# Indiana Classified Forest & Wildlands
# Forestry Best Management Practices
# Monitoring Results
# 1996-2017

By: Jennifer Sobecki & Duane McCoy

# Indiana Classified Forest & Wildlands

# Forestry Best Management Practices

# Monitoring Results

# 1996-2017


By: Jennifer Sobecki & Duane McCoy

# 1996 through 2017

# Indiana Classified Forest and Wildlands BMP Report


I. Introduction & Indiana Forestry Best Management Practice (BMP) History

- A. BMP Introduction
- B. BMP History

II. Methods

- A. BMP Monitoring Objectives
- B. Site Selection
- C. Data Collection, Entry & Analysis
- D. Monitoring Team Selection
- E. Site Evaluation

III. Results

- A. Comprehensive BMP Application and Effectiveness
- B. BMPs by Category; Application & Effectiveness
    1. Access Roads
    2. Log Landings
    3. Skid Trails
    4. Stream Crossings
    5. Riparian Management Zones

IV. Discussion

V. Recommendations

VI. Conclusions

## I. **Introduction & Indiana Forestry BMP History**

### A. Best Management Practice (BMP) Introduction

Indiana has 4,858,596 acres of forestland, which is 20.8% of the state's land base. This area provides 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 partake in these activities benefit greatly from the biodiversity, clean air and water that our forests produce. Since forests are important to all citizens of our state, it is imperative that timber harvesting on all forests, no matter who owns the land, is 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. Forestry Best Management Practices (BMPs) are employed to protect forest soils and water quality during and after a harvest.

Forestry 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 private Classified Forest properties statewide from 1996-2017. There are 810,265 acres of land in the Classified Forest & Wildlands (CLFW) Program statewide. The data cover all BMP monitoring for 517 CLFW 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 DNR Division of Forestry, in cooperation with the Woodland Steward Institute, took on a statewide project to develop a 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 that cause NPS pollution, such as agriculture and development. In response, the Woodland Steward Institute took on the project called "The Forest Health Initiative." The BMP guidelines were completed in 1995, with the first round of BMP monitoring occurring in 1996. The Forestry BMP Field Guide was published in 1998. All 50 states have a Forestry BMP manual that was either developed by the state's forestry agency or produced with the heavy involvement of that agency (Nat'l Assoc. National Association of State Foresters 2015).

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 facilitated 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 that would be 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 Best Management Practices (BMPs) for several land-use practices, such as agriculture, urban development, and forestry. In forestry, the states were directed to establish Forestry BMPs, but were given the option of making the used of BMPs either 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. The publication is 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. State forestry agencies nationwide have reported the training and certification are vital to the adoption and use of forestry BMPs (Cristain et al. 2016). 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 watershed of Monroe Lake, which 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 and 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 to seek permission to use their site as part of the study. Once sites were accepted for monitoring, teams of people with diverse technical backgrounds were assembled. Each team was led by a DNR forester to provide technical and logistical support. Other team members were landowners or came from the forest industry or environmental community, or had a planning-and-development, wildlife-biology, hydrology, or soil-conservation background. Team size was four to five individuals, often with team members possessing multiple areas of expertise. Team size was 4-5 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 changed and evolved over time, as necessary. The first few rounds of monitoring were paid for through funds from IDEM or the Great Lakes Commission under the Clean Water Act, among other federal programs. BMP monitoring has also become a staple on state forest property harvest sites, where all harvest sites are now monitored for BMP compliance. Since 2009, 10 percent of CLFW sites that have reported a timber harvest have also been monitored each year. This report contains the findings from the CLFW BMP monitoring from the beginning of the program to present.

## II. **Methods**

### A. BMP Monitoring Objectives

The objectives of BMP monitoring are to:

1) Assess the effectiveness of BMP guidelines in minimizing soil erosion and stream sedimentation
2) Provide information on the extent of BMP implementation, past and current
3) Identify where to focus future program training and educational efforts to improve BMP implementation and effectiveness
4) Identify BMP specifications that may need technical modification
5) Identify improvements needed in future monitoring efforts

### B. Site Selection for Classified Forest and Wildland

Beginning in 2009 and henceforth, at least 10 percent of CLFW Program sites reported as having a harvest the previous year will be monitored. CLFW monitoring began in order to make their properties eligible for certification with the Forest Stewardship Council (FSC). These sites are randomly selected from the annual reports. Annual reports are required for properties conducting a harvest during the reporting year. 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 percent of the harvests in each district are then monitored. For instance, if a district gets back 31 annual reports that said they had a harvest in that year, the first four sites that come out of the random number generator will be monitored.

From 1996 through 2004 monitoring, sites were selected by their geographic position. The 1996 and 1997 surveys were in the Monroe Lake watershed. In 1999, surveys were conducted in five randomly selected counties throughout the state (Ohio, Jefferson, Clay, Martin and Steuben). In 2000, the monitored sites in seven of the 13 counties had 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. All others were recorded as being in another type of ownership or their ownership type was unknown.

The 2009 monitoring survey focused on CLFW. In 2008, there were approximately 374 harvests from the tracts in the CLFW program from which the Division of Forestry (DoF) had to monitor at least 10 percent. From the total 374 sites reported to have been harvested in 2008, the DoF monitored 40 randomly selected sites, 10.69 percent of the total sites harvested.

In 2010, sites reported to be harvested in 2009 were randomly selected for CLFW monitoring. In 2009, there were approximately 366 harvests from the tracts in the CLFW program, from which the DoF had to monitor at least 10 percent. From the total 366 sites harvested in 2009, the DoF monitored 45 for a 12.3 percent of the total sites harvested.

In 2011, CLFW monitoring consisted of 60 sites that were randomly selected from the 519 sites that were reported to have harvests in 2010. The 60 sites that were reviewed made up 11.6 percent of the CLFW sites reported to have been harvested in 2010.

In 2012, monitoring involved 56 sites randomly chosen from a total of 467 sites that reported a harvest in 2011. A total of 12 percent of sites reported to have been harvested in 2011 were monitored in the 2012 round of monitoring.

In 2013, monitoring consisted of 53 sites chosen randomly from 422 sites that reported a harvest in 2012. A total of 12.6 percent of reported 2012 harvest sites were randomly chosen for monitoring in 2013.

In 2014, monitoring included 60 sites randomly chosen from 515 sites that reported a harvest in 2013. A total of 11.6 percent of sites reporting harvests were chosen randomly for the 2014 monitoring surveys.

In 2015, monitoring included 74 sites that were randomly chosen from 672 sites that reported a harvest in 2014. At total of 11 percent of sites reporting a harvest were monitored.

In 2016, monitoring consisted of 53 sites chosen randomly from 460 sites that landowners reported a harvest on in 2015. 11.5 percent of sites reporting a harvest were monitored.

In 2017, monitoring consisted of 64 sites chosen randomly from 539 sites that were reported as harvested in 2016. 11.9 percent of sites reported were monitored.

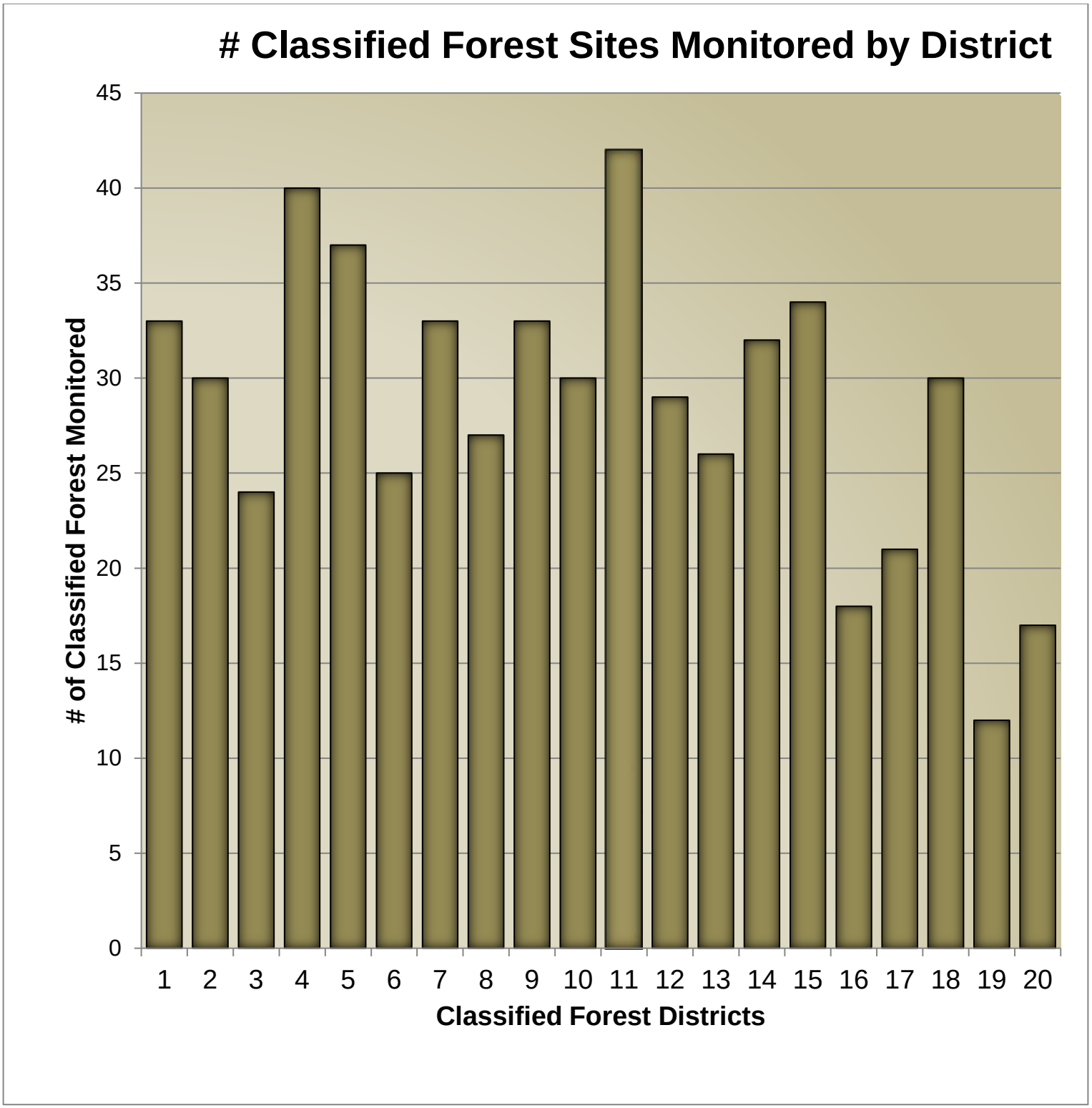



Figure 1: Number of CLFW timber-harvest sites monitored for BMPs by district through the 21-year history of the BMP program.

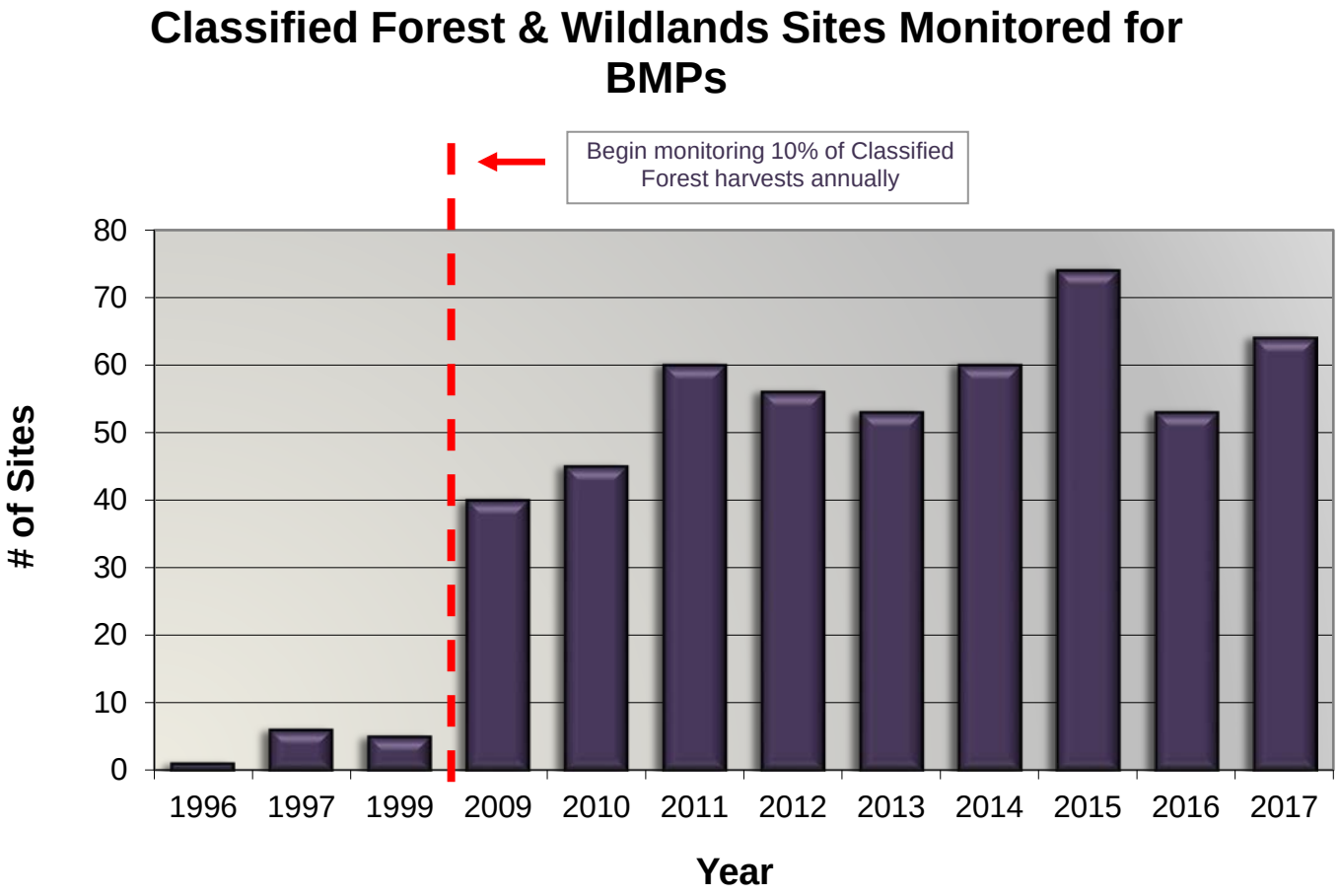



Figure 2. Total number of sites monitored each year since the program began 21 years ago.

C. Data Collection, Entry and Analysis

The BMP Monitoring Form is used to collect data both in the office and field. Much of the first page can be completed by consulting maps, harvest paperwork and/or talking to the forester, timber buyer, or landowner. The remaining pages of the form are all completed in the field during and after the site evaluation. See the "Site Evaluation" section for more details.

These raw datasheets are then brought back to the office and given to a DoF employee to enter into the Indiana Forestry BMP Database. Datasheets are processed, and copies are supplied to concerned parties, including foresters, landowners, timber buyers, and managers. The database is used to construct various reports, like this one, in addition to annual reports for State Forests, CLFW and quality-control reports.

### D. Monitoring Team Selection

The selection of monitoring parties has been modified over the course of Forestry BMP monitoring in Indiana from 1996 through 2017. It has also varied based upon the landownership and monitoring objectives. In the 2009 through 2017 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 also monitored, they were included in the process but did not participate in the scoring of the site.

### 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 the prevention of pollutants entering a water body or 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 high 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 58 individual BMPs measured for application and effectiveness on each site evaluation. These individual BMPs are within five categories:

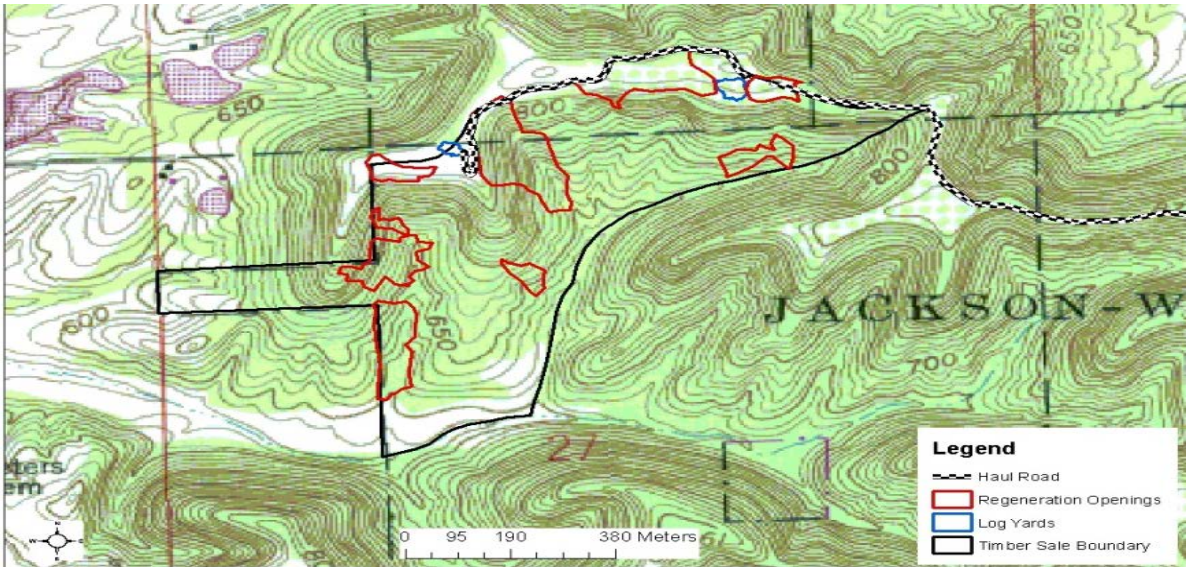
1. Access or Haul Roads
2. Log Landings or Yards
3. Skid Trails
4. Stream Crossings
5. Riparian Management Zones (RMZ)

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 comments 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, they come together to 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.




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

## IV. Results

### A. Comprehensive BMP Application & Effectiveness

This report quantifies the application and effectiveness of Forestry BMPs on CLFW sites, based upon guidelines laid out in the Indiana Forestry BMP Field Guide. This report includes 517 CLFW timber harvests monitored between November 1996 and February 2018, ranging in size from one to 785 acres.

A figure of 85.37 percent of the BMPs were applied as directed in the BMP guidelines, and 12.69 percent had minor departures as defined in the monitoring sheet. There have been 374 major departures, which add up to 1.88 percent of all practices monitored. Of the total 517 sites monitored on CLFW sites, 14 practices scored “Total Negligence” for 0.07 percent, as shown in Figure 1.

Effectiveness rates are used to evaluate the success of the BMPs applied to a site. The effectiveness rate for the 517 sites monitored is 89.63 percent. Indirect and temporary impacts to water quality were found 3.29 percent of the time. Indirect and prolonged impacts were found 1.27 percent of the time. Direct and temporary impacts occurred 3.53 percent of the time. And there were 2.28 percent direct and prolonged impacts to water quality. All of this is shown in Figure 2.

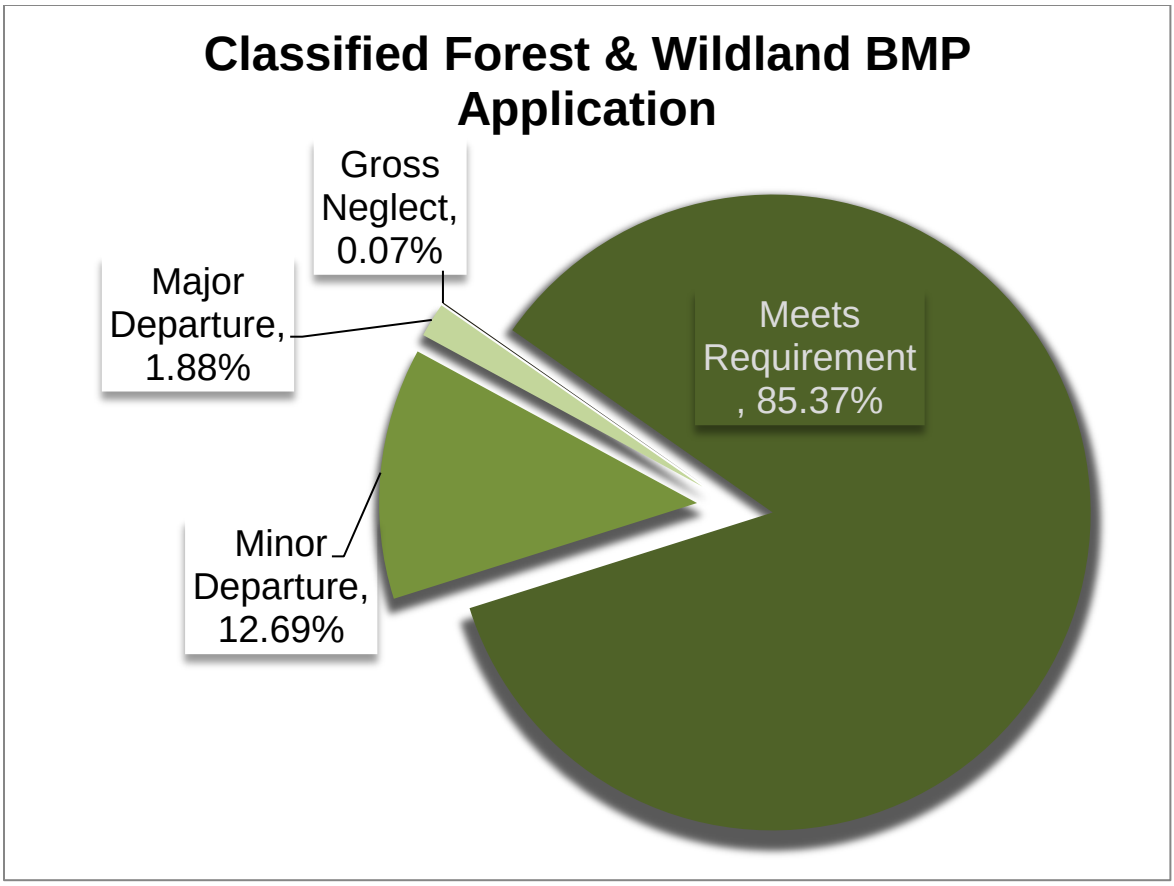


Figure 3. BMP Application for all 517 CLFW sites monitored from 1996 through 2017.

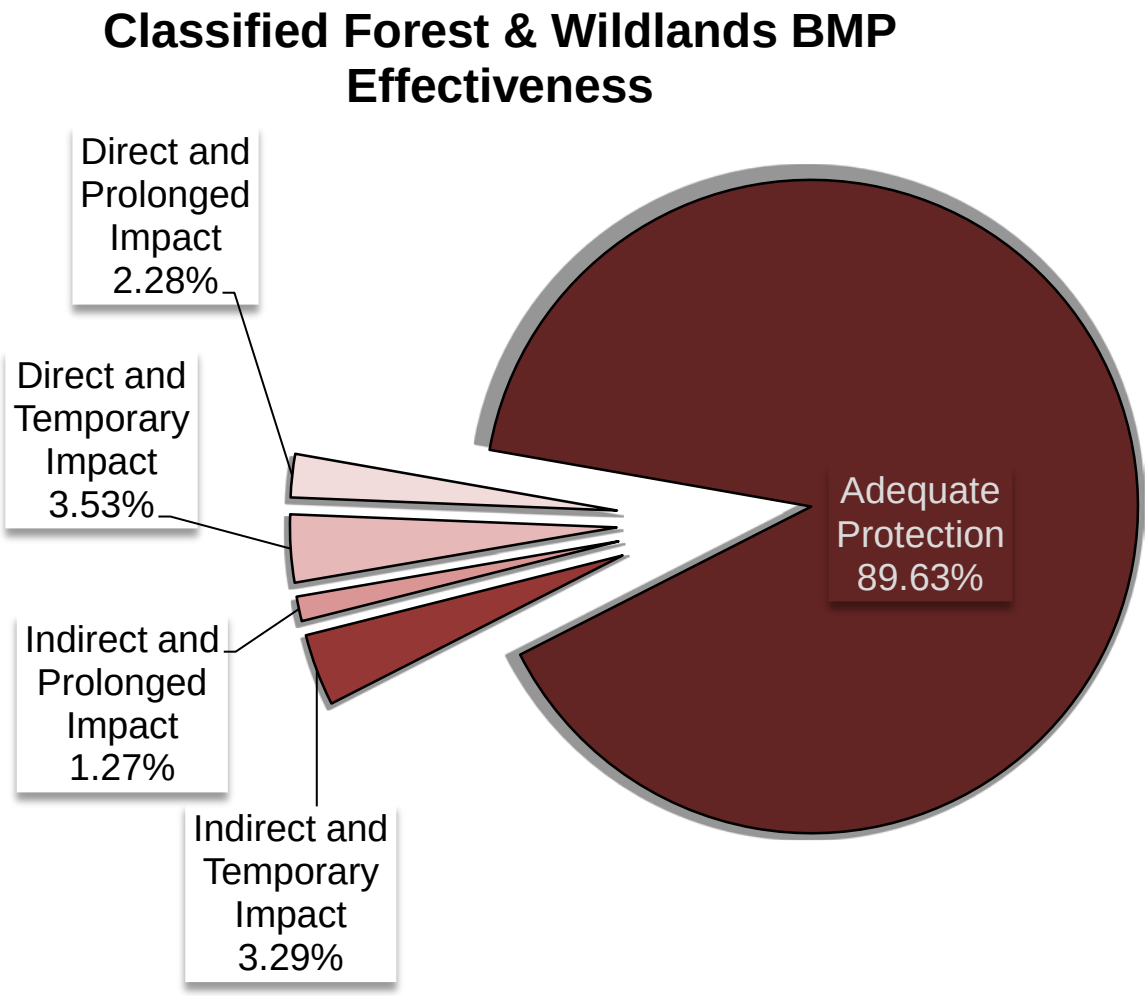



Figure 4. BMP Effectiveness for all 517 CLFW sites monitored from 1996 through 2017.

The application and effectiveness rates for forestry BMPs used to protect sites after timber harvests are excellent for the 517 sites monitored since 1996. The overall application rate is 85.37 percent, and the overall effectiveness rate is 89.63 percent.

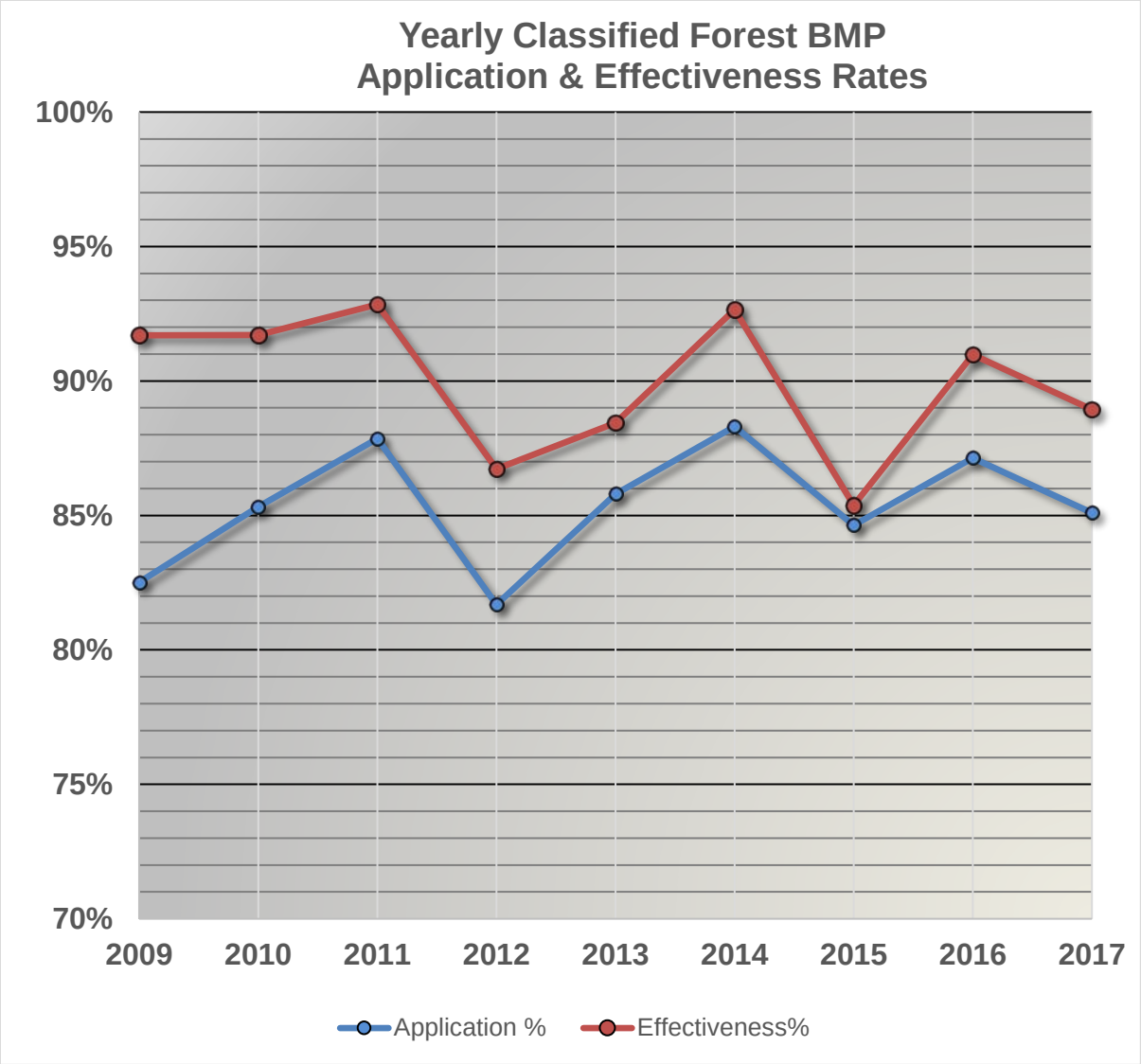



Figure 5. Yearly trends of overall BMP application and effectiveness scores on CLFW sites. These percentages are calculated for each year's data separately, rather than being combined with the running totals from previous years.

Application and effectiveness rates of sites monitored varied from year to year, and no real positive or negative trend can be extrapolated. However, there are several conclusions one can draw from Figure 5. First, effectiveness rates are commonly higher than application rates. Second, is the rates seem to mirror one another.

B. Application & Effectiveness of BMPs by Category

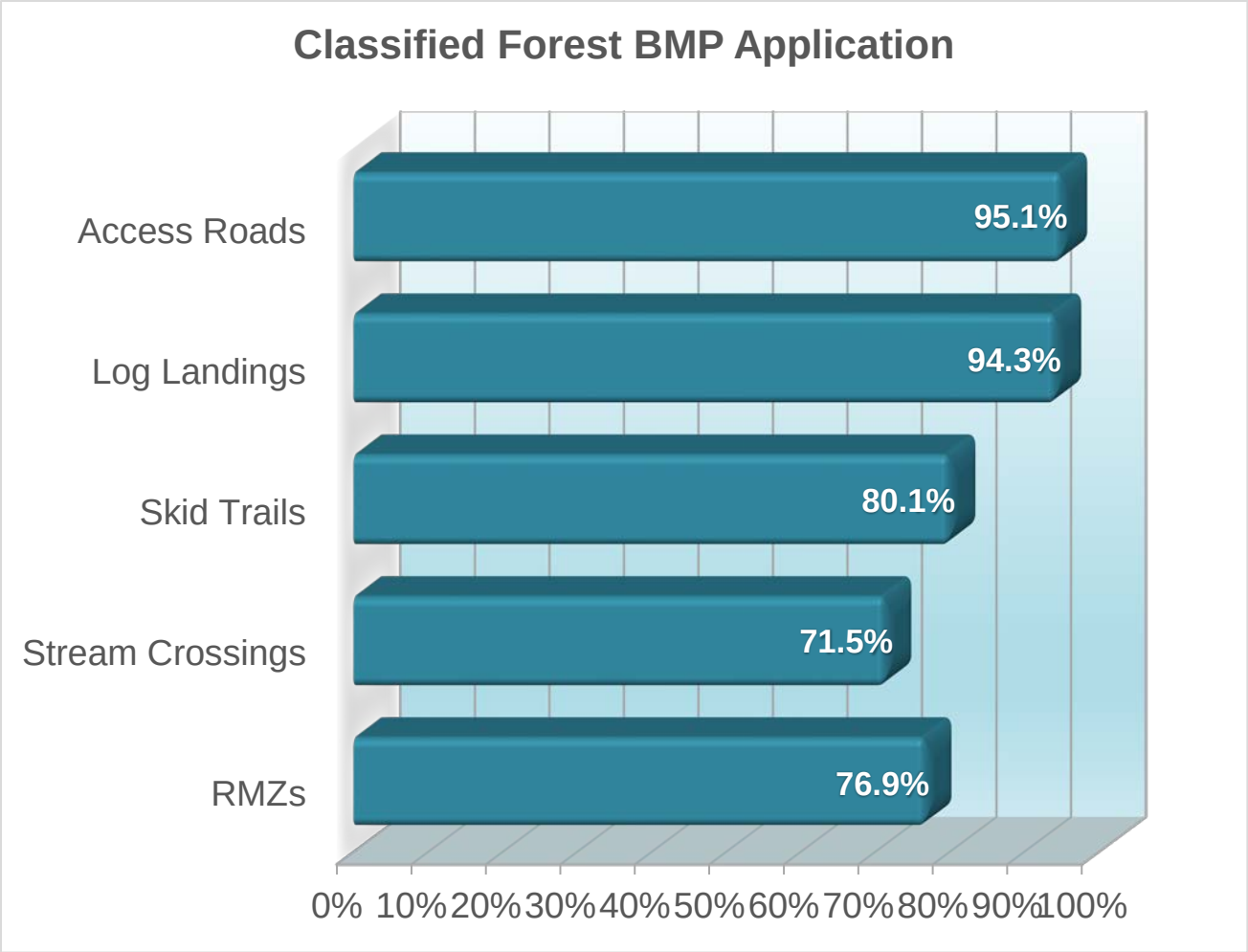



Figure 6: Overall BMP application percentages by BMP category.

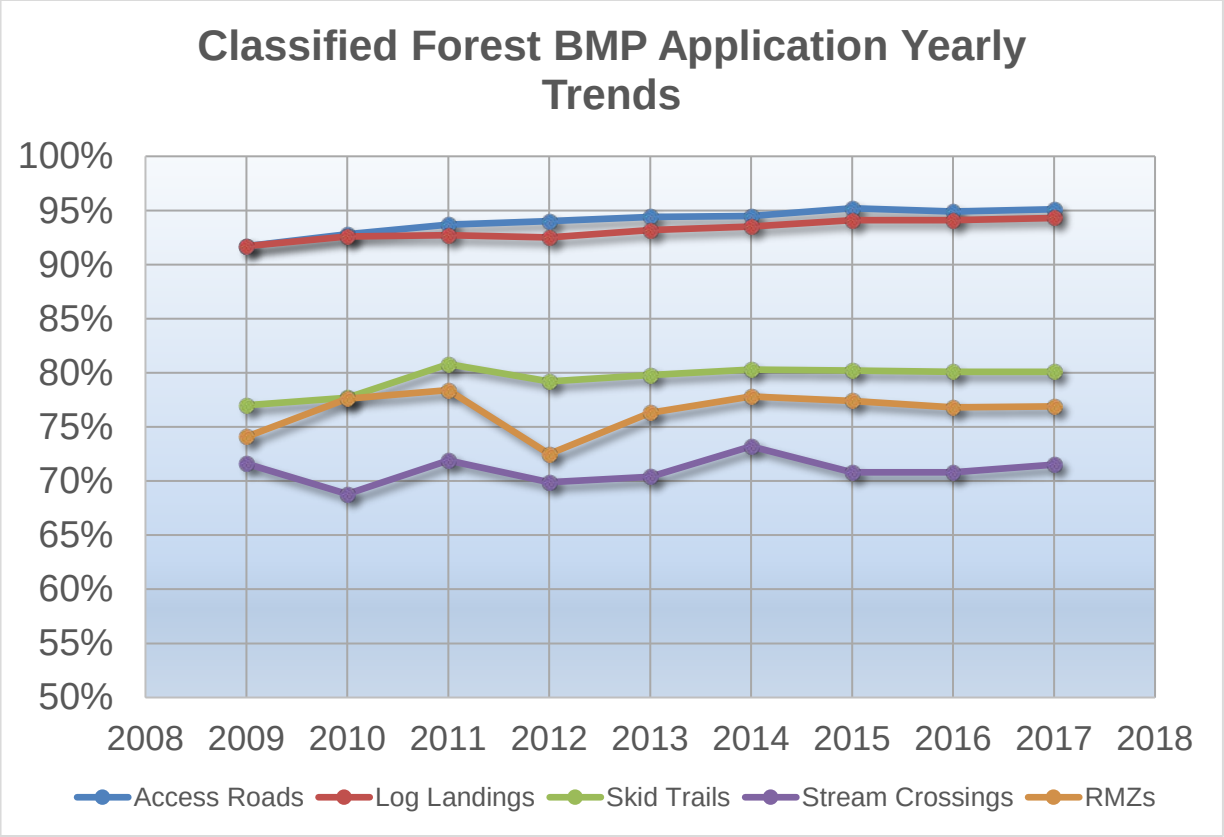



Figure 7. Yearly BMP application trends by BMP category.

Access roads and landings are areas of a timber harvest where machines concentrate much of their activity, including using tractor trailers, which cannot handle much variation in the terrain when traveling. Therefore, access roads and log landings are often well stabilized, well drained and located in areas that have established travel routes that avoid water bodies as much as possible. BMP application trends remain consistently high for access roads and log landings through the 21 years of monitoring, remaining generally in the high 90s. 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. Since 2011, skid trails have had applications scores near 80 percent. When it comes to stream crossings and RMZ areas, they are mostly dealing with skid trails leading to them or in them, and they are close to the water bodies. This means there is an increased chance there can be an impact on water quality, regardless of whether there is an application problem. RMZ application has generally stayed in the mid- to high 70s. Stream crossings have the lowest application scores on CLFW lands, generally staying around 70 percent.

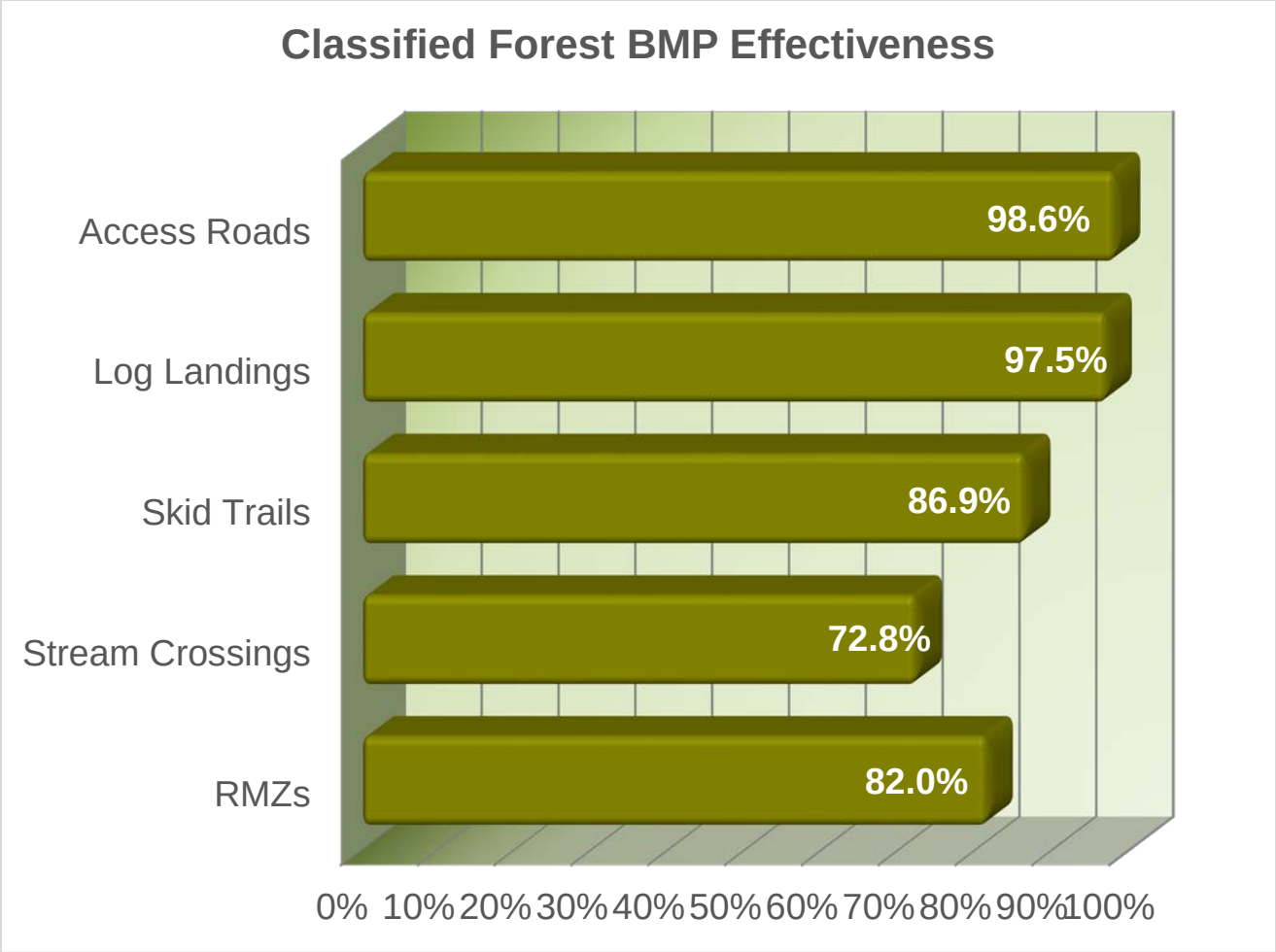



Figure: 8. Overall BMP Effectiveness percentages by BMP category.

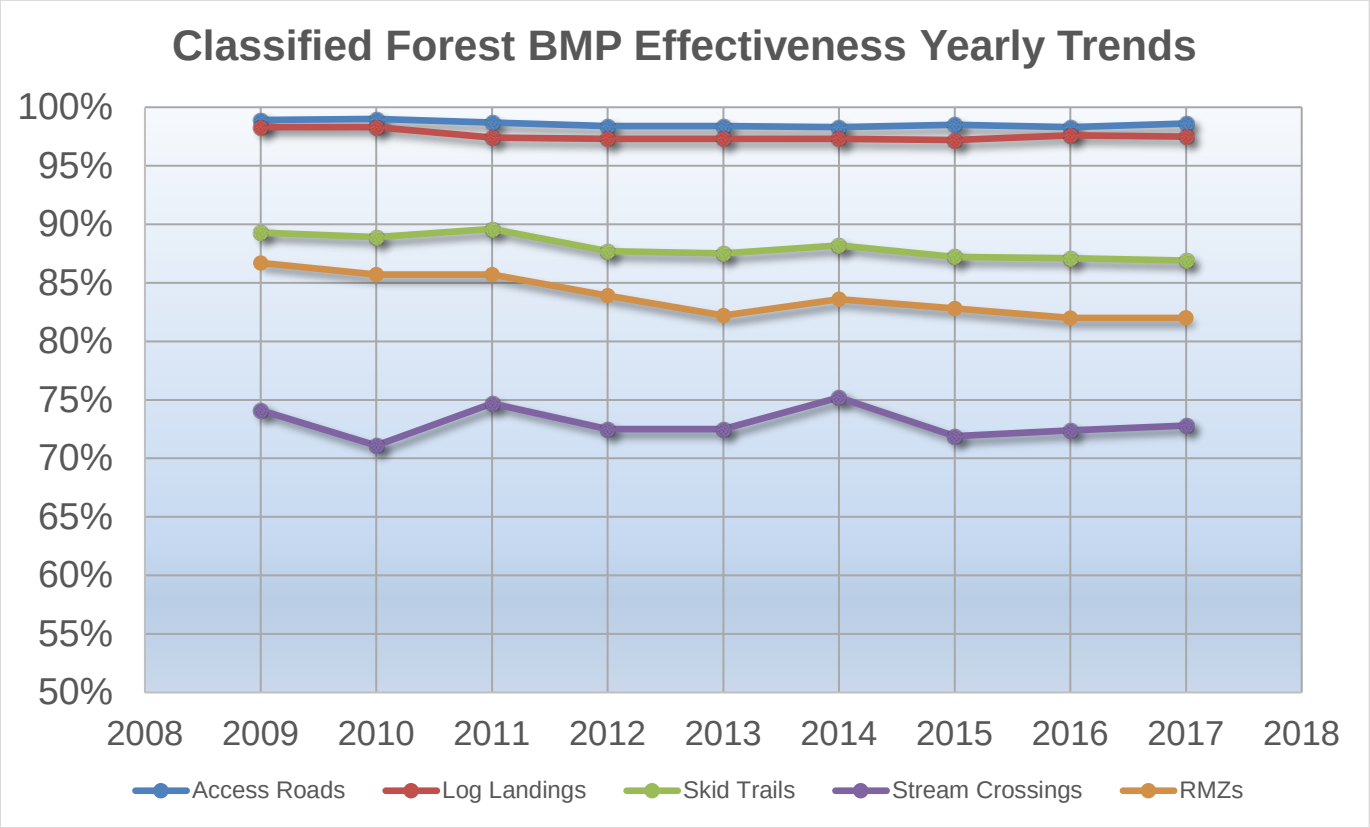



Figure 9. Overall BMP effectiveness yearly trends by BMP Category.

The BMP category effectiveness trends mirror the application trends, with effectiveness rates generally higher than application rates. As with application, effectiveness rates for access roads and log landings are consistently high, with effectiveness rates generally 5 percent or higher than application rates for both categories. RMZ and skid trail effectiveness was similar to application scores, although they ranged around 5 percentage points higher. Stream crossings came in last in both application and effectiveness, with application rates lower than effectiveness as with other categories; however, stream crossing effectiveness is generally only around 1 to 2 percent higher than stream-crossing application scores. 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 direct impacts due to their proximity to water.

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 95.1 percent application and 98.6 percent effectiveness rate. Log landing application rate was 94.3 percent and effectiveness was 97.5 percent. The third-highest category was skid trails, with 80.1 percent application and 86.9 percent effectiveness rates. RMZs ranked next to last, with 76.9 percent application and 82 percent effectiveness. The BMP area with the most difficulty was stream crossings, with an application of 71.5 percent and effectiveness of 72.8 percent. 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 departures from effective management with stream crossings.

1. Access Roads

Access road on an Indiana State Forest property.

Access roads connecting the harvest area to the public road system aid the transport of the logs to the mills for processing. This connection means that 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 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.

Effective cut out on a permanent access road.

Table 1. Access road BMP application and effectiveness for all CLFW sites monitored from 1996 through 2017.

| Classified Access Roads | % Application | % Effective |
|---|---|---|
| A1. Uses existing routes where appropriate | 99.1 | 99.7 |
| A2. Adequate buffer strip next to water courses and sensitive areas | 94.1 | 99.1 |
| A3. Avoids unstable gullies, seeps, very poorly drained areas | 96.5 | 98.8 |
| A4. Road grades are within standards | 99.1 | 99.7 |
| A5. Amount of roads minimized | 100.0 | 100.0 |
| A6. Stream crossings minimized | 99.7 | 99.7 |
| A7. Road excavation minimized | 99.4 | 100.0 |
| A8. Excavated and fill materials placed properly | 99.7 | 99.7 |
| A9. Roads constructed to drain well | 92.2 | 96.8 |
| A10. Appropriate road stabilization, drainage and diversions installed | 88.7 | 94.6 |
| A11. Water diversions functioning properly | 96.3 | 96.9 |
| A12. Runoff diverted onto stable forest floor areas | 93.7 | 96.2 |
| A13. Mud kept off public roadways | 99.7 | 99.7 |
| A14. Public road's drainage maintained | 99.4 | 99.7 |
| A15. Traffic barriers installed | 68.9 | 97.9 |
| Overall Access Road | 95.1 | 98.6 |

Access roads on CLFWs, as with most private lands, are not as long on public properties. They are usually not used as often. Not as much is invested in them 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 often poses a different set of problems from access roads on State Forest properties.

Table 1 depicts the breakdown of each individual BMP specification in the area of access roads from all 517 sites monitored across the 21-year monitoring period. CLFWs had two areas of application concern. A10: “Appropriate road stabilization, drainage and diversion installed” has application rate of 88.7 percent; however, the effectiveness was 94.6 percent. A15: “Traffic barriers installed” had a 68.9 percent implementation rate but the effectiveness rate was 97.9 percent, providing evidence that this caused no problems on CLFWs. In many cases on CLFWs, the road leading back to the forest is also the driveway to the residence, and this limits any trespassing that would damage the forest.

Permanent haul road protected by rock.

2. Log Landings

Log landing that was used during a wet period, causing rutting and the collection of runoff at the site.

Seeded landing two years after closeout.

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 the logs away 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 gathering in this one area.

Table 2. Log landing BMP application and effectiveness for all CLFW sites monitored.

| Classified Forest Log Landings | % Application | % Effective |
|---|---|---|
| Y1. Suitable number and size of landings | 98.6 | 100.0 |
| Y2. Landings located outside RMZ | 89.8 | 97.6 |
| Y3. Landings located on stable areas | 95.2 | 97.5 |
| Y4. Excavation of site minimized | 97.9 | 99.5 |
| Y5. Landings avoid concentrating or collecting runoff | 85.5 | 95.6 |
| Y6. Landing's runoff enters stable area | 91.6 | 94.7 |
| Y7. Proper water diversions in working order | 93.3 | 95.1 |
| Y8. Landing smoothed and soil stabilized | 92.8 | 95.6 |
| Y9. Landings free of fuel and lubricant spills and litter | 99.1 | 99.3 |
| Y10. Landing location suitable for equipment fueling and maintenance | 98.8 | 99.5 |
| Overall Log Landings | 94.3 | 97.5 |

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 repeated 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 their roots.

CLFW had two areas of log-landing implementation challenges. Individual BMPs for Y2: "Landings located outside RMZ" is 89.8 percent, Y5: "Landings avoid concentrating or collecting runoff," 85.5 percent. Each has a high effectiveness rates at 95.6 percent or higher.

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

3. Skid Trails

A steep skid trail that has well established vegetative cover.

Skid trails are the part of the harvest infrastructure where equipment conveys 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, water bodies, 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. Because of this, 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 proximity to water bodies.

An effective water bar conveying runoff from a skid trail and diverting the flow onto 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.

Effective skid-trail revegetation two years after a harvest.

Table 3. Skid trail BMP application and effectiveness for all CLFW sites monitored.

| Classified Forest Skid Trails | % Application | % Effective |
|---|---|---|
| S1. Uses existing routes were appropriate | 96.1 | 97.4 |
| S2. Adequate buffer strip next to water courses and sensitive areas | 73.0 | 88.3 |
| S3. Avoids steep and long straight grades (>20% for >200') | 85.8 | 94.0 |
| S4. Avoids unstable gullies, seeps, poorly drained areas | 84.2 | 92.6 |
| S5. Amount of skid trails minimized | 91.2 | 95.5 |
| S6. Trail excavation minimized | 89.7 | 92.4 |
| S7. Appropriate drainage and diversions installed | 47.2 | 64.0 |
| S8. Water diversions in working order | 75.7 | 81.7 |
| S9. Runoff diverted onto stable forest-floor areas | 71.6 | 76.6 |
| S10. Streams not used as skid trails (except for crossings) | 84.2 | 84.4 |
| Overall Skid Trail | 80.1 | 86.9 |

Skid trails on CLFW sites are commonly shorter than those on State Forest harvest sites, but they do have a few similarities they are commonly on marginal terrain, they may be too steep or too wet, or they were likely converted to crop or pasture fields long ago. Some were woods that were used for firewood or timber since the settlement era, and some were minimally used. With their variable backgrounds, these forests are not usually as susceptible to erosion as

are 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 47.2 percent, a 19-percent increase from 28.2 percent in the 2011 report, and the effectiveness rate was 64 percent, an improvement of 1.2 percent. These numbers indicate that implementation departures in this area may be causing significant impacts to water quality on CLFW harvest sites. However, trends are showing improvement in application of drainage and diversion installation. Other skid-trail BMPs in CLFWs that need further attention are: S2, S8 and S9. These have application rates of 73 percent, 75.7 percent and 71.6 percent, respectively. Effectiveness rates for S2 are 88.3 percent, 81.7 percent for S8, 76.6 percent for S9. These departures in application seem to have minimal total effect on water resources of the sites, with overall effectiveness at 86.9 percent.

Water bars on a revegetated and stable skid trail.

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

Deep skid-trail ruts, causing tree-root damage.

4. Stream Crossings

Stream crossings have historically been the most challenging area of BMPs in Indiana. Mistakes are likely to result in a direct impact to water quality due to their proximity to water. Every practice could be applied without departure and there could still be an impact to water quality. BMP training often emphasizes having a minimal number of stream crossings and mitigating their possible impacts by practicing BMPs for just this reason.

Access road ford across a small stream with low and stable banks.

A poorly applied and implemented stream crossing with no attempt to repair. There are no water diversions before stream crossing, no stream bank stabilization/revegetation.

Table 4. Stream crossing BMP application and effectiveness for all CLFW sites monitored.

| Classified Forest Stream Crossing | % Application | % Effective |
|---|---|---|
| X1. Number of crossings minimized | 89.0 | 89.9 |
| X2. Crossings minimize disturbance to the natural bed and banks | 56.5 | 58.6 |
| X3. Stream-bank approaches properly designed and stabilized | 51.1 | 53.6 |
| X4. Water runoff diverted from road prior to crossing | 47.6 | 52.4 |
| X5. Crossing as close to 90 degrees as practicable | 91.4 | 93.1 |
| X6. Crossing does not unduly restrict water flow | 82.8 | 83.7 |
| X7. Soil has not been used as fill in the stream (except culverts) | 72.4 | 72.4 |
| X8. Ford constructed of non-erosive materials | 76.9 | 76.4 |
| X9. Fords have stable banks and streambeds | 55.8 | 55.8 |
| X10. Culverts are properly sized and installed | 90.5 | 90.5 |
| X11. Culverts clear of significant flow obstructions | 92.7 | 92.7 |
| X12. Temporary structures properly anchored | 90.0 | 86.7 |
| X13. Temporary structures and resulting obstructions removed | 64.9 | 64.9 |
| Stream Crossing | 71.5 | 72.8 |

Areas of concern for CLFW stream crossings were X2, X3, X4, X9 & X13. Other areas of concern were X7, where soil has not been used to fill in the stream and X8, where fords were constructed with non-erosive materials. X2 application was 56.5 percent with 58.6 percent effectiveness. The proper design and stabilization of stream-bank approaches (X3) were low, at 51.1 percent for application and 53.6 percent 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 47.6 percent, for an effectiveness rate of 52.4 percent. In X7, where soil was not used as fill in the stream, there was an application and effectiveness rate of 72.4 percent for both. For X8, the ford was constructed with non-erosive materials and had an application and effectiveness rate of 76.9 percent and 76.4 percent, respectively. Fords needed more stable banks and streambeds (X9), with an application and effectiveness rate at 55.8 percent. X13 had concerns with the removal of temporary crossing structures and resulting obstructions, and reported application and effectiveness rates were 64.9 percent. Many of these cases result when log corduroy bridges and/or fill used for stream crossings are not pulled out after harvest is closed.

A stream crossing that was poorly executed and not closed after the harvest was completed.

A skidder crossing a log bridge.

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

5. Riparian Management Zones

RMZs are somewhat like stream crossings in that they are close to the water; therefore, departures in application are more likely to have an impact on water quality. RMZ BMPs are applied to the ground next to water bodies, but are of different widths, according to the type of water body and the slope of the ground next to it. An example of this is a perennial stream 20-feet wide that has an RMZ of 50 feet if the slope is 0 to 5 percent, whereas the same stream with the ground next to it at 40 percent or more slope has an RMZ of 105 to 165 feet. Another would be an open sinkhole that has a 25-foot RMZ if the ground is 0 to 5 percent slope, but if the slope changes to 20 to 40 percent, then the RMZ for the open sinkhole is 105 feet. RMZs, defined this way, are similar across landowner types. Any differences between landowner types is the result of landowners and/or foresters' involvement, and their ability and desire to enforce these guidelines. See full list of RMZ widths here: dnr.IN.gov/forestry/4588.htm

Lake or pond RMZ.

Table 5. 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 | 58.8 | 61.1 |
| Z3. Treetops and cutoffs placed back from water course to prevent movement into streams during floods | 88.8 | 92.7 |
| Z4. RMZ free of excavated material and debris (other than above) | 92.9 | 95.1 |
| Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings) | 95.4 | 96.3 |
| Z6. Adequate tree stocking in primary RMZ next to perennial streams | 97.8 | 98.6 |
| Z7. RMZ free of roads and landings (except crossing) | 60.0 | 80.0 |
| Z8. Water diverted from roads before entering RMZ | 63.8 | 73.0 |
| Z9. Water diverted onto stable areas of the forest floor | 71.3 | 76.2 |
| Z10. Road and trail surfaces stabilized as needed within RMZ | 77.4 | 80.7 |
| Z11. Ephemeral channels free of excavated material | 72.1 | 72.8 |
| Riparian Management Zones | 76.9 | 82.0 |

Obstructing debris in streams (Z2) is an issue with a 58.8 percent application and 61.1-percent effectiveness. RMZs "free of roads and landings" (Z7) with a 60-percent implementation rate, effectiveness was 80 percent. RMZs had landings and or roads 40 percent of the time; however, the effectiveness rate was 80 percent. Water was not well diverted before entering RMZ (Z8) with application of 63.8 percent and effectiveness of 73.0 percent. When water was diverted, it was not always diverted onto stable areas of the forest floor (Z9); this process had 71.3 percent application and 76.2 percent effectiveness. Roads and trails were not always stabilized as needed within the RMZ

(Z10), with an application rate of 77.4 percent and effectiveness rate of 80.7 percent. Ephemeral channels were not always free of excavated materials (Z11) with a 72.1-percent application rate and 72.8-percent effectiveness rate.

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

Dozer installing bridge for stream crossing on timber-harvest site.

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

## V. Discussion

The overall forestry BMP application rate for CLFW is 85.37 percent, and the overall effectiveness is 89.63 percent. There are many things that are being done well on CLFW harvests; however, in order to see the most improvement, BMPs with the most departures must be examined to determine how to best enhance the implementation of BMPs on Classified Forest sites.

The highlight of Indiana's Forestry BMPs in the last 21 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 95.1 percent and 98.6 percent, respectively. Log landings had a 94.3 percent application and 97.5 percent effectiveness rating. Access road runoff drainage and diversion was the only real concern. Each had an overall application rate of more than 88.7 percent and a 94.6 percent effectiveness rate. The only problem with log landings is the area concentrating and/or collecting runoff. This area had application rates of 85.5 percent but effectiveness was more than 95.6 percent, demonstrating that impacts to water quality were minimal.

Skid trails are where much of the work of a harvest occurs, so it is no surprise that many departures occur in this area. Skid trails had an overall application rate of 80.1 percent and effectiveness of 86.9 percent. These figures indicate 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 depending on how often equipment drives over a particular point on the trail. 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. An area traveled over only twice, once to access trees and the other pulling the logs out, has 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 adjacent vegetation will often limit the equipment's ability to place structures where they would be most effective.

Overall stream crossing BMP application is 71.5 percent, and overall effectiveness is 72.8 percent. Due to the nature of stream crossings, impacts to water quality are, at times, inevitable. However, the duration 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 a viable option. The largest problem on stream crossings is the diversion of water before the stream crossing, X4. State Forest sites were about 5 percent higher in application and effectiveness for stream crossings than CLFW sites. This individual BMP (X4) had an overall application of 47.6 percent and effectiveness of 52.4 percent. The proper design and stabilization of stream banks at crossings (X3) was also a problem area, with an overall application of 51.1 percent and effectiveness of 53.6 percent.

RMZs are much like stream crossings. Both are in close to water bodies. If there is a problem, it often leads to direct impacts to 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 an application rate at 76.9 percent. The effectiveness rate for overall RMZs was 82 percent. 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 58.8 percent and effectiveness of 61.1 percent overall. Z7, BMP concerning roads and landings in RMZ, had an application of 60 percent and effectiveness rate of

80 percent. Z8 is the BMP concerning water diversion before entry to the RMZ. Its application was 63.8 percent, and its effectiveness was 73 percent.

## 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 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 forestry BMP standards developed by the division and other stakeholders are revised and updated to reflect the current science.

It is the desire of the Division of Forestry 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. Forestry BMPs are the means by which this can be accomplished.