Monitoring Results • 1996-2022

Indiana Classified Forest & Wildlands

Forestry Best Management Practices

DNR
Indiana Department of Natural Resources

Forestry DNR

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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 21% 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 our forests produce. Because 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) in waterways, they also can be a source of pollutants. When forest soils are disturbed, NPS pollution can 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. They are also guidelines for protecting water quality during forest operations. The purpose of BMPs is to minimize the impact of forest activities that can 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 1996-2021. There are 864,363 acres of land in the Classified Forest & Wildlands (CLFW) program statewide. This acreage is owned by 13,025 landowners in 17,822 tracts. The data covers all BMP monitoring for 754 CLFW sites during 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, 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 (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 committees were set up 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—some of the practices even 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 Forestry BMPs, but were given the option of making the use 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 Indiana Forestry BMP field guide was updated in 2022. www.IN.gov/dnr/forestry/files/BMP.pdf

The second component was BMP training, which consisted of teaching the BMPs to the different members 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). A total of 1,057 forestry professionals have been trained by the Division of Forestry staff since 1998. 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. Thus far, more than 1,680 sites throughout the state on a wide variety of landowner types have been evaluated for Forestry BMPs after a harvest.

DNR Forestry staff trains loggers on the application of BMPs.

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 that had been logged within the 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 planning-and-development, wildlife-biology, hydrology, or soil-conservation backgrounds. 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 as necessary over time. 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% 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

FIGURE 1

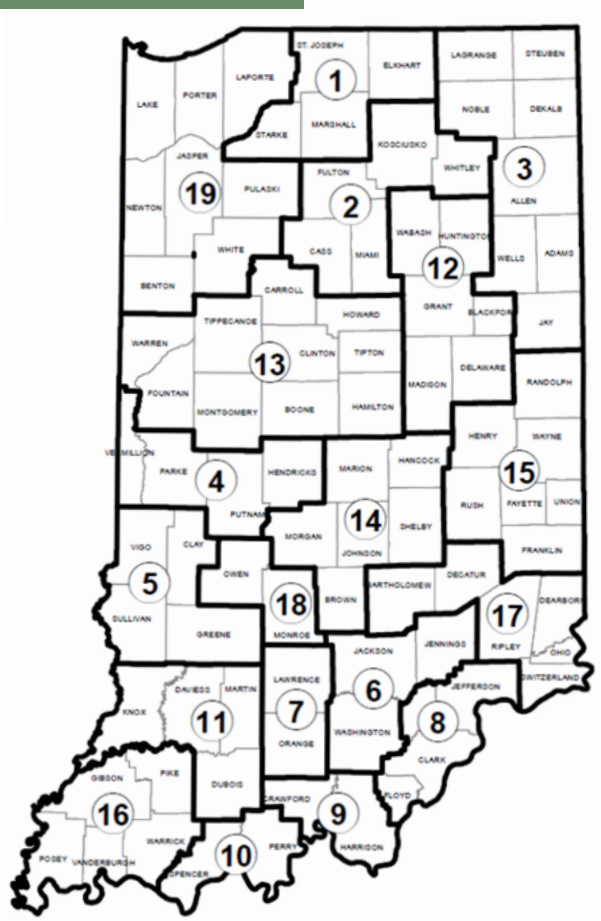

Figure 1: Current Classified Forest & Wildland District lines. These districts have shifted over time with changes in workload per county and staff availability. Note that District 20 is not active at this time.

Since 2009, at least 10% of CLFW Program sites that reported having a harvest the previous year have been 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. As the annual reports come 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, as shown in Table 1. 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 having 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.

TABLE 1 Number of harvests reported, and sites monitored per year since monitoring of 10% of sites began.

Year	Number of Harvests reported	Number of sites monitored	% of reported sites monitored
2009	374	40	10.7
2010	366	45	12.3
2011	519	60	11.6
2012	467	56	12.0
2013	422	53	12.6
2014	515	60	11.6
2015	672	74	11.0
2016	460	53	11.5
2017	539	64	11.9
2018	529	61	11.5
2019	395	45	11.4
2020	339	42	12.4
2021	395	51	12.9
2022	302	38	12.6

FIGURE 2

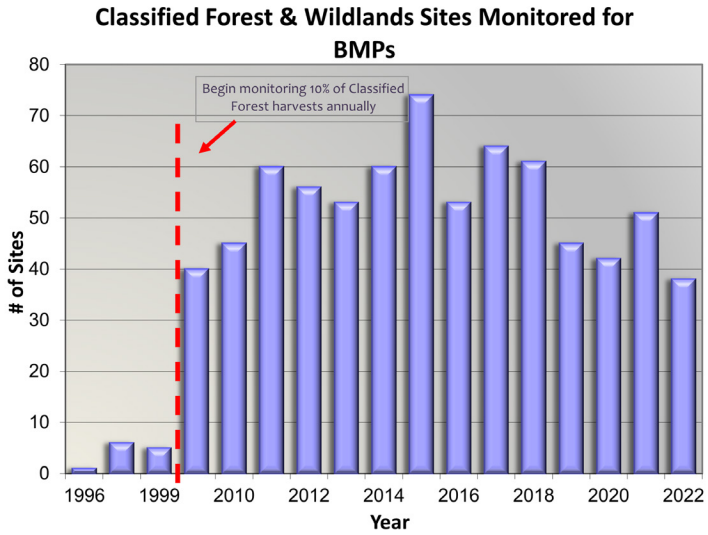

Figure 2: Number of CLFW timber-harvest sites monitored for BMPs through the 25-year history of the BMP program.

FIGURE 3

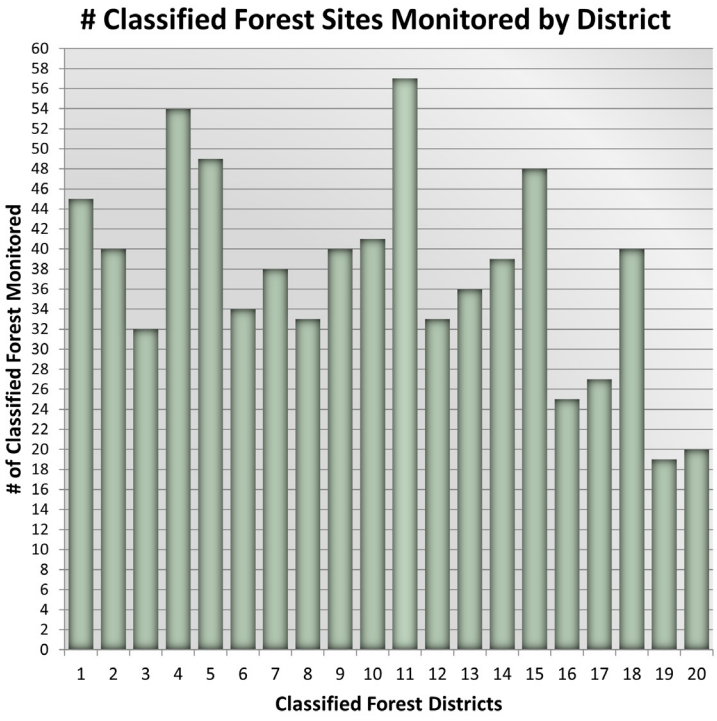

Figure 3: Number of sites monitored per each district since monitoring began.

C. Data Collection, Entry & 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 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 Division of Forestry 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 and quality-control reports.

D. Monitoring Team Selection

The selection of monitoring parties has been modified during 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 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 body of water or the level of impact the pollutant is having on the body of water 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, bodies of water, 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 each individual's respective scores on the BMP monitoring form until they reach consensus as a team on each 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 754 CLFW timber harvests monitored between November 1996 and March 2022, ranging in size from 1 to 785 acres.

A total of 83.62% of the BMPs were applied as directed in the BMP guidelines, and 14.58% had minor departures as defined in the monitoring sheet. There have been 511 major departures, which add up to 1.74% of all practices monitored. Of the total 754 sites monitored on CLFW sites, 16 practices scored "Total Negligence" for 0.05%, 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 754 sites monitored is 88.25%. Indirect and temporary impacts to water quality were found 3.1% of the time. Indirect and prolonged impacts were found 1.43% of the time. Direct and temporary impacts occurred 3.66% of the time, and there were 3.57% direct and prolonged impacts to water quality. All of this is shown in Figure 5.

FIGURE 4

Classified Forest & Wildland BMP Application

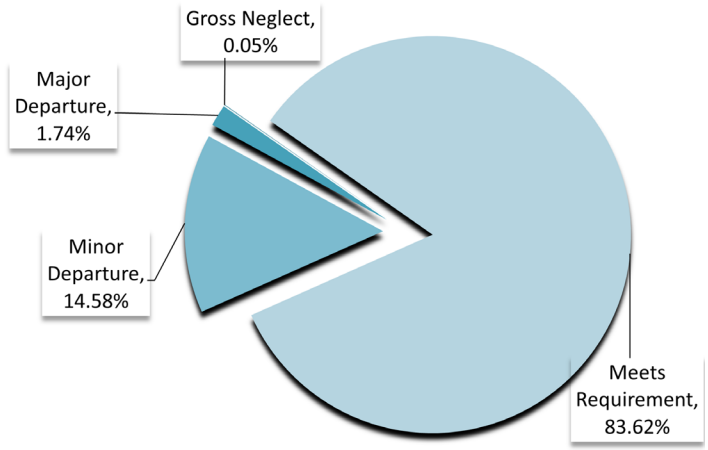

Figure 4. BMP Application for all 754 CLFW sites monitored from 1996 through 2022.

FIGURE 5

Classified Forest & Wildlands BMP Effectiveness

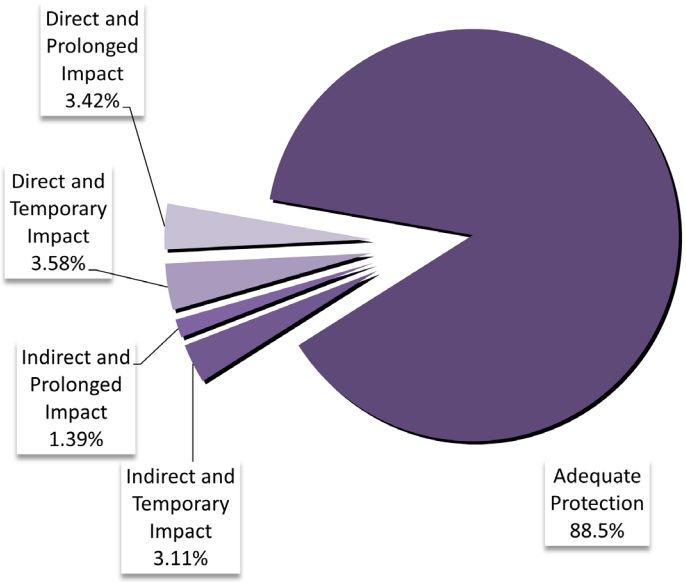

Figure 5. BMP Effectiveness for all 754 CLFW sites monitored from 1996 through 2022.

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.

FIGURE 6

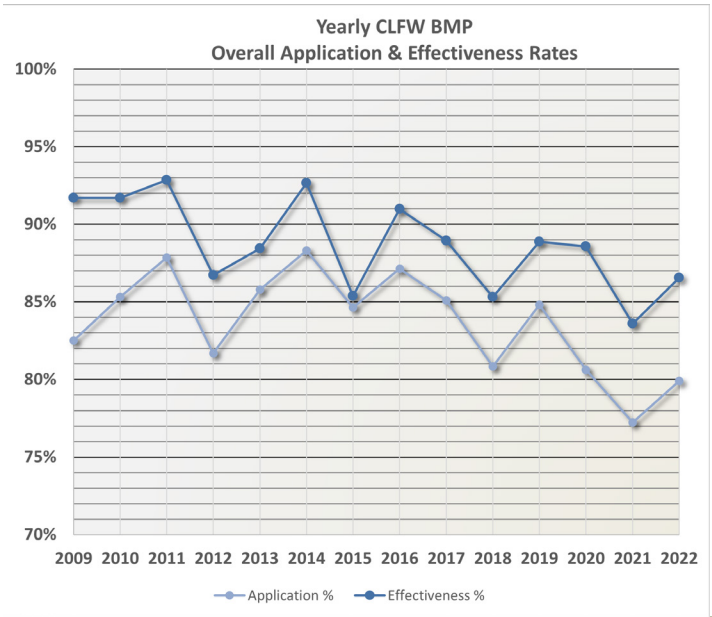

Figure 6. Yearly trends of overall BMP application and effectiveness scores on CLFW sites. These percentages are calculated for each year's data separately rather than being combined with the running totals from previous years.

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 7

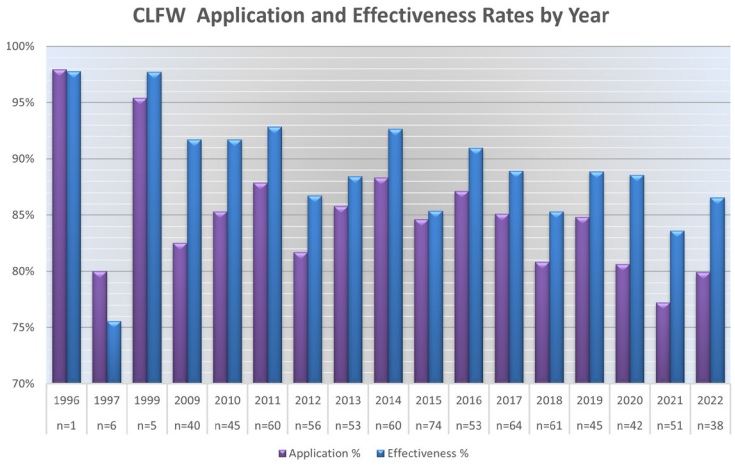

Figure 7. Application and effectiveness scores annually for Classified Forest & Wildland sites.

B. BMP Category Application & Effectiveness

FIGURE 8

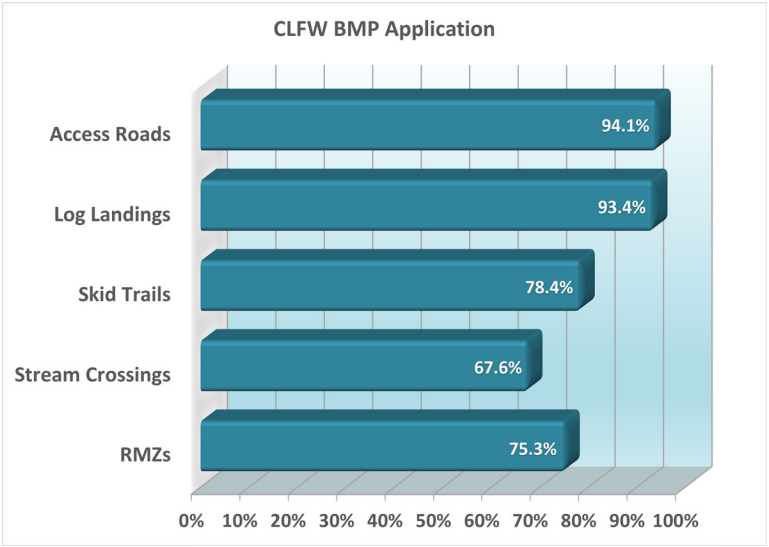

Figure 8: Overall BMP application percentages by BMP category.

FIGURE 9

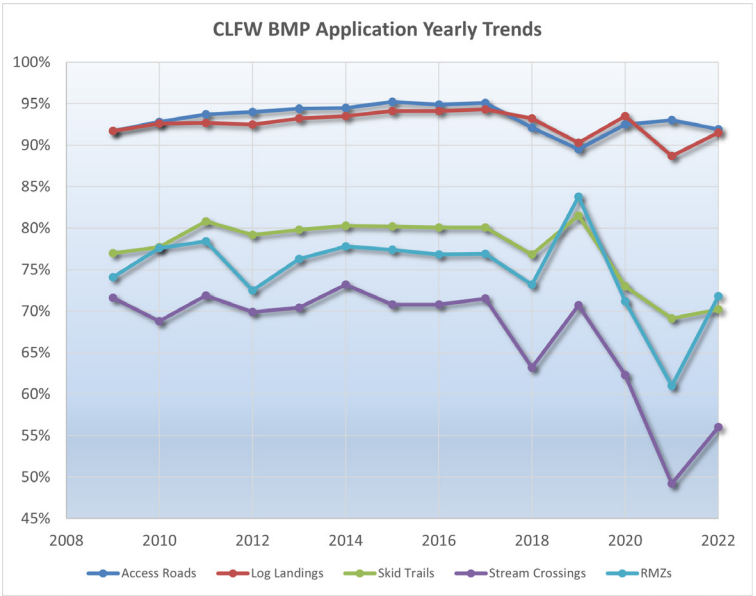

Figure 9. Yearly BMP application trends by BMP category.

Access roads and landings are areas of a timber harvest where machines concentrate much of their activity, including the use of 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 bodies of water 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 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%. Skid trails usually lead to stream crossings, and RMZ areas and are close to the bodies of water. This means there is an increased chance for 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 with a 67.6% overall application.

FIGURE 10

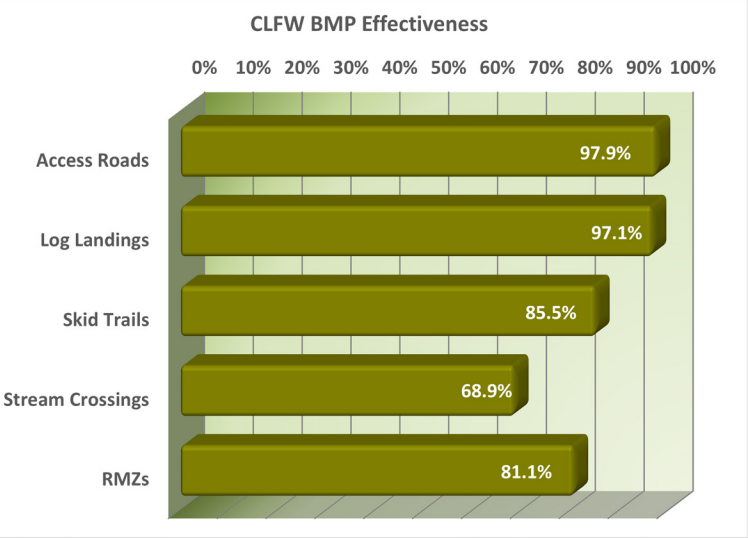

Figure: 10. Overall BMP effectiveness percentages by BMP category.

FIGURE 11

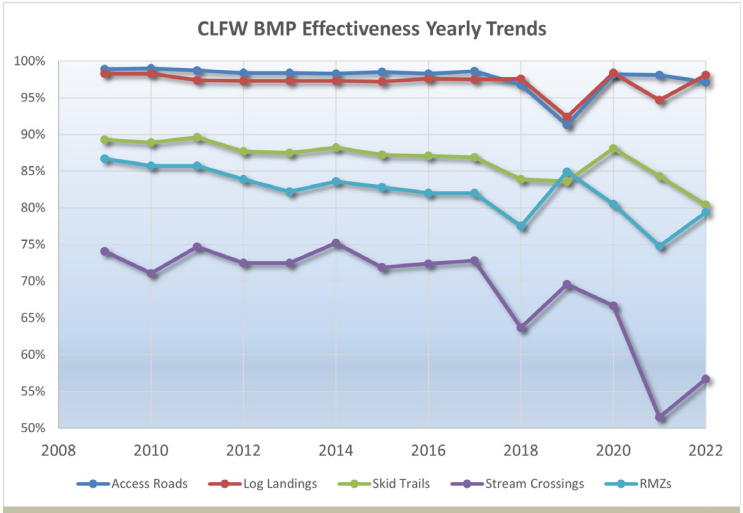

Figure 11. Overall BMP effectiveness yearly trends by BMP Category.

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% or higher than application rates for both categories. RMZ and skid trail application are similar, in the mid 70%, while skid trails application is about 3% above RMZ effectiveness, in the mid 70s%. Stream crossings came in last in both application and effectiveness, with application rates slightly lower than effectiveness. Due to the nature of stream crossings, regardless of whether there are any errors in application, most impacts are direct to the water resources of the site, so any problems in this area are more likely to be 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 94.1% application and 97.9% effectiveness rate. Log landing application rate was 93.4%, and effectiveness was 97.1%. The third-highest category was skid trails, with 78.4% application and 85.5% effectiveness rates. RMZs ranked next to last, with 75.3% application and 81.1% effectiveness. The BMP area with the most difficulty was stream crossings, with an application of 67.6% and effectiveness of 68.9%. 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 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 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 commonly away from bodies of water 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. Generally, less money is invested in them. They generally do not have as strong a base to support the intense traffic over the short term. That often poses a different set of problems from access roads on State Forest properties, which tend to establish stable access roads to reach multiple tracts over the long term.

Table 1 depicts the breakdown of each individual BMP specification in the area of access roads from all 754 sites monitored 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 84.3%; however, the effectiveness was 91.8%. A15: "Traffic barriers installed" had a 70.6% 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 2 Access road BMP application and effectiveness for all CLFW sites monitored from 1996 through 2022.

Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.2	99.8
A2. Adequate buffer strip next to watercourses and sensitive areas	93.5	98.7
A3. Avoids unstable gullies, seeps, very poorly drained areas	94.7	97.5
A4. Road grades are within standards	98.4	99.6
A5. Amount of roads minimized	100.0	100.0
A6. Stream crossings minimized	99.8	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	85.7	94.4
A10. Appropriate road stabilization, drainage and diversions installed	84.3	91.8
A11. Water diversions functioning properly	95.1	95.6
A12. Runoff diverted onto stable forest floor areas	91.2	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	70.6	97.7
Overall Access Road	94.1	97.9

2. Log Landings

Log landings are the areas of highest equipment concentration. Equipment brings the logs to the landing from the area where they were standing in the woods. The logs 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 then the trucks haul 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 of all of the equipment gathering in this one area.

Landings on CLFW sites commonly have only 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 89.9%, Y5: "Landings avoid concentrating or collecting runoff," 85.6%. Each has a high effectiveness rate, exceeding 95%.

Crop fields are often used for log landings during the dormant portions of the year.

Wet and unstabilized landings can lead to many delays in the harvest and cause long-term damage to the site.

TABLE 3 Log landing BMP application and effectiveness for all CLFW sites monitored.

Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	98.3	99.7
Y2. Landings located outside RMZ	89.9	97.0
Y3. Landings located on stable areas	94.7	97.7
Y4. Excavation of site minimized	98.0	99.4
Y5. Landings avoid concentrating or collecting runoff	85.6	95.3
Y6. Landing's runoff enters stable area	89.1	93.5
Y7. Proper water diversions in working order	89.1	93.5
Y8. Landing smoothed and soil stabilized	91.1	95.6
Y9. Landings free of fuel and lubricant spills and litter	98.7	99.4
Y10. Landing location suitable for equipment fueling and maintenance	98.3	99.5
Overall Log Landings	93.4	97.1

Seed and straw on a skid trail stabilize and protect soil until new vegetation can be established.

A skid trail crossing an unmapped intermittent diverts water from the stream down the skid trail.

3. Skid Trails

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, bodies of water, 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 a 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 bodies of water.

Skid trails on CLFW sites are commonly shorter than those on State Forest harvest sites, but they have a few similarities. They are commonly on marginal terrain, they may be very steep and 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 are those on state and federal properties; however, there are some CLFW and other private sites in areas that 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 43.6%; however, this is a 15.4% increase from 28.2% in the 2011 report. The effectiveness rate for appropriate drainage and diversions installed was 60.7%. These numbers indicate that implementation departures in this area may be having some level of 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 70.1%, 73.2%, and 69.1%, respectively. Effectiveness rates for S2 are 84.8%, 80.5% for S8, and 74.6% for S9. These departures in application seem to have minimal total effect on water resources of the sites, with overall effectiveness at 85.5%.

TABLE 4 Skid trail BMP application and effectiveness for all CLFW sites monitored.

Skid Trails	% Application	% Effective
S1. Uses existing routes were appropriate	96.6	97.6
S2. Adequate buffer strip next to water courses and sensitive areas	70.1	84.8
S3. Avoids steep and long straight grades (>20% for >200')	85.4	93.5
S4. Avoids unstable gullies, seeps, poorly drained areas	78.8	88.6
S5. Amount of skid trails minimized	89.9	94.8
S6. Trail excavation minimized	90.2	92.9
S7. Appropriate drainage and diversions installed	43.6	60.7
S8. Water diversions in working order	73.2	80.5
S9. Runoff diverted onto stable forest floor areas	69.1	74.6
S10. Streams not used as skid trails (except for crossings)	85.0	85.3
Overall Skid Trail	78.4	85.5

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.

Stream crossings on Classified Forest sites had lower application scores on five specific questions that lead to direct impacts from the crossings that were monitored. These shortcomings in application lead to unstable banks because they have weakened the banks themselves or affected 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 52.3% and effectiveness of 53.4%. 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 42.1% for application and 45.1% 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 39.6% for an effectiveness rate of 44.3%. Because these practices are low in implementation, the "fords have stable banks and streambeds", (X9) with application and effectiveness rate of 49.7% and 50.2%. X13 had concerns with the removal of temporary crossing structures and resulting obstructions, and reported application and effectiveness rates were 60.9% for 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.

TABLE 5 Stream Crossing BMP application and effectiveness for all CLFW sites monitored.

Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	89.2	89.7
X2. Crossings minimize disturbance to the natural bed and banks	52.3	53.4
X3. Streambank approaches properly designed and stabilized	42.1	45.1
X4. Water runoff diverted from road prior to crossing	39.6	44.3
X5. Crossing as close to 90 degrees as practicable	88.9	90.2
X6. Crossing does not unduly restrict water flow	77.2	78.3
X7. Soil has not been used as fill in the stream (except culverts)	72.8	72.8
X8. Ford constructed of non-erosive materials	78.2	77.2
X9. Fords have stable banks and streambeds	49.7	50.2
X10. Culverts are properly sized and installed	74.6	79.1
X11. Culverts clear of significant flow obstructions	85.1	87.9
X12. Temporary structures properly anchored	87.8	87.8
X13. Temporary structures and resulting obstructions removed	62.3	60.9
Stream Crossing	67.6	69.9

This stream crossing is lined with flat rocks that protect the approaches and stream bed.

There are multiple issues with this stream crossing. The culvert is too small, causing a backup of water on the upstream side. Water was not diverted from the trail, and the trail was not armored as it crossed the stream, so there is ponding and very muddy conditions on the crossing.

5. Riparian Management Zones

Tops felled into a stream cause debris to build up in the stream.

Riparian Management Zones are the areas of land that transition between upland and a body of water and therefore are much like a stream crossing in that they are close the water and are more likely to have a direct impact. RMZs are different widths according to the type of waterbody 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. See full list of RMZ widths at https://www.in.gov/dnr/forestry/files/BMP.pdf

TABLE 6 RMZ BMP application and effectiveness of all CLFW sites monitored.

Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	60.0	62.1
Z3. Tree tops and cutoffs placed back from water course to prevent movement into streams during floods	86.8	92.3
Z4. RMZ free of excavated material & debris (other than above)	92.3	95.4
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	96.9	99.2
Z7. RMZ free of roads and landings (except crossing)	61.2	80.4
Z8. Water diverted from roads before entering RMZ	57.3	68.2
Z9. Water diverted onto stable areas of the forest floor	65.2	72.1
Z10. Road and trail surfaces stabilized as needed within RMZ	73.6	78.2
Z11. Ephemeral channels free of excavated material	69.6	70.3
Riparian Management Zones	75.3	81.1

Obstructing debris logging in streams (Z2) has a score of 60.0% application and 62.1% effectiveness. RMZs "free of roads and landings" (Z7) with a 61.2% implementation rate, effectiveness was 80.4%. Water was not commonly diverted before entering RMZ (Z8) with application of 57.3% 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 65.2% application and 72.1% effectiveness. Some ephemeral channels contained excavated materials (Z11) with a 69.6% application rate and 70.3% effectiveness rate.

Harvest debris removed from a stream.

IV. Discussion

The overall forestry BMP application rate for CLFW is 83.62%, and the overall effectiveness is 88.25%. There are many things that are being done well on CLFW harvests; however, in order to see the most improvement, those with the most BMP 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 the areas of access roads and log landings. Access road application and effectiveness rates were 94.1% and 97.9%, respectively. Log landings had a 93.4% application and 97.1% effectiveness rating. Access road runoff drainage and diversion may be a concern. This practice has an application rate of more than 84.3% 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 85.6%, but effectiveness was more than 95.3%, 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 78.4% and effectiveness of 86.5%. 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 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. The appropriate drainage and diversion BMP is challenging on skid trails, with 43.6% application and 60.7% effectiveness.

Overall stream crossing BMP application is 67.6%, and overall effectiveness is 68.9%. 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. This individual BMP (X4) had an overall application of 39.6% and effectiveness of 44.3%. The proper design and stabilization of stream banks at crossings (X3) was also a problem area, with an overall application of 42.1% and effectiveness of 45.1%. Forests are multi-use by the landowner and are driven 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 doesn't occur as often. RMZs are much like stream crossings. Both are in close proximity to bodies of water. 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 75.3%. The effectiveness rate for overall RMZs was 81.1%. 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 60.0% and effectiveness of 62.1% overall. Z7, the BMP concerning roads and landings in RMZ, had an application of 61.2% and effectiveness rate of 80.4%. Z8 is the BMP concerning water diversions before entry to the RMZ. Its application was 57.3%, and its effectiveness was 68.2%.

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.
- Importance of removal of these obstructions to stream flow needs to continue to be emphasized to landowners and loggers as this remains to be an area of concern, especially on private lands.

A harvest opening within an intact forest.

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 desire 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.

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