Monitoring Results • 1996-2021

Indiana Classified Forest & Wildlands

Forestry Best Management Practices

DNR
Indiana Department of Natural Resources

Forestry DNR

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By: Jennifer Sobecki & Duane McCoy

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I. Introduction & Indiana Forestry BMP History

A. Best Management Practice (BMP) Introduction

Indiana has 4.77 million acres of forestland, which is 20.7% of the state's land base, providing many benefits to Indiana residents and wildlife. Indiana state forest properties currently occupy 160,238 acres, 0.7% of the state. 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 do not participate in these activities benefit greatly from the biodiversity, clean air, and water that forests produce. Because forests are important to all citizens of Indiana, it is imperative that timber harvesting on all forests, of all land ownerships, be done in a way that reduces or mitigates environmental impacts. Although forests are known to be the best way to reduce non-point source pollution (NPS) to waterways, they also can generate pollutants. When forest soils are bared, NPS pollution can occur, and Best Management Practices (BMPs) are in place to minimize it.

Forestry BMPs are a foundation for water quality protection during forest operations. The purpose of BMPs is to minimize the impact of forest activities that may affect soil and water quality. This report summarizes the application and effectiveness of BMPs for timber harvests conducted on State Forest properties from 1996-2021. Data in this report cover all BMP monitoring for 721 state forest timber harvest sites over those years, looking at time trends and making comparisons.

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 (DoF), in cooperation with the Woodland Steward Institute, began a statewide 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 use, such as agriculture and development, that caused NPS pollution. In response, the Woodland Steward Institute took on "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. The respective forestry agency in each of the 50 states either developed a forestry BMP manual for its state or was heavily involved in such a document's development (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 DoF arranged a series of meetings that included individuals from many public agencies and private interests. In these meetings DoF representatives 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. Some of these activities enhance 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, which they declared as either voluntary or regulatory.

The Indiana forestry BMP program was divided into three main components. The first element was the BMP guidelines themselves, 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 loggers, landowners, and foresters. State forestry agencies nationwide have reported that 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.

Attendees look at the different aspects of a timber sale during BMP training. *Photo by Jennifer Sobecki.*

In 1996, timber-harvest sites were selected for BMP monitoring, 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 that were logged within the last two years 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 of four to five people were formed of people with diverse technical backgrounds. Each team was led by a DNR forester who provided technical and logistical support. Other team members came from the forest industry, the environmental community, landowners, planning and development professionals, and wildlife-biology, hydrology, and soil-conservation experts.

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, the Great Lakes Commission under the Clean Water Act, or some other federal program. Since 2009, 10% of all reported harvest on private lands in the Classified Forest & Wildlands Program have been monitored for BMPs. BMP monitoring has also become a staple on State Forest property harvest sites.

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. Since 2009, 10% 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 & Wildland

Since 2009, at least 10% of CLFW Program sites that had a harvest the previous year have been monitored. CLFW monitoring began to make their properties eligible for certification with the Forest Stewardship Council (FSC). These sites are randomly selected from the annual reports, which 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. 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, 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, and 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 reported CLFW harvests. In 2008, there were approximately 374 harvests from tracts in the CLFW program in which the Division of Forestry (DoF) conducted CLFW monitoring. From the total 374 sites reported to have been harvested in 2008, the DoF monitored 40 randomly selected sites, 10.69% 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 tracts in the CLFW program. From that total, the DoF monitored 45, which was 12.3% of the total sites harvested.

In 2011, CLFW monitoring consisted of 60 sites randomly selected from the 519 sites reported to have harvests in 2010. The 60 sites reviewed made up 11.6% of the CLFW sites 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% of sites in 2011 were monitored in 2012.

In 2013, monitoring consisted of 53 sites chosen randomly from 422 sites that reported a harvest in 2012. A total of 12.6% percent 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% of sites 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. A total of 11% of sites were monitored.

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

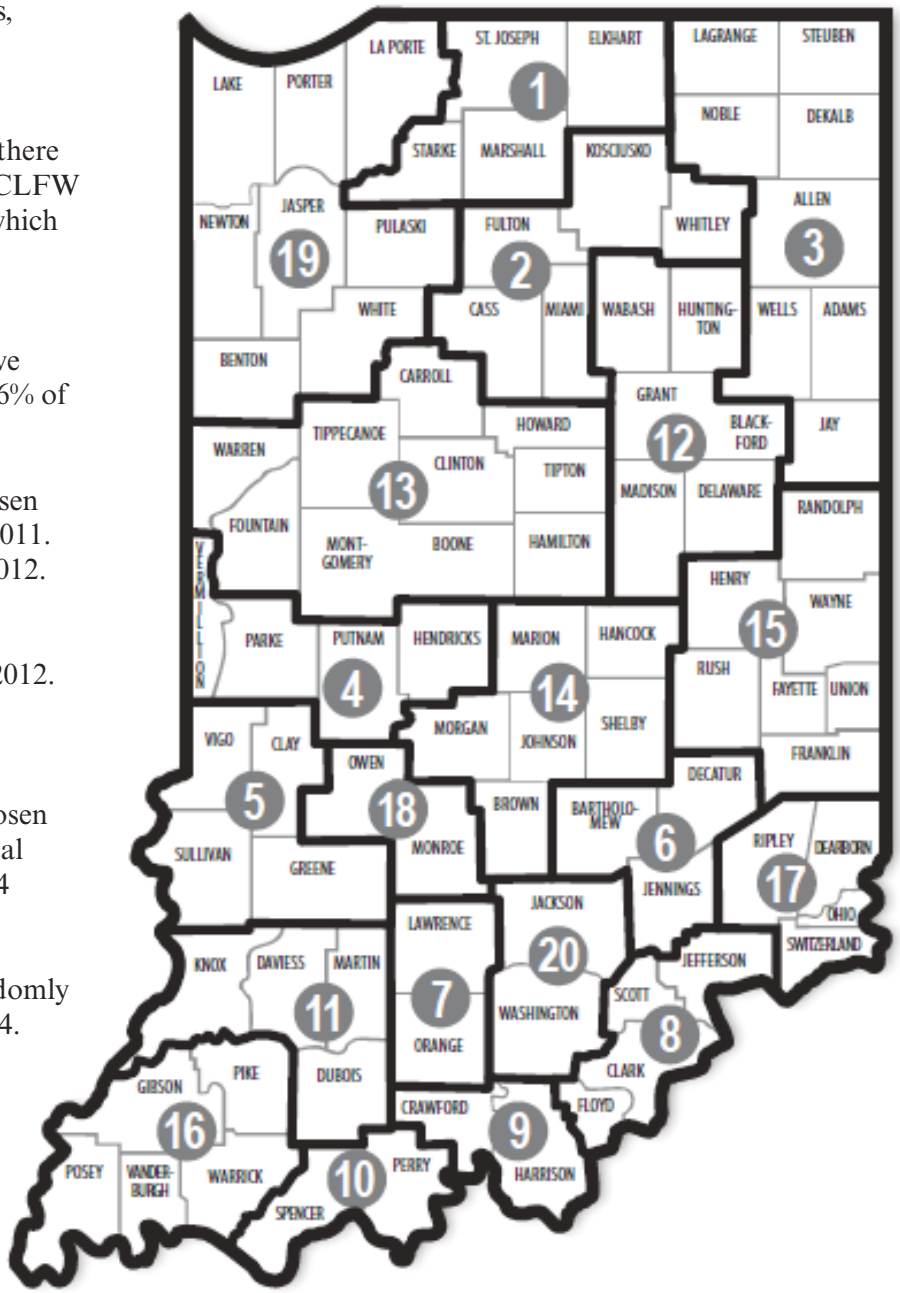
In 2017, monitoring consisted of 64 sites chosen randomly from 539 sites that were reported as harvested in 2016. A total of 11.9% of sites were monitored.

In 2018, 61 sites were randomly chosen from the 529 sites reported as harvested in 2017. That equated to 11.5% of sites being monitored.

In 2019, 45 sites were randomly chosen from the 395 sites reported to have had a harvest in 2018. That equaled 11.4% of sites being monitored.

FIGURE 1

Map of private forestry districts



In 2020 42 sites were chosen randomly from the 339 sites reported to have a harvest in 2019. A total of 12.4% of sites were monitored.

In 2021 51 sites were randomly chosen from the 395 sites reported to have had a harvest in 2020. A total of 12.9% of sites were monitored.

FIGURE 2

 # Classified Forest Sites Monitored by District

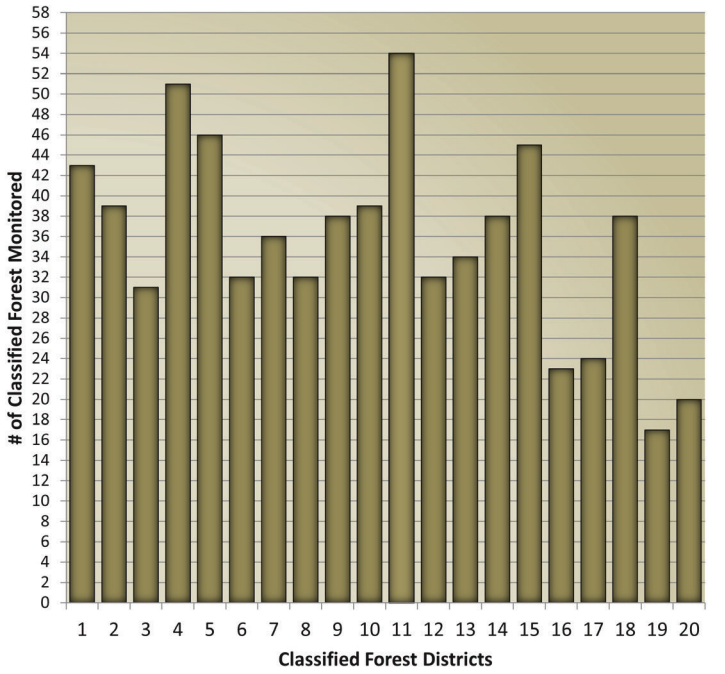


Figure 2. Number of CLFW timber-harvest sites monitored for BMPs by district through the 25-year history of the BMP program.

FIGURE 3

Classified Forest & Wildlands Sites Monitored for BMPs

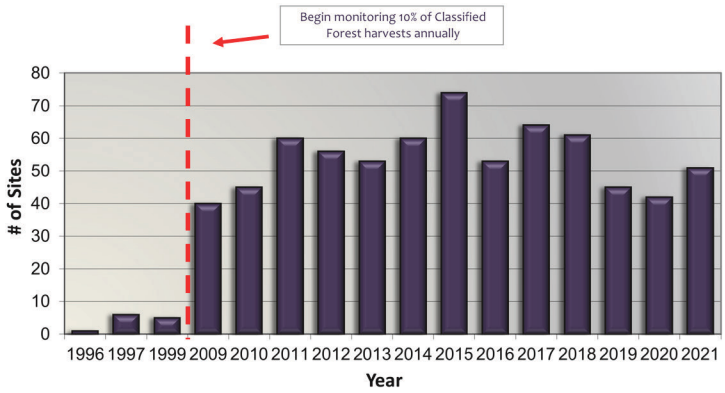


Figure 3. Total number of sites monitored each year since the program began.

C. Data Collection, Entry & Analysis

The BMP Monitoring Form is used to collect data both in the office and the 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 completed in the field during and after the site evaluation. See the "Site Evaluation" section for more details.

These raw datasheets are emailed 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 annual reports, Classified Forests & Wildlands and comprehensive reports of harvests on all land ownership types, quality-control reports, and other various 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 2021. It has also varied based upon the landownership and monitoring objectives. In the 2009 through 2021 monitoring of CLFW sites, the district forester and one or more of the BMP 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 practice for application and effectiveness. Application is the installation and 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.

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, its members come together to discuss each question and everyone's respective scores on the BMP monitoring form until they reach consensus as a team on a score for each question.

III. 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 716 CLFW timber harvests monitored between November 1996 and January 2021, ranging in size from one to 785 acres.

A total of 83.82% of the BMPs were applied as directed in the BMP guidelines, and 14.35% had minor departures as defined in the monitoring sheet. There have been 494 major departures, which add up to 1.77% of all practices monitored. Of the total 716 sites monitored on CLFW sites, 16 practices scored "Total Negligence" for 0.06%, as shown in Figure 4.

Effectiveness rates are used to evaluate the success of the BMPs applied to a site. The effectiveness rate for the 716 sites monitored is 88.46%. Indirect and temporary impacts to water quality were found 2.91% of the time. Indirect and prolonged impacts were found 1.4% of the time. Direct and temporary impacts occurred 3.68% of the time, and there were 3.54% direct and prolonged impacts to water quality. All of this is shown in Figure 5.

FIGURE 4

Classified Forest & Wildland BMP Application

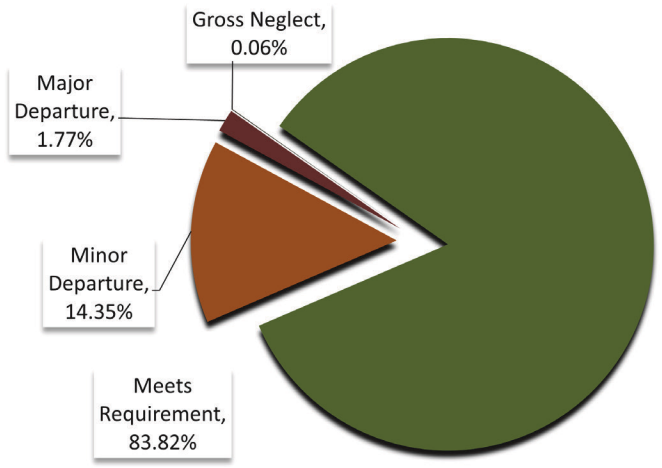


Figure 4. BMP Application for all 716 CLFW sites monitored from 1996 through 2021.

FIGURE 5

Classified Forest & Wildland BMP Effectiveness

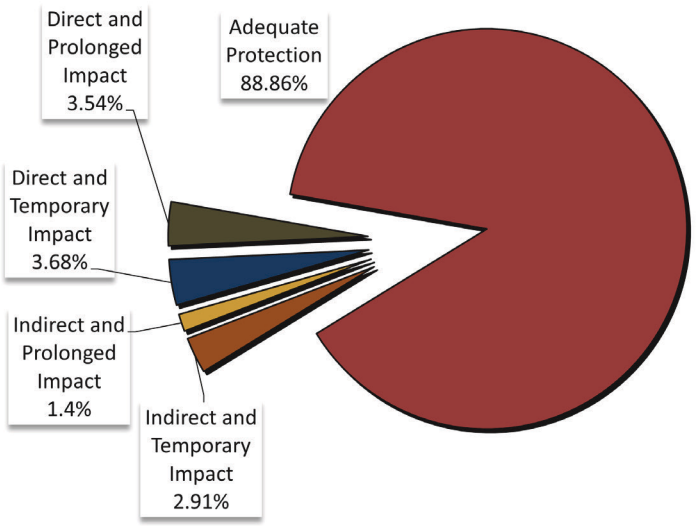


Figure 5. BMP Effectiveness for all 716 CLFW sites monitored from 1996 through 2021.

Application and effectiveness rates of sites monitored vary from year to year, and no real positive or negative trend can be extrapolated; however, there are several conclusions one can draw from Figure 6. First, effectiveness rates are commonly higher than application rates. Second, the rates seem to generally mirror one another.

FIGURE 6

Yearly Classified Forest BMP Overall Application & Effectiveness Rates

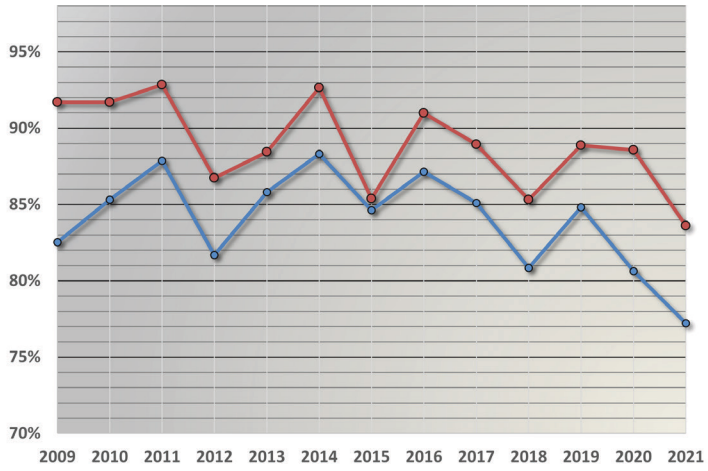


Figure 6. Yearly trends of overall BMP application and effectiveness scores on CLFW sites. These percentages are calculated for each year's data separately, rather than being combined with the running totals from previous years.

B. BMP Category Application & Effectiveness

Access roads and landings are timber harvest areas where much of the machine activity is concentrated, including the use of tractor trailers, which cannot handle much variation in the terrain when traveling. Because of this, access roads and log landings are often well drained, stabilized, 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 25 years of monitoring. Skid trails are usually 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 effective drainage for, given the trees, rough terrain, and soil-structure variability. Since 2011, skid trails have had applications scores near 80%. Skid trails usually lead to stream crossings and RMZ areas and are close to the water bodies. This means there is an increased chance for water quality impact, 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 with a 68% overall application.

FIGURE 7

Classified Forest BMP Application

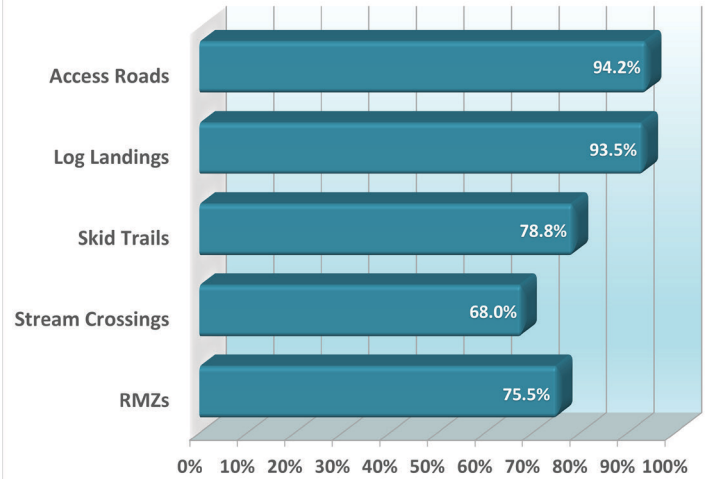


Figure 7. Overall BMP application percentages by BMP category.

Effectiveness trends mirror the application trends, with rates generally higher than application rates. As with application trends, effectiveness rates for access roads and log landings are consistently high, at least 5% higher than application rates for both categories. RMZ and skid trail application are similar, in the mid-70% area, while skid trails application is about 3% above RMZ effectiveness, also in the mid-70% area. Stream crossings came in last in both application and effectiveness, with application rates slightly lower than effectiveness. Most stream crossings, regardless of whether there are any errors in application, directly impact the water resources of the site due to their proximity to water.

FIGURE 8

Classified Forest BMP Application Yearly Trends

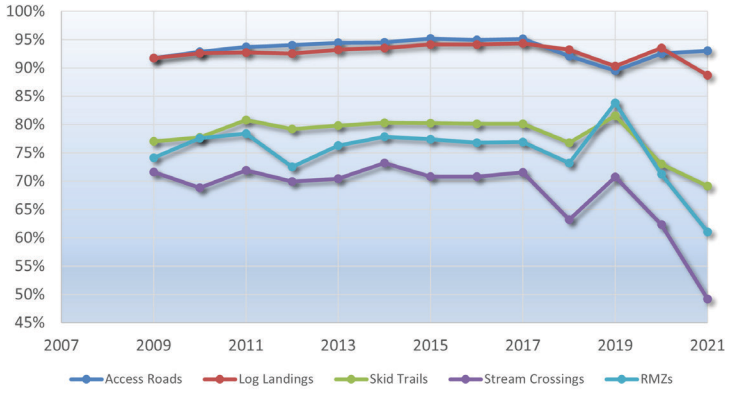


Figure 8. Yearly BMP application trends by category.

The overall BMP application and effectiveness for the five categories, access roads and log landings were the highest ranked, with access roads having a 94.2% application and 97.9% effectiveness rate. Log landing application rate was 93.5% and effectiveness was 97%. The third-highest category was skid trails, with 78.8% application and 86.3% effectiveness rates. RMZs ranked next to last, with 75.5% application and 81.2% effectiveness. The BMP area with the most difficulty was stream crossings, with an application of 68.0% and effectiveness of 69.3%. 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. Wet conditions can also lead to departures from effective management with stream crossings.

FIGURE 9

Classified Forest BMP Effectiveness

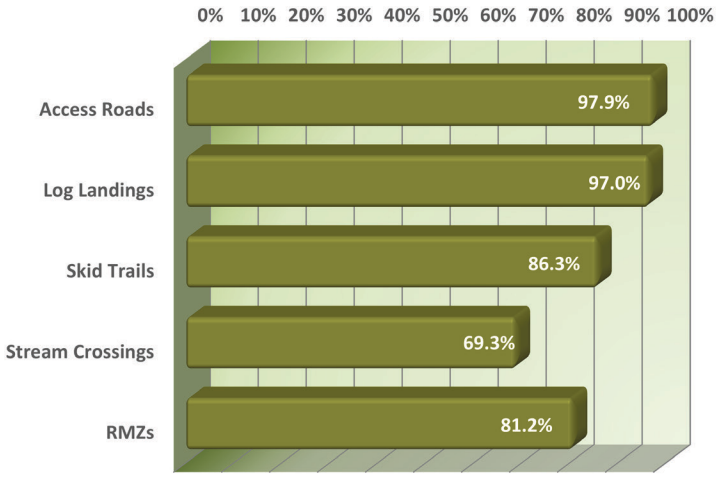


Figure: 9. Overall BMP effectiveness percentages by BMP category.

FIGURE 10

Classified Forest BMP Effectiveness Yearly Trends

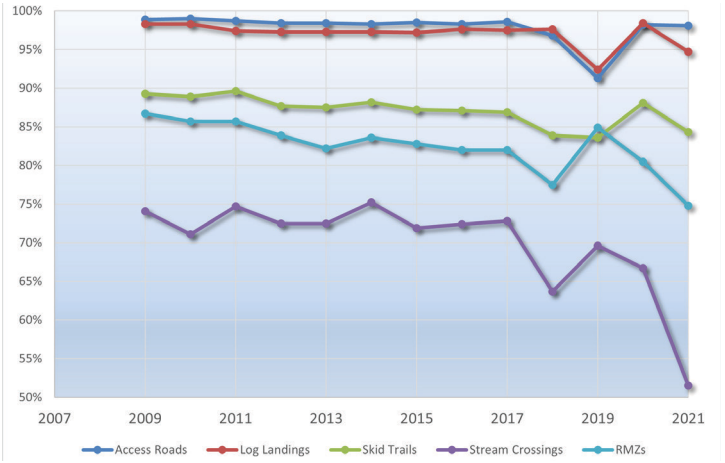


Figure 10. Overall BMP effectiveness yearly trends by BMP Category.

1. Access Roads

Access roads connecting the harvest area to the public road system aid the transport of logs to mills for processing. This connection means that regular vehicles, such as tractor trailers, need to be able to traverse them without difficulty. Often access roads are stable and have a good base or are very short, so they are commonly 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 than skid trails.

Access roads on CLFWs, as with most private lands, are not as long as those on public properties. Not as much is invested in them. Since access roads on private property are not used as often as those on public forests, they generally do not have as strong a base as state forest roads to support intense traffic over the short term. That often poses a different set of problems from access roads on State Forest properties.

Stable access road with rock and water diversions.
Photo by Jennifer Sobecki.

Table 1 depicts the breakdown of each individual BMP specification in access roads from all 716 sites across the 25-year monitoring period. CLFWs had two areas of application concern. A10: "Appropriate road stabilization, drainage and diversion installed" has application rate of 84.4%; however, the effectiveness was 91.4%. A15: "Traffic barriers installed" had a 70.4% implementation rate, but the effectiveness rate was 97.7%, 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.

TABLE 1 Access road BMP application and effectiveness for all CLFW sites monitored from 1996-2020.

Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.2	99.8
A2. Adequate buffer strip next to watercourses and sensitive areas	93.8	98.7
A3. Avoids unstable gullies, seeps, very poorly drained areas	95.2	97.5
A4. Road grades are within standards	98.3	99.6
A5. Amount of roads minimized	100.0	100.0
A6. Stream crossings minimized	99.7	99.3
A7. Road excavation minimized	99.6	100.0
A8. Excavated and fill materials placed properly	99.8	99.8
A9. Roads constructed to drain well	86.5	94.4
A10. Appropriate road stabilization, drainage, and diversions installed	84.7	91.8
A11. Water diversions functioning properly	95.1	95.6
A12. Runoff diverted onto stable forest floor areas	91.6	94.4
A13. Mud kept off public roadways	99.6	99.8
A14. Public road's drainage maintained	99.6	99.8
A15. Traffic barriers installed	70.4	97.7
Overall Access Road	94.2	97.9

2. Log Landings

Log landings are the areas of highest equipment concentration. Equipment brings the logs to the landing from where they were standing. They are then cut to length and piled by grade and species, then the piles are loaded onto trucks by either a knuckle boom or loader and hauled 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 of all the equipment gathering in this one area.

Landings on CLFW sites commonly have one landing that is used only 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 landings with common departures in application. Individual BMPs for Y2: "Landings located outside RMZ" is 89.8%, Y5: "Landings avoid concentrating or collecting runoff," 86.0%. Each has a high effectiveness rate.

A well-closed-out log landing, smoothed, strawed, and seeded. *Photo by Duane McCoy.*

Log landing was properly closed out, smoothed, and seeded in the fall. The resulting grass has protected the landing during the winter. *Photo by Duane McCoy.*

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

Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	98.2	99.7
Y2. Landings located outside RMZ	89.8	97.0
Y3. Landings located on stable areas	94.6	97.5
Y4. Excavation of site minimized	98.0	99.5
Y5. Landings avoid concentrating or collecting runoff	86.0	95.2
Y6. Landing's runoff enters stable area	89.5	93.5
Y7. Proper water diversions in working order	89.5	93.2
Y8. Landing smoothed and soil stabilized	91.3	95.5
Y9. Landings free of fuel and lubricant spills, and litter	98.8	99.3
Y10. Landing location suitable for equipment fueling, and maintenance	98.3	99.5
Overall Log Landings	93.5	97.0

3. Skid Trails

Skid trails are where equipment moves logs from the place where the trees were standing to the landing. These trails are used intermittently so they have varying degrees of exposure and compaction. Different equipment can also influence this.

Physical obstacles, slopes, water bodies, and other kinds of topographic features are just some features of skid trails. They 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. 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 have the lowest percentage of BMP compliance on a timber harvest with respect to application. Their impact to water quality can vary widely due to their proximity to water bodies.

Skid trails on CLFW sites are commonly shorter than those on State Forest harvest sites, but there are a few similarities. They are commonly on marginal terrain, they may be very steep or wet, or they were likely converted to forest from crop or pasture fields. 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 those on state and federal properties. Nevertheless, there are some CLFW and other private sites in areas that do have erosion problems, 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 44.3%, but this is a 16.1% increase from 28.2% in the 2011 report.

Harvest debris can be a great way to armor a trail and create water diversions. *Photo by Evan McDevitt.*

The effectiveness rate for appropriate drainage and diversions installed was 62.3%. These numbers indicate that implementation departures in this area may be having some impact on water quality on CLFW harvest sites. 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 70.9%, 73.9% and 70.1%, respectively. Effectiveness rates for S2 are 86.5%, 81.5% for S8, and 76% for S9. These departures in application seem to have minimal total effect on water resources of the sites, with overall effectiveness at 86.3%.

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

Skid Trails	% Application	% Effective
S1. Uses existing routes were appropriate	96.3	97.6
S2. Adequate buffer strip next to water courses and sensitive areas	70.9	86.5
S3. Avoids steep and long straight grades (>20% for >200')	85.3	93.8
S4. Avoids unstable gullies, seeps, poorly drained areas	80.1	90.4
S5. Amount of skid trails minimized	89.7	94.9
S6. Trail excavation minimized	89.9	92.8
S7. Appropriate drainage and diversions installed	44.3	62.3
S8. Water diversions in working order	73.9	81.5
S9. Runoff diverted onto stable forest floor areas	70.1	76.0
S10. Streams not used as skid trails (except for crossings)	85.4	85.7
Overall Skid Trail	78.8	86.3

This waterbar at the top of a hill was poorly constructed, leading to a breach of the waterbar, which allowed water to run down the trail, causing erosion. *Photo by Jennifer Sobecki.*

Using this bridge to cross a small intermittent stream protects the stream banks and reduces the amount of soil entering the water. *Photo by Duane McCoy.*

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 on water quality. Every practice could be applied without departure, and there could still be an impact on water quality. BMP training often emphasizes using a minimal number of stream crossings and mitigating their possible impacts by practicing BMPs for this reason.

Stream crossings on Classified Forest sites had lower application scores on five questions, which lead to direct impacts from the crossings that were monitored. These shortcomings in application lead to unstable banks because they affect the flow of water, which can lead to direct and prolonged impacts. An example of this is X2, "crossings minimize disturbance to natural bed and banks," which had an application score of 52.7% and effectiveness of 54.4%. Due to this departure, the banks may have been compromised so that X9, "fords have stable banks and streambeds" gets low scores as well. The proper design and stabilization of stream-bank approaches (X3) were low, at 43.5% for application and 46.0% 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 40.2%, for an effectiveness rate of 45.0%. X13 had concerns with the removal of temporary crossing structures and resulting obstructions, and reported application and effectiveness rates were 60.6% each. Many of these cases result when log corduroy bridges and/or fill used for stream crossings are not pulled out after harvest is closed. X13 can have an impact on X2 as well.

Corduroy logs not removed from a stream after harvest. *Photo by: Duane McCoy.*

TABLE 4 Stream Crossing BMP application and effectiveness for all CLFW sites monitored.

Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	89.0	89.4
X2. Crossings minimize disturbance to the natural bed and banks	52.7	54.4
X3. Streambank approaches properly designed and stabilized	43.5	46.0
X4. Water runoff diverted from road prior to crossing	40.2	45.0
X5. Crossing as close to 90 degrees as practicable	89.9	91.3
X6. Crossing does not unduly restrict water flow	78.0	79.2
X7. Soil has not been used as fill in the stream (except culverts)	73.4	73.4
X8. Ford constructed of non-erosive materials	78.3	77.3
X9. Fords have stable banks and streambeds	50.3	50.7
X10. Culverts are properly sized and installed	75.8	80.3
X11. Culverts clear of significant flow obstructions	84.6	87.7
X12. Temporary structures properly anchored	89.1	87.0
X13. Temporary structures and resulting obstructions removed	60.6	60.6
Stream Crossing	68.0	69.3

5. Riparian Management Zones

Riparian Management Zones are the areas of land that transition between upland and a waterbody and therefore are like a stream crossing because they are close to the water and are more likely to have a direct impact on water bodies. RMZs are different widths according to the type of water body and the slope of the ground. 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%, whereas the same stream with the ground next to it at 40% 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% slope, but if the slope changes to 20% to 40%, then the RMZ for the open sinkhole is 105 feet. RMZs, defined this way, are physically similar across landowner types. Any differences in application and effectiveness scores between landowner types is the result of landowners and/or foresters' involvement, and their ability and desire to enforce these guidelines.

Obstructing debris logging in streams (Z2) has a score of 59.7% application and 61.9% effectiveness. RMZs "free of roads and landings" (Z7) with a 61.1% implementation rate, effectiveness was 80.6%. Water was not commonly diverted before entering RMZ (Z8) with application of 57.6% and effectiveness of 68.2%. When water was diverted, it was not always diverted onto stable areas of the forest floor (Z9); this process had 66.0% application and 72.5% effectiveness. Ephemeral channels were not always free of excavated materials (Z11) with a 69.7% application rate and 71.4% effectiveness rate.

TABLE 5 Total RMZ widths*

Watercourse Characteristics	0-5% slope	5-10% slope	10-20% slope	20-40% slope	40%+ slope	Primary RMZ
Perennial 40' Wide	200	200	200	200	200	200 feet
Perennial 20-40' Wide	75	75	75	105	105-165	75
Perennial 20' Wide	50	50	65	105	105-165	35
Intermittent	25	45	65	105	105-165	--
Sinkhole Openings	25	45	65	105	105-165	--
Water supply reservoirs and their perennial streams	75	90	130	210	210-300	75
Other lakes and ponds	35	45	65	105	105-165	35

**widths in feet on each side of the watercourse*

Harvest debris left in a stream, causing additional debris build up and blockage of flow.
Photo by Duane McCoy.

IV. Discussion

The overall forestry BMP application rate for CLFW is 83.82%, and the overall effectiveness is 88.46%. There are many things that are being done well on CLFW harvests; however, 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 25 years has been the high implementation and performance rates in access roads and log landings. Access road application and effectiveness rates were 94.2% and 97.9%, respectively. Log landings had a 93.5% application and 97% effectiveness rating. Access road runoff drainage and diversion may be a concern. This practice has an application rate of more than 84.7% and a 91.8% effectiveness rate. The only problem with log landings is the area concentrating and/or collecting runoff. This area had application rates of 86%, but effectiveness was more than 95.2%, demonstrating that impacts to water quality were minimal.

Skid trails are where much of the work of a harvest occurs. Skid trails traverse other harvest areas such as stream crossings and RMZs. Therefore, practices not carried out on skid trails show up in the other areas and vice versa. Skid trails had an overall application rate of 78.8% and effectiveness of 86.3%. These figures indicate that although there are some difficulties carrying out BMPs on skid trails, most do not result in large impacts to water quality. Skid trails can have many 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 to 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. Appropriate drainage and diversion is challenging on skid trails with 44.3% application and 62.3% effectiveness.

Overall stream crossing BMP application is 68.0%, and overall effectiveness is 69.3%. Due to the nature of stream crossings, impacts to water quality are, at times, inevitable. However, the duration and severity of impacts can be mitigated 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 18% higher in application and 14% higher in effectiveness for runoff diverted before stream crossings (X4) than CLFW sites. This individual BMP (X4) had an overall application of 40.2% and effectiveness of 45.0%. The proper design and stabilization of stream banks at crossings (X3) was also a problem area, with an overall application of 58.2% and effectiveness of 59.9%. Another area of stream crossing BMPs that differs greatly from State Forests is X13, removing temporary crossing structures, in most cases corduroy bridges. The state sites have a 19% higher application and 16% effectiveness rate for removing these obstructions after a harvest is completed. Culvert sizing and maintenance is higher in application and effectiveness for private classified sites compared to state sites. Culvert maintenance application and effectiveness is around 17% higher on Classified Forests. This is likely since many of the lanes used for private forest are multi-use by the landowner and are driven on often. Sizing and maintenance are key to keeping these roads functional. On state forest crossings,

culverts are much less frequent and not typically in heavy use, therefore maintenance does not occur as often.

RMZs are much like stream crossings. Both are near water bodies, so if there is a problem, it often leads to direct impacts to water quality. 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 76.7 %. The effectiveness rate for overall RMZs was 81.7%. The two main problem areas for RMZs were 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 59.7% and effectiveness of 61.9% overall. Z7, BMP concerning roads and landings in RMZ had an application of 61.1% and effectiveness rate of 80.6%. Z8 is the BMP concerning water diversions before entry to the RMZ. Its application was 57.6%, and its effectiveness was 68.2%.

Forest opening created by a harvest. *Photo by Jamie Winner.*

V. Recommendations

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

Continue to emphasize the 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.

The difference in removal of temporary structures from a stream crossing after a harvest (generally corduroy logs) is 19% lower for Classified Forest harvests than state forest sites. Importance of removal of these obstructions to stream flow needs to continue to be emphasized to landowners and loggers.

VI. Conclusions

Since 1996, the Indiana Division of Forestry has provided forestry BMP leadership, training, and implementation for private, industrial, 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 goal of the Division of Forestry to use information that is found in this and similar reports to raise awareness to the challenging areas of forestry BMPs and to continue to improve. Managing Indiana's timberlands for forest production while maintaining the highest environmental quality is of the utmost importance to the division. Forestry BMPs are how this can be accomplished.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