Monitoring Results for State Forest Properties • 1996-2023

Indiana Forestry Best Management Practices

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Indiana State Forest BMP Report

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I. Introduction & Indiana Forestry BMP History

A. BMP Introduction

Indiana has 4.8 million acres of forestland, which is 21% of the state's land. State forest properties comprise 160,252 acres, around 0.7% of the state. Forestland is important to Hoosiers for a host of reasons. Recreation activities including hiking, biking, hunting, fishing, and wildlife watching are popular in these areas. Residents who do not participate in recreation still 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, no matter who owns the land, be done in a way that reduces or mitigates negative 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 critical to water quality protection during forest operations. The purpose of BMPs is to minimize the negative 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 1996-2023. A total of Three sites in this study are from state owned lands but not specifically state forest property. Data in this report covers all BMP monitoring for 772 state forest timber harvest sites over those years, looking at time trends and making comparisons.

B. BMP History

In response to the federal Clean Water Act amendments of 1987 and a request from Indiana's forest owners, the DNR Division of Forestry (DoF), in cooperation with the Woodland Steward Institute, 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 negative impacts of silvicultural practices as well as 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). States declared BMPs as either voluntary or regulatory.

In cooperation with the United States Environmental Protection Agency (EPA), the Indiana Department of Environmental Management (IDEM) and the Woodland Steward Institute, the DoF arranged a series of meetings that included individuals from many public agencies and private interests in the early 1990s. They set up committees that would develop a set of forest practices designed to mitigate or minimize impacts of forest-management activities on water quality. Occasionally these BMPs would enhance water quality. This effort was designed under the auspices of the Clean Water Act, which directed the EPA to guide the states in developing BMPs for several land-use practices such as agriculture, urban development and forestry. In forestry, the states were directed to establish BMPs, and declare them as either voluntary or regulatory.

The Indiana forestry BMP program was divided into three main components. The first element was the 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.

Indiana DNR Forestry BMP teams have at least one calibration training per year to discuss forestry BMP application and effectiveness on a recently harvested site. Photo taken on private property by Jennifer Sobecki, DNR.

The third part was BMP monitoring, which consisted of looking at how BMPs were applied in the field and how well those practices protected water quality.

By 1996, 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. There were four to five people on a team and members possessed multiple areas of expertise.

All BMP monitoring has followed the model that was set by that mid-1990s group, though 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 have 93.4% implementation of BMPs, while regulatory states have 95% percent 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 current and historical information on the extent of BMP implementation
3. Identify where to focus future program training and educational efforts to improve BMP imple mentation 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

State BMP Monitoring by Property

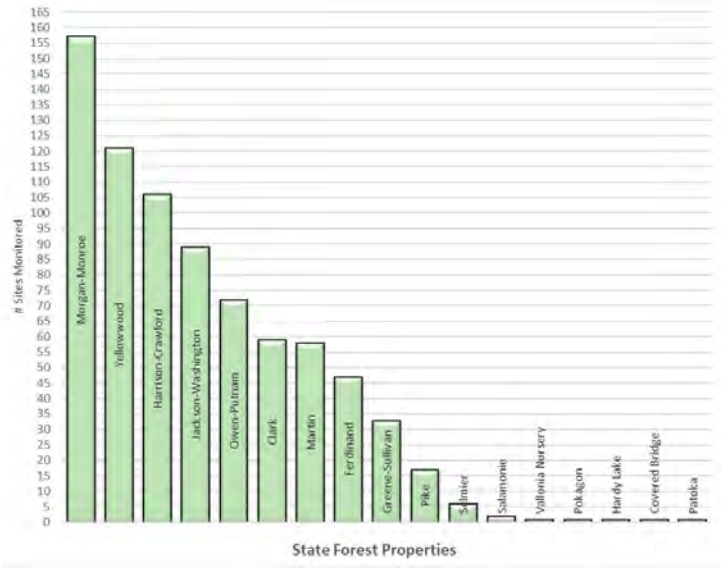

Figure 1. Number of timber harvests monitored for BMPs in Indiana state forest and other DNR properties.

FIGURE 2

Number of State Forest Sites Monitored for BMPs

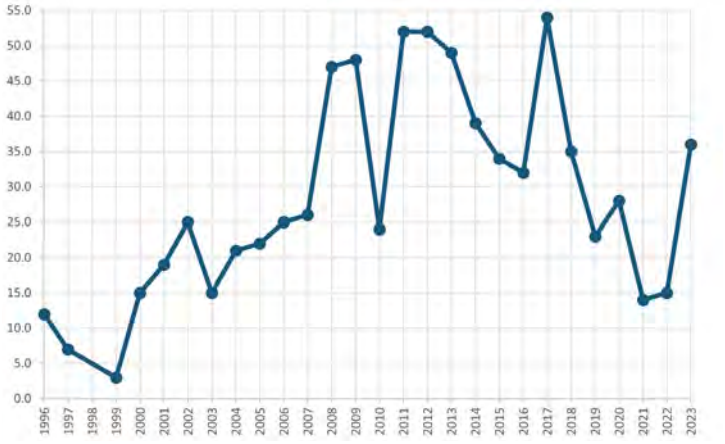

Figure 2. Total number of state sites monitored per year for the last 27 years.

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 like this one, Classified Forests & Wildlands, comprehensive reports of harvests on all land ownership types, and quality-control reports.

D. Monitoring Team Selection

On state forest properties, foresters from either the Watershed Conservation (WC) or 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 whose focus is 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 monitoring coordination was carried out by the state forest resources supervisor, who also attended 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 negative 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.

A total of 58 BMPs are measured for application and effectiveness on each site evaluation. These BMPs are within five categories:

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

The monitoring team inspects the harvest area covering all access roads, log landings, skid trails, water bodies, riparian management zones and stream crossings 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 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 was 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 not part of the definition for intermittent streams on other forest ownership types listed in the BMP field guide, which was inconsistent with state forest properties. That's why in July 2010 the 4-Foot Rule was abolished, to be consistent across all properties as to the definition of intermittent streams and where woody debris needed to be removed. Woody debris now needs to be removed from mapped intermittent streams or larger as determined by USGS.

III. Results

A. Comprehensive BMP Application and Effectiveness

FIGURE 3

State Forest BMP Application

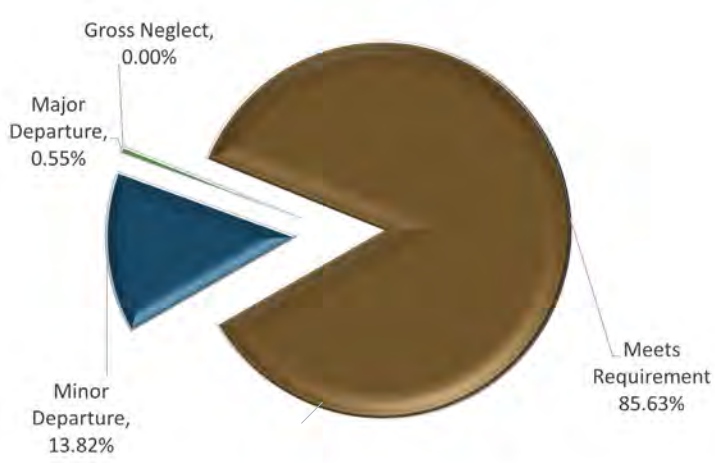

Figure 3. BMP application rates for all 772 sites monitored on state properties since 1996.

FIGURE 4

State Forest BMP Effectiveness

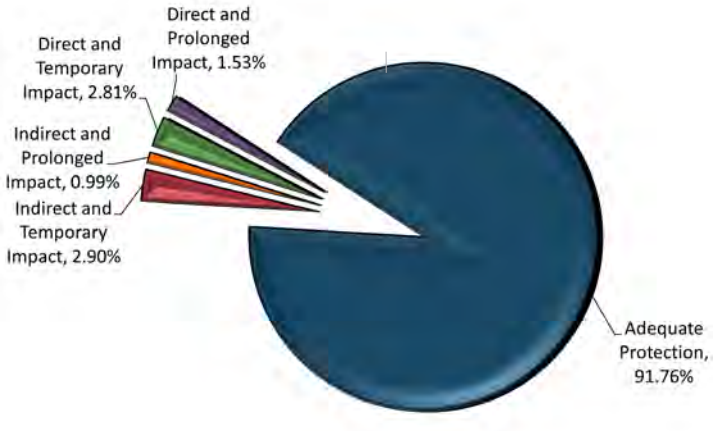

Figure 4. BMP effectiveness rates for all 772 sites monitored on state properties since 1996.

The application and effectiveness rates for BMPs used to protect sites after timber harvests are excellent for the 772 state forest sites monitored since 1996. The overall application rate is 85.63 percent, and the overall effectiveness rate is 91.76 percent.

FIGURE 5

Yearly State Forest BMP Application & Effectiveness Rates

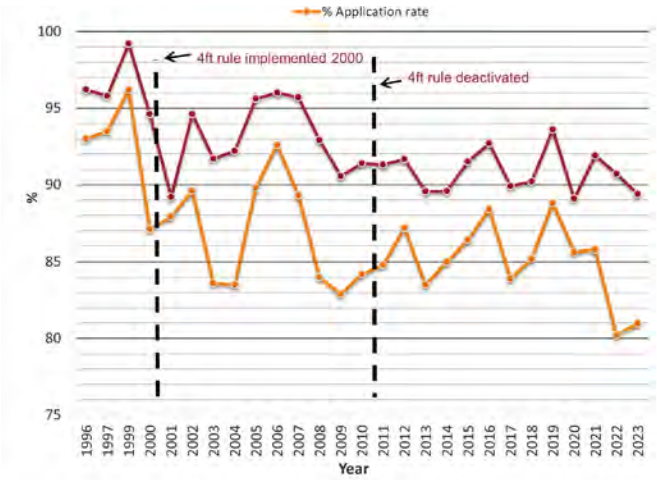

Figure 5: Yearly trends of BMP application and effectiveness on Indiana State Forests for 27 years of monitoring. These percentages are calculated for each year's data separately, not combined with the running totals from previous years.

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 terrain variation when traveling. Therefore, access roads are often well stabilized and drained and usually constructed in areas that have established travel away from water bodies 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

State Forest BMP Application

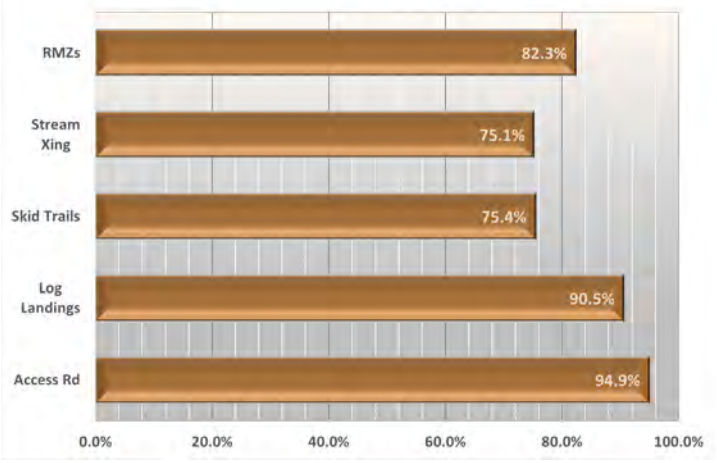

Figure 6. Overall BMP application for each of the five BMP categories.

FIGURE 7

State Forest BMP Effectiveness

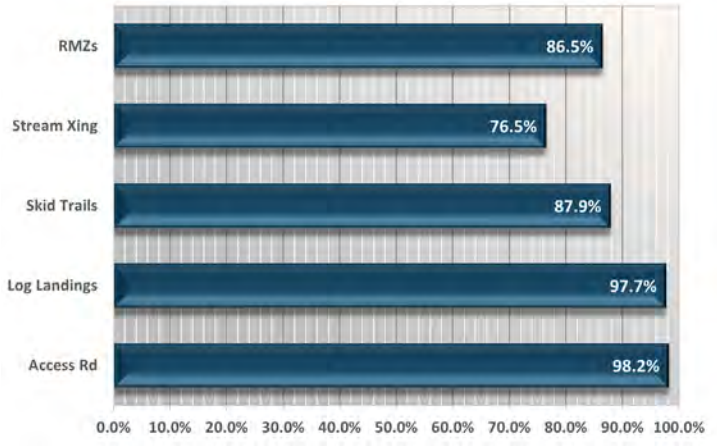

Figure 7. Overall BMP effectiveness for each of the five BMP categories.

FIGURE 8

Yearly Application by BMP Catagory

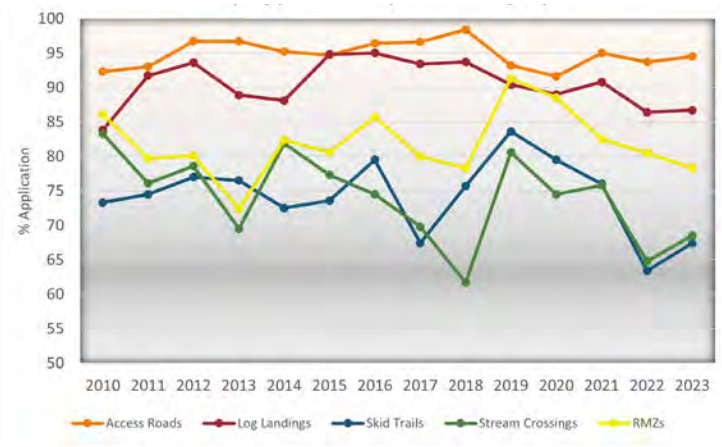

Figure 8. Yearly BMP application trends by category.

FIGURE 9

Yearly Effectiveness by BMP Category

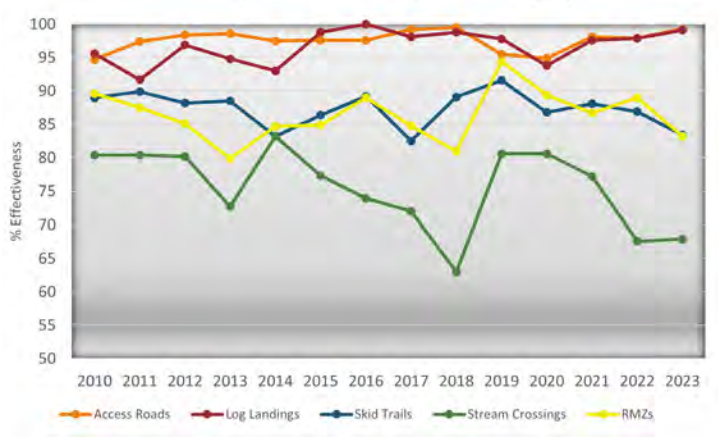

Figure 9. Yearly effectiveness trends by BMP category since 2010.

The overall BMP application and effectiveness for the five categories was highest for access roads, which had a 94.9% application rate and 98.2% effectiveness rate. Second-highest was log-landing application with an application rate of 90.5% and effectiveness of 97.7%. The third-highest category was RMZs with 82.3% application and 86.5% effectiveness rates. While skid trails rated low in application at 75.4%, the effectiveness was still good at 87.9%. Stream crossings had the lowest application rate of all categories but had a 75.1% application rate. Effectiveness on stream crossings is 76.5%. Because of the direct negative impact crossings can have on water resources, BMP application are most critical in this area. Small problems in stream crossings can lead to lower effectiveness rates. Wet conditions can also lead to more departures in effectiveness of stream crossings.

Restricting access to a harvest can be accomplished with a simple cable gate, limiting trespass that could cause significant damage to the soil and water resources on the site. Photo by Duane McCoy, DNR.

1. Access Roads

Access roads connect the harvest area to public roads, which is critical for getting logs to mills for processing. This connection means vehicles such as tractor-trailers need to be able to drive on them without much difficulty. Often access roads are stable with a good base, or are short. They are often located away from water bodies and are constructed to drain well. This is why they typically have higher application and effectiveness scores.

TABLE 1 Access road BMP application and effectiveness for all state sites monitored from 1996-2023.

Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.9	99.9
A2. Adequate buffer strip next to watercourses and sensitive areas	95.1	98.5
A3. Avoids unstable gullies, seeps, very poorly drained areas	95.8	99.1
A4. Road grades are within standards	97.8	99.9
A5. Amount of roads minimized	99.9	100.0
A6. Stream crossings minimized	98.7	99.8
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	85.3	96.3
A10. Appropriate road stabilization, drainage, and diversions installed	83.6	92.9
A11. Water diversions functioning properly	91.4	96.0
A12. Runoff diverted onto stable forest floor areas	88.6	92.7
A13. Public road drainage system maintained	99.3	99.6
A14. Public road's drainage maintained	99.5	99.8
A15. Traffic barriers installed	90.7	98.8
Overall Access Road	94.9	98.2

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," (85.3%) and A10, "Appropriate road stabilization, drainage and diversions installed," (83.6%). 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.

2. Log Landings

Log landings are the areas of highest equipment concentration, since it takes multiple trips by heavy equipment to bring logs to the landing from the area where it was standing in the woods. The logs are 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 tract being harvested. Others have been established for decades and are used for multiple tracts. The older landings are often left as grass and forbs wildlife areas between uses. Smaller landings often convert back to forested areas until the next harvest on that tract.

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 in state forest. Photo by Duane McCoy, DNR

Log landing BMPs Y5 & Y6 were an application challenge on state forests. Y5's application rate was 74.0% and the A6 application was 82.3%. Both had high effectiveness rates at 95.9% and 94.0%, respectively. Overall log-landing application was 90.5%, and overall log-landing effectiveness was 97.7%.

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

Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	95.8	99.7
Y2. Landings located outside RMZ	95.4	99.1
Y3. Landings located on stable areas	94.1	99.2
Y4. Excavation of site minimized	93.4	98.7
Y5. Landings avoid concentrating or collecting runoff	74.0	95.9
Y6. Landing's runoff enters stable area	82.3	94.0
Y7. Proper water diversions in working order	88.6	94.9
Y8. Landing smoothed and soil stabilized	88.0	96.8
Y9. Landings free of fuel and lubricant spills, and litter	94.3	98.8
Y10. Landing location suitable for equipment fueling, and maintenance	99.2	99.9
Overall Log Landings	90.5	97.7

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 onsite. Photo taken on private property by Jennifer Sobecki, DNR.

Despite leaf cover and some revegetation, the lack of diversions on this trail are leading to deepening gully erosion. Photo taken on private property by Duane McCoy, DNR.

3. 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 sometimes heavily used and at other times only used lightly. Because of that skid trails 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 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 for 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 negative 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	96.9	98.4
S2. Adequate buffer strip next to water courses and sensitive areas	66.7	83.7
S3. Avoids steep and long straight grades (>20% for >200')	71.1	96.6
S4. Avoids unstable gullies, seeps, poorly drained areas	78.9	90.4
S5. Amount of skid trails minimized	81.9	94.4
S6. Trail excavation minimized	84.9	93.4
S7. Appropriate drainage and diversions installed	46.8	77.3
S8. Water diversions in working order	76.3	85.3
S9. Runoff diverted onto stable forest floor areas	67.5	75.0
S10. Streams not used as skid trails (except for crossings)	82.8	84.7
Overall Skid Trail	75.4	87.9

This skid trail was mulched with straw after a harvest on state forest land. Photo by Duane McCoy, DNR

Skid did not avoid this poorly drained area. Photo taken on private property by Duane McCoy, DNR.

Skid trails on state sites are often longer because of guidelines that determine 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 many state forest properties were once subsistence farms that failed during the Great Depression and were then reverted to state ownership. Many farms were located steep slopes and the farms eroded the topsoil, leaving large gullies and little to no vegetation by the 1920s. The forest has now grown back and soils are thriving again, but these former farms can 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 (66.7%), S3 (71.1%), S7 (46.8%), S8 (76.3%) and S9 (67.5%) 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 75.0% effectiveness rate as did S9, “runoff diverted onto stable forest floor.” The comprehensive application rate for all skid trails monitored on State Forest properties is 75.4%, and the effectiveness rate is 87.9%.

4. Stream Crossings

Stream crossings have historically been the most challenging area for forestry BMPs in Indiana, but they are critical because there is little margin for error. Mistakes are likely to directly affect water quality because they are so close to 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 negative impact by decreasing the amount of sediment delivered and hastening the stabilization process.

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 of their sites are inspected by the BMP audit team. Sites on other ownerships often do not have a forester so the incentive to minimize stream crossings is lessened. A total of 758 stream crossings were reported on 291 sites, an average of 2.6 crossings per site that had at least one. There were 19 perennial crossings, 423 crossings of mapped intermittent streams and 316 crossings of unmapped intermittent streams. A total of 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 64.1%, and effectiveness rate was 66.4%. X3 application rate was 55.3%, and effectiveness rate was 57.6.%, X4 application rate was 56.3%, with a 57.0% effectiveness rate. X9 and X10 were also areas needing further attention, with application rates of 59.2% and 73.3% and effectiveness rates of 58.4% and 75.6%, respectively. X11, culverts clear of significant flow obstructions, was also a problem on state sites, with an application rate of 68.2%. Culverts free of flow obstructions had an effectiveness rate of 70.5%. The state stream-crossing application and effectiveness overall percentages were 75.1% and 76.5%, respectively.

This low ford crossing is well done, with the exception that water should have been diverted prior to crossing. Photo taken on private property by Duane McCoy, 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	64.1	66.4
X3. Streambank approaches properly designed and stabilized	55.3	57.6
X4. Water runoff diverted from road prior to crossing	56.3	57.0
X5. Crossing as close to 90 degrees as practicable	88.2	92.4
X6. Crossing does not unduly restrict water flow	81.9	82.9
X7. Soil has not been used as fill in the stream (except culverts)	76.8	77.2
X8. Ford constructed of non-erosive materials	83.8	84.2
X9. Fords have stable banks and streambeds	59.2	58.4
X10. Culverts are properly sized and installed	73.3	75.6
X11. Culverts clear of significant flow obstructions	68.2	70.5
X12. Temporary structures properly anchored	98.5	97.0
X13. Temporary structures and resulting obstructions removed	81.8	77.9
Stream Crossing	75.1	76.5

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.

FIGURE 10

Yearly Stream Crossings 2010-2023
State Forest BMP Monitoring

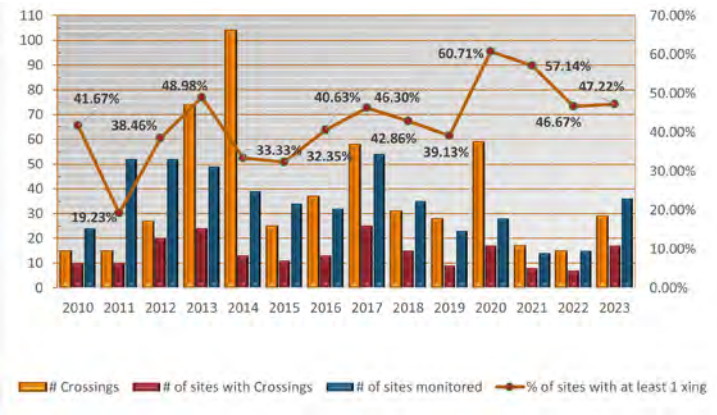

Figure 10. Number of crossings, number of sites with crossings and percentage of sites with crossings for each year of state monitoring since 2010. High crossing numbers in 2013 were partially due to the Henryville Tornado salvage harvest and a dredging of Starve Hollow Lake. In 2014 high number of crossings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

While it appears some sort of bridge or mat was used to cross this stream, it was not smoothed or stabilized after closeout, which will cause erosion for years to come. Taken on private property by Jennifer Sobecki, DNR.

5. Riparian Management Zones

RMZs are similar to stream crossings in that they are also 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 water body 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 percent, whereas the same stream with the adjacent ground at a slope of 40 percent 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 percent 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 sediment due to large area of bared soils near the stream and runoff from that area flowing directly into the stream. 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	72.0	73.3
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)	95.2	97.3
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	85.1
Z8. Water diverted from roads before entering RMZ	82.2	86.9
Z9. Water diverted onto stable areas of the forest floor	86.0	89.0
Z10. Road and trail surfaces stabilized as needed within RMZ	88.0	89.1
Z11. Ephemeral channels free of excavated material	61.2	63.1
Riparian Management Zones	82.3	86.5

Most state forest sites have at least one RMZ, 693 of 772 sites. BMPs of RMZs on state land with challenges were Z2, Z7 and Z11. Obstructing debris in streams (Z2) was a problem with a 72.0% application rate and 73.3% effectiveness. 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 85.1%. More care is needed in keeping ephemeral channels free of excavated materials. Application was 61.2%, and effectiveness was 63.1%. Overall, RMZs are in good condition with an application rate of 82.3% and effectiveness of 86.5%.

This trail in the RMZ was scoured by overflow from the creek resulting in erosion and sediment deposition. Photo taken on private property by Duane McCoy, DNR.

IV. Discussion

The overall state forestry BMP application rate is 85.63%. Overall effectiveness is 91.76%. 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 26 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 90.5% 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 85.3%, though it was somewhat mitigated with an effectiveness rate of 96.3%. The two problem areas for landings are the categories of collecting or concentrating runoff and runoff being diverted onto stable areas of the forest floor. The application rates are 74.0% and 82.3% respectively, but the effectiveness for both is over 94.0%, showing that they have little negative 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 75.4% and effectiveness of 87.9%. This indicates that although there are some difficulties correctly carrying out BMPs on skid trails, the negative impacts to water quality are minimal. Two areas of skid trails have effectiveness scores below 80%, these are; S7, appropriate drainage and diversions installed, and S9, water diversions in working order. S7 effectiveness was 77.3% and S9 effectiveness was 75.0%.

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 must 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 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 (24.1% of skid-trail application scores are minor departures), with little to no effect on water quality.

Overall stream crossing BMP application is 75.1%, and overall effectiveness is 76.5%. Due to the nature of stream crossings, impacts to water quality are, at times, inevitable. The largest problem on stream crossings continues to be the diversion of water before the stream crossing, X4. This individual BMP had an overall application of 56.3% and effectiveness of 57.0%. The proper design and stabilization of stream banks at crossings (X3) was also a problem, with an overall application of 55.3% and effectiveness of 57.6%.

Overall RMZs had a respectable application rate at 82.3%. The effectiveness rate for overall RMZs was 86.5%. The two main areas of RMZ's 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 negative impacts are coming from. Perennial and large intermittents were found to be free of obstructing logging debris 72% of the time with a effectiveness rate of 73.3%. Ephemeral channels are the area with the lowest implementation and effectiveness rate with 61.2% and 63.1% respectively.

V. Recommendations

• Concentrate training, education, and implementation on areas where 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 will continue to hold itself and others to a high

Oak seedlings in an opening created by timber harvest. Photo by Jennifer Sobecki, DNR

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 the current science.

The DoF will use information that is found this report and others like it 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, and forestry BMPs are one way this can be accomplished.

VII. Literature Cited

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