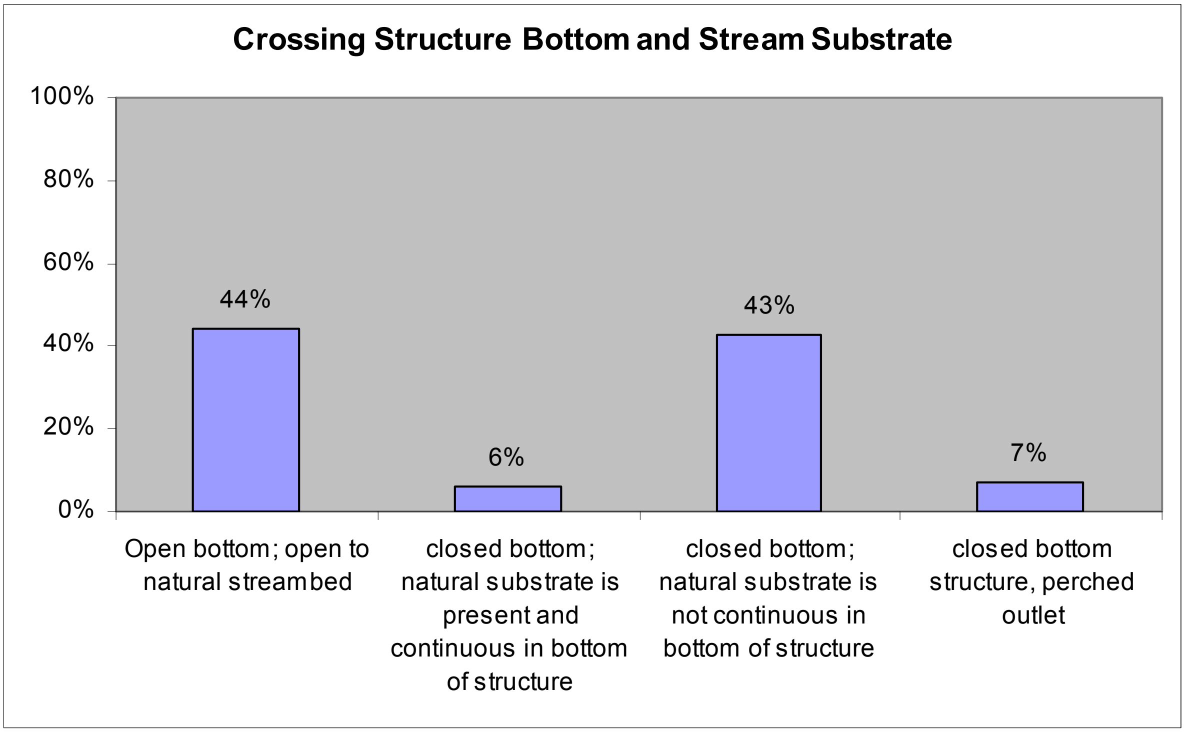

Figure 22 Crossing structure bottom and stream substrate Note: prior to 2006 perched outlets were not recorded.

Crossing Structure Sizing

In Maine legal requirements for structure opening size vary depending on the jurisdiction. MFS BMPs recommend that crossings structures *at least span the stream channel at normal high watermark*. Maine Forest Service BMPs also recommend that temporary crossings and permanent structures that will be regularly maintained be sized to accommodate a 10-year flood event (2.5 times the cross sectional area of the stream channel at the normal high water mark). BMPs recommend permanent crossings that will not be regularly maintained be sized to accommodate a 25 year flood event (3.5 times cross sectional area). *It is important to note that a structure properly sized to accommodate a 10 or 25-year flood event may not be large enough to achieve the desired outcomes associated with minimizing barriers to fish passage.*

Skid trail crossings were more likely to span the bankfull channel than haul road crossings. Most skid trail crossings are temporary and usually removed after the harvest, the protocol includes crossings that have been removed in the sample. The percentage of haul road crossings evaluated that spanned the bankfull channel increased substantially from 9% in 2005 to 33% in 2009 (Figure 24). Bridges were by far the most common haul road structure type to span the channel (data not shown). This is a very encouraging trend but additional years of data and analysis of new vs. existing structures will be required to see if this represents a genuine trend in crossing upsizing.

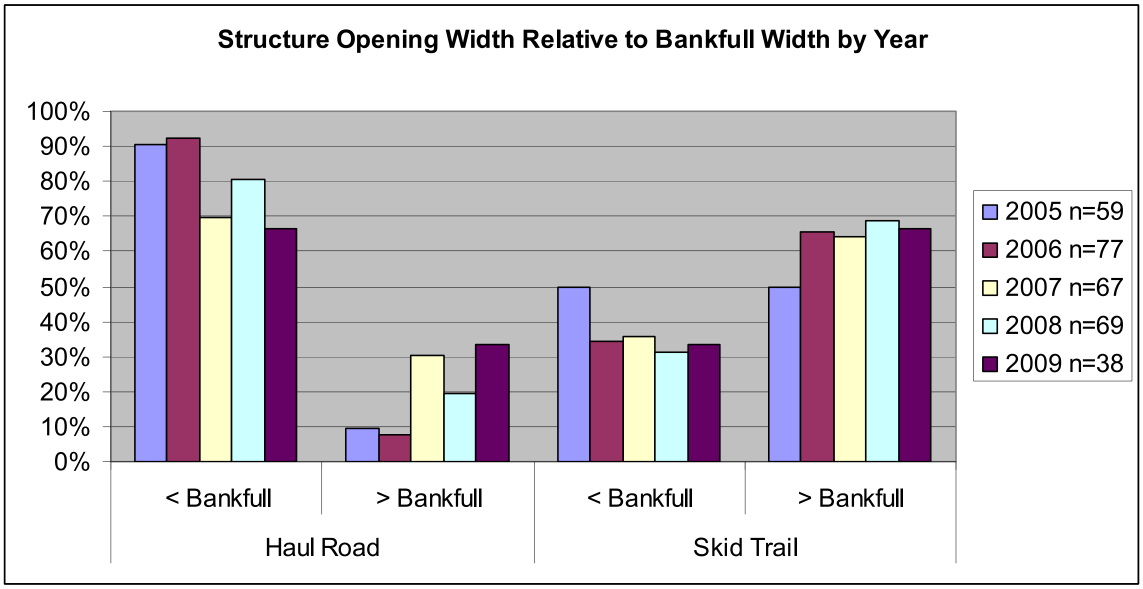

Figure 23 Crossing structure openings relative to bankfull width for sample units with crossings by year
.

Temporary stream crossings do not require long term maintenance and are often less likely to impede fish passage. Options, such as the portable steel bridges pictured here, exist for temporary crossings on haul roads as well as skid trails.

Chemical Pollution Prevention

Loggers and foresters generally take seriously the importance of keeping chemical pollutants out of water supplies. **In only one case out of 500 samples was a spill of 10-100 square feet recorded.** The remaining observations of chemical pollution were limited to minor dripping from machines and occasional empty containers left at woodyards (Figures 25 and 26). On the 500 sample units there were no cases of chemical pollutants entering the water recorded and only 2 cases where it was not known if pollutants entered the waterbody (data not shown).

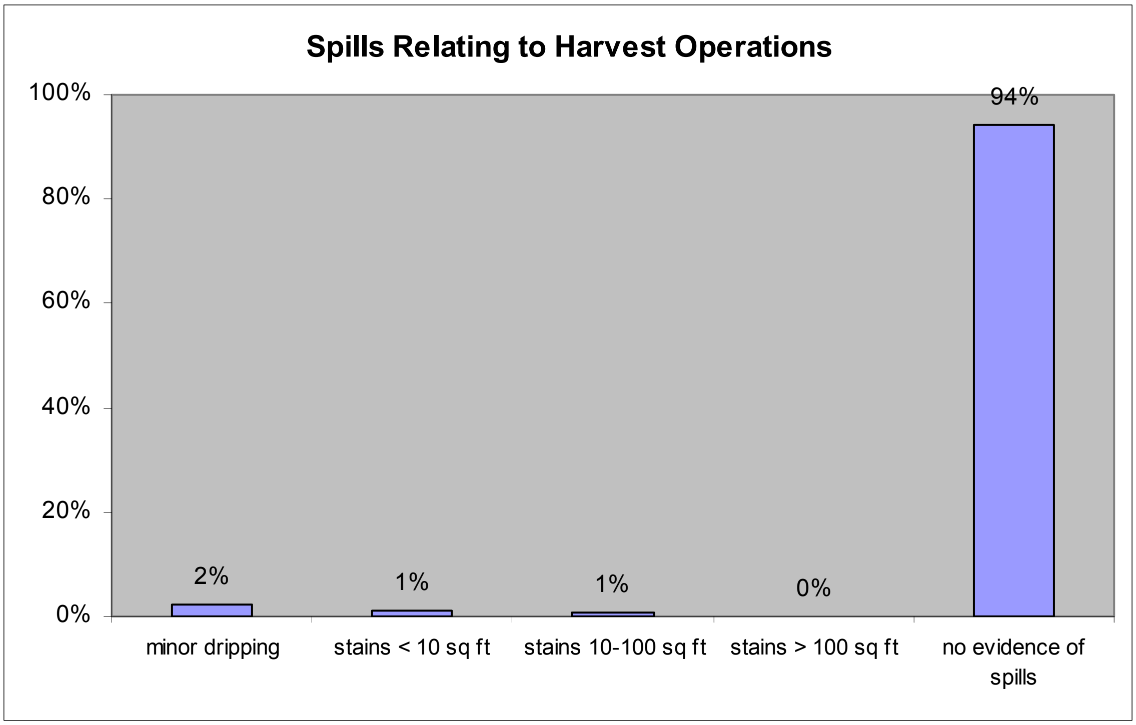

Figure 24 Spills relating to harvest operations on all sample units n=500.

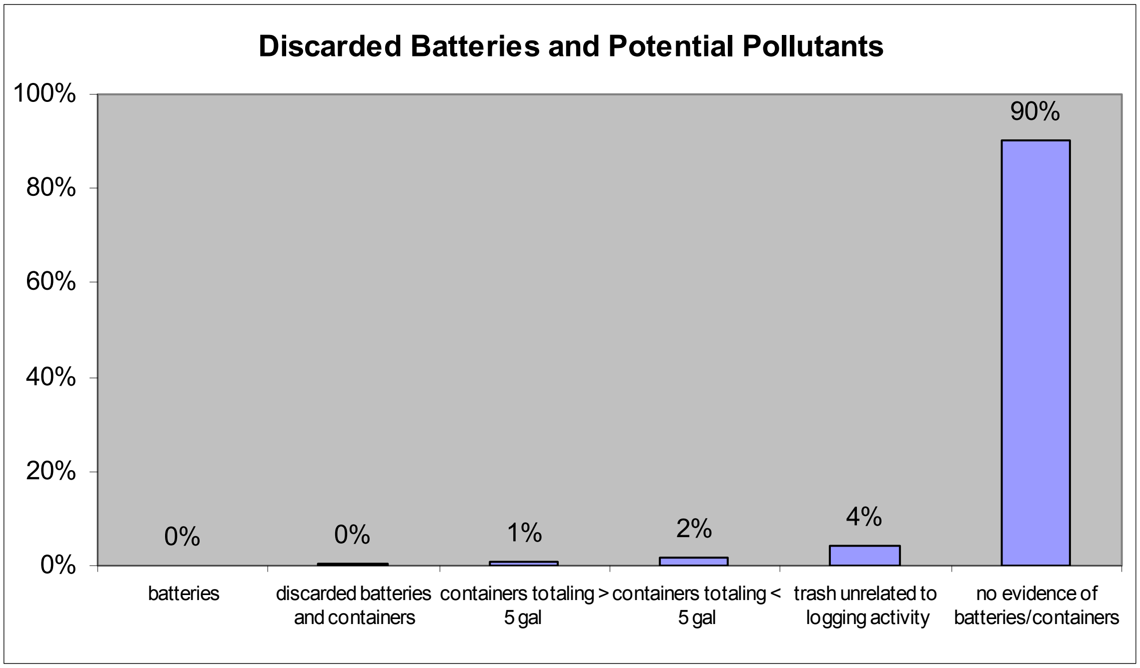

Figure 25 Discarded batteries and other potential pollutants on all sample units n=500.

Conclusions

The creation of the Northeast Regional Forestry BMP protocol and the effort of the MFS and its partners to collect data in a consistent manner on a yearly basis, allows us to quantify trends in BMP performance. Previous BMP monitoring efforts tended to occur in a periodic fashion and often used different protocols making direct comparisons difficult. The Northeast Regional Forestry BMP Protocol truly allows an objective assessment of the continual improvement process.

The 2005-2009 BMP monitoring shows some very encouraging trends in environmental understanding on the part of the logging industry. The reduction in the number of cases of sedimentation that has occurred over the 5 years of the monitoring is a real and important improvement.

Although work remains in this area, the increased use of channel spanning crossing structures is another important improvement.

These improvements **indicate that a voluntary outcome based approach to Best Management Practices can be effective in protecting the states water resources.** They also give an indication that the training in efforts of the Maine Forest Service and its industry partners including Maine's Sustainable Forestry Initiative, the Certified Logging Professional and Qualified Logging Professional and the Northeast Master Logger Certification programs are paying off.

The fact that 84% of cases evaluated showed no sedimentation and only 5% of crossings did not have BMPs applied indicates that most foresters and loggers understand the importance of maintaining water quality and know what steps to take to protect it.

Monitoring, education and training is key to sustaining the progress that has been made with Forestry BMPs and will allow Maine’s forestry community to continually improve as we move into the future.

Appendix A

What is Bankfull Elevation and Width?

The terms bankfull elevation and bankfull width are used throughout this report. Since this is a relatively new term used for BMP monitoring, further explanation is provided below.

Bankfull elevation is the maximum elevation of the annual spring flood 2 years out of three. As such, it is also point of demarcation between the stream channel and the floodplain. The bankfull elevation is at the elevation of the lowest depositional flat immediately above the channel and is often identified by the deposition of fine sediments indicated by the first depositional flat above the channel.

Bankfull width is the channel width from the bankfull elevation on the one side of the channel to the bankfull elevation on the other side of the channel.

Bankfull indicators visible at low flow. The bankfull elevation is indicated by the first depositional flat above the channel. On very confined channels, the bankfull elevation may only be evident as the discontinuous flat depositional areas shaded on the photo.

Appendix B

The Seven BMP Fundamentals

Most BMP techniques are based on a few basic principles. This section provides an overview of these fundamental BMPs and how they protect water quality. Understanding these principles will enable you to select or adapt the BMPs that are the most appropriate and effective. Think of these principles as goals. Any single practice or combination of practices that effectively achieves one or more of these key goals could be considered an appropriate BMP.

1. DEFINE OBJECTIVES AND RESPONSIBILITIES

- **Determine the harvest objectives with the landowner, forester, and logger.** The first step in planning, prior to beginning work, is to communicate with everyone involved what the harvest objectives are. Discuss what's going to be cut, where, and the desired condition of the remaining forest.

- **Decide who is responsible for BMPs.** You will want to agree in advance (and in a written contract) who is responsible for implementing the BMPs, including deciding when to operate, locating streams, laying out the operation, and planning and maintaining the BMPs.

- **Find out what legal requirements apply to waterbodies in the harvest area.** The basic legal requirement in Maine is to keep pollution—including mud, silt, rock, soil, brush, or chemicals —out of the water. When working near waterbodies, find out what town, state, or federal standards apply, and if permits are needed.

2. PRE-HARVEST PLANNING

Pre-harvest planning is good business practice and avoids many problems. Planning will help reduce costs, make the job more efficient, protect roads and trails that will stay in place after the job, leave the job looking better, *and* protect water quality.

- **Determine the harvest area limits and property boundaries on the ground. Know whose responsibility it is to identify the property boundaries correctly.** While not essential to protecting water quality, locating property boundaries is common sense and good planning. There may be survey pins, blazes, wire fences, or stone walls that mark boundaries or property corners. Forest type maps, soil or topographic maps, or aerial photos help, too.

- **Identify streams, lakes or ponds, wetlands, and other features on maps and on the ground.** Maps and aerial photographs can help identify features like waterbodies, steep slopes, or poorly drained soils. Walking the property to locate important features on the ground is essential. If possible, do your planning on bare ground in wet seasons when surface water is visible.

- **Identify the areas where you need BMPs.** Forest harvesting BMPs are most critical in and immediately next to waterbodies including intermittent and perennial streams, lakes or ponds, wetlands and coastal areas—wherever direct impacts to surface water may occur. You may also need to use BMPs in other areas of the watershed where flowing water could be substantially altered or carry sediment into these waterbodies.

- **Lay out the harvest operation on the ground.** Harvest planning includes determining where operational features such as roads, stream crossings, landings, cut-and-fill areas, main skid trails, and particular BMPs will be needed. While on-site, make sure everyone involved in the harvest operation is aware of the layout—especially roads, skid trails, and filter areas next to waterbodies.

- **Choose BMPs that are appropriate to the site conditions.** Most sedimentation occurs during short periods of heavy rain or snowmelt. How much rain falls during a storm, how much water streams carry, how stable the soils are, and what type of vegetation is present are all conditions that vary. BMPs that are sited, designed, and installed to anticipate adverse conditions work best.

- **Decide on BMPs for the entire harvest area and for closeout before beginning work.** BMP systems need not be complicated, but they require planning across the entire harvest area and over the entire duration of the operation, including closeout. Applying BMPs in one location can sometimes solve problems elsewhere on the site, or prevent problems after the operation is complete. When you understand the natural drainage system in the watershed, often you can use a combination of simple BMPs that are more effective—and cheaper—than more complex or expensive techniques.

- **Consider the needs of future operations on the same property.** Will roads, trails and landings be used again in five years, 15 years, or longer? Are there other areas of the property that can be accessed using the same roads? If you need to access the lot in the future, plan roads and trails accordingly. Otherwise, consider restricting vehicle access after the harvest. Because of the possibility of extreme weather conditions, it is important to design and close out roads properly. Identify which structures—such as culverts—will be left in place, and which will be removed. Considering the future can avoid problems and costly solutions.

3. ANTICIPATE SITE CONDITIONS

- **Time operations appropriately.** Harvesting under frozen, snowcovered, or dry conditions can minimize the need for additional BMPs. At the same time, a range of BMPs that are appropriately chosen, installed, and maintained can extend the harvest season. Use extra caution during fall and spring when streams are high and the ground is typically wetter—you may need to use additional BMPs to control the larger volume of water.

- **Determine whether previous operations in the harvest area created conditions that are impacting—or could impact—water quality.** Old roads, log landings, and skid trails can be reused or upgraded. However, in some situations, avoiding or retiring them is a better choice. Using old roads, landings, and trails may be cheaper in the short run, but may be more costly to fix or maintain later. Pre-existing conditions may also influence your choice of BMPs.

- **Plan to monitor, maintain, and adjust BMPs as needed, especially to deal with seasonal or weather-related changes.** After installation, many BMPs require maintenance or modification. Conditions-such as the amount of water flowing in streams, soil moisture, or the depth of frost—can change quickly, even with one storm. Take into account how conditions may change, and maintain or install additional BMPs as needed. Determine who will be responsible **for** this work. In many instances, the landowner will want to periodically check and maintain BMPs that have been installed after harvesting is done. This often prevents washouts and a loss of access while protecting water quality at the same time.

4. CONTROL WATER FLOW

- **Understand how water moves within and around the harvest area, and decide how water flow will be controlled.** Concentrated flows of water on roads, skid trails, landings, and in drainage systems develops more force and a greater ability to erode soil and carry sediment. It is easiest and most effective to control small volumes of water, before they converge and accumulate into concentrated flows.

- **Slow down runoff and spread it out.** Many BMPs work by directing small amounts of water into areas of undisturbed forest floor where it can be absorbed.

- **Protect the natural movement of water through wetlands.** Wetlands play an important role in the environment by storing water in wet periods and slowly releasing it back into the surrounding ground and streams. Logging roads and trail crossings can affect the flow of water within or through a wetland. This changes how much water the wetland stores, the degree of flooding that occurs, and the rate at which water leaves the wetland. Such impacts can affect the health of the wetland and waterbodies downstream.

5. MINIMIZE AND STABILIZE EXPOSED SOIL

Limiting soil disturbance and stabilizing areas where mineral soil is exposed are among the most important BMPs for preventing erosion. These practices are most critical in and around filter areas—forest areas bordering waterbodies. Generally speaking, there are two major objectives:

- **Minimize disturbance of the forest floor, especially in filter areas.** The forest floor absorbs water and filters out sediment and other pollutants. Exposed soil, on the other hand, can erode very rapidly. Most of the sediment that ends up in streams near managed forests comes from exposed soil on roads, landings, and skid trails. Know where the filter areas are and how to protect their capacity to absorb and filter runoff.

- **Stabilize areas of exposed soil within filter areas and in other locations where runoff has the potential to reach filter areas.** Use BMPs during or immediately after the harvest to prevent exposed soil or fill from eroding. These techniques and materials can be used near waterbodies, at stream crossings, road cut-and-fills, ditches, landings, and skid trails. In some situations, you may need to seed and/or plant vegetation in order to stabilize the soil.

6. PROTECT THE INTEGRITY OF WATERBODIES

- **Protect stream channels and banks.** Blocking or altering streams (with slash, for instance) may keep fish from swimming past the blockage. Damaged stream banks erode quickly, causing sedimentation and siltation. By protecting the physical integrity of streams, BMPs prevent these problems.

- **Leave enough shoreland vegetation to maintain water quality.** BMPs maintain the benefits that nearby trees and plants provide waterbodies. Streamside vegetation shades the water, minimizing temperature changes. Live roots stabilize the banks and maintain the soil's physical and chemical properties. Trees along the banks drop leaf litter and woody debris that supply nutrients and become habitat for plants and animals in the stream. Shoreland vegetation plays an important role in maintaining water quality.

7. HANDLE HAZARDOUS MATERIALS SAFELY

- **Be prepared for any emergency.** Keep an emergency response kit and contact information at the site for fuel, oil, or chemical spills. Remember that fertilizers, herbicides, pesticides, and road chemicals (calcium chloride, road salt, etc.) are hazardous materials, too. Know whom to call for help with unexpected erosion, accidents, or other emergencies. Having a backup plan and being prepared for unexpected and special situations can help avoid or minimize negative impacts to water quality. Industry groups, equipment suppliers, and local and state government agencies all have specialists available to help.

- **Use and store hazardous materials properly.** The best way to avoid accidental spills of hazardous materials is to store and handle them so that the chance of these types of emergencies occurring is minimized.