1996–2025

Indiana Classified Forest & Wildlands Forestry Best Management Practices Monitoring Results

DNR
Indiana Department of Natural Resources
Forestry

1996–2025

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By Jennifer Sobecki & Duane McCoy

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I. Introduction & Indiana Forestry BMP History

Best Management Practice (BMP) Introduction

Indiana has 4.8 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. Residents who don't participate 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 soil is disturbed, NPS pollution can occur. Forestry Best Management Practices (BMPs) are employed to protect forest soil 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 1996-2025. There are 901,768 acres of land in the Classified Forest & Wildlands (CLFW) program statewide. This acreage is owned by 13,712 landowners in 18,673 tracts. The data covers all BMP monitoring for 877 CLFW sites during those years, looking at time trends and making comparisons.

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 and other land uses that cause NPS pollution, such as agriculture and development. In response, the Woodland Steward Institute took on "The Forest Health Initiative." The BMP guidelines were completed in 1995, and the first round of BMP monitoring occurred in 1996. The Forestry BMP Field Guide was published in 1998. All 50 states have a Forestry BMP program and manual that was either developed by the state's forestry agency or produced with that agency's heavy involvement. (National Association of State Foresters 2019).

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 develop a set of forest practices throughout the early 1990s designed to mitigate or minimize impacts of forest management activities on water quality. Some of these practices would enhance water quality. This effort was designed under the Clean Water Act, which directed the EPA to guide 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 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 and was updated in 2022. It can be found at dnr.IN.gov/forestry/files/BMP.pdf.


DNR Forestry staff train loggers on the application of forestry BMPs. Photo: Jennifer Sobecki, DNR

The second component was BMP training, which consisted of teaching 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 1,234 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 1,860 sites throughout the state on a wide variety of landowner types have been evaluated for Forestry BMPs after a harvest.

By 1996, the BMP guidelines were constructed, and each program was ready to begin. Selected sites were predominately within the watershed of Monroe Lake, 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 had been 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. Permission was sought from perspective site owners 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, professionals in 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. 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 been monitored each year. This report contains the findings from the CLFW BMP monitoring from the beginning of the program to present.

II. Methods

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
6. Site Selection for Classified Forest & Wildland

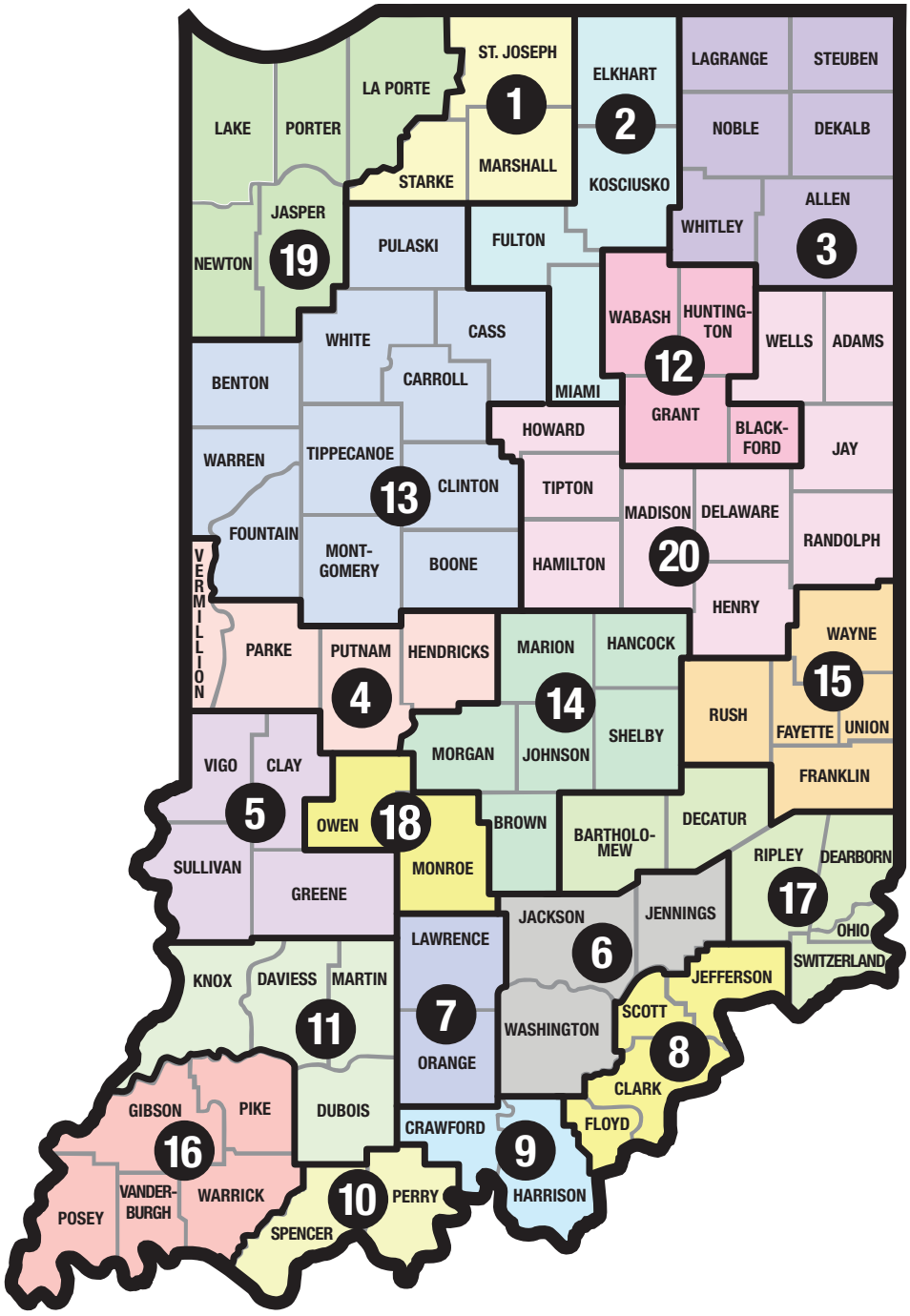

Figure 1. Current Classified Forest and Wildland District lines. These districts have shifted over time with changes in workload per county and staff availability. dnr.IN.gov/forestry/private-forestland-management/district-foresters

Since 2009, at least 10% of CLFW program sites that reported having 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. 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 on page 7. 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. Many reports were sent in late in 2023. Oct. 31 was the cutoff date and the 10+% sites for monitoring were taken from what was reported.

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, 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
2023	302	44	14.6
2024	291	38	13.1
2025	321	41	12.8

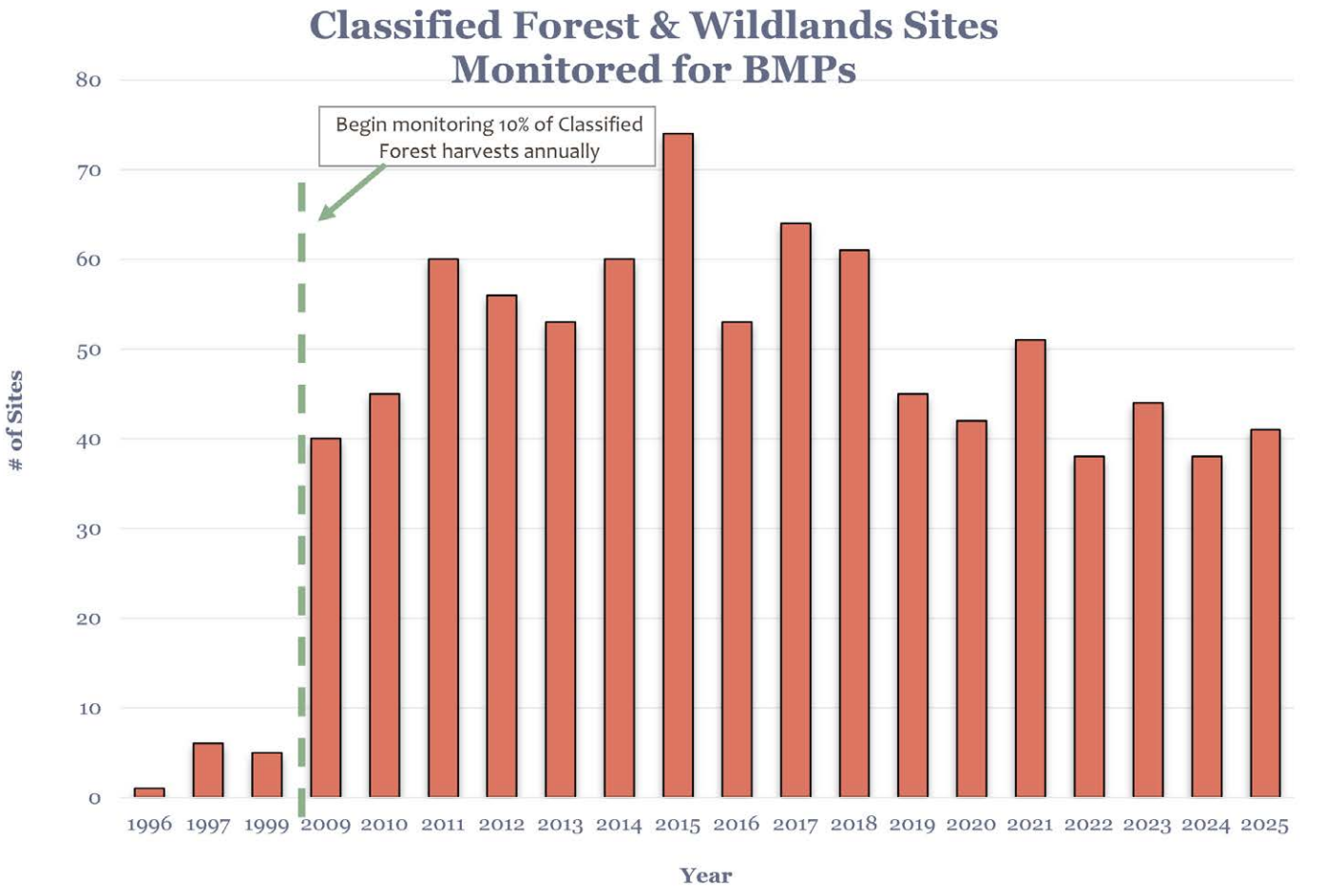

Figure 2. Number of CLFW timber-harvest sites monitored for BMPs throughout the 29-year history of the BMP program.

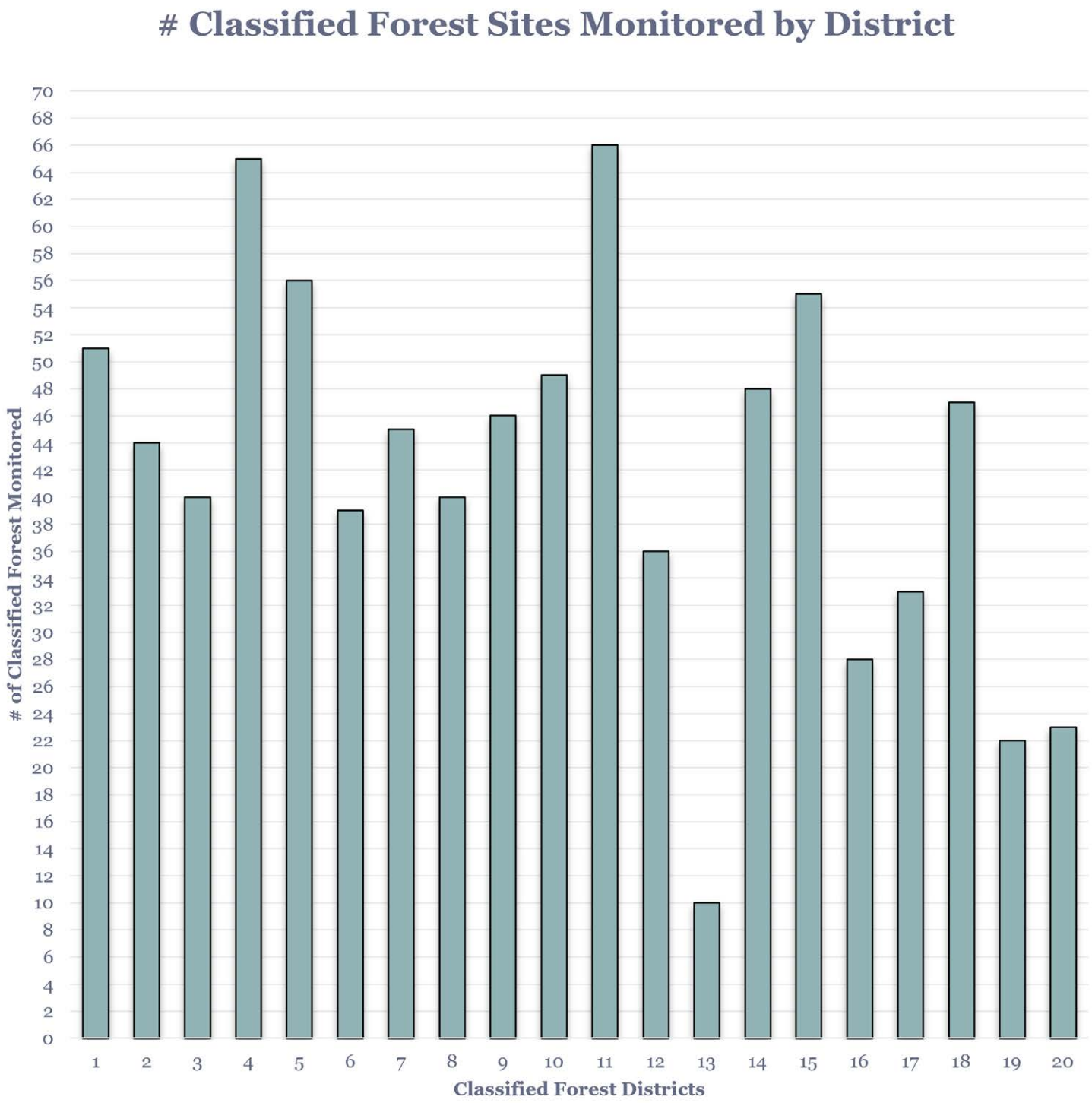

Figure 3. Number of CLFW timber-harvest sites monitored for BMPs by district throughout the 29-year history of the BMP program.

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 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 in addition to annual reports for State Forests and quality control.

Monitoring Team Selection

The selection of monitoring parties has been modified during BMP monitoring in Indiana from 1996 through 2025. It has also varied based upon landownership and monitoring objectives. In the 2009 through 2025 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.

Site Evaluation

BMP monitoring is based on the evaluation of each specific practice for application and effectiveness. Application is the installation and condition of a 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 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 also be possible.

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. 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 the score for each question.

III. Results

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 877 CLFW timber harvests monitored between November 1996 and March 2025, ranging in size from 1 to 785 acres.

A total of 82.96% of the BMPs were applied as directed in the BMP guidelines, and 15.23% had minor departures as defined in the monitoring sheet. There have been 582 major departures, which added up to 1.74% of all practices monitored. Of the total 877 sites monitored on CLFW sites, 26 practices scored "Gross Negligence" for 0.08%, as shown in Figure 4.

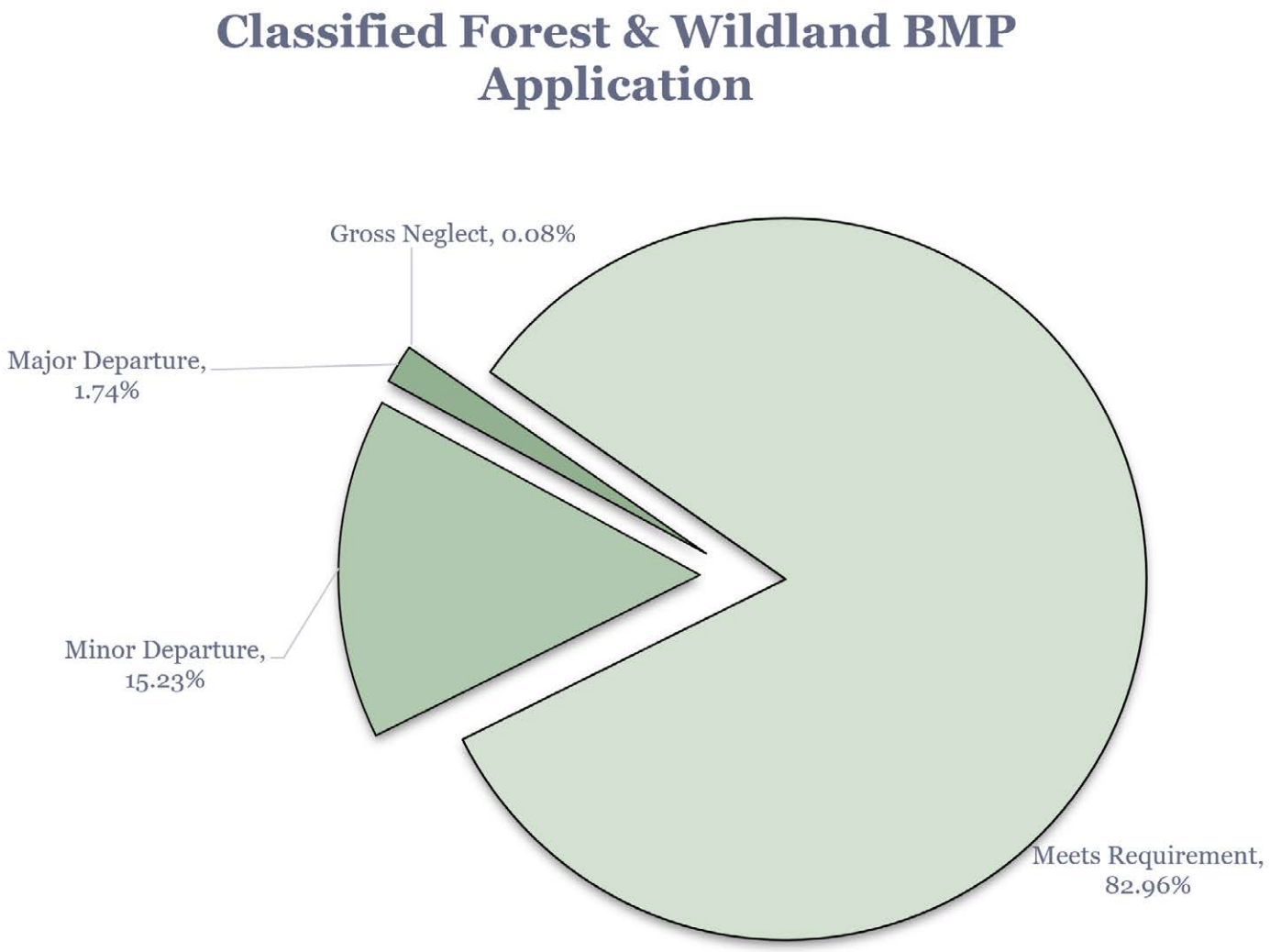

Figure 4. BMP Application for all 877 CLFW sites monitored from 1996 through 2025.

Effectiveness rates are used to evaluate the success of the BMPs applied to a site. The effectiveness rate for the 877 sites monitored is 87.75%. Indirect and temporary impacts on water quality were found 2.93% of the time. Indirect and prolonged impacts were found 1.5% of the time. Direct and temporary impacts occurred 3.62% of the time, and there were 4.2% direct and prolonged impacts to water quality. All of this is shown in Figure 5.

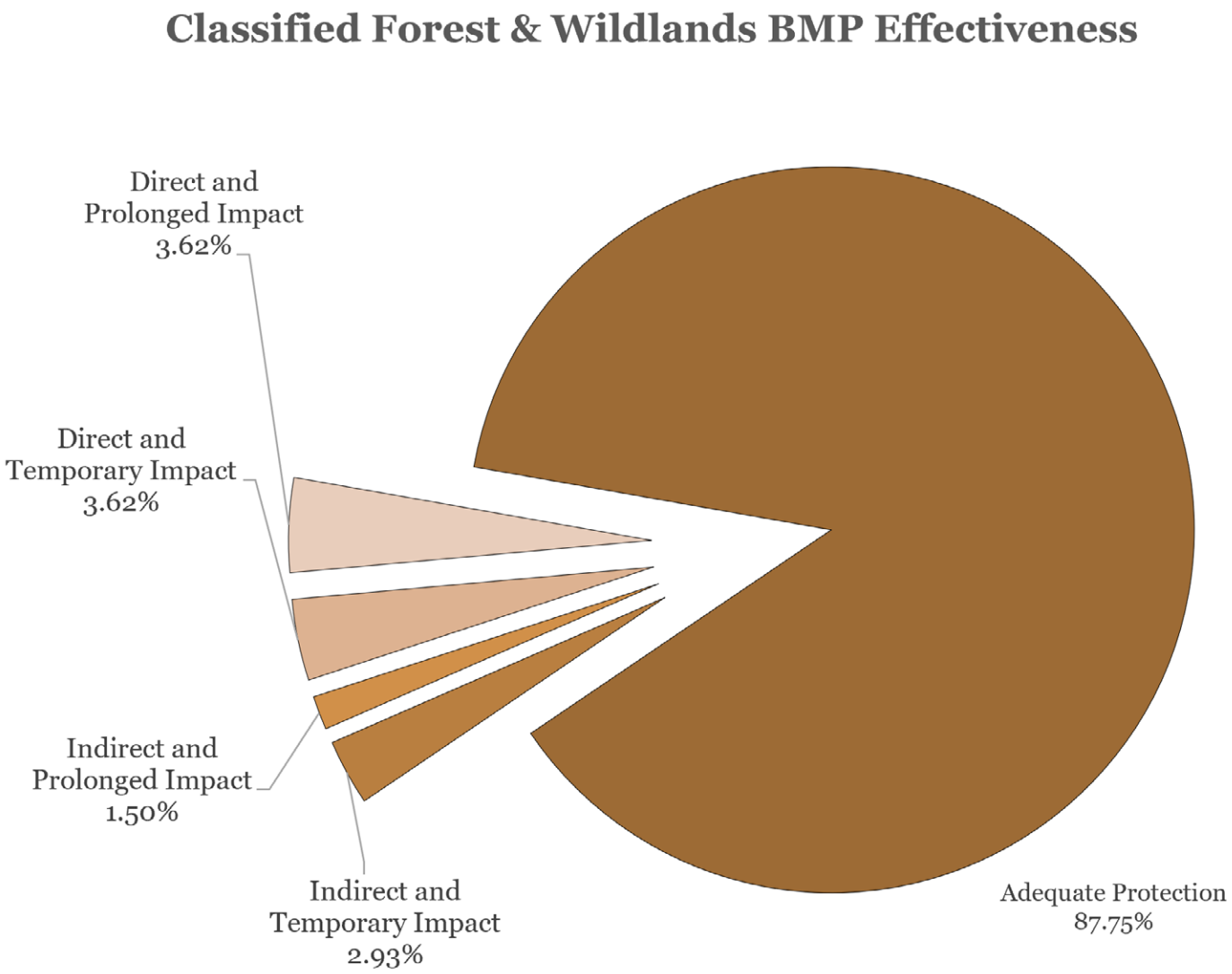

Figure 5. BMP Effectiveness for all 877 CLFW sites monitored from 1996 through 2025.

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 that can be drawn from Figure 6. First, effectiveness rates are commonly higher than application rates. Second, the rates seem to generally mirror one another.

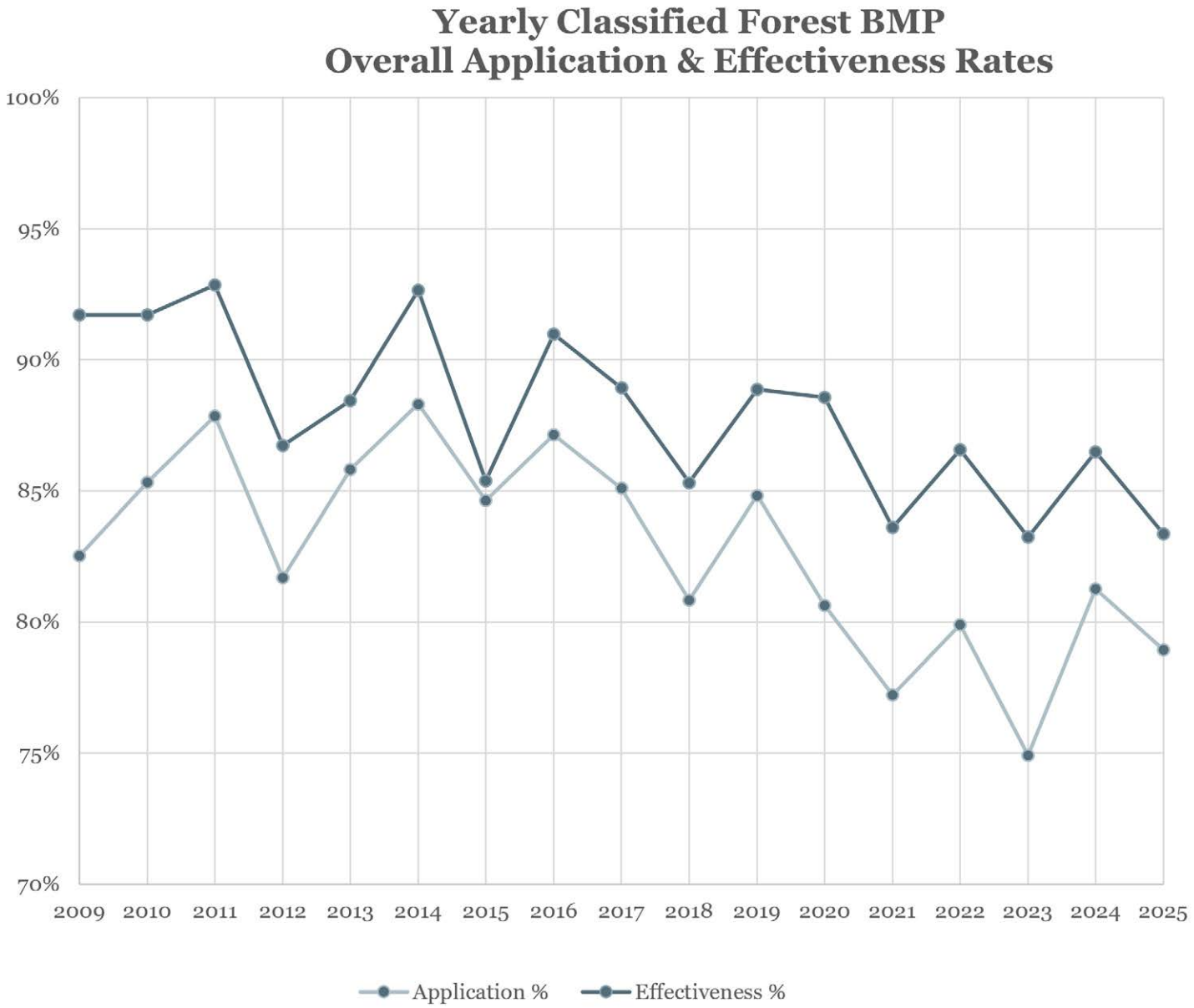

Figure 6. Yearly trends of overall BMP application and effectiveness scores on CLFW sites. These percentages are calculated for each year's data separately, rather than being combined with the running totals from previous years.

BMP Category Application & Effectiveness

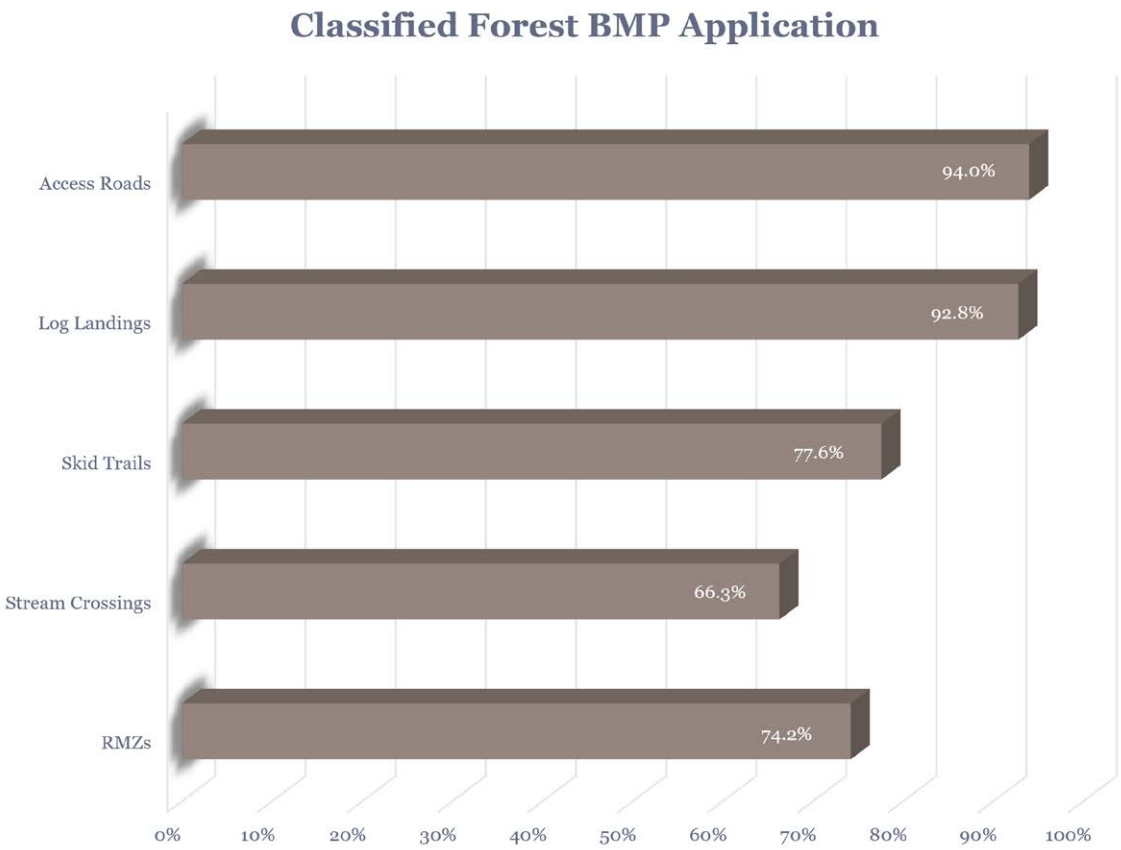

Figure 7. Overall BMP application percentages by BMP category.

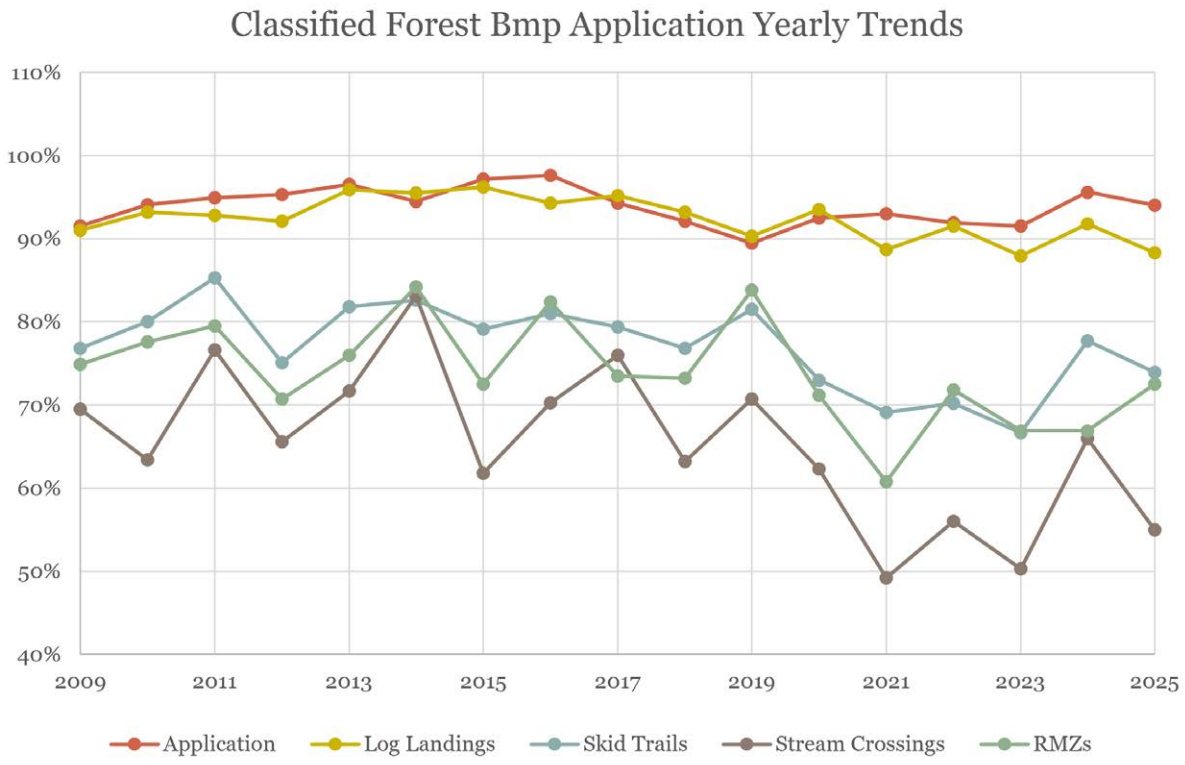

Figure 8. Yearly BMP application trends by BMP category.

Access roads and landings are areas of a timber harvest where machines, including tractor trailers, concentrate much of their activity. Many of these machines 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 29 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. Skid trail application has generally stayed in the low 80s to high 70s%. 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 of 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, usually in the 60th to 70th percentile.

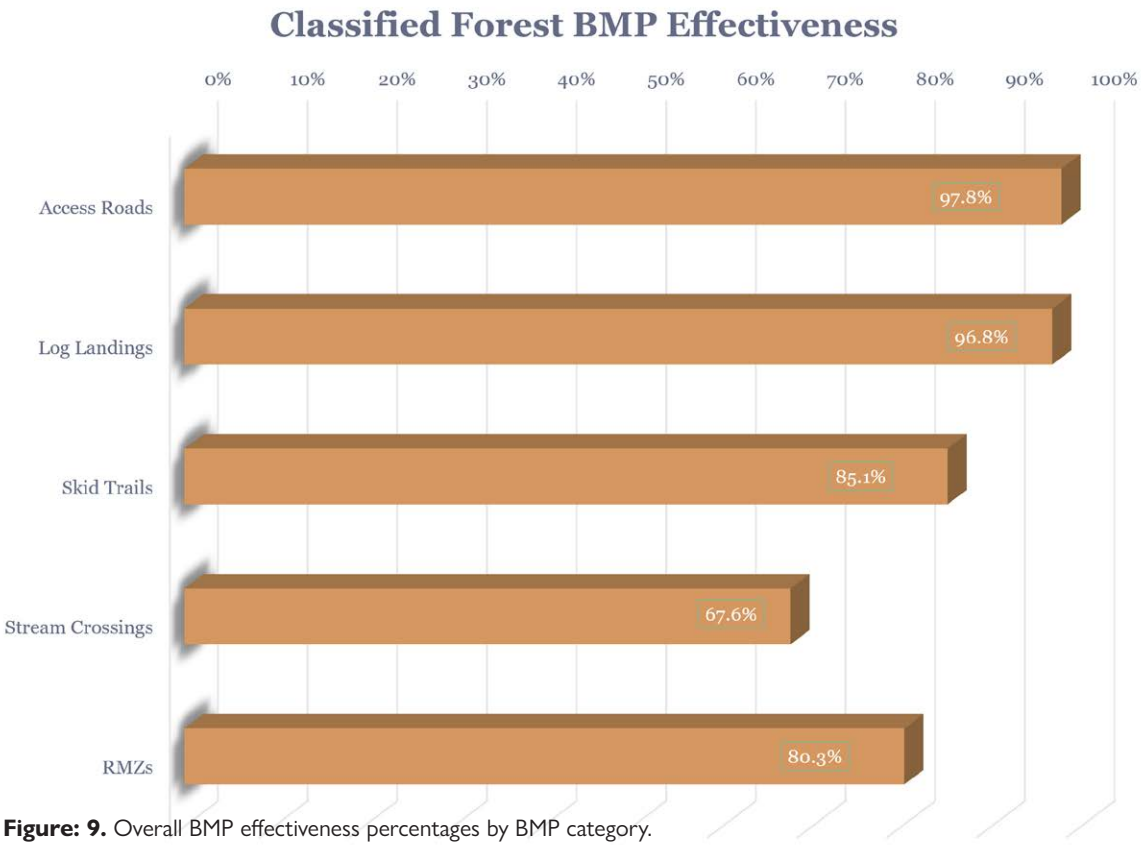

Figure: 9. Overall BMP effectiveness percentages by BMP category.

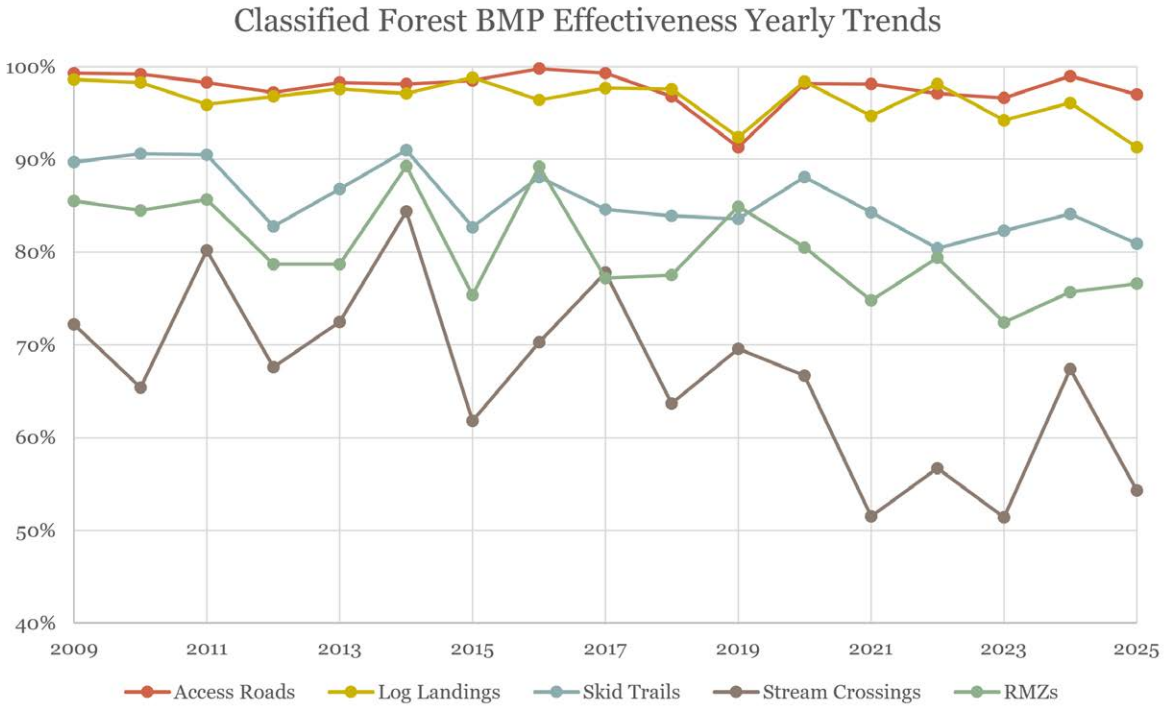

Figure 10. Overall BMP effectiveness yearly trends by BMP category.

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 4% or higher than application rates for both categories. RMZ and skid trail application rates are similar, in the mid-70s to high 60s, while skid trails applications are about 5% above RMZ effectiveness. 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 next to the water resources of the site, so any problems in this area are more likely to have direct impacts due to their proximity to water.

The overall BMP application and effectiveness rate for access roads was the highest ranked, having a 94.0% application and 97.8% effectiveness. The log landing application rate was 92.8%, and effectiveness was 96.7%. The third-highest category was skid trails, with 77.6% application and 85.1% effectiveness rates. RMZs ranked next to last, with 74.2% application and 80.3% effectiveness rates. The BMP area with the most difficulty was stream crossings, with an application of 66.3% and effectiveness of 67.6%. 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 disturbances in streams. Wet conditions can also lead to departures from effective management with stream crossings.

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 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 usually do not have a strong base to support 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 2 depicts the breakdown of each individual BMP specification in access roads from all 877 sites monitored across the 29-year monitoring period. CLFWs had two areas of application concern. A10: "Appropriate road stabilization, drainage and diversion installed" has an application rate of 84.3%; however, the effectiveness was 91.8%. A15: "Traffic barriers installed" had a 70.8% 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 most trespassing that would damage the forest.

An outslope on this access road channels runoff to the forest floor. This prevents runoff from continuing down the access road, thus limiting erosion potential. Photo by Duane McCoy, DNR

Table 2. Access road BMP application and effectiveness for all CLFW sites monitored from 1996 through 2025.

Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.3	99.7
A2. Adequate buffer strip next to watercourses and sensitive areas	93.7	98.7
A3. Avoids unstable gullies, seeps, very poorly drained areas	94.6	97.5
A4. Road grades are within standards	98.4	99.5
A5. Amount of roads minimized	100.0	100.0
A6. Stream crossings minimized	99.8	99.3
A7. Road excavation minimized	99.7	100.0
A8. Excavated and fill materials placed properly	99.8	99.8
A9. Roads constructed to drain well	85.0	94.4
A10. Appropriate road stabilization, drainage and diversions installed	84.3	91.8
A11. Water diversions functioning properly	95.0	95.6
A12. Runoff diverted onto stable forest floor areas	91.1	94.4
A13. Mud kept off public roadways	99.5	99.8
A14. Public road's drainage maintained	99.5	99.6
A15. Traffic barriers installed	70.8	97.7
Overall Access Road	**94.0**	**97.8**

Log Landings

Log landings are the areas of highest equipment concentration. Equipment brings the logs to the landing area from 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. The trucks then haul the logs from the site using the access road. Log landings are commonly the largest area of exposed soil and have the most soil compaction because of all of the equipment gathered in this area.

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

Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	98.1	99.5
Y2. Landings located outside RMZ	89.8	96.7
Y3. Landings located on stable areas	93.5	96.9
Y4. Excavation of site minimized	97.7	99.2
Y5. Landings avoid concentrating or collecting runoff	84.9	95.1
Y6. Landing's runoff enters stable area	87.4	92.5
Y7. Proper water diversions in working order	88.4	92.4
Y8. Landing smoothed and soil stabilized	91.1	95.1
Y9. Landings free of fuel and lubricant spills and litter	98.9	99.5
Y10. Landing location suitable for equipment fueling and maintenance	97.8	99.5
Overall Log Landings	**92.8**	**96.7**

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," 85.1%. Each has a high effectiveness rate, both exceeding 95%.

Logs stacked in a landing to be loaded after harvest has concluded. Ground was frozen, thus minimal damage to soil. Photo by Jennifer Sobecki, DNR

Skid Trails

Skid trails are the portion 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. Because of that, they 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 are in terrain 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 on 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 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 trails was the installation of appropriate drainage and diversions (S7). The application rate of this BMP for CLFWs was 43.8%; however, this is a 15.6% increase from 28.2% in the 2011 report. The effectiveness rate for appropriate drainage and diversions installed was 60.9%. These numbers indicate that implementation departures in this area may be having some level of impact on 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 69.4%, 71.1%, and 67.0%, respectively. Effectiveness rates for S2 are 84.4%, 79.3% for S8, and 73.2% for S9. These departures in application seem to have a minimal total effect on water resources of the sites, with overall effectiveness at 85.1%.

Short and mostly gentle slopes and heavy seeding have allowed this skid trail to heal and stabilize quickly after a tornado salvage harvest. Photo by Jennifer Sobecki, DNR

Heavy seeding and good revegetation can only protect the soil so much on a steep and long slope. Lack of water diversions on this skid trail is causing erosion and destabilizing the trail after a harvest. Photo by Jennifer Sobecki, DNR

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

Skid Trails	% Application	% Effective
S1. Uses existing routes were appropriate	96.7	97.6
S2. Adequate buffer strip next to water courses and sensitive areas	69.4	84.4
S3. Avoids steep and long straight grades (>20% for >200')	84.0	92.5
S4. Avoids unstable gullies, seeps, poorly drained areas	77.1	87.6
S5. Amount of skid trails minimized	89.3	94.6
S6. Trail excavation minimized	89.3	92.9
S7. Appropriate drainage and diversions installed	43.8	60.9
S8. Water diversions in working order	71.1	79.3
S9. Runoff diverted onto stable forest floor areas	67.0	73.2
S10. Streams not used as skid trails (except for crossings)	85.9	86.1
Overall Skid Trail	**77.6**	**85.1**

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

While water diversions on both sides of the stream prior to the crossing would have been ideal for the crossing, the heaving seeding and good revegetation are holding the soil and have stabilized the crossing. Photo by Jennifer Sobecki, DNR

Stream crossings on Classified Forest sites had lower application scores on five specific questions that led to direct impacts from the crossings that were monitored. These shortcomings in application led to unstable banks because the banks were weakened or the water flow was affected, 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 49.6% and effectiveness of 51.1%. Due to this departure, the banks may have been compromised so that X9, "fords have stable banks and streambeds," gets a low score as well. The proper design and stabilization of stream-bank approaches (X3) were low, at 39.9% for application and 42.5% 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 37.0% for an effectiveness rate of 41.4%. Because these practices are low in implementation, the "fords have stable banks and streambeds," (X9) with application and effectiveness rate of 46.6% and 46.9%. X13 had concerns with the removal of temporary crossing structures and resulting obstructions, and reported application and effectiveness rates were 64.0 and 62.7%. Many of these cases result when log corduroy bridges and 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	89.1	89.4
X2. Crossings minimize disturbance to the natural bed and banks	49.6	51.1
X3. Streambank approaches properly designed and stabilized	39.9	42.5
X4. Water runoff diverted from road prior to crossing	37.0	41.4
X5. Crossing as close to 90 degrees as practicable	87.1	89.0
X6. Crossing does not unduly restrict water flow	76.7	77.9
X7. Soil has not been used as fill in the stream (except culverts)	73.5	73.3
X8. Ford constructed of non-erosive materials	77.5	76.7
X9. Fords have stable banks and streambeds	46.6	46.9
X10. Culverts are properly sized and installed	76.1	78.9
X11. Culverts clear of significant flow obstructions	85.7	87.1
X12. Temporary structures properly anchored	88.9	88.9
X13. Temporary structures and resulting obstructions removed	64.0	62.7
Stream Crossing	**66.3**	**67.6**

Riparian Management Zones

Riparian Management Zones are 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 to the water and are more likely to have a direct impact on it. RMZs are different widths according to the type of body of water 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 dnr.IN.gov/forestry/files/BMP.pdf.

Obstructing logging debris in streams (Z2) has a score of 59.1% application and 61.0% effectiveness. RMZs "free of roads and landings" (Z7) with a 60.1% implementation rate, effectiveness was 80.0%. Water was not commonly diverted before entering RMZ (Z8) with an application rate of 55.9% and effectiveness of 68.1%. When water was diverted, it was not always diverted to stable areas of the forest floor (Z9); this process had 63.0% application and 71.4% effectiveness. Some ephemeral channels contained excavated materials (Z11) with a 68.6% application rate and 69.4% effectiveness rate.

With many trees retained in the RMZ, the debris from floods are allowed to settle and prevents harvest debris from entering the stream. Photo by Jennifer Sobecki, DNR

Skidding next to a stream is a violation of the Forestry BMP guidelines; however, it is sometimes necessary due to geographical constraints. In this instance the trail next to the stream was well closed out and stabilized and soil is not washing into the stream. Photo by Jennifer Sobecki, DNR

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	59.1	61.0
Z3. Tree tops and cutoffs placed back from water course to prevent movement into streams during floods	86.2	91.7
Z4. RMZ free of excavated material & debris (other than above)	90.8	95.0
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.2	97.1
Z6. Adequate tree stocking in primary RMZ next to perennial streams	97.4	99.3
Z7. RMZ free of roads and landings (except crossing)	60.1	80.0
Z8. Water diverted from roads before entering RMZ	55.9	68.1
Z9. Water diverted onto stable areas of the forest floor	63.0	71.4
Z10. Road and trail surfaces stabilized as needed within RMZ	71.6	77.7
Z11. Ephemeral channels free of excavated material	68.6	69.4
Riparian Management Zones	**74.2**	**80.3**

IV. Discussion

The overall forestry BMP application rate for CLFW is 82.96%, and the overall effectiveness is 87.75%. 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 their implementation on Classified Forest sites.

The highlight of Indiana's Forestry BMPs in the last 29 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% and 97.8%, respectively. Log landings had a 92.8% application and 96.7% 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 problem with log landings is concentrating and/or collecting runoff. This area had application rates of 84.9%, but effectiveness was more than 95.1%, demonstrating that impacts on 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 77.6% and effectiveness of 85.1%. These figures indicate that although there are some difficulties carrying out BMPs on skid trails, most do not result in large impacts on 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 must be moved to the landing. An area traveled over only twice, once to access trees and the other to pull 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 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 BMP is challenging on skid trails, with 43.8% application and 60.6% effectiveness.

Overall stream crossing BMP application is 66.3%, and overall effectiveness is 67.6%. Due to the nature of stream crossings, impacts on 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 with stream crossings is the diversion of water before the stream crossing, X4. This individual BMP had an overall application of 37.0% and effectiveness of 41.4%. The proper design and stabilization of stream banks at crossings (X3) was also a problem area, with an overall application of 39.9% and effectiveness of 42.5%. 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 near 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 of 74.2%.

The effectiveness rate for overall RMZs was 80.3%. 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 59.1% and effectiveness of 61.0% overall. Z7, the BMP concerning roads and landings in RMZ, had an application of 60.1% and effectiveness rate of 79.3%. Z8 is the BMP concerning water diversions before entry to the RMZ. Its application was 55.9%, and its effectiveness was 67.6%.

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 land managers, owners, and contractors is of distinct importance.

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

One of several box turtles found on a spring day in a forest opening post-harvest. Photo by Jennifer Sobecki, DNR

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 these and similar reports to raise awareness of 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.