Comprehensive Indiana Forestry Best Management Practices

Monitoring Results

1996-2016

By: Duane McCoy & Jennifer Sobecki

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Indiana BMP Report

I. Executive Summary

Forestry Best Management Practices (BMP) monitoring began in 1996 in the counties that are part of the Monroe Lake Watershed, during which 43 sites were monitored. Over the 20 years in which Forestry BMPs have been monitored in Indiana, 1,172 sites have been covered in 82 of the 92 counties throughout the state. The application percentage for all the 1,172 sites monitored for BMPs in those years is 85.98% (Figure 1). This means that 85.98% of the BMP practices met the guidelines set forth in the BMP Logging and Forestry Best Management Practices Field Guide. The effectiveness rate, which is a qualitative measure of the impact on the water resources from the forestry practices carried out on the site over the history of the Indiana BMP program, has been 91.2% (Figure 2). This effectiveness rate indicates that forestry practices had little to no impact on the water resources 91.2% of the time across all 1,172 sites.

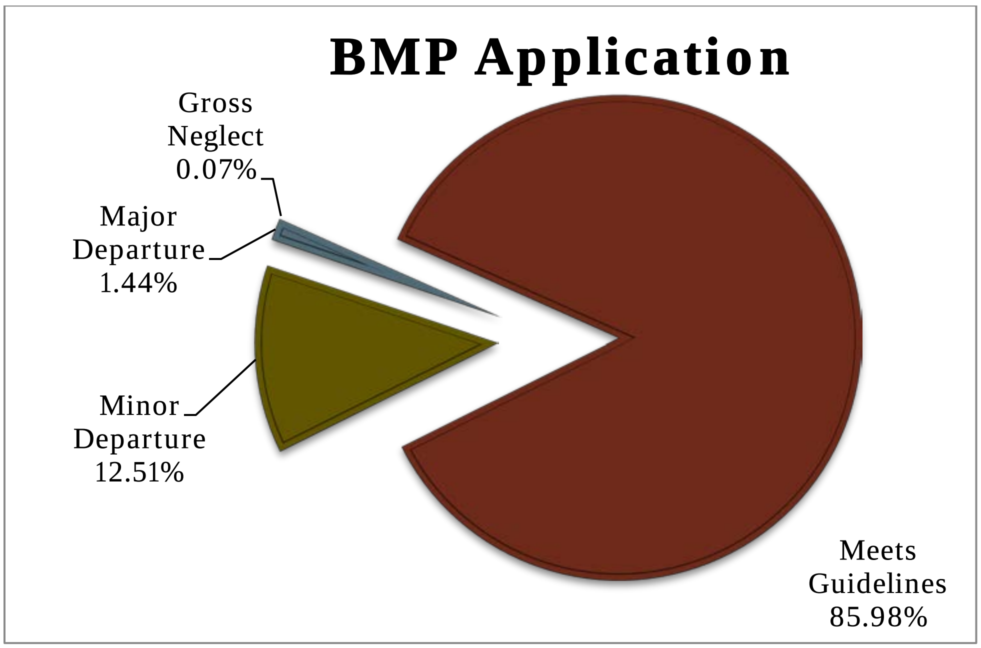


Figure 1. BMP application for all 1,172 sites monitored from 1996–2016.

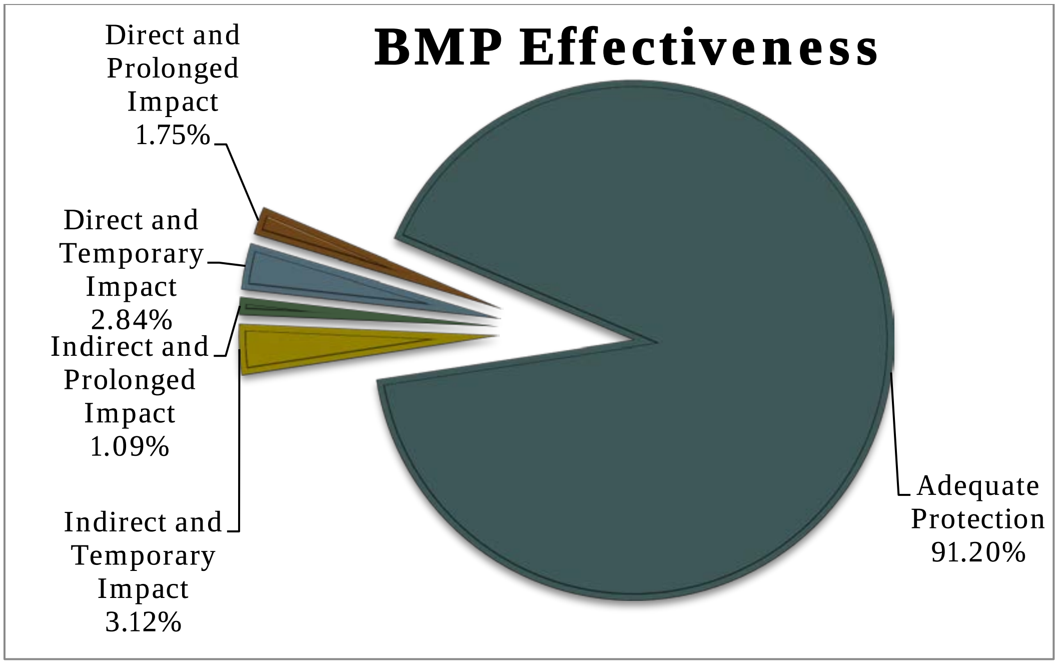


Figure 2. BMP Effectiveness for all 1,172 sites monitored from 1996-2016.

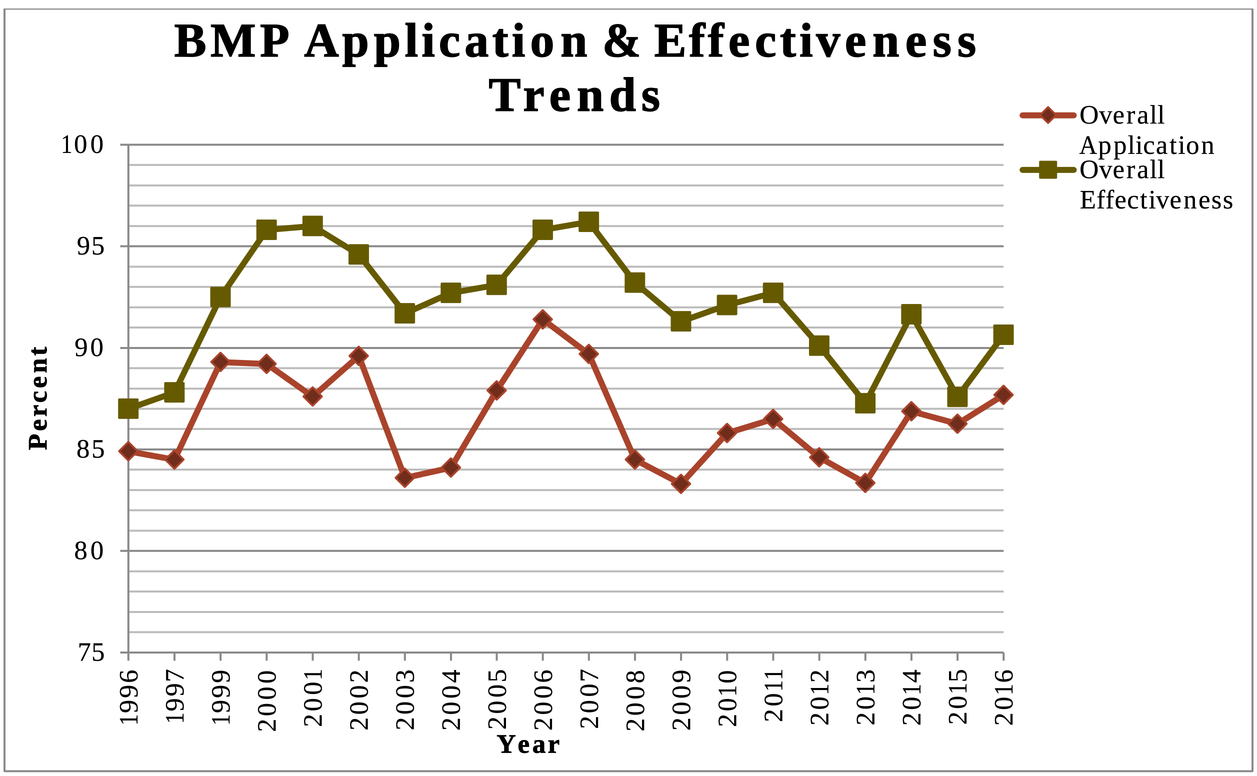


Figure 3. BMP application and effectiveness yearly trends since the beginning of monitoring in Indiana through 2016.

Application and effectiveness rates of sites monitored varied from year to year. No real upward or downward trend can be extrapolated. But there are several conclusions one can draw from Figure 3. First is that effectiveness rates are commonly higher than application rates, and second is that the rates seem to mirror one another. In most years, when application rates have been lower, the effectiveness rates have dipped as well.

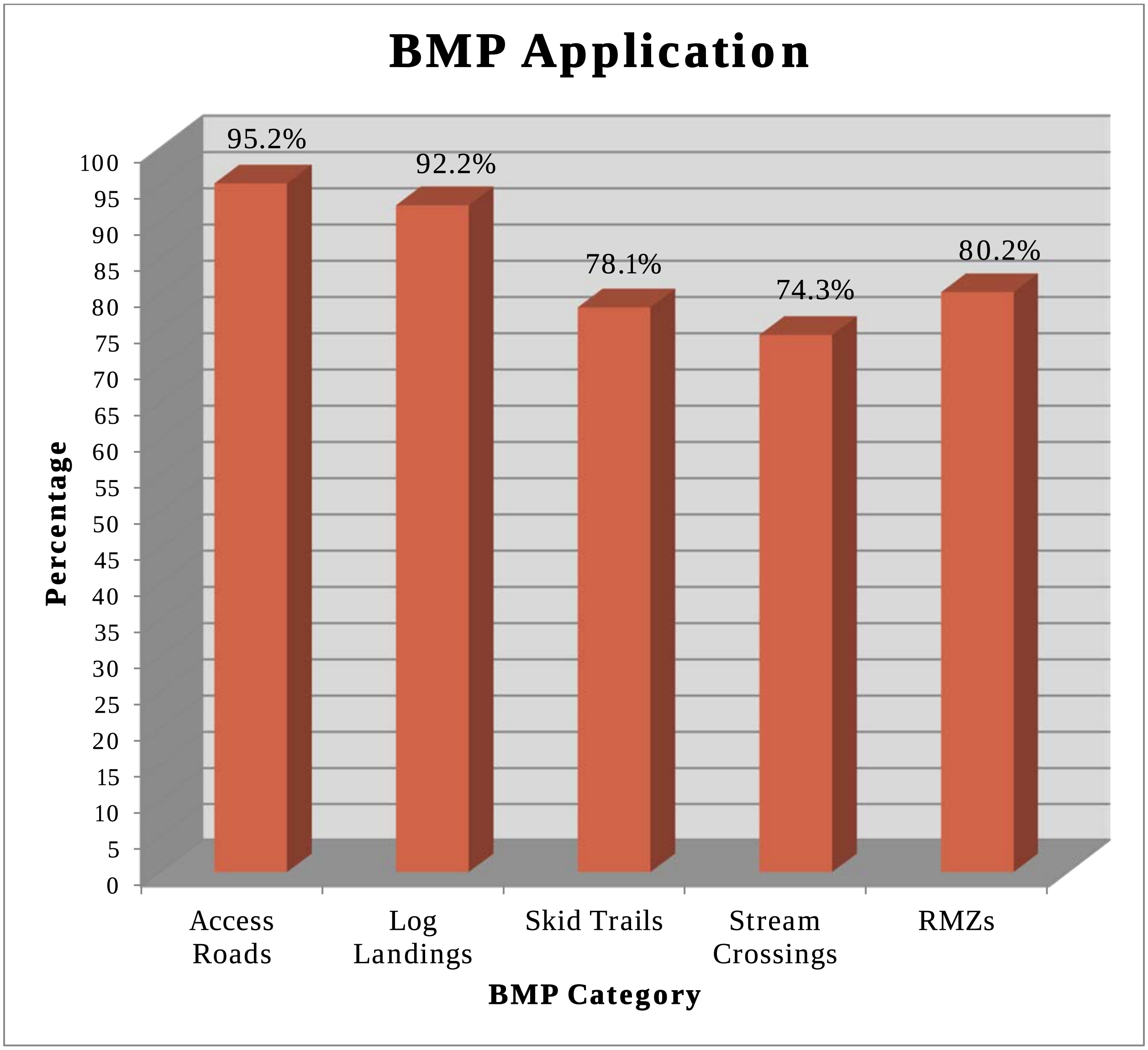


Figure 4. BMP application by BMP category for all 1,172 sites from 1996-2016.

There is clear variation between BMP categories when comparing application and effectiveness rates across the five BMP categories: Access Roads, Log Landings, Skid Trails, Stream Crossings and Riparian Management Zones (Figures 4 & 5). Access roads score highest in application and effectiveness, with log landings following closely. A distant third is RMZs. Skid trail and stream crossings received the lowest application scores, with stream crossings having the lowest scores in both application and effectiveness. While skid trails receive a 77.9% application rate, the effectiveness rate was 89%, indicating that the BMP implementation problems in this category didn't have a significant impact upon the water resources of the sites monitored. Stream-crossings application and effectiveness percentages were both low at 73.6% and 78.6%, respectively. Due to the nature of stream crossings, whether or not there are any errors in application, most impacts are direct to the water resources of the site, so any problems in this area are magnified due to their closeness to water.

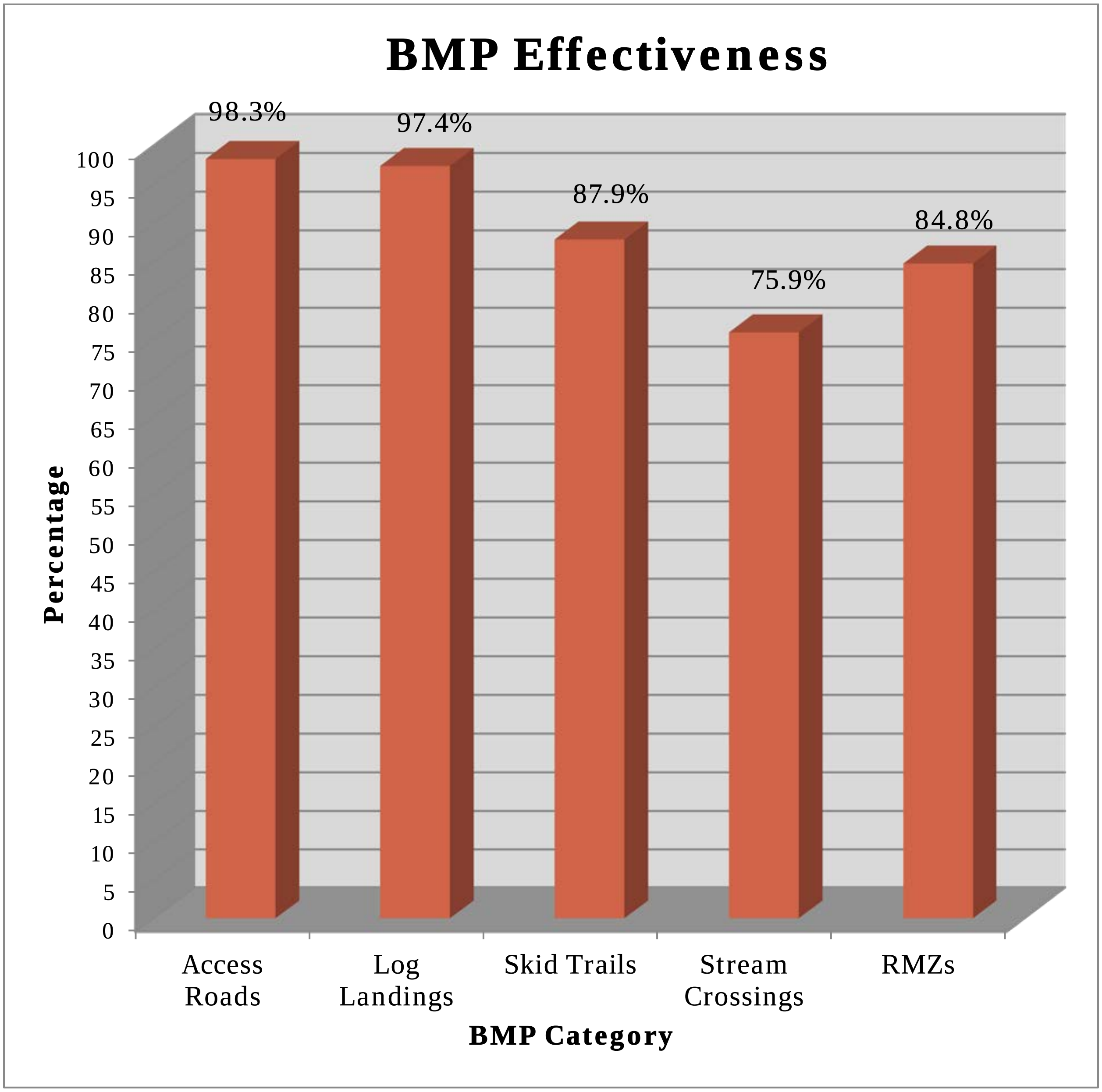


Figure 5. BMP effectiveness by BMP category for all 1,172 sites monitored from 1996-2016.

Effectiveness is the qualitative measure of impact on water quality from erosion reaching a water body in correlation with a specific question or practice. An example would be that skid trails have the largest area of disturbed ground in a timber sale; therefore, those areas often have the lower application scores when compared to RMZs, but RMZs have the lower effectiveness scores due to their closeness to water. It stands to reason that those areas of a timber harvest near water have the lower effectiveness scores. Comparisons of RMZ data and skid-trail data can often be difficult to compare as scores on skid trails within an RMZ are not separated from those outside the RMZ, but it stands to reason that a skid trail within the RMZ is more likely to directly affect water quality because it is closer to the water resource.

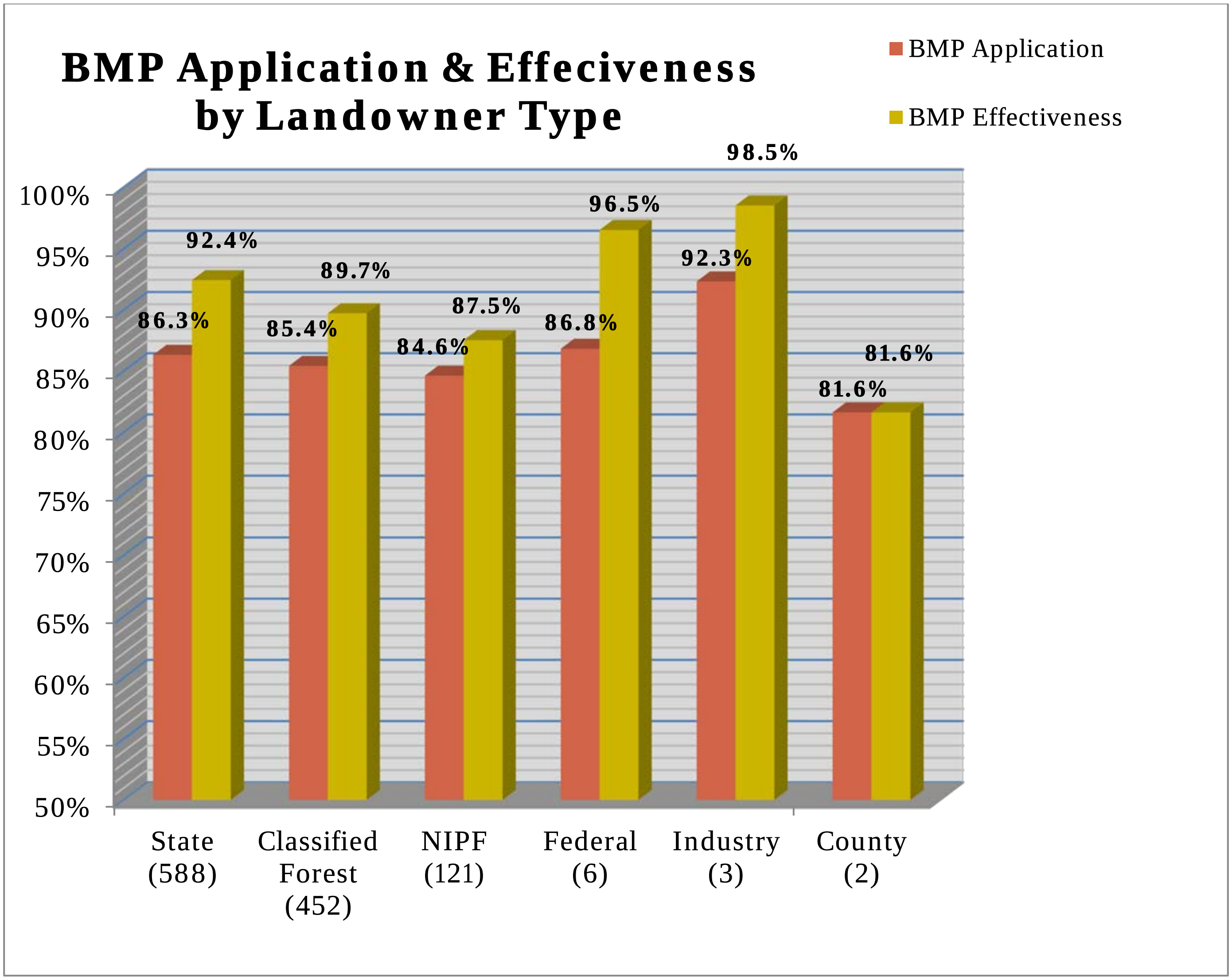


Figure 6. BMP application and effectiveness of all sites monitored from 1996–2016. Number of sites monitored noted below the landownership categories.

BMP application and effectiveness also varied by ownership type. This variation is difficult to draw correlations from due to the difference in site selection and monitoring methodology by landowner type, as well as other factors. A case in point is the period in time when the monitoring of State Forest property sites had one important difference from the other landowner types, but still often came out higher in application as well as effectiveness. State Forest properties were monitored with the 4-foot Rule (Appendix A) for all timber sales starting July 1, 1999, through June 30, 2010, which gave those sites lower application and effectiveness scores when other landowner types may not have gotten them. Starting July 1, 2010, the 4-foot Rule was removed and all BMP monitoring defined large intermittent and perennial streams as starting at where the USGS classifies a stream as an intermittent, thus putting all landowner types on the same definition and aligning the findings of all BMP monitoring in Indiana.

II. **Introduction & Indiana Forestry BMP History**

A. BMP Introduction

Indiana has 6.2 million acres of forestland, 26.8% of the state's land base, providing many benefits to Indiana residents and wildlife. Forestland is important to Hoosiers who frequent the woods for various forms of recreation, including hiking, biking, hunting, fishing and wildlife watching. Even residents who don't do these activities benefit greatly from the biodiversity, clean air and water our forests produce. Since forests are important to all citizens of our state, it is imperative that timber harvesting on all ownerships be done in a way that reduces or mitigates environmental impacts. Although forests are known to be the best way to reduce nonpoint source pollution (NPS) to waterways, they also can be a source of pollutants. When forest soils are bared, there is opportunity for NPS pollution to occur. BMPs are employed to protect forest soils and water quality during and after a harvest.

Table 1. Forestland ownership types in Indiana and the percentage of total area of forestland, percentage of state they make up, the percentage of acres of each forest ownership type that has been monitored for BMPs.

Forest Ownership	Acres	% of Forestland	% of state	% of ownership type acres monitored	% of total acres monitored
Private	5,462,870	87.49%	23.4%	0.51%	36.62%
Federal	426,675	6.82%	1.83%	0.08%	0.46%
State	335,015	5.37%	1.44%	14.34%	62.79%
Local/Municipal	19,740	0.31%	0.08%	0.37%	0.13%

Table2. Number of sites and acres monitored by ownership types in Indiana.

Landowner Type	# Sites Monitored	# Acres Monitored
State	588	48,053
Classified Forest & Wildland	452	22,549
NIPF	121	5,410
Federal	6	355
County	3	100
Industrial	2	66

BMPs are a foundation for water-quality protection and guidelines for protecting water quality during forest operations. The purpose of BMPs is to minimize the impact of forest activities that may affect soil and water quality. This report is a summary of the application and effectiveness of BMPs for timber harvests conducted on forest properties statewide from 1996 – 2016 on all land ownership types. Data cover all BMP monitoring for 1,172 sites over those years, looking at time trends and making comparisons.

Recently closed skid trail seeded with debris used as water diversion.

B. BMP History

In response to the Federal Clean Water Act amendments of 1987 and a request from Indiana's forest owners, the Department of Natural Resources Division of Forestry, in cooperation with the Woodland Steward Institute, took on a statewide project to develop an aggressive program to carry out voluntary BMPs. The Federal Clean Water Act amendments of 1987 prompted states to develop BMP guidelines to control the impacts of silvicultural practices, as well as the impacts of other land uses such as agriculture and development that caused Non-point Source (NPS) pollution. In response, the Woodland Steward Institute took on the project called "The Forest Health Initiative." The BMP guidelines were completed in 1995, the first round of BMP Monitoring occurred in 1996, and the Forestry BMP Field Guide was published in 1998.

In cooperation with the United States Environmental Protection Agency (EPA), the Indiana Department of Environmental Management (IDEM) and the Woodland Steward Institute, the Division of Forestry arranged a series of meetings that included individuals from many public agencies and private interests. In these meetings they set up committees that would, throughout the early 1990s, develop a set of forest practices designed to mitigate or minimize impacts of forest-management activities on water quality, sometimes even enhancing water quality. This effort was designed under the auspices of the Clean Water Act, which directed the EPA to guide the states in developing BMPs for several land-use practices, such as agriculture, urban development and forestry. In forestry, the states were directed to establish BMPs, but were given the option that they could be voluntary or regulatory.

The Indiana Forestry BMP program was divided into three main components. The first element was the BMP guidelines themselves, which were the physical practices, such as water-diversion spacing or seed mixture recommendations, and the publication that has been commonly known as the Indiana Forestry BMP Field Guide. The second component was BMP training, which consisted of teaching the BMPs to the different parts of the Indiana forest products community, such as the loggers, landowners, and foresters. The third part was BMP monitoring, which consisted of looking at how BMPs were applied in the field and how well those practices protected water quality.

By 1996, the BMP guidelines were constructed, and each program was ready to begin. Selected sites were predominately within the Monroe Lake Watershed. Monroe Lake is a reservoir serving many Hoosiers as a chief source of water and recreation. Additional sites were from adjoining Owen County and Morgan-Monroe State Forest. Only legitimate forest sites larger than 10 acres in size that were logged within last two years of the time of monitoring were considered for that round of monitoring. The identification of potential monitoring sites was accomplished by aerial reconnaissance and ground verification, licensed timber buyer records, district and consultant forester recommendations, and Monroe County logging permit records. Owners of prospective sites were contacted for permission to use their site as part of the study. Once sites were accepted for monitoring, teams were made up of people with diverse technical backgrounds. Each team was led by a DNR forester to provide technical and logistical support. Other team members came from the forest industry, environmental community, landowners, planning and development, wildlife biology, hydrology and soil conservation. Team size was four to five individuals, often with team members possessing multiple areas of expertise.

All BMP monitoring since has followed the model that was set by the group in the mid-1990s, but it has evolved over time, either by necessity or for improvements that were recognized as needed. The first few rounds of monitoring were paid for through money from IDEM or the Great Lakes Commission under the Clean Water Act or some other federal program. BMP monitoring has also become a staple on State Forest property harvest sites, where all harvest sites are now monitored for BMP compliance.

III. **Methods**

A. BMP Monitoring Objectives

The objectives of BMP monitoring are: 1) to assess the effectiveness of BMP guidelines in minimizing soil erosion and stream sedimentation; 2) to provide information on the extent of BMP implementation, past and current; 3) to identify areas on which to focus future program training and educational efforts to improve BMP implementation and effectiveness; 4) to identify BMP specifications that may need technical modification; and 5) to identify improvements needed in future monitoring efforts.

B. Site Selection

1. State Forest

Every timber harvest conducted on State Forest property is monitored if the timber was sold after July 1, 1999, unless the harvest occurred in order to change the land use. For example, Ferdinand State Forest had a site where timber was harvested before the area was cleared for a pipeline right-of-way. This kind of land-use change makes it impossible to monitor for BMPs.

2. Classified Forest and Wildland

Beginning in 2008 and after, at least 10% of CLFW and Wildland (CLFW) program sites reported as having a harvest the previous year will be monitored. CLFW monitoring began in order to make CLFW and Wildland properties eligible for certification with the Forest Stewardship Council (FSC). These sites are randomly selected from the annual reports that are requirements of the program that report having had a harvest during the year they are reporting. When the annual reports are in, each timber harvest in each district is given a number, and those are run through a random number generator. Harvests that make up at least 10% of the harvests in each district are then monitored. For instance, if a district gets back 31 annual reports that said a harvest had occured in that year, we will monitor the first four sites that come out of the random-number generator.

3. Random Forests

From 1996 through 2004, monitoring sites other than State Forests and CLFWs were selected by their geographic position. The 1996 and 1997 rounds were in the counties that had land in the Monroe Lake Watershed; the 1999 round was in five randomly selected counties throughout the state (Ohio, Jefferson, Clay, Martin and Stueben); and the 2000 round looked at sites in seven of the 13 counties that have watersheds flowing into the Great Lakes (Adams, Allen, Elkhart, LaGrange, LaPorte, Noble, Steuben). One site in 1996, six sites in 1997, and five sites in 1999 were recorded as being CLFW. Other landowner types included Non-Industrial Private Forests (NIPF), County, Federal and Industrial.

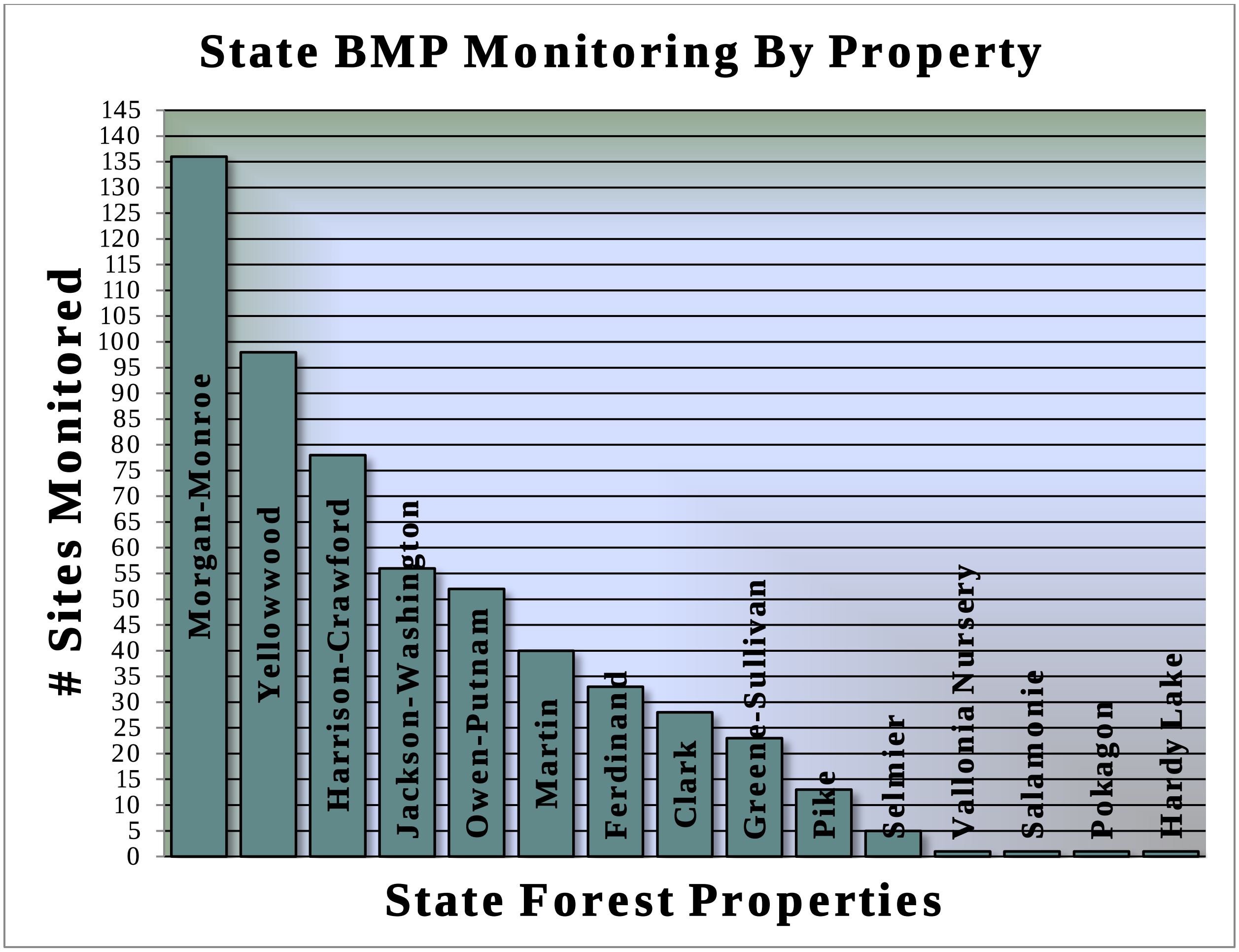


Figure 7. Timber harvests monitored for BMPs in Indiana State Forests by property.

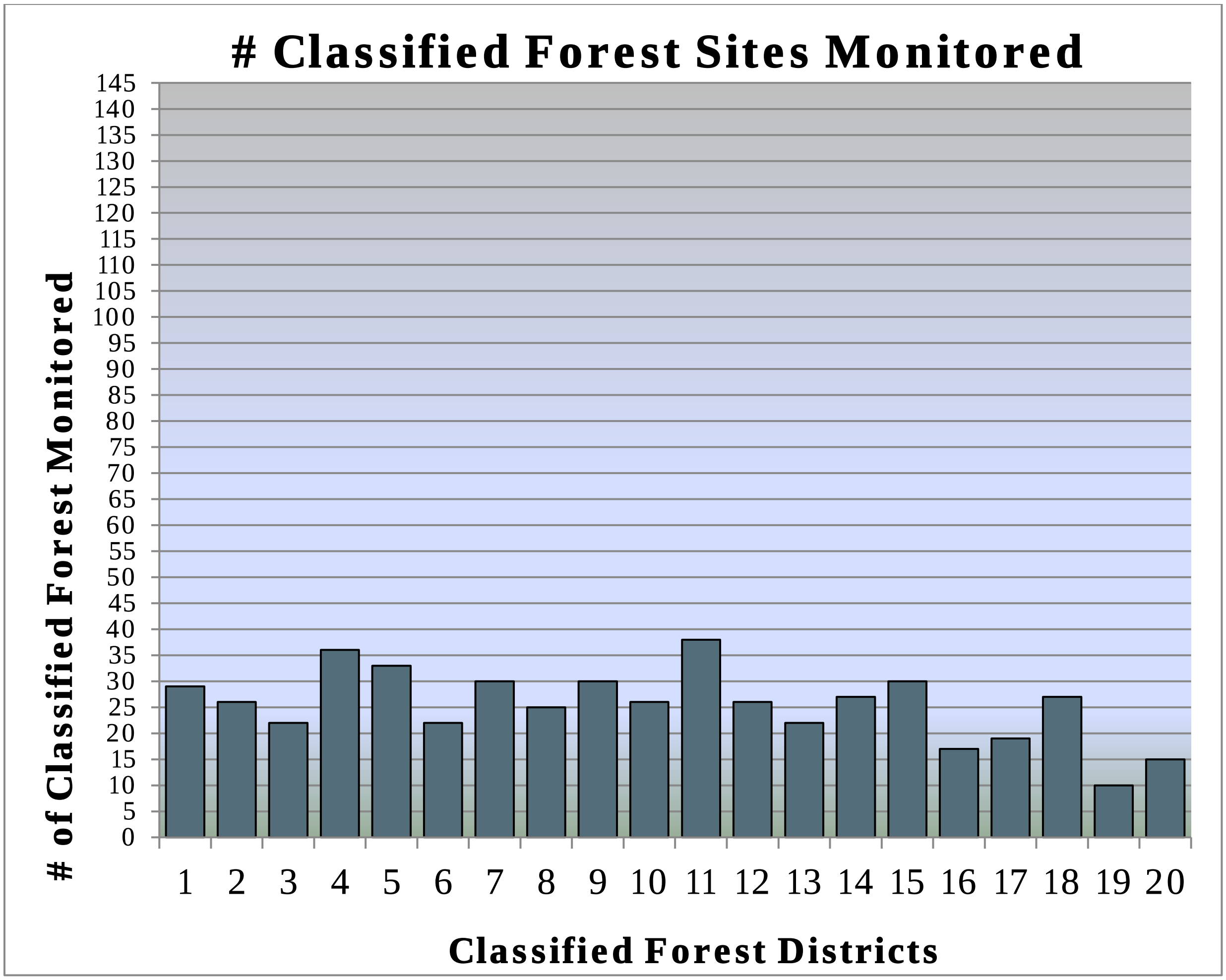


Figure 8: Number of CLFW timber harvest sites monitored for BMPs by district.

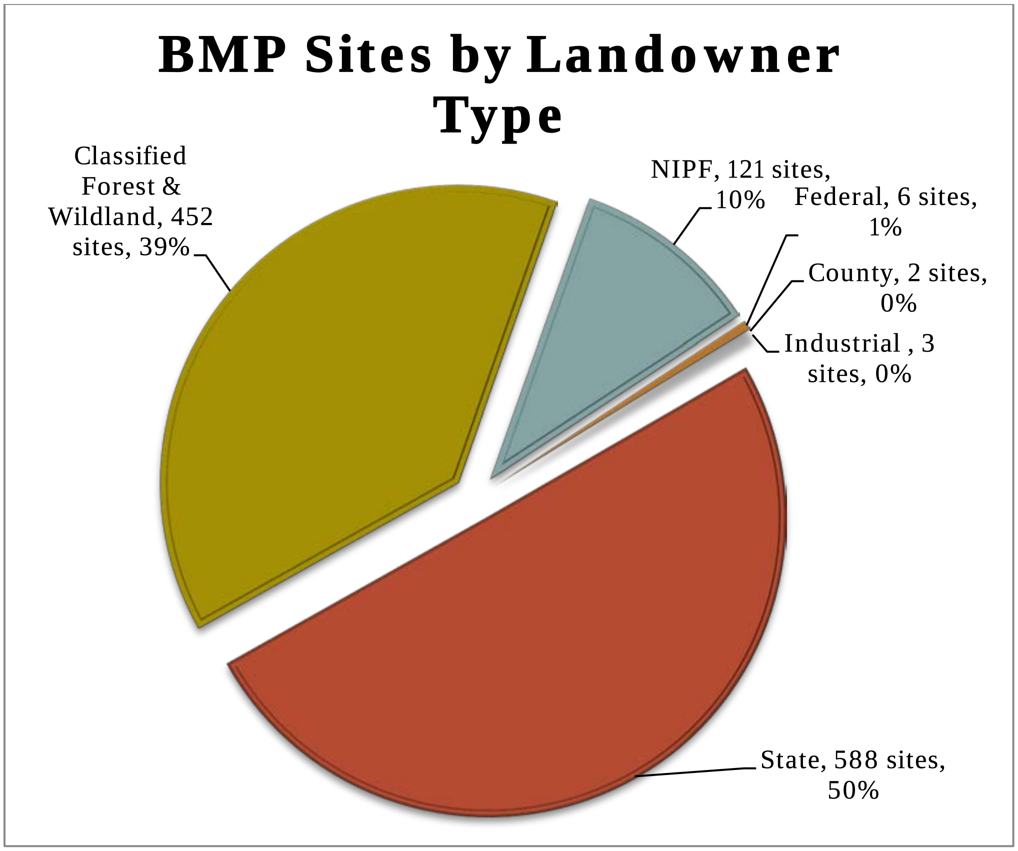


Figure 9. Proportion of land-ownership type for total number of sites monitored.

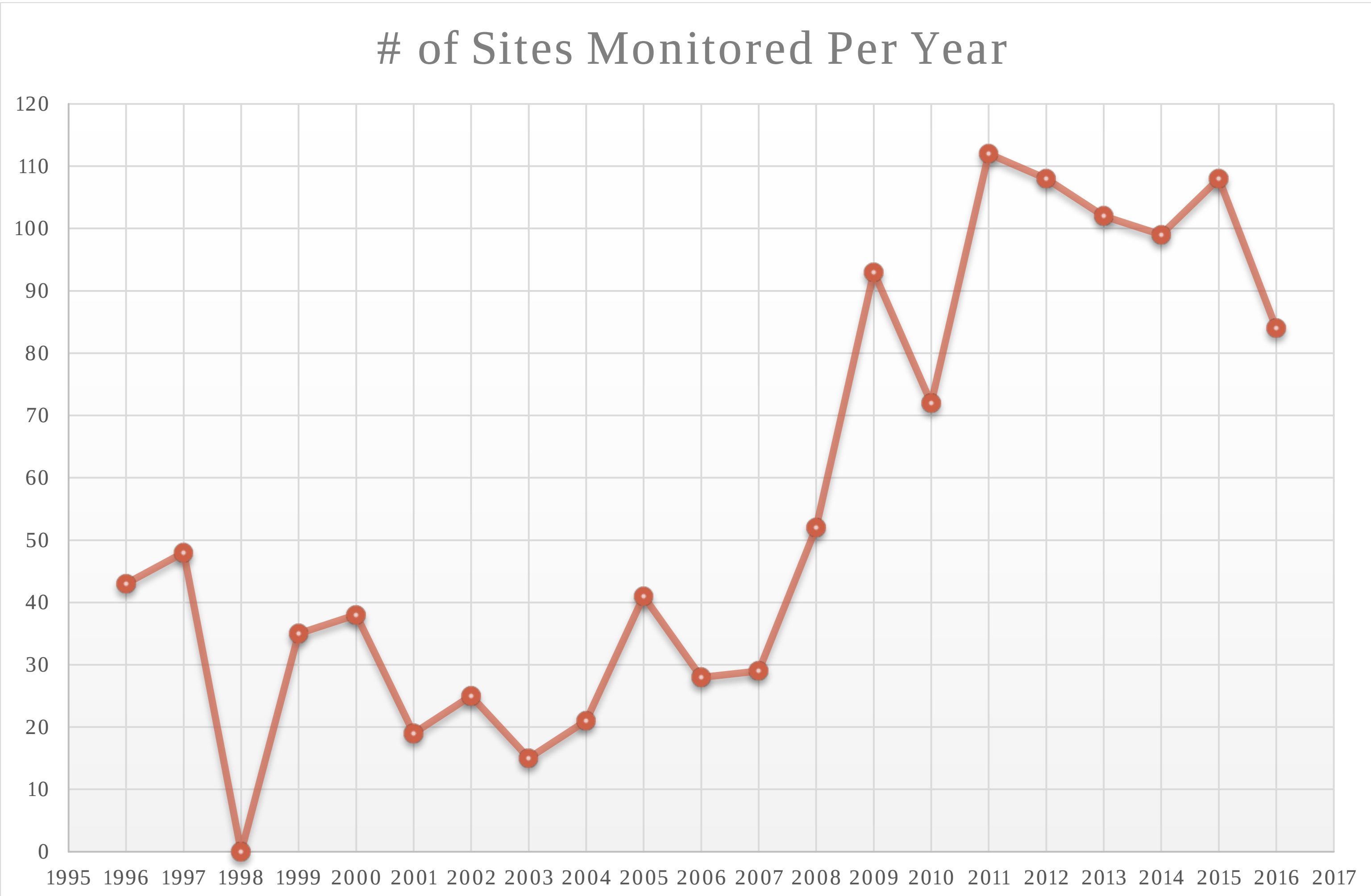


Figure 10. Total number of sites monitored each year since the program began 20 years ago.

C. Data Collection, Entry and Analysis

The BMP Monitoring Form (Appendix B) is used to collect data both in the office and field. Much of the first page can be completed by consulting maps, harvest paperwork or talking to the forester, timber buyer, or landowner. The remaining pages of the form are completed in the field during and after the site evaluation. More details about that process can be found later in the “Site Evaluation” section.

These “raw” datasheets are then brought back to the office and given to a Division of Forestry employee to enter into the Indiana Forestry BMP Database. Datasheets are “cleaned up” and copies are supplied to concerned parties: foresters, landowners, timber buyers, and managers. The database is used to construct various reports such as this one, as well as annual reports for State Forest, CLFW and quality-control reports.

D. Monitoring Team Selection

Selection of monitors has been modified over the course of BMP monitoring in Indiana (1996 -2016). It has also varied based upon the landownership and monitoring objectives.

State Forests

At first, on State Forest properties, either or both of the Watershed Conservation (WC) and Licensed Timber Buyers (LTB) foresters came to every BMP-monitoring site. This kept a balance for consistency in the monitoring and resulting data. There is now a BMP-monitoring staff that includes the LTB Forester and one or two intermittent positions whose focus is BMP monitoring. The other participants are the Administering Forester, and at times, other foresters on the property. This provides balance in the monitoring process and provides good training and discussion.

From July 1999 until 2003, the coordination of monitoring dates and people was carried out by the Property Specialist who also attended the monitoring of every timber harvest. This practice was discontinued when administrative duties increased for that position, and coordination of monitoring was passed to the LTB forester.

3rd Party Quality Control

The 3rd party team needs to have at least two or three people who could visit the 22 sites together. The team represented an array of interested parties from outside state government.

Ownership other than State

In the monitoring rounds from 1996–2004, an assortment of technical backgrounds was the basis for monitoring team selection. Each team was led by a DNR forester to provide technical and logistic support. Team members also included individuals from the forest industry, the environmental community, landowners, planning-and-development staff, wildlife biology, hydrology, loggers and soil conservation. Team size was four to five individuals, often with team members possessing multiple areas of expertise.

Classified Forest

In the 2008-2011 monitoring of CLFW sites, the District Forester and one or more of the BMP monitoring staff monitored each site. If the landowner or harvesting professional came as well, that person was included in the process.

E. Site Evaluation

BMP monitoring is based on the evaluation of each specific practice for application and effectiveness. Application is the installation of a practice and the condition of the practice at the time of monitoring. Effectiveness is the level of success a practice has in preventing pollutants from entering a water body or reducing the level of impact the pollutant is having on the water body at the time of monitoring. It is possible to apply all of the BMPs properly and get a good score in application but still have soil entering a stream, which would call for a lower score in effectiveness. The opposite may be possible as well.

There are 53 individual BMPs measured for application and effectiveness on each site evaluation. These individual BMPs are within five categories:

1. Access or Haul Roads
2. Log Landings or Yards
3. Skid Trails
4. Stream Crossings
5. Riparian Management Zones (RMZ)

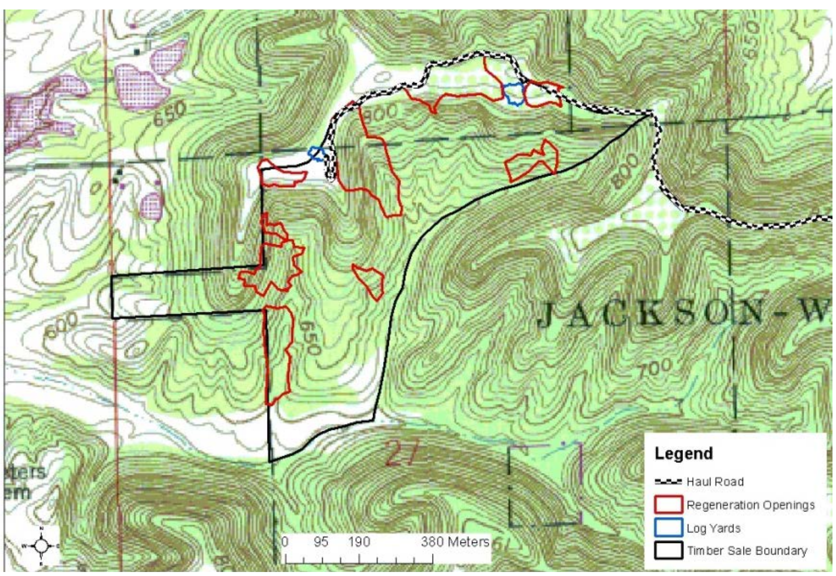
The monitoring team inspects the harvest area, covering all access roads, log landings, skid trails, water bodies, riparian management zones, and stream crossings as suggested in the Indiana BMP Monitoring Protocol, and commenting on successes and departures from the BMP guidelines.

BMP monitoring team discusses implementation and effectiveness of a water diversion.

Once on the site, the monitoring team walks the area and its adjacent and interior intermittent or larger streams carrying maps of the site, the BMP monitoring form and the BMP Field Guide. This allows each team member to evaluate the BMPs on the site. Once the team has walked the area, members discuss each question and each team member's scores on the BMP monitoring form until they reach consensus as a team on each score for each question.

BMP training on a recently harvested site.

On State Forest properties, between 1999 and 2010, the definition of large intermittent streams focused on streams that were 4 feet wide at the bed of the stream or marked as mapped intermittent streams, or larger on U.S. Geological Survey quadrangle maps. This was done to more easily determine what streams need to be monitored for the presence of large woody debris caused by the harvest that must be removed. A better history and definition for streams that qualified as 4 feet is in Appendix A.



Harvest planning map. Harvest pre-planning is an essential part of BMPs.

The “4-Foot Rule” (Appendix A) was adopted as an automatic intermittent stream starting July 1, 1999, when BMPs officially were put in state-timber sale contracts. On other forest ownership types, the definition of an intermittent was defined in the BMP Field Guide and was how the monitoring crew interpreted what it saw on the site. As of July 1, 2010, the “4-Foot Rule” gave way to consistency with the other property-ownership types regarding woody debris. With this rule, there were streams on State Forest properties that had woody debris in them that was required to be removed but this would not have been counted against them on other ownership types. Now the rule for all ownership types is consistent in this matter

3rd Party Quality Control

It was determined in 2007 that 10% of State Forest sites monitored the two previous years and every year thereafter would be re-monitored for quality-control purposes to ensure the accuracy of the Division of Forestry’s internal audits. Sites were given numbers, and then the numbers were chosen randomly to select the 10% of sites to be re-monitored by professionals not employed by the state. A total of 10% of sites monitored each year are to be reviewed. This process continued through 2010; however, due to difficulty in finding external monitors to participate, this practice has not continued. A new system is being considered to resume these external audits. http://www.in.gov/dnr/forestry/files/fo-BMP_2009_3rdPartyRpt.pdf

Quality-control evaluation was conducted on the statewide regional monitoring that was conducted in 2005. No such monitoring endeavor of mixed-ownership types has occurred since.

IV. Results

A. Comprehensive BMP Application & Effectiveness

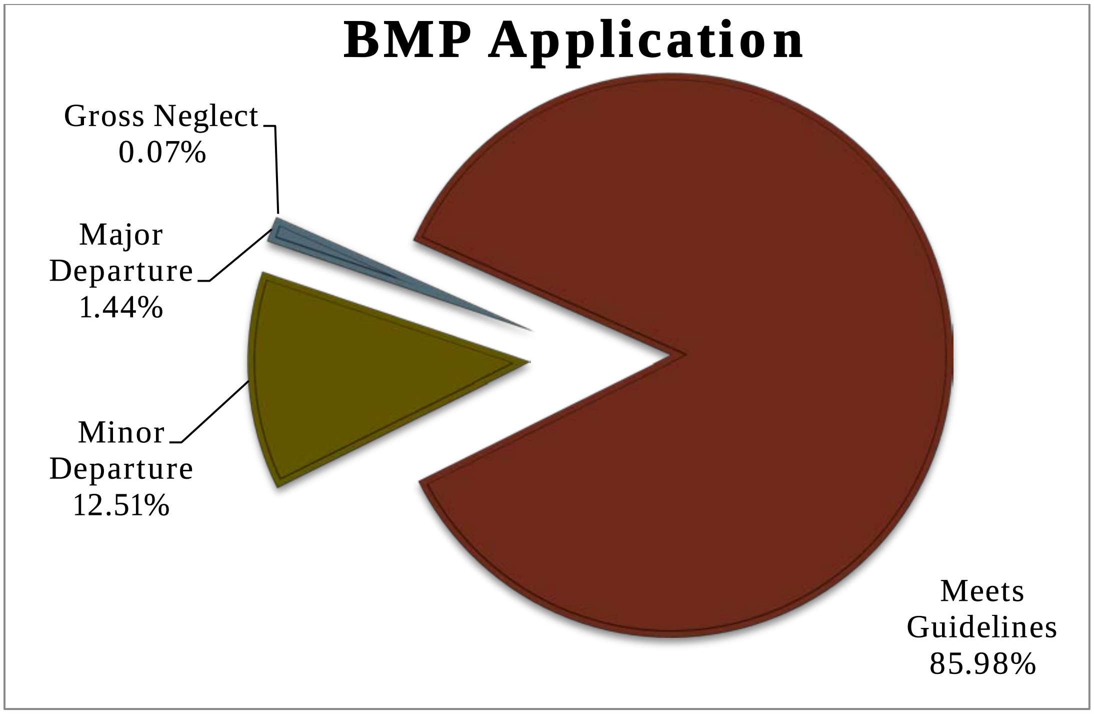


Figure 11. BMP application for all 1,172 sites monitored from 1996–2016.

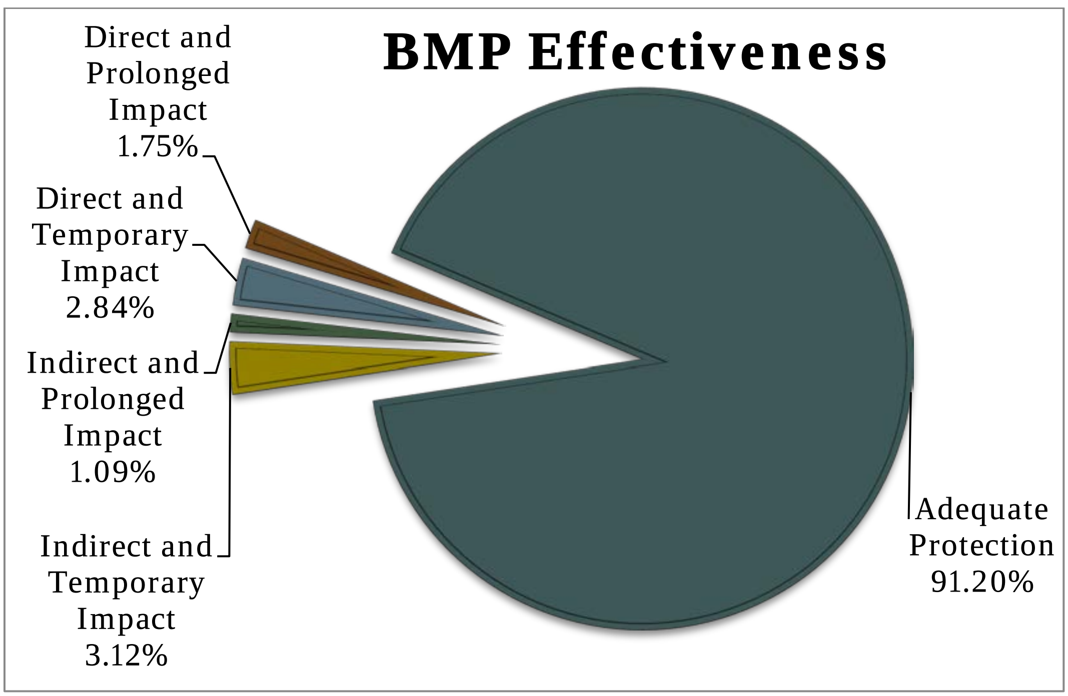


Figure 12. BMP effectiveness for all 1,172 sites monitored from 1996-2016.

The application and effectiveness rates for BMPs used to protect sites after timber harvests are excellent for the 1,172 sites monitored since 1996. The overall application rate is 85.98% and the overall effectiveness rate is 91.20%.

B. Application & Effectiveness of BMPs by Category

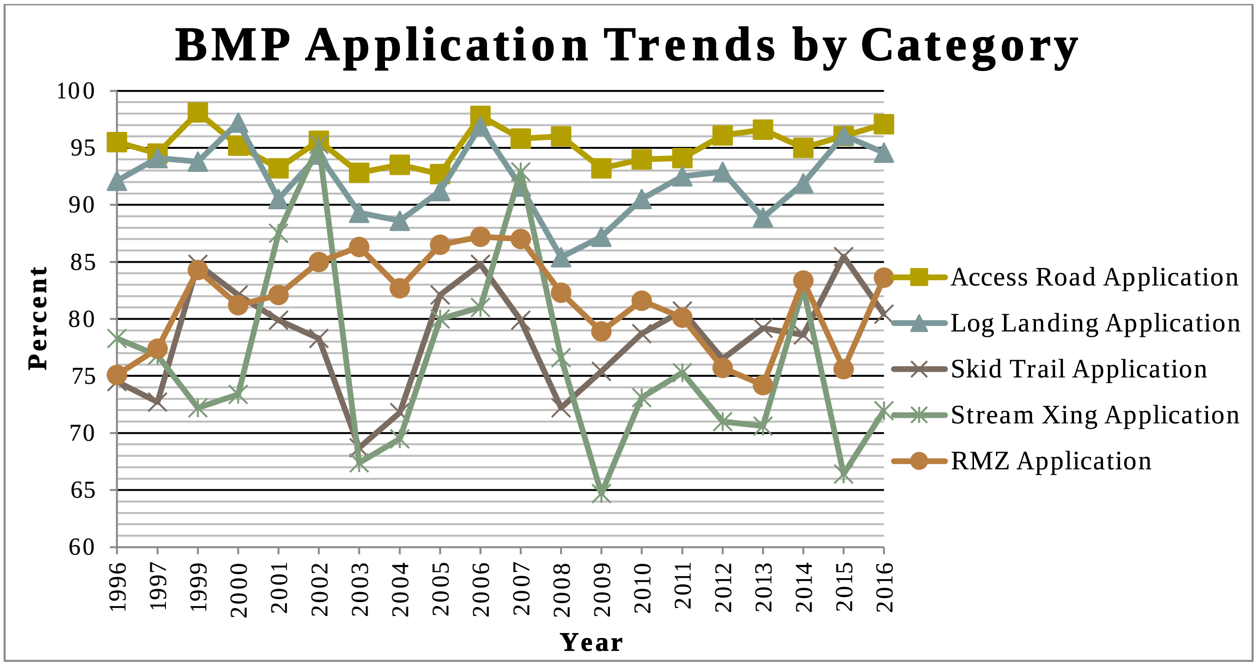


Figure 13. Yearly BMP application trends by BMP category.

BMP application trends remained consistently high for access roads and log landings through the 20 years of monitoring. RMZ application generally stayed between 75% - 83%. Since 2007 there has been an overall decline in RMZ application rates, but since 2013 the scores have been up and down ranging from 74% to 83%. Skid trails and stream crossings are the most challenging parts of the majority of timber harvests. The application trend lines for both of these BMP categories fluctuate widely across the monitoring term. In the past five years, skid trails have improved application scores, reaching a high of 85% application in 2015 and finishing with 80% application in 2016. Stream crossings are the most erratic, fluctuating from 95.3% at their highest point in 2002 and 64.7% at their lowest point in 2009. This category in particular can greatly fluctuate with changing weather conditions.

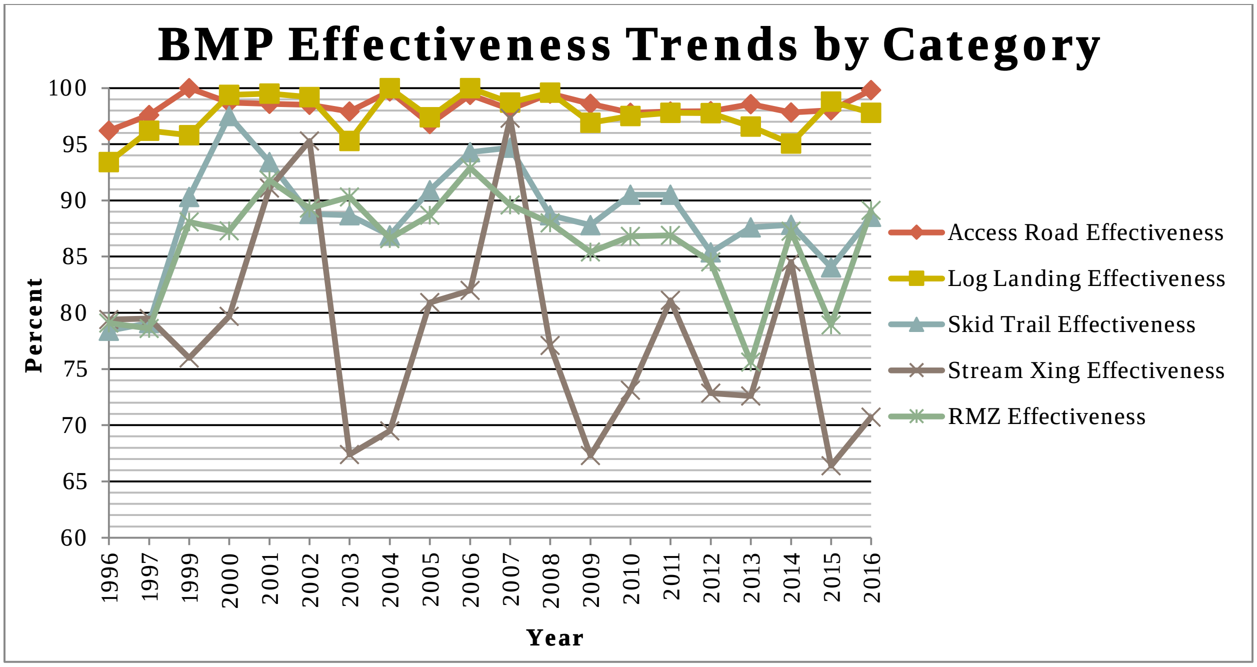


Figure 14. Overall BMP effectiveness yearly trends by BMP Category.

The BMP effectiveness trends mirror the application trends; however, the effectiveness rates are generally higher than application rates. As with application, effectiveness rates for access roads and log landings are consistently high. Skid trails show the most variation between application and effectiveness. While application had many ups and downs, skid trail effectiveness is much more consistent. It seems after the first two years (78.4% and 79%, respectively), that effectiveness of skid trails became much improved, and percentages ranged from the mid-80s to the high 90s. RMZ effectiveness was similar to RMZ application, although it ranged a few percentage points higher. Stream-crossing effectiveness closely mirrored the application percentages and remained erratic. Stream crossings and RMZs are both done close to the water, which means there is strong correlation between application and effectiveness, whereas skid trails are only in those areas 20% of the time or less across a site. They are therefore less likely to affect the water resources.

Table 3. BMP category application and effectiveness by land ownership.

	State		Classified		NIPF	
	% Application	% Effectiveness	% Application	% Effectiveness	% Application	% Effectiveness
Access Road	95.1	98.3	95.2	98.5	95.5	97
Log Landing	90.6	97.7	94.1	97.4	93	94.6
Skid Trail	76.6	88.6	80.12	87.2	75.9	82.3
Stream Crossing	77.5	79.4	70.8	71.9	73.1	74.8
RMZ	82.4	86.7	77.4	82.8	73.9	78.7
Overall	86.3	92.4	85.4	89.7	84.6	87.5

	Federal		Industry		County	
	% Application	% Effectiveness	% Application	% Effectiveness	% Application	% Effectiveness
Access Road	86.7	100	90.9	100	N/A	N/A
Log Landing	87.5	94.6	100	96.2	100	94.6
Skid Trail	80.0	92.7	84.0	100	68.4	100
Stream Crossing	100	100	N/A	N/A	N/A	N/A
RMZ	93.9	97.0	100	100	0.0	0.0
Overall	86.8	96.5	92.3	98.5	81.6	81.6

While it is impossible to make any direct correlation between landowner types due to the different site-selection methods used, there are still useful data from these sources. We can conclusively say that across all landownership types' effectiveness rates are always higher than application rates. This indicates that although BMPs may not be applied perfectly, there is still satisfactory safeguard being provided to the water resources of the site. Federal, industry and county ownerships only had six, three and two sites monitored, respectively, and thus do not provide a clear picture of the status of BMPs on timber harvest of those ownerships statewide. State, classified and non-industrial private forests had 588, 452 and 121 sites monitored, respectively. This amount of sites gives a better snapshot of what the BMPs on timber harvest of these ownership types look like. State Forests have the highest overall application (86.3%) and effectiveness (92.4%) rates when compared to Classified and NPIF. Classified application rates were 85.4%; effectiveness rate was 89.7%. NPIF had 84.6% application and 87.5% effectiveness.

The five BMP categories had many similarities between ownership types. There were also some notable differences. Similarities were access roads and log landings, which were areas of high implementation for all ownership types. Skid trails on Classified lands had the highest application rate at 80.12%; however, state sites had the highest skid trail effectiveness rate at 88.6%. Larger gaps in application and effectiveness between these three ownerships are seen in the stream crossing and RMZ categories. State Forest application score for stream crossing was 77.5% and effectiveness was 79.4%. CLFW stream crossing had the lowest application and effectiveness rates at 70.8% and 71.9% effectiveness. NIPF stream crossings scored 73.1% application and 74.8% effectiveness. RMZs for these three ownerships followed a similar pattern, in that State Forests had a higher application and effectiveness rate than classified or NPIF. Conversely, in RMZs, NIPF had the lowest application (73.9%) and (78.7%).

Table 4. Overall application and effectiveness by BMP category.

	Overall	
	% Application	% Effectiveness
Access Road	95.2	98.3
Log Landing	92.2	97.4
Skid Trail	78.1	87.9
Stream Crossing	74.3	75.9

RMZ	80.2	84.8
Overall	**85.97**	**91.2**

Access roads and landings are areas of a timber harvest where much of the activity done by machines is concentrated, including that done by over-the-road tractor-trailers, which cannot take much variation in the terrain when traveling. Therefore, access roads are often well stabilized and drained well as well as being constructed in areas that have established travel away from water bodies as much as possible. Skid trails are over rough ground that may have been traveled at some point in the past and then left alone, so they tend to be harder to engineer to drain correctly, given the trees, rough terrain and soil structure variability. When it comes to stream crossings and RMZ areas, they are mostly dealing with skid trails, both leading and in them, and they are in close to the water bodies. This increases chances that there can be an impact to water quality, whether there is an application problem or not.

With these facts in mind, the overall BMP application and effectiveness for the five categories, access roads and log landings were, again, the highest ranked, with access roads having a 95.2% application and 98.3% effectiveness rate. Log-landing application rate was 92.2% and effectiveness, 97.4%. The third-highest category was RMZs, with 80.2% application and 84.8% effectiveness rates. Skid trails ranked next to last, with 78.1% application and 87.9% effectiveness. The BMP area with the most difficulty was stream crossings. Because of the direct impact all crossings can have on water resources, BMP application and effectiveness are most critical in this area. Small problems in application on stream crossings can lead to large-scale disturbance to the streams, making this area the most critical and important BMP area. Wet conditions can also lead to large departures in effective management of stream crossings. The application of stream crossings across the 20 years of monitoring, on all land ownerships, is 74.3% and 75.8% effectiveness.

1. Access Roads

Access road on an Indiana State Forest property.

Table 5. Overall Access road application and effectiveness from all 1,172 sites monitored from 1996-2016.

Comprehensive Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.7	99.9
A2. Adequate buffer strip next to water courses and sensitive areas	94.5	98.5
A3. Avoids unstable gullies, seeps, very poorly drained areas	96.1	99.0
A4. Road grades are within standards	98.3	99.8
A5. Amount of roads minimized	99.8	100
A6. Stream crossings minimized	99.8	99.8
A7. Road excavation minimized	98.7	99.8
A8. Excavated and fill materials placed properly	99.1	99.3
A9. Roads constructed to drain well	89.3	96.9
A10. Appropriate road stabilization, drainage and diversions installed	86.2	94.0
A11. Water diversions functioning properly	92.2	95.7
A12. Runoff diverted onto stable forest floor areas	90.7	93.6
A13. Mud kept off of public roadway	99.4	99.4
A14. Public road's drainage maintained	99.4	99.8
A15. Traffic barriers installed	84.6	98.5
Overall Access Road	95.2	98.3

Access roads connect the harvest area to the public road system in order to get the logs to the mills for processing. This connection means regular vehicles, such as tractor trailers, need to be able to drive without difficulty. Often access roads are stable and have a good base, or are very short; therefore, they are often located away from water bodies and are constructed to drain well. Typically, they have higher application and effectiveness scores because they are often covered with rock and are more stable.

Table 5 depicts the breakdown of each individual BMP specification in the area of access roads from all 1,172 sites monitored across the 20-year monitoring period. With this table and each successive table of this type, the individual BMPs that were deemed to be challenging (lowest scores) will be discussed. Three BMPs had application issues. Those were A9. "Roads constructed to drain well" (82.5%), A10. "Appropriate road stabilization, drainage and diversions installed," 89.3% and A15; "Traffic barriers installed," (84.6%). These minor problem areas seemed to have little effect on the water resources of the site. All of these had 94% effectiveness or above.

Effective cutout on a permanent access road.

Table 6. Access road BMP application and effectiveness for all state sites monitored from 1996-2016.

State Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.8	99.8
A2. Adequate buffer strip next to water courses and sensitive areas	94.2	98.4
A3. Avoids unstable gullies, seeps, very poorly drained areas	95.7	99.2
A4. Road grades are within standards	98.1	100
A5. Amount of roads minimized	99.8	100
A6. Stream crossings minimized	100	100
A7. Road excavation minimized	98.2	99.8
A8. Excavated and fill materials placed properly	99.0	99.2
A9. Roads constructed to drain well	87.1	97.3
A10. Appropriate road stabilization, drainage and diversions installed	85.1	93.9
A11. Water diversions functioning properly	91.3	96.0
A12. Runoff diverted onto stable forest floor areas	88.9	92.3
A13. Public road drainage system maintained	99.0	99.4
A14. Public road's drainage maintained	99.4	99.8
A15. Traffic barriers installed	91.7	98.8
Overall Access Road	95.1	98.3

Access roads on State Forests are commonly longer with a good base because they are often used as fire trails and have to access hundreds of acres of land. Some of these access roads were established even before the state had declared the area to be a State Forest. They were old county roads, driveways to subsistence farms, or CCC roads. These roads usually run through rough terrain with many ridges, valleys, and steep slopes.

State access-road problem areas were A9. "Roads constructed to drain well," (87.1%); A10. "Appropriate road stabilization, drainage and diversions installed," (85.1%); and a 12. "Runoff diverted to stable forest floor" (88.9%). Effectiveness on these areas was still high at 92.3% and above.

Table 7. Access-road BMP application and effectiveness for all CLFW sites monitored from 1996-2016.

Classified Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.3	100
A2. Adequate buffer strip next to water courses and sensitive areas	94.2	99.0
A3. Avoids unstable gullies, seeps, very poorly drained areas	96.3	99.0
A4. Road grades are within standards	99.1	99.7
A5. Amount of roads minimized	100	100
A6. Stream crossings minimized	99.6	99.6
A7. Road excavation minimized	99.3	100
A8. Excavated and fill materials placed properly	99.7	99.7
A9. Roads constructed to drain well	91.7	96.7
A10. Appropriate road stabilization, drainage and diversions installed	88.3	94.2
A11. Water diversions functioning properly	95.7	96.5
A12. Runoff diverted onto stable forest floor areas	93.8	96.0
A13. Public road drainage system maintained	100	99.7
A14. Public road's drainage maintained	99.7	99.7
A15. Traffic barriers installed	71.7	97.6
Overall Access Road	95.2	98.5

Access roads on CLFWs, as with most private lands, are not as long as on State Forest properties, are not usually used as often, and therefore do not often have as much invested in them in order to build a base that can support the equipment needed to move the timber. This is not always the case, but is often true, and therefore often has a different set of problems from state forest access roads.

CLFWs also had three areas of application concern. A9. "Roads constructed to drain well" has an application rate of 91.7%. A10. "Appropriate road stabilization, drainage and diversion installed" has application rate of 88.3%. A15. "Traffic barriers installed" has a 71.7% implementation rate; however, the effectiveness rate was 97.6%, showing that this caused no problems on CLFWs. In many CLFWs, the road leading back to the forest is also the driveway to the residence. This limits trespassing that would damage the forest. The other effectiveness rates were high as well, A9 being 98.7%, and A10 at 96.5%.

Table 8. Access Road BMP application and effectiveness for all NIPF sites monitored from 1996-2016.

NIPF Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	100	100
A2. Adequate buffer strip next to water courses and sensitive areas	96.1	96.2
A3. Avoids unstable gullies, seeps, very poorly drained areas	96.1	97.4

A4. Road grades are within standards	97.6	98.8
A5. Amount of roads minimized	98.8	100
A6. Stream crossings minimized	97.0	97.2
A7. Road excavation minimized	98.5	98.5
A8. Excavated and fill materials placed properly	95.6	97.9
A9. Roads constructed to drain well	93.6	94.8
A10. Appropriate road stabilization, drainage and diversions installed	85.1	90
A11. Water diversions functioning properly	78.1	82.9
A12. Runoff diverted onto stable forest floor areas	91.5	91.2
A13. Mud kept off public road	100	100
A14. Public road's drainage maintained	98.6	100
A15. Traffic barriers installed	90.2	100
Overall Access Road	95.5	97

NIPF had two areas of concern within access road BMP implementation. A10. "Appropriate road stabilization, drainage and diversions installed," had an application rate of 85.1%. A11. "Water diversions functioning properly" had an implementation rate of 78.1%. A10's effectiveness rate was 90%, showing a very small amount of impact to water resources. However A11's impact was a bit greater, at 82.9% effectiveness.

Permanent haul road protected by rock.

Table 9. Access-road BMP application and effectiveness for all federal sites monitored from 1996-2011.

Federal Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	100	100
A2. Adequate buffer strip next to water courses and sensitive areas	100	100
A3. Avoids unstable gullies, seeps, very poorly drained areas	100	100

A4. Road grades are within standards	75.0	100
A5. Amount of roads minimized	100	100
A6. Stream crossings minimized	100	100
A7. Road excavation minimized	100	100
A8. Excavated and fill materials placed properly	100	100
A9. Roads constructed to drain well	66.7	100
A10. Appropriate road stabilization, drainage and diversions installed	50.0	100
A11. Water diversions functioning properly	75.0	100
A12. Runoff diverted onto stable forest floor areas	75.0	100
A13. Public road drainage system maintained	100	100
A14. Public road's drainage maintained	100	100
A15. Traffic barriers installed	N/A	N/A
Overall Access Road	86.7	100

Access roads on federal properties are often like State Forest properties in their history and the amount of land they access. However, the U.S Forest Service has a higher standard of engineering for its access roads than State Forests do for construction, maintenance and closeout after any activity.

The six federal sites had several problem areas in access-road implementation, A4, A9, A10, A11, A12 were all at 75% or below in application. Fortunately, the effectiveness rates of all access BMPs on the federal sites were 100%, showing no effect to the water resources of the six sites.

Table10. Access road BMP application and effectiveness for the three industry sites monitored from 1996-2011.

Industry Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	100	100
A2. Adequate buffer strip next to water courses and sensitive areas	N/A	N/A
A3. Avoids unstable gullies, seeps, very poorly drained areas	100	100
A4. Road grades are within standards	100	100
A5. Amount of roads minimized	100	100
A6. Stream crossings minimized	100	100
A7. Road excavation minimized	100	100
A8. Excavated and fill materials placed properly	N/A	N/A
A9. Roads constructed to drain well	100	100
A10. Appropriate road stabilization, drainage and diversions installed	N/A	100
A11. Water diversions functioning properly	N/A	N/A
A12. Runoff diverted onto stable forest floor areas	N/A	N/A
A13. Mud kept off public road	100	100
A14. Public road's drainage maintained	100	100
A15. Traffic barriers installed	0.0	100

Overall Access Road	90.9	100

The only thing of note about the three industry sites was that no traffic barriers had been installed; however, the effectiveness rate was still 100%, showing that the lack of gates didn't impair the road.

The two county sites monitored had no access roads and therefore no access-road data.

2. Log Landings

Log landing that was used during a wet period, causing rutting and the site to collect runoff.

Seeded landing two years after closeout.

Table 11. BMP application and effectiveness on log landings for all 1,172 sites monitored from 1996-2016.

Comprehensive Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	96.5	99.6
Y2. Landings located outside RMZ	93.2	98.1
Y3. Landings located on stable areas	94.0	98.2
Y4. Excavation of site minimized	95.2	98.8
Y5. Landings avoid concentrating or collecting runoff	91.0	95.7
Y6. Landing’s runoff enters stable area	86.7	94.1
Y7. Proper water diversions in working order	90.4	95.0
Y8. Landing smoothed and soil stabilized	90.3	95.9
Y9. Landings free of fuel and lubricant spills and litter	96.0	99.0
Y10. Landing location suitable for equipment fueling and maintenance	98.2	99.0
Overall Log Landings	92.2	97.4

Log landings are the areas of highest equipment concentration. Equipment brings the logs to the landing from the area where it was standing in the woods. The logs are then cut to length and piled by grade and species, then the piles are loaded onto a truck by either a knuckle boom or loader, and then the truck hauls away the logs from the site using the access road. Log landings are commonly the largest area of exposed soil and have the most soil compaction because all of the equipment comes together in this one area.

Log landings for all 1,172 sites monitored from 1996–2016 had good application and effectiveness scores. Y5. “Landings avoid collecting runoff,” had some implementation problems (91.0%). Y6. “Runoff enters stable area,” had some application complications as well at 86.7%, also Y8. “Water diversions in working order” needed improvement at 90.3%. These three areas did not significantly affect water quality. Each had a rate above 94.1%.

Table 12. Log landing BMP application and effectiveness for all state sites monitored.

State Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	94.6	99.6
Y2. Landings located outside RMZ	95.5	99.1
Y3. Landings located on stable areas	93.2	99.3
Y4. Excavation of site minimized	93.2	98.4
Y5. Landings avoid concentrating or collecting runoff	75.6	96.1
Y6. Landing's runoff enters stable area	82.7	94.1
Y7. Proper water diversions in working order	88.8	95.2
Y8. Landing smoothed and soil stabilized	88.9	96.6
Y9. Landings free of fuel and lubricant spills and litter	93.9	98.7
Y10. Landing location suitable for equipment fueling and maintenance	99.3	99.8
Overall Log Landings	90.6	97.7

Landings on State Forests have a spectrum of use. Some are landings that are newly installed and used only for the one tract being harvested. Others have been established for decades and are used for multiple tracts. Those that are older and used for multiple tracts are often left as grass wildlife areas between used, where the little used ones often convert back to forested areas until the next harvest on that tract.

Log landings A5 –A7 were an application challenge on State Forests. A5's application rate was 75.6% A6, 82.7% and Y7 at 88.8%. All had high effectiveness rates at 96.1%, 94.1% and 95.2%, respectively.

Table 13. Log-landing BMP application and effectiveness for all CLFW sites monitored.

Classified Forest Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	98.9	100.0
Y2. Landings located outside RMZ	89.0	97.5
Y3. Landings located on stable areas	94.6	97.3
Y4. Excavation of site minimized	97.6	99.5
Y5. Landings avoid concentrating or collecting runoff	86.6	96.2
Y6. Landing's runoff enters stable area	90.8	94.3
Y7. Proper water diversions in working order	92.9	94.8
Y8. Landing smoothed and soil stabilized	92.6	95.6
Y9. Landings free of fuel and lubricant spills and litter	98.9	99.2
Y10. Landing location suitable for equipment fueling and maintenance	98.9	99.5
Overall Log Landings	94.1	97.4

Landings on CLFW sites are often used for a single area and are only used when that area is harvested. Because of this lack of use, many of these landings start to convert back to forest before the next use, depending on the time it takes for the vegetation to break up the compaction with its roots.

CLFW also had three areas of log-landing implementation challenges. Individual BMPs for Y2 is 89.0%, Y5, 86.6%, and Y6 is 90.8% application. All have high effectiveness rates at 94.3% or above.

Table 14. Log-landing BMP application and effectiveness for all NIPF sites monitored.

NIPF Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	98.2	99.1
Y2. Landings located outside RMZ	94.6	94.6
Y3. Landings located on stable areas	94.5	95.4
Y4. Excavation of site minimized	96.0	98.0
Y5. Landings avoid concentrating or collecting runoff	88.1	91.7
Y6. Landing's runoff enters stable area	91.6	91.6
Y7. Proper water diversions in working order	85.7	89.5
Y8. Landing smoothed and soil stabilized	89.4	90.4
Y9. Landings free of fuel and lubricant spills and litter	96.3	99.1
Y10. Landing location suitable for equipment fueling and maintenance	89.8	92.6
Overall Log Landings	93.0	94.6

Landings on NIPF sites are much like those on CLFW sites, except these sites tend to have shorter timespans between harvests as they are sold and new owners look for a way to get a return on their investment as quickly as possible.

NIPF log landings need improvement in two areas, Y5 and Y7. There was an 88.1% application rate for landings avoiding collecting runoff. Proper water diversions were in working order 85.7% of the time. The effectiveness rates for each of these were lower than in other ownerships, but still acceptable at 91.7% and 89.5%, respectively.

Table 15. Log-landing BMP application and effectiveness for the six federal sites monitored.

Federal Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	83.3	100
Y2. Landings located outside RMZ	83.3	83.3
Y3. Landings located on stable areas	100	100
Y4. Excavation of site minimized	100	100
Y5. Landings avoid concentrating or collecting runoff	66.7	83.3
Y6. Landing's runoff enters stable area	83.3	100
Y7. Proper water diversions in working order	50.0	100
Y8. Landing smoothed and soil stabilized	83.3	100
Y9. Landings free of fuel and lubricant spills and litter	100	100
Y10. Landing location suitable for equipment fueling and maintenance	100	96.4
Overall Log Landings	87.5	94.6

Landings on federal forests are much like those on State Forests, except that in the past 20 years they have had fewer harvests. The landings are likely regenerating forest vegetation unless the land is used for something else.

Only six sites from federal lands were monitored; therefore, any problem had much more impact on the final percentages. For this reason, only two areas, Y5 and Y7, were deemed to have implementation problems. Y5 had an application rate of 66.7% and Y7, 50%. The effectiveness rates for these two were acceptable at 83% and 100%, respectively.

Skid trail not closed out, causing erosion and sediment plume to build up on log yard.

Table 16. Log-landing BMP application and effectiveness for the three industry sites monitored.

Industry Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	100	100
Y2. Landings located outside RMZ	100	100
Y3. Landings located on stable areas	100	100
Y4. Excavation of site minimized	100	100
Y5. Landings avoid concentrating or collecting runoff	100	100
Y6. Landing’s runoff enters stable area	100	100

Y7. Proper water diversions in working order	N/A	N/A
Y8. Landing smoothed and soil stabilized	100	66.7
Y9. Landings free of fuel and lubricant spills and litter	100	100
Y10. Landing location suitable for equipment fueling and maintenance	100	100
Overall Log Landings	100	96.2

Landings on industry-owned properties are much like those on State Forests, except they are often used on a cycle determined by a mixture of silviculture and the market. They might have a tract of forest on a similar rotation as state and federal forests commonly are, but will enter certain tracts if there are species and grades that are in high demand by the market, in which case they usually enter those tracts for just those trees. Also, industry sites can be variable as to how much land the industry owns in that area.

There was only one negative mark on the three industry sites monitored. That mark was in effectiveness for Y8. All application scores and the remainder of effectiveness scores were 100%.

Table 17. Log-landing BMP application and effectiveness for the two county sites monitored.

County Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	100	100
Y2. Landings located outside RMZ	100	100
Y3. Landings located on stable areas	100	100
Y4. Excavation of site minimized	100	100
Y5. Landings avoid concentrating or collecting runoff	100	100
Y6. Landing’s runoff enters stable area	100	100
Y7. Proper water diversions in working order	100	100
Y8. Landing smoothed and soil stabilized	100	100
Y9. Landings free of fuel and lubricant spills and litter	100	100
Y10. Landing location suitable for equipment fueling and maintenance	100	100
Overall Log Landings	100	100

Landings on county sites are much like those on industry ground, except they are more apt to follow the common view of the county officials rather than the market, and those views can change every four years or remain the same for decades. Most county forests are smaller land holdings, and therefore are similar to those of private landowners in that regard.

Log landings were well managed on the two county sites and were very well applied and very effective at protecting the resources of the site. All had scores of 100%.

3. Skid Trails

A steep skid trail that has well established vegetative cover.

Table 18. Skid-trail BMP application and effectiveness for all 1,172 sites monitored from 1996 – 2016.

Comprehensive Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	97.3	98.0
S2. Adequate buffer strip next to water courses and sensitive areas	71.3	86.8
S3. Avoids steep and long straight grades (>20% for >200’)	79.8	95.4
S4. Avoids unstable gullies, seeps, poorly drained areas	81.2	90.8
S5. Amount of skid trails minimized	84.9	94.8
S6. Trail excavation minimized	87.9	93.7
S7. Appropriate drainage and diversions installed	46.7	71.1
S8. Water diversions in working order	76.4	85.1
S9. Runoff diverted onto stable forest floor areas	70.8	77.5
S10. Streams not used as skid trails (except for crossings)	83.1	84.5
Overall Skid Trail	78.1	87.9

Skid trails are the part of the harvest infrastructure where equipment moves logs from the place where the trees were standing to the landing. These trails are used to varying degrees and, as such, have varying degrees of exposure and compaction. Different equipment can have the same variance concerning soil exposure and compaction. These trails often traverse the roughest terrain on the site with physical obstacles, slopes, waterbodies, and other kinds of topographic features. Skid trails often disturb the largest portion of soil and cover ground that has a higher susceptibility to erosion if exposed and compacted; therefore, they are found to have the lower percentage of compliance on a timber harvest with respect to application. Their impact to water quality can be highly variable considering their closeness to water bodies.

Skid trails are always a demanding portion of any BMP implementation because this is where most of the action of the harvest is—typically on difficult terrain. As a result, any scores above 80% will not be discussed in length. Instead, we focus on areas with greater challenges. Across all sites monitored in the 16-year span, covering the variety of ownership types, skid trails had several areas of BMP implementation and effectiveness problems. S2, "adequate buffer next to water courses and sensitive areas" was a problem area of implementation at 71.3%, effectiveness of this particular specification was good at 86.5%. S3, "avoids steep and long grades" had a 79.8% application rate, but a 95.4% effectiveness rate. S4, "avoidance of seeps, gullies, and poorly drained areas" had an 81.2 % application rate and 90.8% effectiveness rate. By far, the largest issue on skid trails is S7, "appropriate drainage and diversions installed, with an application rate of 46.7% and effectiveness rate of 73%. This shows that the lack of adequate drainage and diversions did affect the water quality of some sites. However, application of drainage and diversions installed went up 6% points in the last five years, showing definite improvement. S8, "water diversions in working order," had a 76.4% application rate and an 85.1% effectiveness rate. S9, "runoff diverted onto stable forest floor areas," had a 70.8% application rate and a 77.5% effectiveness rate. This indicated improperly directing runoff affected water quality.

An effective water bar conveying runoff from a skid trail and diverting the flow 0nto the forest duff layer, where it will infiltrate, remove sediment and return to groundwater.

Water bar outlet conveying runoff 0n to the stable forest floor.

Table 19. Skid-trail BMP application and effectiveness for all state sites monitored.

State Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	97.4	98.5
S2. Adequate buffer strip next to water courses and sensitive areas	68.8	85.0
S3. Avoids steep and long straight grades (>20% for >200')	73.5	97.0
S4. Avoids unstable gullies, seeps, poorly drained areas	80.5	90.9
S5. Amount of skid trails minimized	81.1	93.8
S6. Trail excavation minimized	85.4	94.5
S7. Appropriate drainage and diversions installed	50.1	79.6
S8. Water diversions in working order	79.0	87.8
S9. Runoff diverted onto stable forest floor areas	69.2	76.3
S10. Streams not used as skid trails (except for crossings)	81.2	83.4
Overall Skid Trail	76.6	88.6

Skid trails on state sites are often longer because the state controls the location and number of landings, with some input from the timber buyer on some sites. State sites are the most closely monitored timber harvests in the state from marking the sale through post closeout. Because of that, they are often the most controlled. However, the infrastructure and terrain are consistently the worst because State Forest properties are on large tracts of land that had a general history of subsistence farms that were on terrain where they failed at the time of the Depression and were reverted to state ownership. Many tracts are on very rough terrain where the topsoil had eroded away, leaving large erosion gullies and little to no vegetation on them by the 1920s. The forest has grown back and the soils are thriving again, but they still can be hard to negotiate and can be susceptible to erosion. This makes these BMPs even more important while these soils continue to heal.

BMP specifications S2 (68.8%), S3 (73.5%), S4 (80.5%), S7 (50.1%) and S9 (69.2%) had application departures. Of those application problem areas, only two had effectiveness issues due to poor implementation. S7 "appropriate drainage and diversions installed," had an 80.9% effectiveness rate. S9, "runoff diverted onto stable forest floor," had an effectiveness rating of 76.3%. The comprehensive application rate for all skid trails monitored on State Forest properties is 76.6%, and the effectiveness rate is 88.6%.

Effective skid-trail re-vegetation two years after a harvest.

Table 20. Skid-trail BMP application and effectiveness for all CLFW sites monitored.

Classified Forest Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	96.9	97.8
S2. Adequate buffer strip next to water courses and sensitive areas	74.0	89.5
S3. Avoids steep and long straight grades (>20% for >200')	87.5	95.4
S4. Avoids unstable gullies, seeps, poorly drained areas	83.1	91.8
S5. Amount of skid trails minimized	90.9	95.8
S6. Trail excavation minimized	89.8	92.9
S7. Appropriate drainage and diversions installed	46.2	63.7
S8. Water diversions in working order	75.5	81.9
S9. Runoff diverted onto stable forest floor areas	72.2	77.8
S10. Streams not used as skid trails (except for crossings)	83.2	83.7

Overall Skid Trail		80.2	87.2

Skid trails on CLFW sites are commonly shorter on these sites and do not have the severe history state sites have, but they do have a few similarities. They are usually on marginal terrain or they would have commonly been converted to crop or pasture fields long ago. Some were woods that were used for firewood or timber during the settlement era, and some were minimally used. With their variable backgrounds, these forests are not usually as susceptible to erosion as those on state and federal properties. However, there are some CLFW and other private sites in areas that do have a history of erosion, like those in Harrison and Crawford counties.

The main area of concern on CLFW skid trials was the installation of appropriate drainage and diversions (S7). The application rate of this BMP for CLFWs was 46.2%, an 18% increase from 28.2% in the 2011 report, and the effectiveness rate was 63.7%, a figure that improved only 0.9%. These numbers indicate that implementation departures in this area are significantly affecting water quality on CLFW harvest sites. But trends are showing improvement in application of drainage and diversion installation. Other skid-trail BMPs in CLFWs that need further attention are S2, S4 and S9. These have application rates of 74%, 83.1% and 72.2%, respectively. S2 and S4 application rates improved 9% each from the 2011 data, showing marked improvement in avoidance of sensitive areas. Effectiveness rates for these are S2, 89.5%, an increase of almost 8% from 2011 data; S4, 91.8%; and S9, 77.8%, a decrease of 7% from 2011 data. These departures in application seem to have minimal effect on water resources of the sites, with overall effectiveness at 87.2%.

Table 21. Skid-trail BMP application and effectiveness for all NIPF sites monitored.

NIPF Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	97.9	96.0
S2. Adequate buffer strip next to water courses and sensitive areas	70.7	78.7
S3. Avoids steep and long straight grades (>20% for >200')	79.5	81.0
S4. Avoids unstable gullies, seeps, poorly drained areas	78.4	87.4
S5. Amount of skid trails minimized	83.6	91.4
S6. Trail excavation minimized	93.3	92.4
S7. Appropriate drainage and diversions installed	17.7	38.3
S8. Water diversions in working order	48.8	69.6
S9. Runoff diverted onto stable forest floor areas	68.8	78.1
S10. Streams not used as skid trails (except for crossings)	92.4	92.7
Overall Skid Trail	75.9	82.3

Skid trails on NIPF sites are resemble those in CLFW, except in their current management. Those in CLFW have the legal obligation to assure there are not high levels of erosion, and there is a group within CLFW that are certified for their management that have motivation to make sure that BMPs are applied. On NIPF sites, those incentives are not present, except where the Indiana Flood Control Act and the U.S. Clean Water Act apply. Therefore, NIPF owners do not have the same level of scrutiny that are present on CLFW and government-owned sites.

S7 was also a problem area for NIPF with an application percentage of 17.7% and effectiveness of 38.3%. This indicated a significant impact to water quality of NIPF sites, due to lack of proper water drainage and diversions. S8, “water diversions in working order,” was also a significant issue for NIPF. Application rate for water diversions in working order was 68.8% and effectiveness was 78.1%. Therefore, even on NIPF sites monitored that had water diversions installed, they were not working correctly due to installation, damage or other factors. This rendered them inadequate at protecting water quality. Other areas with application and effectiveness departures were S2, S3 and S4. Application rates for these three were 70.7%, 79.5%, and 78.4%. Effectiveness rates for these three, in order, were 78.7%, 81%, and 87.4%.

Water bars on a re-vegetated and stable skid trail.

Table 22. Skid-trail BMP application and effectiveness for the six federal sites monitored.

Federal Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	100	100
S2. Adequate buffer strip next to water courses and sensitive areas	75.0	100
S3. Avoids steep and long straight grades (>20% for >200’)	100	100
S4. Avoids unstable gullies, seeps, poorly drained areas	66.7	66.7
S5. Amount of skid trails minimized	66.7	83.3
S6. Trail excavation minimized	83.3	100
S7. Appropriate drainage and diversions installed	83.3	83.3
S8. Water diversions in working order	83.3	100
S9. Runoff diverted onto stable forest floor areas	100	100

S10. Streams not used as skid trails (except for crossings)	100	100
Overall Skid Trail	80.0	92.7

Skid trails on federal sites have a high level of engineering that is to be applied to their sites, but there are so few sites that it is difficult to draw comparisons. However, their history and terrain are similar to those of the state sites.

The six federal sites monitored had three areas of skid-trail implementation problems. S2, S4 and S5 were problem areas for these sites, with 75% for S2, and 66.7% for S4 and S5. The effectiveness rate for S2 was 100%, showing no impact from inadequate buffers near water courses and sensitive areas. S4 had an effectiveness rate of 66.7%, indicating that there was water-quality impact due to the lack of avoidance of unstable gullies, seeps and other poorly drained areas. The S4 effectiveness rate was 83.3%, showing that although there were too many skid trails in some areas, there wasn't a huge effect on water quality of the sites.

Table 23. Skid-trail BMP application and effectiveness for the three industry sites monitored.

Industry Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	100	100
S2. Adequate buffer strip next to water courses and sensitive areas	100	100
S3. Avoids steep and long straight grades (>20% for >200')	100	100
S4. Avoids unstable gullies, seeps, poorly drained areas	66.7	100
S5. Amount of skid trails minimized	66.7	100
S6. Trail excavation minimized	100	100
S7. Appropriate drainage and diversions installed	66.7	100
S8. Water diversions in working order	100	100
S9. Runoff diverted onto stable forest floor areas	66.7	100
S10. Streams not used as skid trails (except for crossings)	100	100
Overall Skid Trail	84.0	100

Four skid-trail BMPs needed improvement on the three industry sites monitored. S4, S5, S7 and S9 had application rates of 66.7%. These departures in implementation seemed to cause no problem in effectiveness. All received scores of 100%.

Extreme skid-trail rutting due to operations taking place during wet winter conditions.

Deep skid-trail ruts, causing tree root damage.

Table 24. Skid-trail BMP application and effectiveness for the two county sites monitored.

County Skid Trails	% Application	% Effective
S1. Uses existing routes where appropriate	100	100
S2. Adequate buffer strip next to water courses and sensitive areas	0.0	100
S3. Avoids steep and long straight grades (>20% for >200’)	100	100
S4. Avoids unstable gullies, seeps, poorly drained areas	0.0	100
S5. Amount of skid trails minimized	100	100
S6. Trail excavation minimized	50.0	100
S7. Appropriate drainage and diversions installed	100	100
S8. Water diversions in working order	100	100
S9. Runoff diverted onto stable forest floor areas	100	100
S10. Streams not used as skid trails (except for crossings)	50.0	100
Overall Skid Trail	68.4	100

Skid trails on county sites are variable. Their history resembles that of state and federal sites, but the size of their tracts are more like NIPF-owned sites, and their terrain is often limited by the terrain in their county.

The two county sites monitored had some skid-trail BMP implementation issues. Both sites did not leave an adequate buffer for water courses, sensitive sites, gullies, seeps and poorly drained areas. This led to 0% application scores for S2 and S4. The effectiveness rates for both sites still remained at 100%, which was the effectiveness rate for this category on all county sites. One site had problems with too much trail excavation (S6), resulting in an application score of 50%. One site, (S10), had a stream used as a skid trail. This resulted in an application score of 50%. Effectiveness for both sites was 100%, showing no impact to water quality at the two sites in spite of these departures.

4. Stream Crossings

Table 25. Stream-crossing BMP application and effectiveness for all 1,172 sites monitored.

Comprehensive Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	89.0	90.5
X2. Crossings minimize disturbance to the natural bed and banks	64.0	65.9
X3. Stream-bank approaches properly designed and stabilized	56.1	58.7
X4. Water runoff diverted from road prior to crossing	51.8	55.8
X5. Crossing as close to 90 degrees as practicable	88.5	91.5
X6. Crossing does not unduly restrict water flow	83.0	83.7
X7. Soil has not been used as fill in the stream (except culverts)	76.3	76.7
X8. Ford constructed of non-erosive materials	82.6	82.6
X9. Fords have stable banks and streambeds	62.1	62.1
X10. Culverts are properly sized and installed	76.5	78.6
X11. Culverts clear of significant flow obstructions	80.3	82.1
X12. Temporary structures properly anchored	91.2	89.5
X13. Temporary structures and resulting obstructions removed	71.6	72.1
Stream Crossing	74.3	75.9

Stream crossings have historically been the most challenging area of BMPs in Indiana. There is little margin of error for crossings. Mistakes are likely to directly affect water quality due to their happening close to water. Even if every practice could be applied without departure, water quality could still be affected. In training, we often talk about avoiding stream crossings for this reason.

There are several problem areas for stream crossings across all landowner types. The first is X2, minimization of disturbance to natural bed and banks, with an application score of 64%, down 5% since 2011, and effectiveness score of 65.9%, which also went down 5%. The proper design and stabilization of stream banks, (X3), is a problem area, with an application score of 56.1% and effectiveness of 58.7%, down 5% since 2011. The stream-crossing BMP with the most problems was X4, water runoff diverted from road prior to crossing. The application for X4 was 51.8% and effectiveness was 55.8%. Improvement is also needed in the area of fords having stable banks and streambeds (X9). That application score was 62.1%, and effectiveness was 62.1%. X10, proper sizing and installation of culverts, also needs further attention. That application score was 76.5%, a 7% increase from the 2011 figure, and effectiveness rate was 78.6%, an increase of 5%. The overall stream-crossing application rate for all ownership types was 74.3%, down 2% from the 2011 rate. The effectiveness rate was 78.6%, down almost 3% since 2011.

An access-road ford across a small stream with low and stable banks.

A poorly applied and implemented stream crossing with no attempt to repair.

Table 26. Stream-crossing BMP application and effectiveness for all state sites monitored.

State Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	88.8	91.3
X2. Crossings minimize disturbance to the natural bed and banks	70.2	72.6
X3. Stream-bank approaches properly designed and stabilized	63.5	65.9
X4. Water runoff diverted from road prior to crossing	61.7	64.1
X5. Crossing as close to 90 degrees as practicable	86.5	91.3
X6. Crossing does not unduly restrict water flow	82.2	832.0
X7. Soil has not been used as fill in the stream (except culverts)	77.7	78.6
X8. Ford constructed of non-erosive materials	86.7	87.3
X9. Fords have stable banks and streambeds	64.6	64.1
X10. Culverts are properly sized and installed	66.7	70.4
X11. Culverts clear of significant flow obstructions	69.2	73.1
X12. Temporary structures properly anchored	96.6	96.6
X13. Temporary structures and resulting obstructions removed	84.4	84.4
Stream Crossing	77.5	79.4

There are often fewer stream crossings on state sites than on most others because of avoidance. Foresters on state sites will often avoid or minimize stream crossings on sites to minimize the impact to water quality. These foresters are regularly trained, and all their sites are inspected. Sites on other ownerships often do not have a forester, and the incentive to minimize stream crossings is lessened.

State stream-crossing problem areas closely mimicked those for overall stream crossings. X2, X3 and X4 had low application and effectiveness rates. X2 application rate was 70.2%, down 4%; and effectiveness rate was 72.6%, down 6%. X3 application rate was 63.5%, down 5%; and effectiveness rate was 65.9%, a drop of more than 6%. X4 application rate was 61.7%, with a 64.1% effectiveness rate. X9 and X10 were also areas needing further attention, with application rates of 64.6% and 66.7% and effectiveness rates of 64.1% and 70.4%, respectively. X11, culverts clear of significant flow obstructions, was also a problem on state sites, with an application rate of 69.2%, more than 8% lower than in 2011. Culverts free of flow obstructions had an effectiveness rate of 83.3%, down 10% since 2011. The state stream-crossing application and effectiveness rates were several points higher than the overall rates.

No water diversions before stream crossing. No stream bank stabilization/re-vegetation.

Table 27. Stream-crossing BMP application and effectiveness for all CLFW sites monitored.

Classified Forest Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	89.2	89.9
X2. Crossings minimize disturbance to the natural bed and banks	55.8	57.9
X3. Stream-bank approaches properly designed and stabilized	49.5	52.0
X4. Water runoff diverted from road prior to crossing	47.4	52.0
X5. Crossing as close to 90 degrees as practicable	90.9	92.9
X6. Crossing does not unduly restrict water flow	82.8	83.3
X7. Soil has not been used as fill in the stream (except culverts)	70.6	70.6
X8. Ford constructed of non-erosive materials	76.6	76.0
X9. Fords have stable banks and streambeds	54.9	54.9
X10. Culverts are properly sized and installed	87.9	87.9
X11. Culverts clear of significant flow obstructions	90.6	90.6
X12. Temporary structures properly anchored	88.5	84.6
X13. Temporary structures and resulting obstructions removed	60.6	60.6
Stream Crossing	70.8	71.9

Stream crossings on CLFW sites are highly variable in the number of crossings and the application of BMPs. Again, CLFW ownership involvement, forester involvement, certification involvement, and other factors contribute to the variability of these sites and the scores in these different areas of the BMPs. However, the numbers are often higher than those of the NIPF sites, even though we monitor many more CLFW sites than NIPF sites.

CLFW stream-crossings application and effectiveness rates were almost 11% below those for state crossings. Areas of concern were X2, X3, X4 and X9. Other areas of concern were X6, crossing does not unduly restrict water flow; X7, soil has not been used as fill in stream; and X8, fords constructed of non-erosive materials. X2 application was 55.8% and 57.9% effectiveness. The proper design and stabilization of stream-bank approaches (X3) was low at 49.5% for application and 52% effectiveness. The crossing BMP with the lowest implementation and performance rates was X4, water runoff diverted from road prior to crossing, with an implementation rate of 47.4%, an increase of more than 14%, and an effectiveness or performance rate of 52%, a 2% decrease. Soil not used as fill in stream, had an application and effectiveness rate of 70.6% for both categories. X8, ford constructed of non-erosive materials, had an 76.6% rate for application and 76% rate for effectiveness, a 5% increase for both. Fords were in need of more-stable banks and stream beds (X9), with application and effectiveness rate at 54.9%. X13 concerns the removal of temporary crossing structures and resulting obstructions. Application and effectiveness rates for this BMP were 60.6%. Many of these cases result when log corduroy bridges and/or fill used for stream crossing is not pulled out after harvest is closed.

Poorly executed and stream crossing not closed out after harvest completed.

Table 28. Stream-crossing BMP application and effectiveness for all NIPF sites monitored.

NIPF Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	88.0	87.8
X2. Crossings minimize disturbance to the natural bed and banks	69.6	67.4
X3. Stream-bank approaches properly designed and stabilized	46.7	51.1
X4. Water runoff diverted from road prior to crossing	20.0	30.0
X5. Crossing as close to 90 degrees as practicable	87.0	87.0

X6. Crossing does not unduly restrict water flow	84.7	87.0
X7. Soil has not been used as fill in the stream (except culverts)	93.3	93.3
X8. Ford constructed of non-erosive materials	93.1	93.1
X9. Fords have stable banks and streambeds	82.1	82.1
X10. Culverts are properly sized and installed	57.1	62.5
X11. Culverts clear of significant flow obstructions	66.7	71.4
X12. Temporary structures properly anchored	50.0	66.7
X13. Temporary structures and resulting obstructions removed	0.0	0.0
Stream Crossing	73.1	74.8

Stream crossings on NIPF sites are mostly at the mercy of the company that is harvesting the timber because forester involvement decreases. The site terrain and history resemble those in CLFW in many ways except for landowner and forester involvement with the timber harvest and enforcement of contract specifications, such as application of BMPs.

NIPF stream crossings have the same problems of the other ownerships. X2 had an application rate of 69.6% and an effectiveness rate of 67.4%. X3 and especially X4 need extra attention on NIPFs. The X3 application rate was 46.7% and its effectiveness rate was 51.1%. X4, water diverted before road crossing, was a problem area, with a 20% application rate and a 30% effectiveness rate. Culverts were an area of concern as well, with X10 application at 57.1% and effectiveness at 62.5%. X11 application was 66.7%, and effectiveness was 71.4%. There were also some issues with the few temporary structures that were employed on these NIPF sites. X12 had a 50% application rate and a 66.7% effectiveness rate. X13 had a 0% application rate and a 50% effectiveness rate.

A skidder crosses a log bridge.

Table 29. Stream-crossing BMP application and effectiveness for the six federal sites monitored.

Federal Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	100	100
X2. Crossings minimize disturbance to the natural bed and banks	100	100
X3. Stream-bank approaches properly designed and stabilized	100	100
X4. Water runoff diverted from road prior to crossing	N/A	N/A
X5. Crossing as close to 90 degrees as practicable	100	100
X6. Crossing does not unduly restrict water flow	100	100
X7. Soil has not been used as fill in the stream (except culverts)	100	100
X8. Ford constructed of non-erosive materials	N/A	N/A
X9. Fords have stable banks and streambeds	100	100
X10. Culverts are properly sized and installed	N/A	N/A
X11. Culverts clear of significant flow obstructions	N/A	N/A
X12. Temporary structures properly anchored	N/A	N/A
X13. Temporary structures and resulting obstructions removed	100	100
Stream Crossing	100	100

Stream crossings on federal sites were well done. They scored 100% in application and effectiveness on all applicable BMPs.

There were no stream crossings on industry or county sites.

A well-closed-out stream crossing, with seed and straw applied to stabilize bare soil and promote re-vegetation.

5. Riparian Management Zones

Table 30. RMZ BMP application and effectiveness for all 1,172 sites monitored.

Comprehensive Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	66.9	68.9
Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	88.9	93.0
Z4. RMZ free of excavated material & debris (other than above)	93.9	96.1
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.4	97.2
Z6. Adequate tree stocking in primary RMZ next to perennial streams	97.1	97.9
Z7. RMZ free of roads and landings (except crossing)	64.9	84.7
Z8. Water diverted from roads before entering RMZ	72.9	80.0
Z9. Water diverted onto stable areas of the forest floor	79.7	83.8
Z10. Road and trail surfaces stabilized as needed within RMZ	83.6	85.6
Z11. Ephemeral channels free of excavated material	67.8	68.6
Riparian Management Zones	80.2	84.8

RMZs are somewhat like stream crossings in that they are close to the water; therefore, departures in application are more likely to affect water quality. RMZs are applied to the ground next to water bodies, but are different widths according to the type of water body and the slope of the ground next to it. For example, a perennial stream 20 feet wide has an RMZ of 50 feet if the slope is 0-5%, whereas the same stream with the adjacent ground at a slope of 40% or more has an RMZ of 105-16 feet. Another example would be an open sinkhole that has a 25-foot RMZ if the ground has 0-5% slope. If the slope changes to 20-40%, then the RMZ for the open sinkhole is 105 feet. RMZs defined in this way make them similar across landowner types. Any differences between landowner types comes from the involvement of the landowners and foresters and their ability and desire to enforce these guidelines.

RMZs have the potential to contribute pollution to the water resources of the site because of the nearness to water. There is a satisfactory application and effectiveness rate of BMPs in this area with an 80.2% and 84.8%. Z2, perennial and large intermittent streams clear of debris, had a fairly low application rate at 66.9% and an effectiveness rate of 68.9%. Z7, RMZ free of roads and landings, had a low implementation rate of 64.9%; however, there were minimal impacts to water quality—the effectiveness rate was 84.7%. Z8, water diverted from roads before entering RMZ, had an application rate of 72.9% and effectiveness of 80%. Z11, ephemeral channels free of excavated material, had an application rate of 67.8% and an effectiveness rate of 68.6%

Lake riparian management zone.

Table 31. RMZ BMP application and effectiveness of all state sites monitored.

State Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	70.0	71.5

Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	90.9	93.9
Z4. RMZ free of excavated material & debris (other than above)	94.6	96.9
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.3	97.5
Z6. Adequate tree stocking in primary RMZ next to perennial streams	99.0	99.0
Z7. RMZ free of roads and landings (except crossing)	65.8	87.3
Z8. Water diverted from roads before entering RMZ	84.2	88.4
Z9. Water diverted onto stable areas of the forest floor	86.5	89.6
Z10. Road and trail surfaces stabilized as needed within RMZ	89.2	89.9
Z11. Ephemeral channels free of excavated material	63.1	64.4
Riparian Management Zones	82.4	86.7

State RMZs had an application and effectiveness rate a few points higher than those of the comprehensive RMZs. Areas of RMZs on state land with challenges were Z2, Z7 and Z11. Obstructing debris in streams (Z2) was a problem with a 70% application rate and 71.5% effectiveness. 65.8% of RMZs were free of roads and landings on state land, but this had little effect on water quality, where there was an effectiveness rate of 87.3%. More care is needed in keeping ephemeral channels free of excavated materials. Application was 63.1%, a decrease of 6% since 2011, and effectiveness was 64.4%, a decrease of more than 5% since 2011.

Table 32. RMZ BMP application and effectiveness of all CLFW sites monitored.

Classified Forest Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	59.0	61.4
Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	89.5	93.9
Z4. RMZ free of excavated material & debris (other than above)	94.4	96.3
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.3	97.2
Z6. Adequate tree stocking in primary RMZ next to perennial streams	97.4	98.3
Z7. RMZ free of roads and landings (except crossing)	60.2	80.5
Z8. Water diverted from roads before entering RMZ	63.8	74.1
Z9. Water diverted onto stable areas of the forest floor	72.4	78.2
Z10. Road and trail surfaces stabilized as needed within RMZ	78.2	82.1
Z11. Ephemeral channels free of excavated material	71.7	72.0
Riparian Management Zones	77.4	82.8

CLFW had a more difficult time with application of RMZ BMPs, scoring 5% below the comprehensive RMZs; however, the effectiveness rates were 4% less than for the overall RMZ. Problem areas were similar to those of state lands but there were also several others. Obstructing debris in streams was still an issue with a 59% application, an 8% decrease from 2011, and 71.2% effectiveness. RMZs were not free of roads and landings, showing a 59% implementation rate. Effectiveness was 61.4%, down almost 10% since 2011. RMZs had landings and/or roads less than 40% of the time; however, the effectiveness rate was 80.5%. Water was not well diverted before entering RMZ (Z8) with application of 63.8%, an increase of almost 9% since 2011 and an effectiveness rate of 80.5%, a 3% increase. When water was diverted, it did not always go to stable areas of the forest floor (Z9). There was a 72.4% application rate and 78.2% effectiveness rate, a decrease of almost 7%. Roads and trails were not always stabilized as needed within the RMZ (Z10). The application rate was 78.2%, and the effectiveness rate was 82.1%. Ephemeral channels were not always free of excavated materials, with a 71.7% application rate and 72% effectiveness rate. CLFW were about 8% higher on this BMP specification than on State Forest sites.

Corduroy logs and soil left in intermittent stream crossing cause obstruction of flow. Impacts from this kind of BMP departure can lead to sometimes extreme erosion and sedimentation. The stream will reroute itself to find ways around the obstruction. This results in destabilization of the stream banks and bed stream both upstream and downstream of the obstruction.

Table 33. RMZ BMP application and effectiveness of all NIPF sites monitored.

NIPF Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	69.1	76.4
Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	64.1	77.4
Z4. RMZ free of excavated material & debris (other than above)	86.3	89
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.1	94.7
Z6. Adequate tree stocking in primary RMZ next to perennial streams	91.7	94.1
Z7. RMZ free of roads and landings (except crossing)	74	84
Z8. Water diverted from roads before entering RMZ	29.8	42.9
Z9. Water diverted onto stable areas of the forest floor	54.8	60.6

Z10. Road and trail surfaces stabilized as needed within RMZ	70.2	71.9
Z11. Ephemeral channels free of excavated material	77.3	77.3
Riparian Management Zones	73.9	78.7

NIPF RMZs were about 8% points below the overall ratings for RMZs for the state, and about 4% behind Classified sites. Z2 was again a problem area, with 69.1% application and 76.4% effectiveness. Z3, placing logging debris back from water course to prevent movement into the streams during floods, was an issue for the first time, with an application of 64.1% and effectiveness of 77.4%. Z7 had an application rate of 74% but an effectiveness rate of 84%. This shows that although there were some roads and landings within RMZs, the impact on them was small. The largest problem RMZs faced on NIPF is the diversion of water from roads before entry to RMZ (Z8). Application of this BMP was 29.8%, and effectiveness was 42.9%. When water was diverted, it was often diverted somewhere other than to stable forest floor (Z9), with an application rate of 54.8% and an effectiveness rate of 60.6%. Some road and trail surfaces needed further stabilization in the RMZ (Z10), with application at 70.2% and effectiveness at 71.9%. Multiple ephemeral channels were found to have excavated material in them (Z11), with application and effectiveness rates at 77.3%.

Dozer installing bridge for stream crossing on timber harvest site.

Table 34. RMZ BMP application and effectiveness of the six federal sites monitored.

Federal Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	100	100
Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	100	100
Z4. RMZ free of excavated material & debris (other than above)	100	100

Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	100	100
Z6. Adequate tree stocking in primary RMZ next to perennial streams	100	100
Z7. RMZ free of roads and landings (except crossing)	80.0	80.0
Z8. Water diverted from roads before entering RMZ	50.0	100
Z9. Water diverted onto stable areas of the forest floor	100	100
Z10. Road and trail surfaces stabilized as needed within RMZ	100	100
Z11. Ephemeral channels free of excavated material	100	100
Riparian Management Zones	93.9	97.0

RMZs were mostly well done on the six federal sites monitored, with a 93.9% application rate and a 97% effectiveness rate. The only two areas that were not rated as perfectly implemented and performing were Z7 and Z8. Application and effectiveness for RMZs free of roads and crossings was 80%. Half of the sites had problems with the diversion of water from roads before entering the RMZ; however, this caused no impact to water quality, with a 100% performance rate.

Logging debris in streams can obstruct stream flow, leading to the stream carving a new bank, which results in erosion and sedimentation going directly into the stream.

Table 35. RMZ BMP application and effectiveness of the three federal sites monitored.

Industry Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	N/A	N/A
Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	N/A	N/A
Z4. RMZ free of excavated material & debris (other than above)	N/A	N/A

Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	N/A	N/A
Z6. Adequate tree stocking in primary RMZ next to perennial streams	N/A	N/A
Z7. RMZ free of roads and landings (except crossing)	N/A	N/A
Z8. Water diverted from roads before entering RMZ	N/A	N/A
Z9. Water diverted onto stable areas of the forest floor	N/A	N/A
Z10. Road and trail surfaces stabilized as needed within RMZ	N/A	N/A
Z11. Ephemeral channels free of excavated material	100	100
Riparian Management Zones	100	100

There were no RMZs on the three industry sites monitored. RMZ BMP Z11 shows that the ephemeral channels on these sites were free of excavated materials, with a 100% application and effectiveness rates.

Table 36. RMZ BMP application and effectiveness of the two county sites monitored.

County Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	N/A	N/A
Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods	N/A	N/A
Z4. RMZ free of excavated material & debris (other than above)	N/A	N/A
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	N/A	N/A
Z6. Adequate tree stocking in primary RMZ next to perennial streams	N/A	N/A
Z7. RMZ free of roads and landings (except crossing)	N/A	N/A
Z8. Water diverted from roads before entering RMZ	N/A	N/A
Z9. Water diverted onto stable areas of the forest floor	N/A	N/A
Z10. Road and trail surfaces stabilized as needed within RMZ	N/A	N/A
Z11. Ephemeral channels free of excavated material	0.0	0.0
Riparian Management Zones	0.0	0.0

There were no riparian management zones on the two county sites. The ephemeral channels on this site were both found to have soil in them. This resulted in a 0% application and effectiveness score for this individual BMP.

V. Discussion

The overall forestry BMP application rate is 85.98%. Overall effectiveness is 91.2%. The high application and effectiveness scores show there are many sound practices taking place throughout the state's forest-harvest sites to maintain the integrity of the soil and water resources. There are many things that are being done well. However, to achieve the most improvement, BMPs with the most departures must be examined to determine how to best enhance the Indiana Forestry BMP program.

The highlight of Indiana's Forestry BMPs in the last 20 years has been the high implementation and performance rates in the areas of access roads and log landings. Access-road application and effectiveness rates were 95.2% and

98.3%, respectively. Log landings had a 92.2% application and 97.4% effectiveness rating. Access-road runoff drainage and diversion was the only real issue of concern despite still having an application rate of 85% overall and a 94% effectiveness rate. Log landing's only problem area was runoff diverted onto stable areas of forest floor. These areas also had application rates of 86.7% but effectiveness was more than 93%. This shows that impacts to water quality were minimal. All ownerships performed well on both of these BMP categories.

Skid trails are where much of the work of a harvest occurs, so it is no surprise that many issues arise in this area. Skid trails had an overall application rate of 78.1% and effectiveness of 87.9%, a decrease of 6% since 2011. This indicates that although there are some difficulties correctly carrying out BMPs on skid trails, most do not result in large impacts to water quality.

Skid trails can have a spectrum of disturbance levels that depend on how often equipment drives over a particular point on the ground. For instance, the main trail just off the landing would have a higher disturbance level because all harvested logs have to be moved to the landing, while an area traveled over only twice—once to access trees and the other to pull out the logs—would have a much lower level of disturbance. Also, skid trails go to areas that other equipment cannot access and cover more surface area across the harvest area, so they may cross drainages, travel down or across hill slopes, or go into areas that are wet most of the time. Therefore, most of the application and effectiveness issues of a site are from skid trails. Also, most closeout practices are put in place with limited space as landforms, and nearby vegetation often limits the equipment's ability to place structures where they would be most effective. This causes minor departures in application (20% of skid-trail application scores are minor departures), with little to no effect on water quality.

Overall stream-crossing BMP application is 74.3%, and overall effectiveness is 75.9%. Due to the nature of stream crossings, impacts to water quality are, at times, inevitable. However, the length and severity of impacts can be lessened if BMPs are applied properly. The best plan is to harvest in a way that avoids stream crossings; however, that is often not viable. The largest problem on stream crossings has been and continues to be the diversion of water before the stream crossing, X4. State Forest sites were about 7% higher in application and effectiveness for stream crossings than CLFW sites. This individual BMP (X4) had an overall application of 51.8% and effectiveness of 55.7%. The ownership types that had the most problems in this area are private lands (CLFW and NIPF). The proper design and stabilization of stream banks at crossings (X3) was also a problem, with an overall application of 56.1% and effectiveness of 58.7%. This problem also seemed more pronounced on sites of private land ownership.

RMZs are much like stream crossings in that they are close to water bodies. If there is a problem, it often directly affects water quality, so managers often try to avoid placing high-impact infrastructure like access roads or landings in RMZs unless they already exist. Overall RMZs had a respectable application rate at 80.2%. The effectiveness rate for overall RMZs was 84.8%. Among landowner types, the State Forests have the highest application and effectiveness rates for RMZs, around 5% higher than CLFW sites. The two main problem areas for RMZs was the presence of obstructing debris in perennials and large intermittent streams, and the presence of excavated materials in ephemeral channels. Z2, the RMZ BMP concerning obstructing debris, had an application rate of 66.9% and effectiveness of 68.9% overall. State sites were about 10% better than Classified sites at keeping obstructing debris out of streams. Z11, the BMP concerning excavated material in ephemeral channels, had an application of 67.8% and effectiveness rate of 68.6%. State sites faired about 8% worse than Classified sites on the application and effectiveness at keeping ephemeral channels free of excavated materials. One RMZ BMP, Z8, had a large deviation of application and effectiveness rates between ownership types. Z8 is the BMP concerning water diversion before entry to the RMZ. On state lands, this BMP, diverting runoff from roads (Z8), was well implemented and performed at 84.2% and 88.4% in application and effectiveness, respectively. On CLFW sites, the application of this BMP was 63.8%, or 20% lower than that state application and effectiveness of 74.1%, and 14% lower than state effectiveness for diverting water before entry to RMZ. It was even lower on NIPF sites, with a 29.8% application and 42.9% effectiveness rate.

VI. Recommendations

- Concentrate training, education, and implementation on areas where problems are more common, such as skid trails, RMZs, and stream crossings.

- Continue to emphasize importance of diverting water before it concentrates on roads, landings and skid trails and enters streams and RMZs. These types of BMPs were particularly challenging on private lands, therefore continuing education for private lands managers, owners and contractors is of distinct importance.

Stream-side investigation during BMP monitoring.

VII. Conclusions

Since 1996 the Indiana DNR Division of Forestry has provided forestry BMP leadership, training and implementation for private, industry, federal, county, municipal and state lands. The division continues to hold itself and others to a high standard by continually monitoring timber harvests on state lands and other ownership types. The BMPs developed by the division and other stakeholders are revised and updated to reflect the current science.

The division wants to use information that is found in reports such as this, and in other similar reports, to raise awareness to the challenging areas of forestry BMPs, and to continue to improve in these areas. Managing Indiana's timberlands for forest production while maintaining the highest environmental quality is of the utmost importance to the division, and forestry BMPs are the means by which this can be accomplished.