IMPLEMENTATION OF FORESTRY BEST MANAGEMENT PRACTICES IN TENNESSEE

Results from the 2007 Forestry BMP Implementation Survey

TENNESSEE DEPARTMENT OF AGRICULTURE
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EXECUTIVE SUMMARY

A survey of forestry best management practices (BMPs) implementation was conducted in 2007 by the Tennessee Department of Agriculture, Division of Forestry in cooperation with the University of Tennessee, Department of Forestry, Wildlife and Fisheries. Survey design was modified from previous BMP implementation surveys to be consistent with methodology as described in the Southern Group of State Forester's (SGSF) *Silvicultural Best Management Practices Implementation Monitoring Framework for State Forestry Agencies*.

A random sample of 208 harvest sites was distributed among Tennessee's Forest Inventory and Analysis (FIA) survey units based on the amount of timber harvested within each unit. Harvest sites were visited spring through winter of 2007 and evaluated for 53 individual BMPs that were categorized by haul roads, skid trails, log decks, streamside management zones (SMZs), stream crossings, debris and hazardous materials, site prep and planting, and applicable BMPs in wetlands.

The 2007 BMP implementation survey revealed an average overall BMP implementation rate of 89.2 percent. This is an improvement of 7.3 percentage points as compared to the 81.9 percent implementation rate reported in the 2004 BMP implementation survey. It is a 26.3 percentage point improvement over the 62.9 percent implementation rate reported in the 1996 BMP implementation survey.

All BMP categories had implementation rates higher than 80 percent. The stream crossings BMP category had the lowest implementation rate (80.2 percent). The debris and hazardous materials BMP category had the highest implementation rate (96.2 percent).

All FIA survey units had implementation rates higher than 80 percent. The West survey unit had the lowest implementation rate (83.2 percent). The Central survey unit had the highest implementation rate (92.7 percent).

As a result of the information obtained through the 2007 BMP implementation survey, the practices that will be the core items of BMP education and training for the next planning phase are 1) streamside management zones, 2) skid trails and 3) stream crossings. These will be addressed through additional courtesy check site visits, logger contacts, educational materials, technical guides, and demonstrations. Regardless of BMP category, special emphasis will also be given to highlight the importance of stabilizing disturbed areas. Additional training to equip West Tennessee operators to follow BMP guidelines will also be a program priority.

Continuing educational programs, such as Tennessee's Master Logger Program, can increase logger's knowledge of BMPs as well as helping them understand the principles of forest management, logging safety, and business

2007 TENNESSEE FORESTRY BEST MANAGEMENT PRACTICES IMPLEMENTATION SURVEY REPORT

INTRODUCTION

Since the mid-1980's The State of Tennessee, Department of Agriculture, Division of Forestry (TDF) has been providing leadership in forestry Best Management Practices (BMPs). The Division's water quality program assists the forestry community with forestry BMP implementation through three major program areas: technical assistance, water quality complaint investigations, and forestry BMP implementation monitoring.

Technical assistance is provided through a partnership with the Tennessee Forestry Association and the University of Tennessee. TDF participates in the Tennessee Master Logger program and forestry BMP workshops and field days. TDF is also engaged in courtesy check site visits to active harvest sites, servicing requests for site-specific technical guidance, logger contacts, and providing educational materials.

Water quality complaint investigations are handled through a memorandum of understanding (MOU) between the Department of Agriculture and the Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control (WPC). Upon receiving a complaint of a possible water quality violation caused by timber harvesting practices, TDF performs an initial site visit to determine if the complaint is valid. TDF subsequently provides technical assistance when corrective actions are needed at these sites. Problem sites are referred to TDEC/WPC.

Forestry BMP implementation monitoring is achieved through logger contacts, courtesy check site visits, and periodic surveys. This report contains the results of the 2007 forestry BMP implementation survey. The purpose of the Tennessee forestry BMP implementation survey is to periodically ascertain and document the extent that forestry BMPs are being applied on-site. BMP guidelines for forestry practices allow normal forestry activities to be conducted while protecting water quality from degradation by point source pollution such as soil erosion. Periodic surveys allow TDF to objectively evaluate the on-site utilization of BMPs and, of particular importance, where specific BMPs are not being implemented. This in turn helps establish training and education priorities for TDF and its partners.

PREVIOUS FORESTRY BMP IMPLEMENTATION SURVEYS

1996 FORESTRY BMP IMPLEMENTATION SURVEY

In 1996, TDF conducted its first forestry BMP implementation survey. This survey provided a method to determine implementation rates associated with individual practices such as forest roads, stream crossings, streamside management zones (SMZs), and timber harvesting. The overall forestry BMP implementation rate was 62.9 percent, indicating room for improvement (figure 1). The 1996 Survey results indicated that continued technical assistance was needed for stream crossings, proper road location, preventing logging debris in streams, and stabilizing disturbed areas. Subsequently, TDF focused attention on these program areas to address those needs.

2004 FORESTRY BMP IMPLEMENTATION SURVEY

For the 2004 forestry BMP implementation survey TDF partnered with the University of Tennessee, Department of Forestry, Wildlife and Fisheries (UT) to develop new forestry BMP implementation survey protocols. The 2004 survey data was collected from 215 harvest sites, resulting in 807 individual observations being evaluated. Of the forestry BMP observations evaluated, 81.9 percent had forestry BMPs implemented to the level that protected water quality.

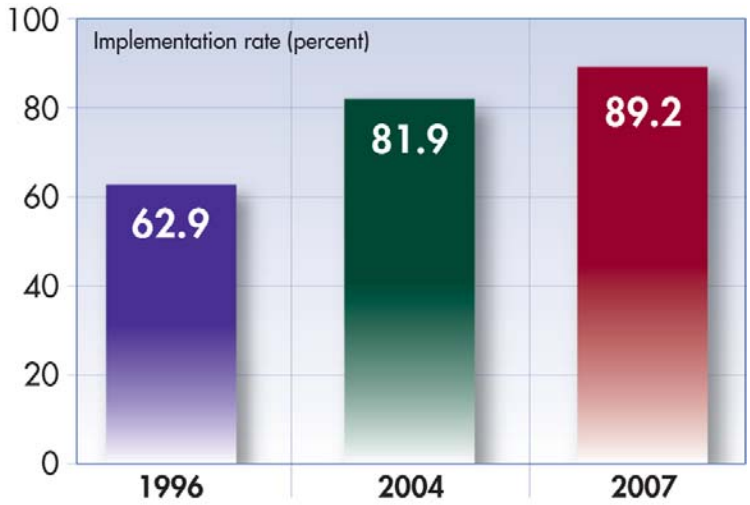


FIGURE 1.
Tennessee Department of Agriculture - Division of Forestry BMP Implementation Survey Results

2007 FORESTRY BMP IMPLEMENTATION SURVEY

A survey of forestry BMP implementation was again conducted in 2007 by TDF and UT. Survey design was modified to be consistent with methodology as described in the Southern Group of State Forester's (SGSF) *Silvicultural Best Management Practices Implementation Monitoring Framework for State Forestry Agencies*.

HARVEST SITE SAMPLE SIZE

Sample size (the number of harvest sites evaluated) was determined by UT for statistical validity. For a margin of error at the 5 percent level and a probability of 90 percent, the smallest plausible sample size was 96. A sample size of 208 was used so there was adequate representation of forestry activity statewide (Refer to Appendix C for details).

Using the five FIA survey units in Tennessee (figure 2), the volume of timber harvested in each unit was determined. A ratio was applied to the number of samples to be taken by the percentage of timber harvested in that unit. Thus, more plots were taken in units where more timber was harvested, and likewise, fewer plots were taken in survey units where less timber was harvested (table 2).

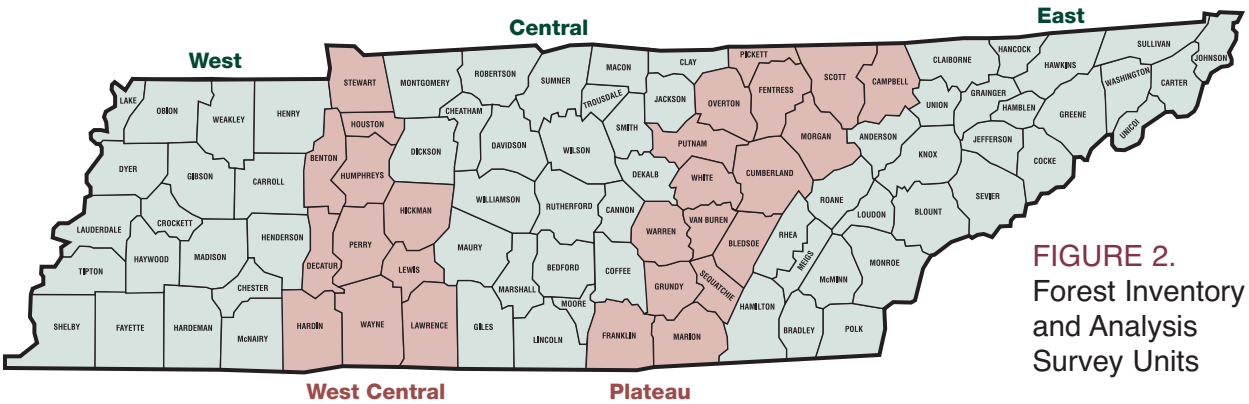


FIGURE 2.
Forest Inventory and Analysis Survey Units

TABLE 2. STRATIFICATION OF HARVEST SITES BY FIA SURVEY UNIT BASED ON TIMBER HARVESTED, 2004 FIA DATA				
REGION	HARVESTED ACRES (thousand acres)	PERCENT	# OF DESIRED SITES	ACTUAL SAMPLE SIZE
East	34.9	14	28	29
Plateau	79.6	33	66	69
Central	34.7	14	28	30
West Central	52.9	22	44	45
West	41.1	17	34	35

HARVEST SITE SELECTION

Specific harvest sites to evaluate were determined by dividing the State into a 4 mile by 7 mile grid. One grid was roughly the size of half of a 7.5 minute topographic map. Statewide, there were 1,445 grids. Grids that were not at least 50 percent forested were discarded.

Forested grids were numbered and catalogued by FIA survey unit and put together in a computer database. Grids for harvest sites were selected by FIA survey unit by a computer random number generator. Thus, if a survey unit had a proposed sample size of 35 plots, the first 35 forested grids selected by the generator were used.

Grids were visited to locate a harvest site. If a grid had two or more harvest sites, the first site found was evaluated. If a harvest site was not found in a grid, that grid was omitted and another grid (next in order) was added from the computer generator selection. The only data taken at this time were global positioning system (GPS) coordinates of the site and location directions.

Steps were taken to assure the selection of evaluated harvest sites was not biased. The evaluators did not know about the harvest sites until those locations were sent to them.

HARVEST SITE EVALUATION

Harvest sites were visited by an evaluator to observe forestry BMP implementation. Individual BMPs were evaluated by the following categories: haul roads, skid trails, log decks, streamside management zones (SMZs), stream crossings, debris / hazardous materials, site preparation / tree planting and applicable BMPs associated with wetlands (table 3). There existed a potential total of 11,024 individual BMP observations on the 208 evaluated harvest sites. All the BMP survey categories were not present on every harvest site. For example, haul roads were not present on sites that

TABLE 3. VARIABLES BY BMP CATEGORY	
BMP CATEGORY	NUMBER OF INDIVIDUAL BMPS
Haul Roads	13
Skid Trails	6
Log Decks	5
SMZs	5
Stream Crossings	9
Debris & Haz Mat	2
Site Prep & Planting	4
Wetlands	9
Total	53
Potential total observations (Total x 208 sites)	11,024

could be accessed by existing public roads. The harvest sites sampled for the 2007 survey resulted in evaluation of 4,625 individual BMP observations.

Observations where individual BMPs were correctly applied were tallied as a “YES”. Observations where individual BMPs were absent but needed or incorrectly applied were tallied as a “NO”. Observations where individual BMPs were not needed were tallied as “NOT APPLICABLE”.

Implementation rates for individual BMPs were calculated by dividing the number of observations where BMPs were correctly applied (YES) by the total number of observations [YES/(YES+NO)]. Individual harvest site implementation rates were calculated using the same formula as for individual BMPs. Implementation rates for BMP categories, FIA survey units and overall implementation rate were then calculated by averaging individual harvest site implementation rates for each respective variable.

Harvest sites were also evaluated to determine if “significant risks” to water quality existed. A significant risk is 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 water body. Such change may or may not violate water quality standards.

TDF employees (non-foresters) were selected from each of TDF’s administrative districts to be the BMP evaluators, as well as TDF's two water quality foresters, and Dr. Wayne Clatterbuck, Professor, University of Tennessee, Department of Forestry, Wildlife and Fisheries (13 evaluators total). In February 2007, the evaluators attended a training session conducted by Dr. Clatterbuck to learn how to evaluate the harvest sites that met the site evaluation criteria established for the study. Harvest site visits began in spring 2007 and were concluded by December 2007.

Site evaluation criteria included:

- **a.** Harvest site must be at least five acres in size.
- **b.** Land must have remained in a forested condition, i.e. harvest for change in land use such as development, agriculture, etc. was not included in the study.
- **c.** If landowners did not want their harvest evaluated, the evaluators were instructed to omit that site and proceed to the next one.
- **d.** Harvest must be completed and loggers gone from the site.
- **e.** Harvest must have taken place after January 2005.

If an evaluator had prior knowledge about a harvest site that they were assigned to visit, they were urged to give that site to another evaluator to maintain objectivity during the evaluation process. Evaluators used in this study were the same used in previous studies. The dedication and consistency of the evaluators was determined to be very good. They took their judgments seriously and gave good written notes about the harvest sites.

RESULTS

BMP IMPLEMENTATION

The statewide average forestry BMP implementation rate for 2007 was determined to be 89.2 percent. Table 4 summarizes BMP implementation by BMP category. Table 5 summarizes BMP implementation by FIA survey unit. Tables 6 through 13 summarize BMP implementation by individual BMPs. Details on statistical calculations can be found in Appendix C.

BMP CATEGORIES (TABLE 4) - All BMP categories had implementation rates higher than 80 percent. The stream crossings BMP category had the lowest implementation rate (80.2 percent). The debris and hazardous materials BMP category had the highest implementation rate (96.2 percent).

TABLE 4. BMP IMPLEMENTATION BY BMP CATEGORY

BMP CATEGORY OF SITES	NUMBER IMPLEMENTATION	AVERAGE %	NUMBER OF SIGNIFICANT RISKS[1]	MARGIN OF ERROR
Haul Roads	150	90.9	5	2.8
Skid Trails	208	85.7	13	3.0
Log Decks	208	90.3	7	2.3
SMZs	101	84.6	17	5.8
Stream Crossings	64	80.2	12	7.2
Debris & Haz Mat	208	96.2	0	2.1
Site Prep & Planting	16	90.1	2	13.0
Wetlands	10	84.3	2	17.1

[1] The 58 significant risks observed occurred on 13 separate harvest sites.

FIA SURVEY UNITS (TABLE 5) - All FIA survey units had implementation rates higher than 80 percent. The West survey unit had the lowest implementation rate (83.2 percent). The Central survey unit had the highest implementation rate (92.7 percent).

TABLE 5. BMP IMPLEMENTATION BY FIA SURVEY UNIT

FIA SURVEY UNIT	NUMBER OF SITES	AVERAGE % IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS[1]	MARGIN OF ERROR
East	29	86.6	15	5.8
Plateau	69	91.8	8	3.2
Central	30	92.7	3	3.2
West Central	45	89.3	0	2.9
West	35	83.2	32	7.0

[1] The 58 significant risks observed occurred on 13 separate harvest sites.

HAUL ROADS (TABLE 6) - The lowest implementation rate for individual haul road BMPs was associated with stabilizing problem areas with seed (58.6 percent). The highest rate was associated with use of existing roads (100 percent).

TABLE 6. IMPLEMENTATION OF BMPS RELATING TO HAUL ROADS

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
HAUL ROADS						
Broad Based Dips	38	15	97	71.7	0	12.4
Waterbars	34	16	100	68.0	0	13.2
Culverts	35	3	112	92.1	1	8.7
Turnouts (wing ditches)	89	10	51	89.9	0	6.1
Water Control Structures at Recommended Intervals	78	20	52	79.6	1	8.1
Crowned or Outsloped	107	9	34	92.2	0	5.0
Avoided Sensitive Areas & SMZs	125	3	22	97.7	1	2.7
Rock Used (BBD or other)	87	9	54	90.6	0	5.9
Problem Areas Stabilized with Seed	51	36	63	58.6	0	10.6
Follows Contour	130	7	13	94.9	0	3.8
Within Grade	145	4	1	97.3	1	2.6
Existing Roads Utilized	112	0	38	100	0	n/a
Located away from Water	137	5	8	96.5	1	3.1

Roads were correctly crowned or outsloped 92.2% of the time.

SKID TRAILS (TABLE 7) - The lowest implementation rate for individual skid trail BMPs was associated with stabilizing problem areas with seed (45.0 percent). The highest rate was associated with maintaining an appropriate grade (96.7 percent).

TABLE 7. IMPLEMENTATION OF BMPS RELATING TO SKID TRAILS

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
SKID TRAILS						
Grade	199	7	2	96.7	0	2.5
Water Control	136	43	29	76.0	9	6.4
Avoided Wet & Sensitive Areas	168	16	24	91.3	0	4.2
Equipment Use	140	16	52	89.7	0	4.9
Problem Areas Stabilized with Seed	59	72	77	45.0	0	8.7
Ruts don't Channel into Streams	170	16	22	91.4	4	4.1

LOGGING DECKS (TABLE 8) - The lowest implementation rate for individual logging deck BMPs was associated with stabilizing problem areas with seed (51.5 percent). The highest rate was associated with using existing decks (100 percent).

TABLE 8. IMPLEMENTATION OF BMPS RELATING TO LOGGING DECKS

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
LOGGING DECKS						
Existing Decks Used	123	0	85	100	0	n/a
Location	199	8	1	96.1	3	2.7
Drainage	192	10	6	95.0	4	3.1
Hazardous Waste Management	197	8	3	96.1	0	2.7
Problem Areas Stabilized with Seed	69	65	74	51.5	0	8.6

STREAMSIDE MANAGEMENT ZONES (TABLE 9) - The lowest implementation rate for individual SMZ BMPs was associated with the width of the SMZ (80.8 percent). The highest rate was associated with use of equipment within the SMZ (88.1 percent).

TABLE 9. IMPLEMENTATION OF BMPS RELATING TO STREAMSIDE MANAGEMENT ZONES

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
STREAMSIDE MANAGEMENT ZONES						
SMZ matched to Stream Type	83	17	1	83.0	3	7.5
Canopy Cover Intact	84	15	2	84.8	3	7.2
Tree Felling	86	14	1	86.0	3	6.9
Equipment Use	89	12	0	88.1	3	6.4
Width	80	19	2	80.8	5	7.9

STREAM CROSSINGS (TABLE 10) - The lowest implementation rate for individual stream crossing BMPs was associated with water control structures (59.6 percent). The highest rate was associated with location of stream crossings (96.7 percent).

TABLE 10. IMPLEMENTATION OF BMPS RELATING TO STREAM CROSSINGS

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
STREAM CROSSINGS						
Crossings Minimized	55	5	4	91.7	1	7.1
Location	59	2	3	96.7	0	4.6
Aquatic Life Movement Disruption Low	50	10	4	83.3	2	9.6
Approaches	43	16	5	72.9	2	11.6
Water Control Structures	28	19	17	59.6	4	14.3
Crossings Appropriate & Properly Installed						
Ford	31	9	24	77.5	1	13.2
Culvert and Fill	15	6	43	71.4	1	19.7
Bridge	6	1	57	85.7	0	26.5
Temporary Structures Removed	30	15	19	66.7	1	14.1

DEBRIS & HAZARDOUS MATERIALS (TABLE 11) - The lowest implementation rate for individual debris and hazardous materials BMPs was associated with absence of oil and fuel spills (96.1 percent). The highest rate was associated with absence of treetops and stumps (96.4 percent).

TABLE 11. IMPLEMENTATION OF BMPS RELATING TO DEBRIS/HAZARD MATERIALS

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
DEBRIS/HAZARD MATERIALS						
Treetops & Stumps	185	7	16	96.4	0	2.7
Oil & Fuel Spills	195	8	5	96.1	0	2.7

SITE PREPARATION (TABLE 12) - The lowest implementation rate for site preparation BMPs was associated with SMZs (83.3 percent). The highest rates were associated with maintaining proper method and slopes (93.8 percent).

TABLE 12. IMPLEMENTATION OF BMPS RELATING TO SITE PREPARATION

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
SITE PREPARATION						
Method	15	1	0	93.8	1	12.1
SMZs	5	1	10	83.3	0	30.4
Slopes	15	1	0	93.8	1	12.1
Firelines	6	1	9	85.7	0	26.5

BMP evaluators seldom encountered situations where logging debris was left in streams.

WETLANDS (TABLE 13) - The lowest implementation rate for individual wetlands BMPs was associated with stabilizing problem areas with seed (40.0 percent). The highest rates were associated with roads, fill material, and log decks (100 percent).

TABLE 13. IMPLEMENTATION OF BMPS RELATING TO WETLANDS

BMP	YES	NO	N/A	% IMPLEMENTATION	NUMBER OF SIGNIFICANT RISKS	MARGIN OF ERROR
WETLANDS						
Method	15	1	0	93.8	1	12.1
Roads	5	0	5	100	0	n/a
Drainage Structures	5	1	4	83.3	0	30.4
Fill Material	4	0	6	100	0	n/a
Stream Crossings	7	1	2	87.5	0	23.4
Problem Areas Stabilized with Seed	2	3	5	40.0	0	43.8
Treetops	8	2	0	80.0	0	25.3
Log Decks	10	0	0	100	0	n/a
SMZs	8	2	0	80.0	1	25.3
Equipment Use	8	2	0	80.0	1	25.3

SIGNIFICANT RISKS

There were a total of 58 Significant Risks observed statewide, or 1.3 percent of the 4,625 individual BMP observations that required BMPs. These significant risks were observed on 13 separate harvest sites, or 6.3 percent of the 208 harvest sites evaluated. The SMZ category of BMPs contained the most significant risks. SMZs, Skid Trails and Stream Crossings together contained 73 percent of the significant risks observed.

In all cases, where it was observed that a significant risk was resulting in the degradation or potential degradation of water quality, the situation was brought to the landowner's attention and corrected in cooperation with landowners and loggers.

Tables 4 through 15, figures 3 and 4, and Appendix B provide additional details to characterize significant risks for this survey.

An example of significant risk mitigation on a non-surveyed site.

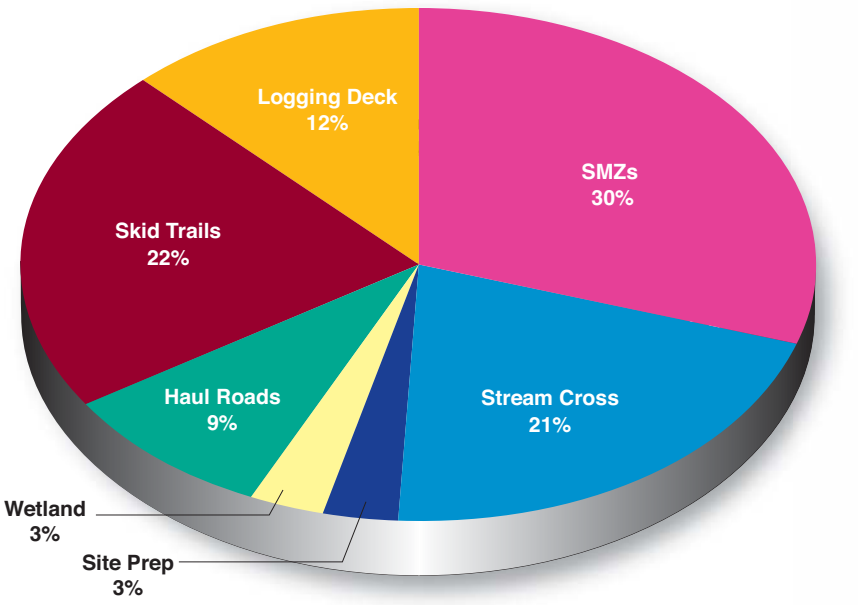
SIGNIFICANT RISKS BY BMP CATEGORY

Table 14 and figure 3 present information on significant risks by BMP category. The SMZ category of BMPs contained the greatest number of significant risks (17 significant risks on 6 harvest sites). The skid trail category of BMPs contained the second greatest number of significant risks (13 significant risks on 11 harvest sites). The Site prep and wetlands categories of BMPs contained the least number of significant risks (2 significant risks on 1 harvest site for each category). Additional details concerning significant risks by individual BMPs are presented in Appendix B.

TABLE 14. SIGNIFICANT RISKS BY BMP CATEGORY

Haul Roads	5
Skid Trails	13
Logging Deck	7
SMZs	17
Stream Crossings	12
Site Prep	2
Wetlands	2
TOTAL	58

FIGURE 3. SIGNIFICANT RISKS BY BMP CATEGORY



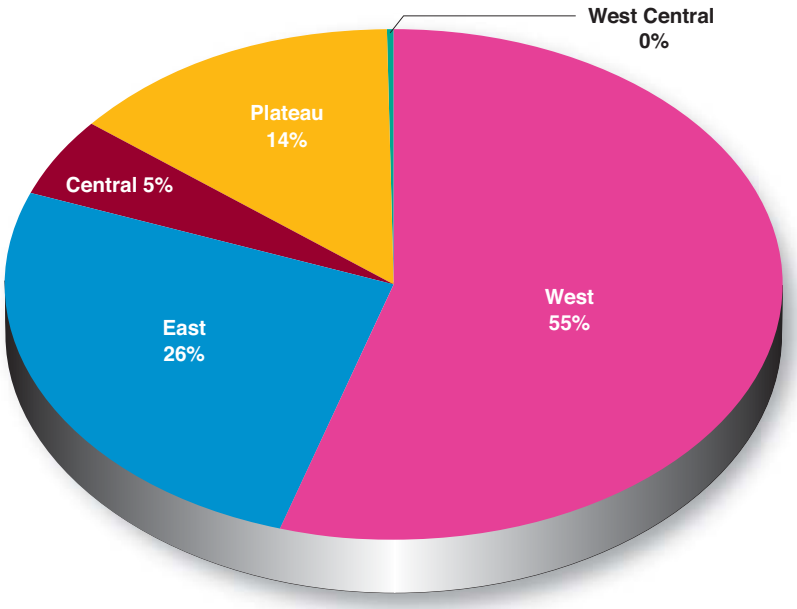
SIGNIFICANT RISKS BY FIA SURVEY UNIT

Table 15 and figure 4 present information on significant risks by FIA survey unit. The West Survey Unit had the highest level of significant risks (32 significant risks on 6 harvest sites). The East Survey Unit had the second highest level of significant risks (15 significant risks on 2 harvest sites). No significant risks were observed in the West Central Survey Unit.

TABLE 15. SIGNIFICANT RISKS BY FIA SURVEY UNIT

East	15
Central	3
Plateau	8
West Central	0
West	32
TOTAL	58

FIGURE 4. SIGNIFICANT RISKS BY FIA SURVEY UNIT



SUMMARY AND CONCLUSIONS

The 2007 Forestry BMP Implementation survey reflects a change in process and evaluation since the last survey. This was done to produce outputs that can be compared on an equal basis with report outputs from states across the South. Even though there have been changes in the process, the comparison of the 2007 survey outputs to those in previous surveys provides evidence that BMP implementation has improved.

The 2007 BMP implementation survey revealed an average overall BMP implementation rate of 89.2 percent. This is an improvement of 7.3 percentage points as compared to the 81.9 percent implementation rate reported in the 2004 BMP implementation survey. It is a 26.3 percentage point improvement over the 62.9 percent implementation rate reported in the 1996 BMP implementation survey. This improvement can be attributed to greater awareness of water quality issues associated with forest practices and improved understanding of correct BMP implementation. The efforts invested over the past two decades to educate the forestry community about practices that protect water quality continue to show positive results.

Future BMP training sessions should focus on stabilizing disturbed areas.

The practices that will be the core items of BMP education and training for the next planning phase are 1) streamside management zones, 2) skid trails and 3) stream crossings. These will be addressed through additional courtesy check site visits, logger contacts, educational materials, technical guides, and demonstrations. Regardless of BMP category, special emphasis will also be given to highlight the importance of stabilizing disturbed areas. Additional training to equip West Tennessee operators to follow BMP guidelines is also a program priority.

The goal of the Division of Forestry's BMP implementation survey is to accurately evaluate BMP use and identify areas for continued improvement. Tennessee Forestry BMP implementation surveys are planned on a three-year cycle. This provides information for timely assessment of forestry BMP use in Tennessee.

The ultimate goal of TDF BMP programs is to assure clean water in association with timber harvesting activities.

GLOSSARY

IMPLEMENTATION MONITORING - The process used to determine the proper application of BMPs according to the specifications in Tennessee Forestry Best Management Practices Guidelines.

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 water body. Such change may or may not violate water quality standards.

BEST MANAGEMENT PRACTICES (BMPS) – A practice or combination of practices which has been determined to be the most effective and practical means of preventing or reducing water pollution to a level compatible with water quality goals.

EROSION - The process by which soil particles are detached and transported by water, wind, and gravity to some downslope or downstream deposition point.

HAUL ROAD - A permanent or temporary woods road over which timber is transported from a harvest site to a public road.

NONPOINT SOURCE POLLUTION – pollution of water which is:

- carried or conveyed by natural processes including precipitation, seepage, percolation, and runoff;
- not traceable to a distinct or identifiable source; and
- better controlled through the application of good management practices.

SILVICULTURE - The science and art of growing forest crops. More particularly, the principles, theories and practices for protecting and enhancing the regeneration, growth and development and use of forests for multiple benefits.

STREAM - Includes perennial (continuous flowing) and intermittent (flows only during wet periods) streams that flow in well-defined channels.

STREAMSIDE MANAGEMENT ZONES - A designated area that consists of the stream itself and an adjacent area of varying width where management practices that might affect water quality, fish, or other aquatic resources are modified. Streamside management zones are areas of closely managed activity, not areas of exclusion.

APPENDIX A

CLIMATOLOGICAL DATA (PRECIPITATION)

The following annual rainfall information is associated with selected climatological sites in Tennessee. This information is accessible from the National Oceanic and Atmospheric Administration's National Climatic Data Center web link (http://cdo.ncdc.noaa.gov/ancsum/ACS). It is notable that the survey timeframe is entirely within a period of extended drought. During this 2005-2007, deficits from normal precipitation occurred across the state. Each year West Tennessee had higher precipitation deficits than other parts of Tennessee. The precipitation deficit reached historic levels in 2007 for most areas of the state.

LOCATION	INCHES OF PRECIPITATION					
	2005	DEFICIT	2006	DEFICIT	2007	DEFICIT
Kingsport	40.06	11.53	na	na	30.82	12.16
Knoxville	38.43	9.79	47.79	0.43	33.89	14.33
Chattanooga	46.27	8.25	46.67	7.85	38.62	15.90
Ave.	41.59	**9.86**	31.49	**2.76**	34.44	**14.13**
Crossville	45.13	11.97	47.44	9.66	38.50	18.60
Jamestown	47.70	7.35	54.01	2.04	41.23	15.62
Ave.	46.42	**9.66**	50.73	**5.85**	39.87	**17.11**
Nashville	39.31	8.80	45.72	2.39	35.66	12.45
Clarksville	45.38	6.40	44.83	6.95	44.05	7.73
Ave.	42.35	**7.60**	45.28	**4.67**	39.86	**10.09**
Jackson	46.69	8.09	47.39	7.39	37.77	17.01
Memphis	40.01	14.64	42.20	12.45	34.81	19.84
Ave.	43.35	**11.37**	44.80	**9.92**	36.29	**18.43**

APPENDIX B

SUMMARY OF SIGNIFICANT RISKS BY CATEGORY, BMP AND FIA SURVEY UNIT

HAUL ROADS	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Broad Based Dips						
2. Waterbars						
3. Culverts					1	1
4. Turnouts (wing ditches)						
5. Water control structures					1	1
6. Crowned or Outsloped						
7. Avoided sensitive areas & SMZs					1	1
8. Rock used (BBD or other)						
9. Problem areas stabilized with seed						
10. Follows contour						
11. Within grade					1	1
12. Existing roads utilized						
13. Located away from water					1	1
TOTALS					5	5

SKID TRAILS	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Grade	1	1	3		4	9
2. Water control						
3. Avoided wet & sensitive areas						
4. Equipment use						
5. Problem areas stabilized with seed						
6. Ruts don't channel into stream	1				3	4
TOTALS	2	1	3		7	13

LOGGING DECKS	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Existing landings used						
2. Location	1	2				3
3. Drainage	1	1	1		1	4
4. Hazardous waste management						
5. Problem areas stabilized with seed						
TOTALS	2	3	1		1	7

STREAMSIDE MANAGEMENT ZONES	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. SMZ matched to stream type	2				1	3
2. Canopy	2				1	3
3. Tree felling	2				1	3
4. Equipment use	1	1			1	3
5. Width	2		1		2	5
TOTALS	9	3	1		6	17

STREAM CROSSINGS	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Crossings minimized					1	1
2. Location						
3. Aquatic life movement disruption low	1				1	2
4. Approaches					2	2
5. Water control structures	1				3	4
6. Crossing appropriate, properly installed						
A. Ford		1				1
B. Culvert and fill					1	1
C. Bridge						
7. Temporary structures removed					1	1
TOTALS	2	1			9	12

DEBRIS & HAZARDOUS MATERIALS	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Treetops & stumps						
2. Oil & fuel spills						
TOTALS						

SITE PREPARATION & TREE PLANTING	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Method					1	1
2. SMZs						
3. Slopes					1	1
4. Firelines						
TOTALS						

WETLANDS	EAST	CENTRAL	PLATEAU	WC	WEST	TOTALS
1. Roads						
2. Drainage structures						
3. Fill material						
4. Stream crossings						
5. Problem areas stabilized with seed						
6. Treetops						
7. Decks						
8. SMZs					1	1
9. Equipment use					1	1
TOTAL					2	2

APPENDIX C

STATISTICAL ANALYSIS

SAMPLE SIZE

The formula for estimating sample size:

$$n = \left(\frac{t\ CV}{AE}\right)^2$$

Where n = the number of sites to evaluate
t = Student's t-value
CV = coefficient of variation
AE = allowable error

Thus given the following parameters:

t = 1.96 — as t at the .05 value approaches a degrees of freedom of infinity, the value is 1.96
CV = coefficient of variation – estimated to be 50% which means that the standard deviation is 50% of the mean (an estimate that seems reasonable)
AE = 10% (90% probability)

These assumptions give the estimate for sample size as

$$n = \left(\frac{1.96*\ 50}{10}\right)^2 = 96$$

Sample size is 200+. There are sufficient samples to make good statistical comparisons depending whether our estimate of CV is close.

The statistical parameters for this study are:
Test of Significance at the .05 level — (95% accurate) with a probability of 90%, i.e., 10% allowable error

These procedures are from the following reference:

W.G. Cochran and G.M. Cox. 1957. Experimental Design. 2nd Edition, Wiley Publishing, New York. 611 p

MARGIN OF ERROR CALCULATIONS FOR INDIVIDUAL BMPS

The margin of error expresses the maximum likely difference observed between the sample mean and the true population mean with 95% probability. The formula used to calculate margin of error for individual BMPs is listed below. Refer to tables 6 through 13 for individual BMP margin of errors.

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

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

Note: If the value of P is 100%, the margin of error is not zero. No calculation can be made.

Example of calculation for BMP implementation for equipment use in SMZs:

Where P (% BMP impl. for equipment use in SMZs) was evaluated to be 88.1% on 101 sites

$$m = 2\sqrt{\frac{88.1(100-88.1)}{101}}$$

$$m = 2\sqrt{\frac{1048.4}{101}}$$

$$m = 2\sqrt{10.38}$$

$$\mathbf{m = 6.4}$$

MARGIN OF ERROR CALCULATIONS FOR BMP CATEGORIES AND FIA SURVEY UNITS

The margin of error expresses the maximum likely difference observed between the sample mean and the true population mean with 95% probability. The formula used to calculate margin of error by BMP category and FIA survey unit is listed below. Refer to table 4 for BMP category margin of errors and table 5 for FIA survey unit margin of errors.

$$\mathbf{m = 2\frac{SD}{\sqrt{n}}}$$

Where m = margin of error for a BMP category or FIA survey unit
SD = the standard deviation for a BMP category or FIA survey unit
n = the number of sites evaluated

Note: If the value of P is 100%, the margin of error is not zero. No calculation can be made.

Example of calculation for BMP implementation for haul roads:

$$\mathbf{m = 2\frac{SD}{\sqrt{n}}}$$

$$m = 2\frac{SD}{\sqrt{n}}$$

$$m = \frac{2(17.1)}{\sqrt{150}}$$

$$m = \frac{34.2}{12.2}$$

$$\mathbf{m = 2.8}$$

CONFIDENCE INTERVAL FOR OVERALL AVERAGE BMP IMPLEMENTATION RATE

A confidence interval is a tool that statisticians use to demonstrate their confidence in the measured mean of a sample. For example, a 95% confidence interval provides a range for which you can be 95% confident (i.e. 19 times out of 20) that the actual mean will be found. To calculate the confidence interval, the mean, variance, standard deviation, standard error, and margin of error must also be calculated. The formula used to calculate the confidence interval is listed below. The 95% confidence interval for the 2007 BMP survey overall BMP implementation rate across all sites was 87.2% to 91.2%.

$$\mathbf{95\%\ CI = Mean \pm Margin\ of\ Error}$$

APPENDIX D

FORESTRY BMP IMPLEMENTATION SURVEY CHECKLIST

BMP IMPLEMENTATION STUDY ---- Spring 2007

I. Site Identification

FIA Region _____ Date of Inspection _____

County _____ Date of Harvest _____ (if known)

GPS Coordinates Latitude _____

Longitude _____

Ownership _____ (if known) Industry, Public, NIPF, Corporate, TIMO

Surveyor: _____ Harvest Site _____ (estimated)

Harvest Number _____ Type of Cut _____ (partial or clearcut)

II. Site Characteristics

A. Physiographic Region

1. Blue Ridge _____
2. Southern Appalachians _____
3. Cumberland Plateau _____
4. Highland Rim _____
5. Central Basin _____
6. Southern Coastal Plain _____
7. Alluvial Plain _____

B. Terrain Type

1. Wetland _____
2. Stream Valley _____
3. Flatland _____
4. Rolling Hills _____
5. Steep Upland _____
6. Ridgetop _____

C. Drainage Features

1. Perennial Stream _____
2. Intermittent Stream _____
3. Ephemeral Stream _____
4. Lake/Pond _____
5. Not Present _____

III. Haul Roads

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Broad Based Dips	_____	_____	_____	_____	_____	9-10
2. Waterbars	_____	_____	_____	_____	_____	13
3. Culverts	_____	_____	_____	_____	_____	11-12
4. Turnouts (wing ditches)	_____	_____	_____	_____	_____	10
5. Water control structures at recommended intervals	_____	_____	_____	_____	_____	9-13
6. Crowned or Outsloped	_____	_____	_____	_____	_____	9
7. Avoided Sensitive Areas & SMZs	_____	_____	_____	_____	_____	7
8. Rock Used (BBD or other)	_____	_____	_____	_____	_____	10
9. Problem Areas Stabilized with Seed	_____	_____	_____	_____	_____	8, 11
10. Follows contour	_____	_____	_____	_____	_____	7
11. Within grade	_____	_____	_____	_____	_____	7
12. Existing roads utilized	_____	_____	_____	_____	_____	7
13. Located away from water	_____	_____	_____	_____	_____	7
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

IV. Skid Trails

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Grade	_____	_____	_____	_____	_____	21
2. Water control	_____	_____	_____	_____	_____	21
3. Avoided Wet & Sensitive Areas	_____	_____	_____	_____	_____	21
4. Equipment use	_____	_____	_____	_____	_____	21
5. Problem Areas Stabilized with Seed	_____	_____	_____	_____	_____	21
6. Ruts don't channel into stream	_____	_____	_____	_____	_____	21
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

V. Logging Decks

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Existing landings used	_____	_____	_____	_____	_____	20
2. Location	_____	_____	_____	_____	_____	20
3. Drainage	_____	_____	_____	_____	_____	20
4. Hazardous waste management	_____	_____	_____	_____	_____	20 & 23
5. Problem Areas Stabilized with Seed	_____	_____	_____	_____	_____	20
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

VI. Streamside Management Zones

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. SMZ matched to stream type	_____	_____	_____	_____	_____	14 - 15
2. Canopy	_____	_____	_____	_____	_____	15
3. Tree felling	_____	_____	_____	_____	_____	22
4. Equipment use	_____	_____	_____	_____	_____	15
5. Width	_____	_____	_____	_____	_____	15
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

VII. Stream Crossings

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Crossings minimized	_____	_____	_____	_____	_____	17
2. Location	_____	_____	_____	_____	_____	17,18,19
3. Aquatic life movement disruption minimized	_____	_____	_____	_____	_____	17
4. Approaches	_____	_____	_____	_____	_____	17
5. Water control structures	_____	_____	_____	_____	_____	17
6. Crossing appropriate, & properly installed						
A. Ford	_____	_____	_____	_____	_____	18
B. Culvert and Fill	_____	_____	_____	_____	_____	18
C. Bridge	_____	_____	_____	_____	_____	19
7. Temporary structures removed	_____	_____	_____	_____	_____	8,19,21
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

VIII. Debris & Hazardous Materials

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Treetops & stumps	_____	_____	_____	_____	_____	22
2. Oil & fuel spills	_____	_____	_____	_____	_____	20 - 23
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

IX. Site Preparation & Tree Planting

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Method	_____	_____	_____	_____	_____	24
2. SMZs	_____	_____	_____	_____	_____	24
3. Slopes	_____	_____	_____	_____	_____	24, 25
4. Firelines	_____	_____	_____	_____	_____	25
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.

X. Wetlands

	Correct	Incorrect	Not Used But Needed	Not Needed	Is Significant Risk	BMP Page
1. Roads	_____	_____	_____	_____	_____	31, 32
2. Drainage structures	_____	_____	_____	_____	_____	31
3. Fill material	_____	_____	_____	_____	_____	31
4. Stream crossings	_____	_____	_____	_____	_____	31
5. Problem Areas Stabilized with Seed	_____	_____	_____	_____	_____	31, 32
6. Treetops	_____	_____	_____	_____	_____	32
7. Decks	_____	_____	_____	_____	_____	32
8. SMZs	_____	_____	_____	_____	_____	32
9. Equipment use	_____	_____	_____	_____	_____	32
Response totals:	_____	_____	_____	_____	_____	

If answered **Incorrect** or **Significant Risk**, describe the problem(s) below. See reverse.