Monitoring Results • 1996-2024

Indiana Forestry Best Management Practices Monitoring Results for State Forest Properties

Forestry Best Management Practices

DNR Indiana Department of Natural Resources | *Forestry*

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By: Jennifer Sobecki & Duane McCoy

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I. Introduction and Indiana Forestry BMP History

A. BMP Introduction

Indiana has 4.8 million acres of forestland, which is 21% of the state's land base. Indiana state forest properties comprise 160,252 acres, around 0.7% of the state. Forestland is important to Hoosiers for various forms of recreation, including hiking, biking, hunting, fishing and wildlife watching. 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 Indiana residents, 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 can also generate pollutants. When forest soils are bared, NPS pollution can occur. Best Management Practices (BMPs) are in place to minimize that.

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 1996-2024. Four sites are from state owned lands but not specifically state forest property. Data in this report covers all BMP monitoring for 783 state owned 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, developed a statewide project to carry out voluntary BMPs. The federal Clean Water Act amendments of 1987 prompted states to develop BMP guidelines to mitigate the impacts of silvicultural practices, as well as the impacts of other land use such as agriculture and development, that cause NPS pollution. 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. The respective forestry agency in all 50 states either developed a forestry BMP manual for its state or was heavily involved in such a document's development (NASF, 2019).

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. They set up committees that would, throughout the early 1990s, develop a set of forest practices designed to mitigate or minimize impacts of forest-management activities on water quality, and sometimes even enhance it. 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 and declare them as 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, and the publication of the Indiana Forestry BMP Field Guide, which was updated in 2022 and can be found at. dnr.IN.gov/forestry/files/BMP.pdf The second component was BMP training, which consisted of teaching BMPs to the different parts of the Indiana forest products community such as loggers, landowners and foresters. The third part was BMP monitoring, which consisted of looking at how BMPs were applied in the field and how well those practices protected water quality.

DNR Division of Forestry conducts training for loggers, foresters and university students throughout the year. Photo taken at a state forest property by Jennifer Sobecki, DNR.

By 1996, the BMP guidelines were put in place and the monitoring program was ready to begin. Timber-harvest sites were selected for BMP monitoring predominately within the Monroe Lake Watershed. Additional sites were monitored 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 of the time of monitoring were considered for that round

of monitoring. The identification of potential monitoring sites was accomplished by aerial reconnaissance and ground verification, licensed timber buyer records, district and consultant forester recommendations, and Monroe County logging permit records. Owners of prospective sites were contacted for permission. Once sites were accepted for monitoring, teams of people with diverse technical backgrounds were formed. 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. Team size was four to five individuals, and members possessed multiple areas of expertise.

All BMP monitoring has followed the model that was set by that mid-1990s group, but it has evolved over time due to improvements and changing regulations. The first few rounds of monitoring were paid for through money from IDEM or the Great Lakes Commission under the Clean Water Act or other federal programs. Since 2009, 10% of all reported harvests 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, where all harvest sites are monitored for BMP compliance.

Studies of nationwide forestry BMP implementation by state indicate that the overall adjusted forestry BMP implementation average is 91% (Cristain, et al. 2018). Indiana is one of 18 states that conducts ongoing forestry BMP effectiveness studies. Each state decides how it handles forestry BMPs, and Indiana has always had voluntary implementation. Other states range from regulatory, to quasi regulatory to local government regulation. A survey of implementation rates across the nation shows that non-regulatory states do almost as well as regulatory states with a 93.4% implementation compared to 95% for regulatory states implementation. (NASF 2019). Non-regulatory states rank higher than quasi-regulatory and local regulation. This indicates that even without regulation, the BMP programs in place are providing the necessary guidance to protect water quality associated with forest management.

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

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

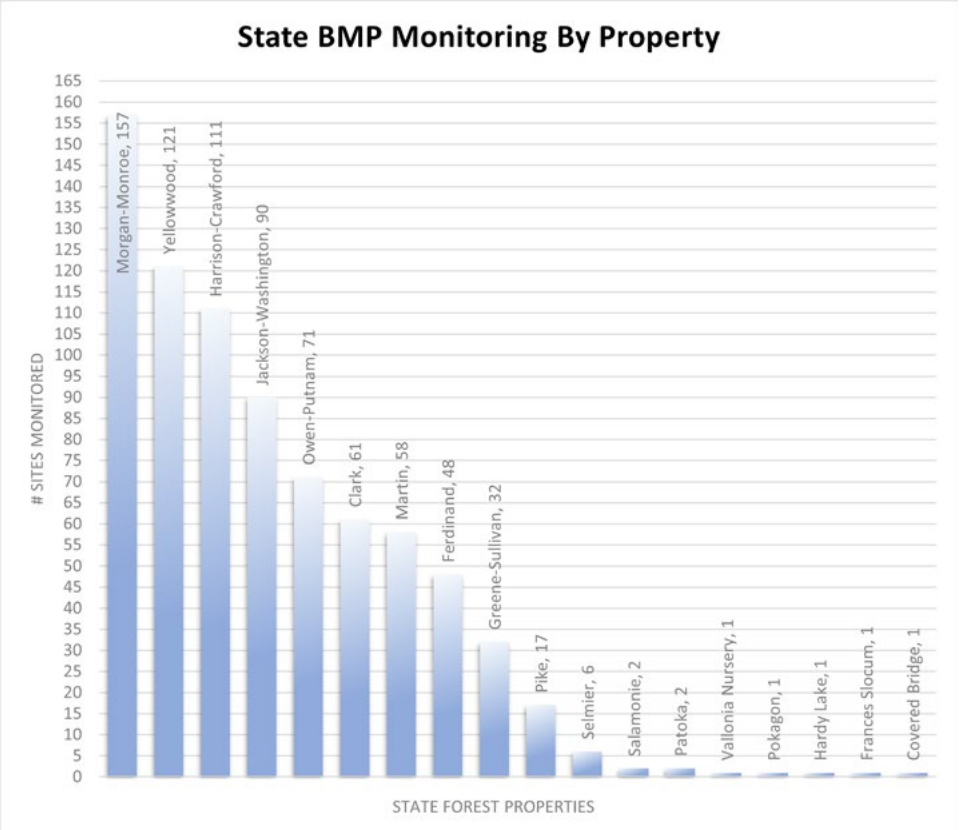

Figure 1. Timber harvests monitored for BMPs in Indiana State Forests and other DNR properties, by property.

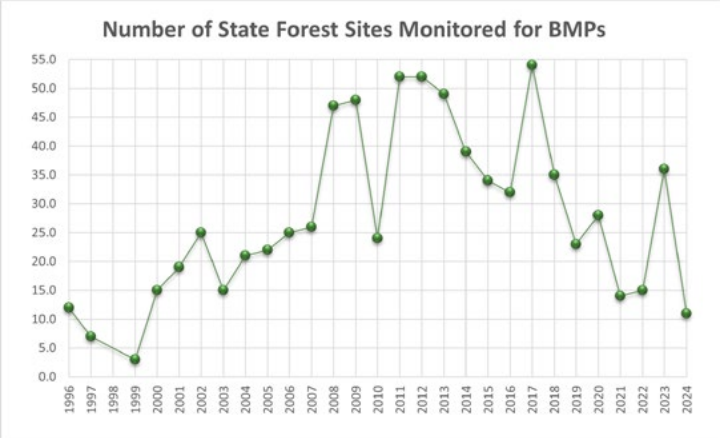

Figure 2. Total number of state forest sites monitored each year since the BMP program began 28 years ago.

C. Data Collection, Entry & Analysis

The BMP monitoring form is used to collect data in the office and the field. Much of the first page can be completed by consulting maps, harvest paperwork or talking to the forester, timber buyer, or landowner. The remaining pages are completed in the field during and after the site evaluation. More details about that process can be found in the site evaluation section of this document.

These "raw" datasheets are then brought back to the office and given to a DoF employee to enter in the Indiana Forestry BMP Database. Datasheets are "cleaned up" and copies are supplied to concerned parties, including foresters, landowners, timber buyers, and managers. The database is used to construct various reports such as this one, as well as annual reports such as Classified Forests & Wildlands, comprehensive reports of harvests on all land ownership types, and quality-control reports.-

D. Monitoring Team Selection

At first, on state forest properties, foresters from either the Watershed Conservation (WC) and Licensed Timber Buyers (LTB) or both came to every BMP-monitoring site. This kept a balance of consistency in monitoring and the resulting data. Now BMP monitoring is conducted by staff that includes the LTB forester, BMP assistant district forester, and district forester, all of whom focus on BMP monitoring. Other participants are the administering forester and at times, other foresters on the property. This group keeps the balance in the monitoring process and provides good training and discussion.

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

E. Site Evaluation

BMP monitoring is based on the evaluation of each practice's application and effectiveness. Application is the installation of a practice and its condition at the time of monitoring. Effectiveness is the level of success a practice has in preventing pollutants from entering a body of water or in reducing the level of impact the pollutant is having on the body of water at the time of monitoring. It is possible to apply all BMPs properly and get a good score in application but still have soil entering a stream. Such a situation 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. This allows each team member to evaluate the BMPs on the site. Once the team has walked the area, members discuss each question and each team member's scores on the BMP monitoring form until they reach consensus as a team on a score for each question.

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

The "4-Foot Rule" (Appendix A) was adopted as definition for large intermittent streams starting July 1, 1999, when BMPs officially were put in state timber-sale contracts. On other forest ownership types, the definition of an intermittent

stream was listed in the BMP field guide, providing the manner in which the monitoring crew was to interpret what it saw on the site. As of July 1, 2010, the "4-Foot Rule" gave way to consistency with the other property-ownership types regarding woody debris. With this rule, there were streams on state forest properties that had woody debris in them that was required to be removed; however, this would not have been counted against properties under other ownership types. The rule was changed to mapped intermittent streams or larger, as determined by the USGS and is now consistent for all landownership types in the Indiana forestry BMP program.

III. Results

A. Comprehensive BMP Application and Effectiveness

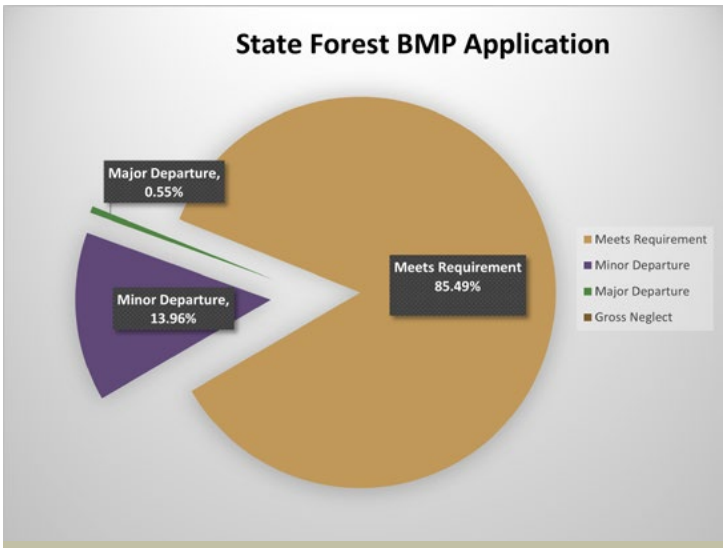

Figure 3. BMP application for 783 state forest sites monitored from 1996-2024

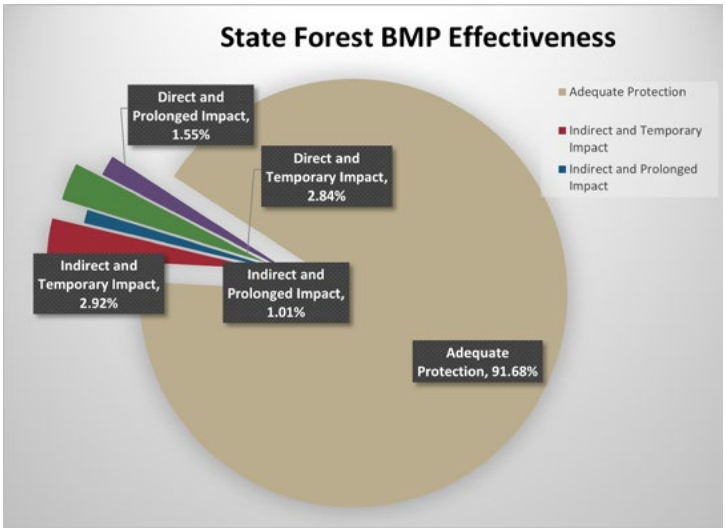

Figure 4. BMP effectiveness for 783 state forest sites monitored from 1996-2024.

The application and effectiveness rates for BMPs used to protect sites after timber harvests are excellent for the 783 state forest sites monitored since 1996. The overall application rate is 85.49%, and the overall effectiveness rate is 91.68%.

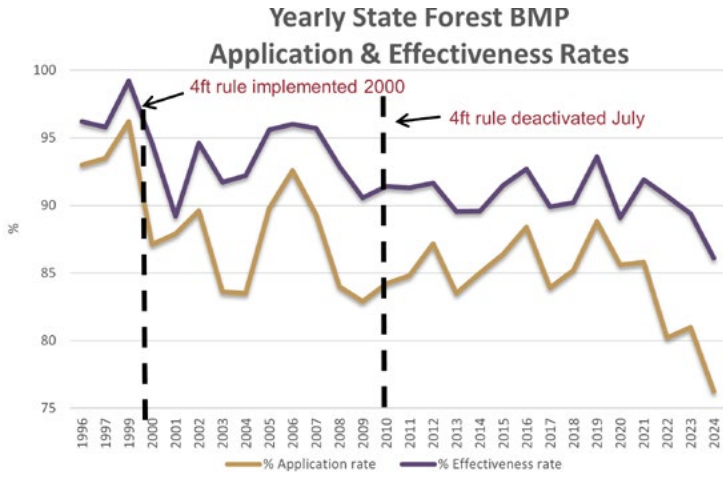

Figure 5. Yearly trends of BMP application and effectiveness on Indiana State Forests for 28 years of monitoring. These percentages are calculated for each year's data separately, not combined with the running totals from previous years.

B. BMP Category Application and Effectiveness

Access roads and landings are areas of a timber harvest where much of the activity completed by machines is concentrated, including over-the-road tractor-trailers, which cannot take much variation in the terrain when traveling. Therefore, access roads are often well stabilized, drained well, and usually constructed in areas that have established travel away from bodies of water as much as possible. Skid trails are over rough ground that may have been traveled at some point in the past and then left alone, so they tend to be harder to engineer to drain correctly, given the trees, rough terrain and soil-structure variability. Roads, trails and landings will sometimes come close to riparian management zones (RMZs) or, in the case of access roads and skid trails, cross streams. Proximity of harvest infrastructure to water increases the chances of sediment reaching water bodies. This is why stream crossings and RMZs typically have lower effectiveness scores than the other three categories.

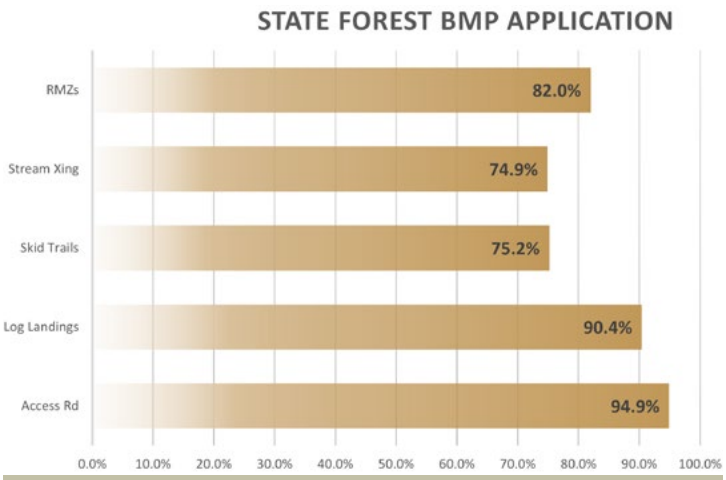

Figure 6. Overall BMP application for each of the five BMP categories.

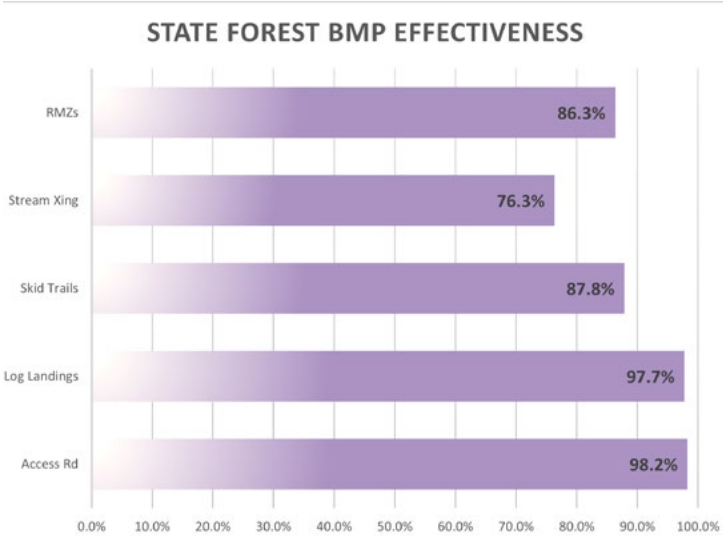

Figure 7. Overall BMP effectiveness for each of the five BMP categories.

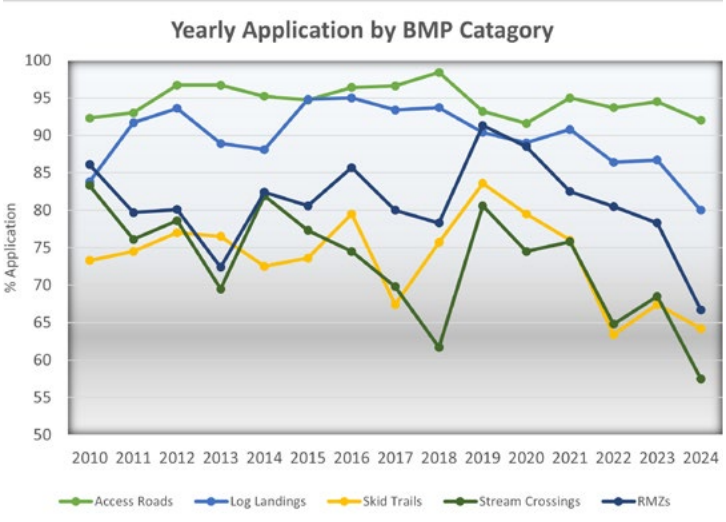

Figure 8. Yearly BMP application trends by category.

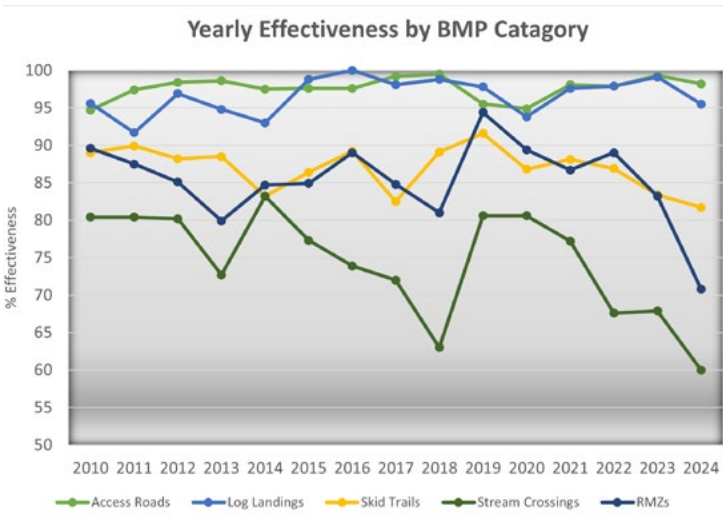

Figure 9. Yearly effectiveness trends by BMP category since 2010.

The overall BMP application and effectiveness for the five categories was highest for access roads, which had a 94.9% application and 98.2% effectiveness rate. Second-highest was log-landing application, with an application rate of 90.4% and effectiveness, 97.7%. The third-highest category was RMZs, with 82.0% application and 86.3% effectiveness rates. While skid trails rated low in application at 75.2%, the effectiveness was still good at 87.8%. Stream crossings had the lowest application rate of all categories but was 74.9% application. Effectiveness on stream crossings is 76.3%. The BMP area with the most difficulty was stream crossings. Because of the direct impact crossings can have on water resources, BMP applications are most critical in this area. Small problems in stream crossings can lead to lower effectiveness with more direct impacts to them. Wet conditions can also lead to more departures in effectiveness of stream crossings.

Access road is the lane that connects log landings to municipal roads. Here an access lane approaches a log landing. Drone photo taken on state forest property by Jamie Winner, DNR.

Table 1. Access road BMP application and effectiveness for all state sites monitored from 1996-2024.

Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.9	99.9
A2. Adequate buffer strip next to watercourses and sensitive areas	94.7	98.5
A3. Avoids unstable gullies, seeps, very poorly drained areas	95.7	99.0
A4. Road grades are within standards	97.7	99.9
A5. Amount of roads minimized	99.9	100.0
A6. Stream crossings minimized	99.9	99.9
A7. Road excavation minimized	98.7	99.9
A8. Excavated and fill materials placed properly	99.0	99.1
A9. Roads constructed to drain well	84.8	96.3
A10. Appropriate road stabilization, drainage and diversions installed	83.4	92.9
A11. Water diversions functioning properly	91.5	96.0
A12. Runoff diverted onto stable forest floor areas	88.8	92.9
A13. Public road drainage system maintained	99.3	99.6
A14. Public road's drainage maintained	99.5	99.8
A15. Traffic barriers installed	90.8	98.8
Overall Access Road	**94.9**	**98.2**

Access Roads

Access roads on state forests are commonly longer with a better base than those on private lands because they are often used as fire trails to access hundreds of acres of land. Some of these access roads were established before the area became a state forest. They were old county roads, driveways to farms, or Civilian Conservation Corps (CCC) roads. They usually run through rough terrain with many ridges, valleys, and steep slopes.

State forest access road application areas that need improvement are: A9. "Roads constructed to drain well," (84.8%) and A10, "Appropriate road stabilization, drainage and diversions installed," (83.4%). Effectiveness on these areas was still high at 92.9% and above. Overall application and effectiveness for access roads was high at 94.9% and 98.2%, respectively.

An outslope and cutout work to move runoff of an access road onto forest floor where it can be absorbed. Photo taken on state forest property by Duane McCoy DNR.

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

Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	95.6	99.7
Y2. Landings located outside RMZ	95.4	99.1
Y3. Landings located on stable areas	94.0	99.2
Y4. Excavation of site minimized	93.0	98.7
Y5. Landings avoid concentrating or collecting runoff	73.7	95.8
Y6. Landing's runoff enters stable area	81.9	94.0
Y7. Proper water diversions in working order	88.5	94.7
Y8. Landing smoothed and soil stabilized	87.8	96.7
Y9. Landings free of fuel and lubricant spills and litter	94.4	98.8
Y10. Landing location suitable for equipment fueling and maintenance	99.2	99.9
Overall Log Landings	**90.4**	**97.7**

Log Landings

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

Landings on state forests have many uses. Some are newly installed and used only for the one tract being harvested. Others have been established for decades and are used for multiple tracts. The older landings are often left as grass and forb wildlife areas between uses. Smaller landings often convert back to forested areas until the next harvest on that tract.

Log landing BMPs Y5 & Y6 were an application challenge on state forests. Y5's application rate was 73.7%, and the A6 application was 81.9%. Both had high effectiveness rates at 95.8% and 94.0%, respectively. Overall log-landing application was 90.4%, and overall log-landing effectiveness was 97.7%.

Seeding and strawing a landing after a harvest helps to quickly establish new plant growth while providing protection to the soil surface. This reduces erosion and increases water infiltration. Photo taken on state forest. Photo by: Jennifer Sobecki DNR

Log landings should generally be avoided near a stream. This landing used debris to filter water before it flowed into the stream, so while this site scored low on application, it was still effective at protecting the water resources on site. Photo taken on private property by Jennifer Sobecki DNR

Debris armoring skid trails reduces compaction and subsequent runoff. This works particularly well if ground conditions deteriorate during a harvest. Photo by: Duane McCoy DNR

Waterbars actively moving stormwater off a skid trail during a rain event. Photo taken on state forest lands by Duane McCoy DNR.

Skid Trails

Skid trails are the part of the harvest infrastructure where equipment moves logs from the place where the trees were standing to the landing. These trails are used to varying degrees and because of that have varying degrees of exposure and compaction. Different equipment can have the same variance concerning soil exposure and compaction. These trails often go over the roughest terrain on the site with obstacles, slopes, bodies of water, and other kinds of topographic features. Skid trails are always a demanding portion of any BMP implementation because this is where most of the action of the harvest is. This is especially true on state forests. Skid trails often disturb soil and ground cover, leaving it with a higher susceptibility to erosion if exposed and compacted. Because of this, they are found to have a lower percentage of BMP compliance in application. Their impact to water quality can vary widely because of their proximity to bodies of water.

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

Skid Trails	% Application	% Effective
S1. Uses existing routes were appropriate	97.0	98.4
S2. Adequate buffer strip next to water courses and sensitive areas	66.1	83.7
S3. Avoids steep and long straight grades (>20% for >200')	71.5	96.6
S4. Avoids unstable gullies, seeps, poorly drained areas	78.7	90.4
S5. Amount of skid trails minimized	81.8	94.2
S6. Trail excavation minimized	84.9	93.4
S7. Appropriate drainage and diversions installed	46.4	76.9
S8. Water diversions in working order	75.8	85.4
S9. Runoff diverted onto stable forest floor areas	67.1	74.7
S10. Streams not used as skid trails (except for crossings)	83.1	84.9
Overall Skid Trail	**75.2**	**87.8**

Skid trails on state sites are often longer because the state determines the location and number of landings, with some input from the timber buyer. State sites are the most closely monitored timber harvests, from marking the sale through post closeout. Because of that, they are often the most controlled; however, the infrastructure and topography are consistently challenging because state forest properties are on large tracts of land that had a general history of subsistence farms that were located on rugged terrain. Those farms failed around the time of the Great Depression and reverted to state ownership. Many tracts are on steep slopes with eroded topsoil, leaving large gullies and little to no vegetation by the 1920s. The forest has grown back, and soils are thriving again, but still can be hard to negotiate and are susceptible to erosion. This factor makes BMPs even more important as these soils continue to heal.

BMP specifications S2 (66.1%), S3 (71.5%), S7 (46.4%), S8 (75.8%), and S9 (67.1%) had application departures. Of those application problem areas, only two had effectiveness of less than 80% due to poor implementation. S7 "appropriate drainage and diversions installed," had a 76.9% effectiveness rate. S9, "runoff diverted onto stable forest floor," had an effectiveness rating of 74.7%. The comprehensive application rate for all skid trails monitored on state forest properties is 75.2%, and the effectiveness rate is 87.8%.

Stream Crossings

Stream crossings have historically been the most challenging area for forestry BMPs in Indiana. There is little margin of error in this category. Mistakes are likely to directly affect water quality because these areas directly involve bodies of water. Even if every practice could be applied without departure, water quality could still be affected. In training, avoidance of stream crossings is encouraged for this reason. Should the crossing be necessary, the BMPs help mitigate their impact by decreasing the amount of sediment delivered and hastening the stabilization process.

Blown waterbar above a stream crossing. Stream is filled with harvest debris. Photo taken on private land by Jennifer Sobecki, DNR.

This bridge crossing was well seeded and vegetated after the harvest was completed. Photo taken on state forest property by Jennifer Sobecki, DNR.

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

Stream Crossing	% Application	% Effective
X1. Number of crossings minimized	89.0	91.4
X2. Crossings minimize disturbance to the natural bed and banks	64.0	66.2
X3. Streambank approaches properly designed and stabilized	54.5	56.8
X4. Water runoff diverted from road prior to crossing	55.9	56.5
X5. Crossing as close to 90 degrees as practicable	88.0	92.5
X6. Crossing does not unduly restrict water flow	81.8	82.5
X7. Soil has not been used as fill in the stream (except culverts)	76.7	77.0
X8. Ford constructed of non-erosive materials	83.6	84.4
X9. Fords have stable banks and streambeds	58.5	57.8
X10. Culverts are properly sized and installed	73.9	76.1
X11. Culverts clear of significant flow obstructions	68.9	71.1
X12. Temporary structures properly anchored	98.5	97.0
X13. Temporary structures and resulting obstructions removed	82.1	78.2
Stream Crossing	**74.9**	**76.3**

There are often fewer stream crossings on state sites than most other sites because foresters are encouraged to avoid them. These foresters are regularly trained, and all their sites are inspected by the BMP audit team. Sites on other ownerships often do not have a forester, and the incentive to minimize stream crossings is lessened. A total of 765 stream crossings were reported on 295 sites, an average of 2.6 crossings per site that had at least one crossing. There were 19 perennial crossings, 427 crossings of mapped intermittent streams, and 319 crossings of unmapped intermittent streams, and 62% of state forest sites monitored had no stream crossing.

BMPs X2, X3 and X4 had lower application and effectiveness rates. X2 application rate was 64.0%, and effectiveness rate was 66.2%. X3 application rate was 54.5%, and effectiveness rate was 56.8.%, and X4 application rate was 55.9%, with a 56.5% effectiveness rate. X9 and X10 were also areas needing further attention, with application rates of 58.5% and 73.9% and effectiveness rates of 57.8% and 76.1%, respectively. X11, culverts clear of significant flow obstructions, was also a problem on state sites, with an application rate of 68.9%. Culverts free of flow obstructions had an effectiveness rate of 71.1%. The state stream-crossing application and effectiveness overall percentages were 74.9% and 76.3%, respectively.

The number of crossings monitored on state forests since 2010 is seen below in Figure 10. The graph also shows the number of sites per year with at least one crossing, and the percentage of sites with crossings per year. In 2014 there was an elevated number of crossings due to a large tornado salvage harvest at Clark State Forest that accounted for 60 crossings on that large salvage harvest (800 acres). Due to numerous obstructions from the tornado, multiple crossings were necessary to access the area.

While there are waterbars leading down to the stream crossing, one more was needed before the crossing. Gully erosion is forming due to allowing the runoff to concentrate down the compacted trail and not diverting it before the crossing. Photo taken on private lands by Duane McCoy, DNR.

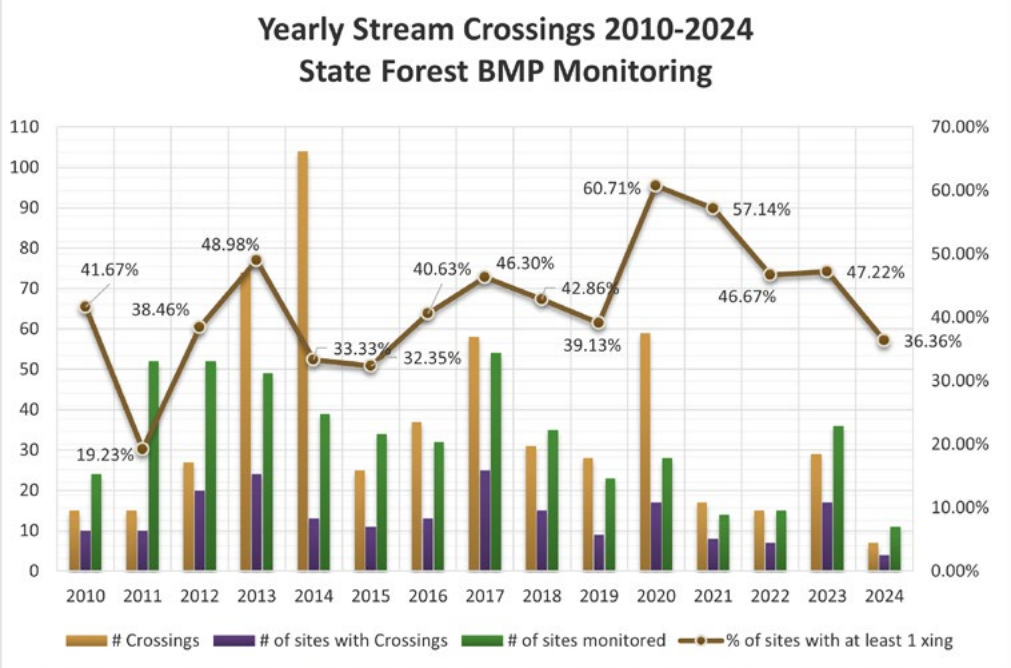

Figure 10. Number of crossings, number of sites with crossings, and percentage of sites with crossings for each year of state monitoring since 2010. High crossing numbers in 2013 were partially due to the Henryville Tornado salvage harvest and a dredging of Starve Hollow Lake. In 2014, high number of crossings was due to another large salvage harvest at the Henryville tornado site monitored on Clark State Forest that year.

Riparian Management Zones

RMZs are similar to stream crossings in that they are adjacent to streams. Because of this, departures in application are more likely to affect water quality. RMZs are applied to the ground next to bodies of water but are different widths according to the type of body of water and the slope of the adjacent land. For example, a perennial stream 20 feet wide has an RMZ of 50 feet if the slope is 0-5%, whereas the same stream with the adjacent ground at a slope of 40% or more has an RMZ of 105-165 feet. Another example would be an open sinkhole that has a 25-foot RMZ if the ground has 0-5% slope. If the slope changes to 20-40%, then the RMZ for the open sinkhole is 105 feet. See page 26 in the 2022 Indiana Forestry BMP Manual for full RMZ width table.

Tops have been removed from the stream in two different areas along this stream on state forest lands. Photo by: Duane McCoy, DNR

A small stream clogged with logging debris. Photo taken on private property by Duane McCoy DNR.

Table 5. RMZ BMP application and effectiveness of all state sites monitored.

Riparian Management Zones	% Application	% Effective
Z2. Perennial & large intermittent streams clear of obstructing debris	71.7	72.9
Z3. Tree tops and cutoffs placed back from water course to prevent movement into streams during floods	92.4	95.2
Z4. RMZ free of excavated material & debris (other than above)	95.1	97.2
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.5	97.6
Z6. Adequate tree stocking in primary RMZ next to perennial streams	99.5	99.5
Z7. RMZ free of roads and landings (except crossing)	63.9	85.0
Z8. Water diverted from roads before entering RMZ	81.5	86.4
Z9. Water diverted onto stable areas of the forest floor	85.4	88.5
Z10. Road and trail surfaces stabilized as needed within RMZ	87.4	88.4
Z11. Ephemeral channels free of excavated material	60.9	62.7
Riparian Management Zones	**82.0**	**86.3**

A harvest was conducted on state forest property near a sinkhole. There were no trails and no soil disturbance near the sinkhole, and tops were felled away and thus properly protected. Picture by: Jennifer Sobecki DNR

Most state forest sites have an RMZ, with 704 of 783 sites having at least one in the harvest area. BMPs of RMZs on state land with challenges were Z2, Z7 and Z11. Obstructing debris in streams (Z2) was a problem with a 71.7% application rate and 72.9% effectiveness. Also, 63.9% of RMZs were free of roads and landings on state land, but this had little effect on water quality, where there was an effectiveness rate of 85.0%. More care is needed in keeping ephemeral channels free of excavated materials. Application was 60.9%, and effectiveness was 62.7%. Overall, RMZs are in good condition with an application rate of 82.0% and effectiveness of 86.3%.

IV. Discussion

The overall state forestry BMP application rate is 85.49%. Overall effectiveness is 91.68%. The high application and effectiveness scores show there are many sound practices taking place throughout state forest harvest sites to maintain the integrity of soil and water resources. There are many things that are being done well. To improve, BMPs with the most departures must be examined to determine how to best enhance the Indiana Forestry BMP program.

The highlight of Indiana's forestry BMPs in the last 28 years has been the high implementation and performance rates for access roads and log landings. Access road application and effectiveness rates were 94.9% and 98.2%, respectively. Log landings had a 90.4% application and 97.7% effectiveness rating. An area of concern for access roads is their ability to drain well as this had an application rate of 84.8%, though it was somewhat mitigated with an effectiveness rate of 96.3%. The two problem areas for landings are collecting or concentrating runoff and runoff being diverted onto stable areas of the forest floor. The application rates are 73.7% and 81.9%, respectively, but the effectiveness for both is more than 94.0%, showing that they have little impact on water quality.

A large portion of the activity of a harvest occurs on skid trails, so it is no surprise that many issues arise in this area. Skid trails had an overall application rate of 75.2% and effectiveness of 87.8%. This indicates that although there are some difficulties correctly carrying out BMPs on skid trails, the impacts to water quality are minimal. Two areas of skid trails have effectiveness scores below 80%: S7, appropriate drainage and diversions installed, and S9, water diversions in working order. S7 effectiveness was 76.9% and S9 effectiveness was 74.7%.

Skid trail disturbance levels can vary depending on how often equipment drives over a particular point on the ground. For instance, the main trail just off the landing would have a higher disturbance level because all harvested logs have to be moved to the landing. An area traveled over only twice, once to access trees and the other to pull out the logs, would have a much lower level of disturbance. Also, skid trails go to areas that other equipment cannot access and cover more surface area across the harvest area, so they may cross drainages, travel down or across hill slopes, or go into areas that can be wet during precipitation. Therefore, most of the application and effectiveness issues of a site are from skid trails. Also, most closeout practices are put in place with limited space as landforms, and nearby vegetation often limits the equipment's ability to place structures where they would be most effective. This causes minor departures in application (24.2% of skid-trail application scores are minor departures), with little to no effect on water quality.

Overall stream crossing BMP application is 74.9%, and overall effectiveness is 76.3%. Due to the nature of stream crossings, impacts to water quality are, at times, inevitable; however, the length 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 viable. Diversion of water before the stream crossing is a weakness, X4. This individual BMP had an overall application of 55.9% and effectiveness of 56.5%. The proper design and stabilization of stream banks at crossings (X3) was also a problem, with an overall application of 54.5% and effectiveness of 56.8%.

RMZs are much like stream crossings in that they are close to bodies of water. If there is a problem, it may directly affect water quality, so managers often try to avoid placing high-impact infrastructure like access roads or landings in RMZs unless they already exist. Overall RMZs had a respectable application rate at 82.0%. The effectiveness rate for overall RMZs was 86.3%. The two main areas of RMZs on state forests that need to be improved are keeping logging debris out of perennial and intermittent streams and ephemeral channels free of excavated materials, as this is where many of the direct and prolonged impacts are coming from. Perennial and large intermittents were found to be free of obstructing logging debris 71.7% of the time, with an effectiveness rate of 72.9%. Ephemeral channels are the area with the lowest implementation and effectiveness rate with 60.9% and 62.7%, respectively.

V. Recommendations

- Concentrate training, education, and implementation on areas in which problems are more 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.
- Focus on BMP areas that have decreased in application and effectiveness in recent years. Emphasize the importance of these during training of foresters and loggers.

VI. Conclusions

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

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

VII. Literature Cited

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White oak seedlings in an opening created by timber harvest.

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