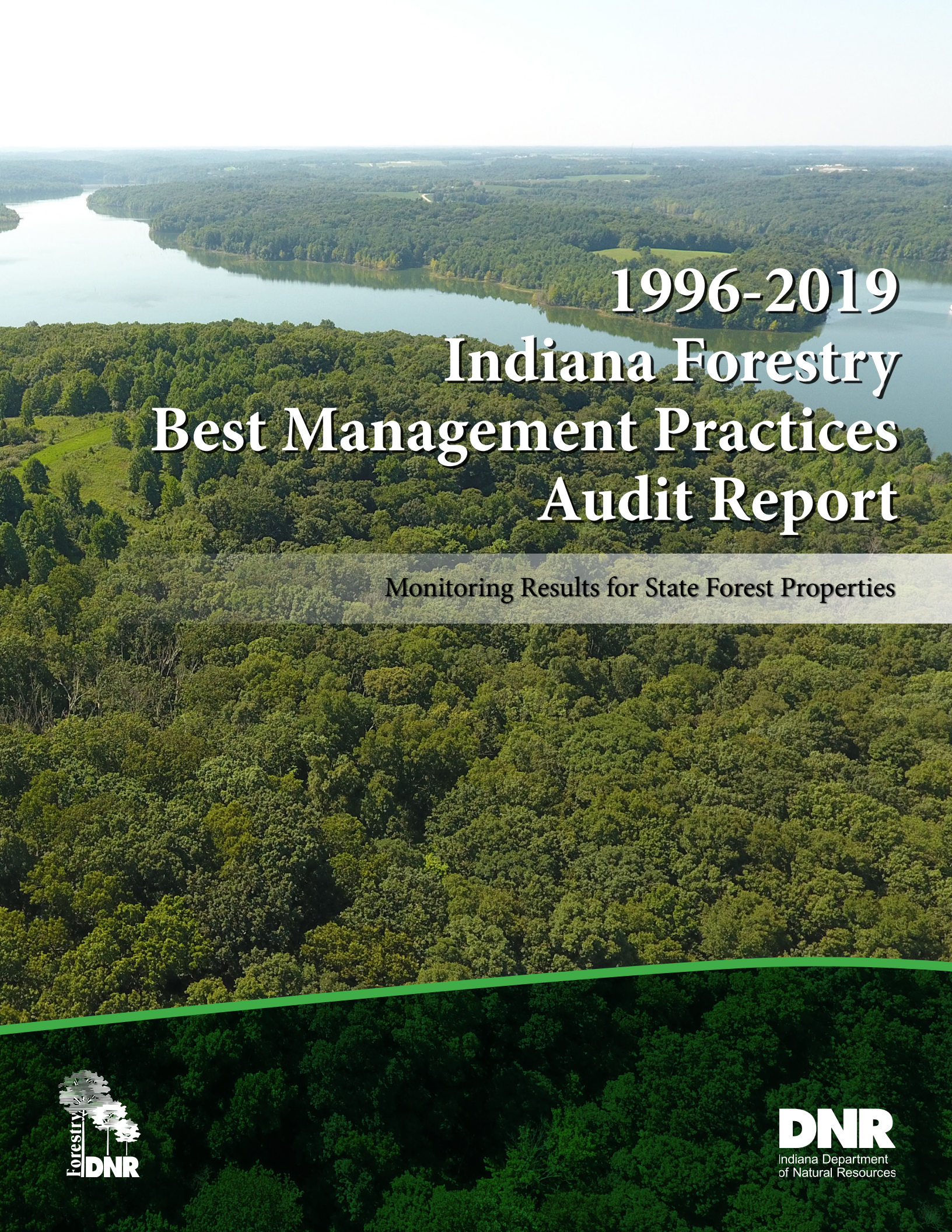


1996-2019 Indiana Forestry Best Management Practices Audit Report

Monitoring Results for State Forest Properties

Forestry DNR

DNR
Indiana Department of Natural Resources

Indiana Forestry Best Management Practices Monitoring Results for State Forest Properties 1996-2019

By: Jennifer Sobecki & Duane McCoy

1996 through 2019

Indiana State Forest BMP Report

I. Introduction & Indiana Forestry BMP History

A. BMP Introduction

Indiana has 4.913 million acres of forestland, 21.2% of the state's land base, providing many benefits to Indiana residents and wildlife. Indiana state forest properties currently number at 158,019 acres, 0.7% of the state. Forestland is important to Hoosiers who frequent the woods for various forms of recreation, including hiking, biking, hunting, fishing and wildlife watching. Even residents who do not participate in these activities benefit greatly from the biodiversity, clean air and water that forests produce. Because forests are important to all citizens of Indiana, it is imperative that timber harvesting on all forests, of all land ownerships, be done in a way that reduces or mitigates environmental impacts. Although forests are known to be the best way to reduce non-point source pollution (NPS) to waterways, they also can generate pollutants. When forest soils are bared, NPS pollution can occur, and Best Management Practices (BMPs) are in place to minimize it.

Forestry BMPs are a foundation for water quality protection during forest operations. The purpose of BMPs is to minimize the impact of forest activities that may affect soil and water quality. This report summarizes the application and effectiveness of BMPs for timber harvests conducted on state forest properties from 1996-2019. Data cover all BMP monitoring for 679 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, took on a statewide project to develop a program to carry out voluntary BMPs. The federal Clean Water Act amendments of 1987 prompted states to develop BMP guidelines to control the impacts of silvicultural practices, as well as the impacts of other land 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, the first round of BMP monitoring occurred in 1996, and the Forestry BMP Field Guide was published in 1998. The respective forestry agency in each of the 50 states either developed a forestry BMP manual for its state or was heavily involved in such a document's development (Nat'l Assoc. 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 DoF arranged a series of meetings that included individuals from many public agencies and private interests. In these meetings 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 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. Regarding forestry, the states were directed to establish BMPs, which they declared as either voluntary or regulatory.

The Indiana forestry BMP program was divided into three main components. The first element was the BMP guidelines themselves, which were the physical practices, such as water-diversion spacing or seed mixture recommendations, and the publication that has been commonly known as the Indiana Forestry BMP Field Guide. The second component was BMP training, which consisted of teaching the BMPs to the different parts of the Indiana forest products community, such as loggers, landowners and foresters. State forestry agencies nationwide have reported that training and certification are vital to the adoption and use of forestry BMPs (Cristain et al. 2016). The third part was BMP monitoring, which consisted of looking at how BMPs were applied in the field and how well those practices protected water quality.

By 1996, the BMP guidelines were constructed, and the monitoring program was ready to begin. Timber-harvest sites were selected for BMP monitoring, predominately within the Monroe Lake Watershed. Monroe Lake is a reservoir serving many Hoosiers as a chief source of water and recreation. Additional sites were from adjoining Owen County and Morgan-Monroe State Forest. Only legitimate forest sites larger than 10 acres that were logged within the last two years 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 to use their site as part of the study. Once sites were accepted for monitoring, teams were formed of people with diverse technical backgrounds. Each team was led by a DNR forester, who provided technical and logistical support. Other team members came from the forest industry, the environmental community, landowners, planning and development professionals, and wildlife-biology, hydrology and soil-conservation experts. Team size was four to five individuals, often with team members possessing multiple areas of expertise.

All BMP monitoring since has followed the model that was set by the group in the mid-1990s, but it has evolved over time, either by necessity or for improvements that were recognized as needed. The first few rounds of monitoring were paid for through money from IDEM or the Great Lakes Commission under the Clean Water Act or some other federal program. Since 2009, 10% of all reported harvest on private lands in the Classified Forest & Wildlands program have been monitored for BMPs. BMP monitoring has also become a staple on state forest property harvest sites, where all harvest sites are monitored for BMP compliance.

Studies of nationwide forestry BMP implementation by state indicate that overall adjusted forestry BMP average is 89% (Ice et al. 2010). At the time of the Ice 2010 study, Indiana had the highest implementation rates of any of its nearest neighbors. BMP implementation was 84% for Michigan, Illinois and Ohio. Indiana was at 88%, and Kentucky had a 68% implementation rate (Ice et al. 2010). The implementation rate for this report of only Indiana state forest sites was 86%.

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 in order 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.

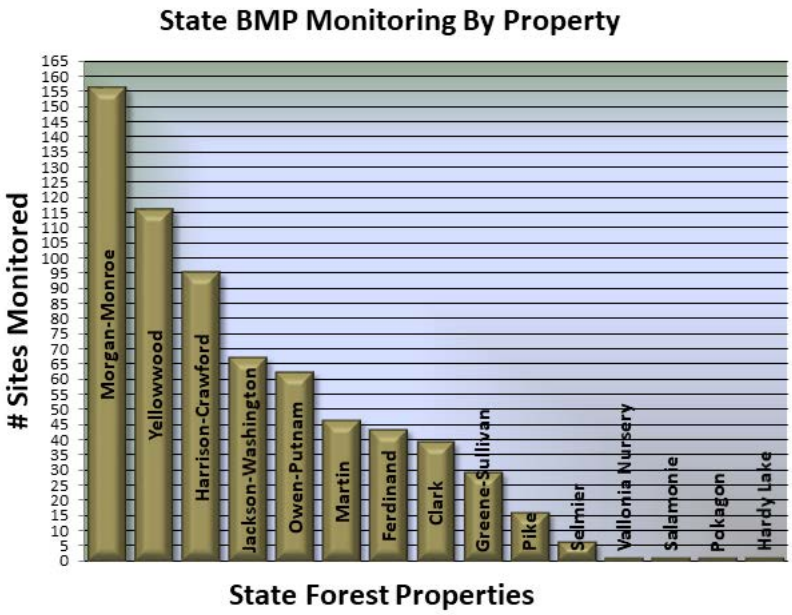


Figure 1. Timber harvests monitored for BMPs in Indiana State Forests and other DNR properties, by property.

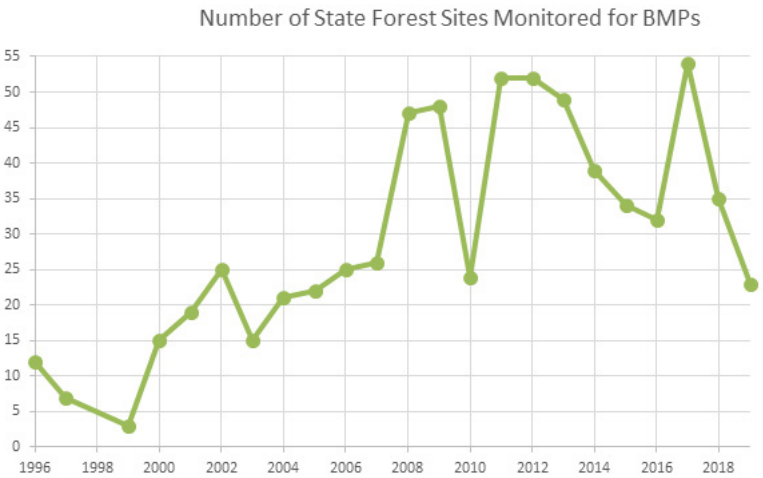


Figure 2. Total number of State Forest sites monitored each year since the BMP program began 23 years ago.

C. Data Collection, Entry and Analysis

The BMP monitoring form is used to collect data both in the office and in 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 later 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 into the Indiana Forestry BMP Database. Datasheets are "cleaned up" and copies are supplied to the parties involved, including foresters, landowners, timber buyers, and managers. The database is used to construct various reports such as this one, as well as annual reports, Classified Forests & Wildlands and comprehensive reports of harvests on all land ownership types, and quality-control reports.

D. Monitoring Team Selection

Monitors for state forest timber sale monitoring has been modified over the course of BMP monitoring in Indiana (1996 -2019). At first, on state forest properties, either or both of the Watershed Conservation (WC) and Licensed Timber Buyers (LTB) foresters came to every BMP-monitoring site. This kept a balance for consistency in the monitoring and resulting data. There is now a BMP-monitoring staff that includes the LTB forester, BMP assistant district forester and one intermittent position whose focus is BMP monitoring. The other participants are the administering forester, and, at times, other foresters on the property. This group provides 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 property specialist, who also attended the monitoring of every timber harvest. This practice was discontinued when administrative duties increased for that position, and coordination of monitoring was passed to the LTB forester.

E. Site Evaluation

BMP monitoring is based on the evaluation of each specific practice for application and effectiveness. Application is the installation of a practice and the condition of the practice at the time of monitoring. Effectiveness is the level of success a practice has in preventing pollutants from entering a water body or in reducing the level of impact the pollutant is having on the water body at the time of monitoring. It is possible to apply all of the BMPs properly and get a 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 be possible as well.

There are 53 individual BMPs measured for application and effectiveness on each site evaluation. These individual BMPs are within five categories:

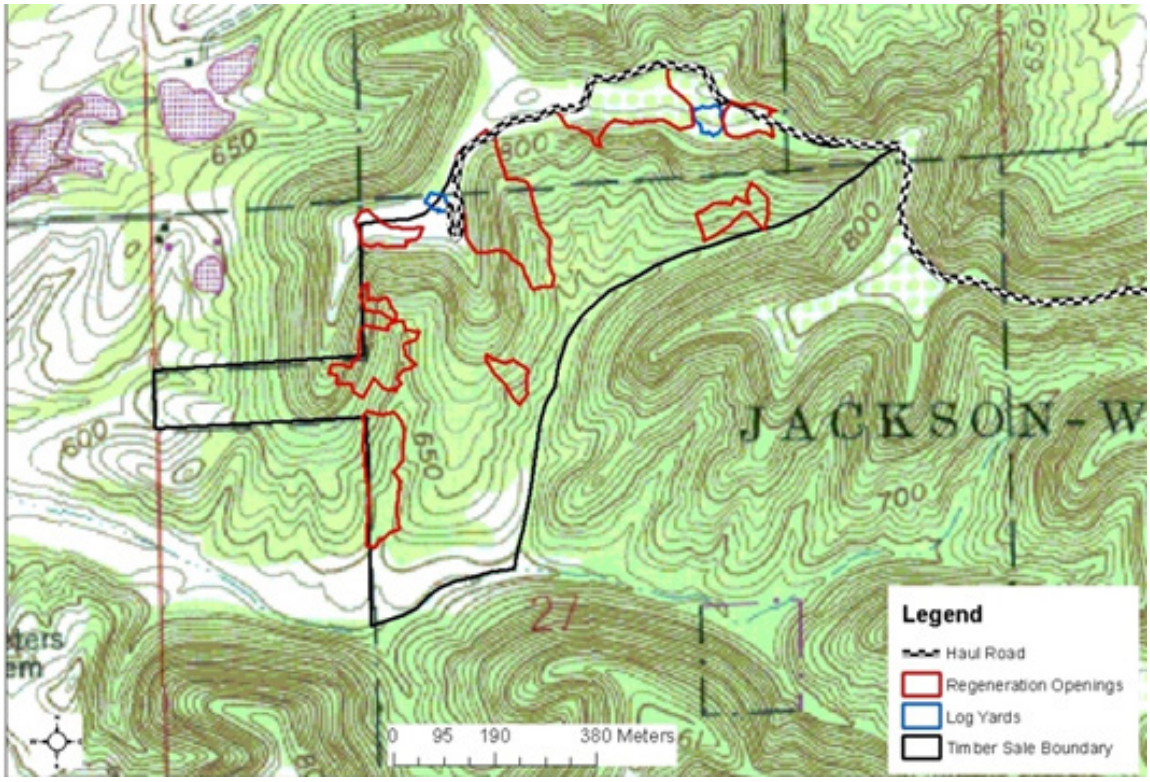
1. Access or Haul Roads
2. Log Landings or Yards
3. Skid Trails
4. Stream Crossings
5. Riparian Management Zones (RMZ)

The monitoring team inspects the harvest area, covering all access roads, log landings, skid trails, water bodies, riparian management zones, and stream crossings, as suggested in the Indiana BMP monitoring protocol, and notes 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 while carrying maps of the site, the BMP monitoring form and the BMP Field Guide. This allows each team member to evaluate the BMPs on the site. Once the team has walked the area, its members discuss each question and each of their scores on the BMP monitoring form until they reach consensus on each score for each question.

BMP training on a recently harvested site. Photo by Duane McCoy, DNR

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



Harvest planning map. Harvest pre-planning is an essential part of BMPs.

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

3rd-Party Quality Control

It was determined in 2007 that 10% of state forest sites monitored the two previous years and every year thereafter would be re-monitored for quality control, to ensure the accuracy of the DoF's internal audits. Sites were given numbers, and then the numbers were chosen randomly to select the 10% of sites to be re-monitored by professionals not employed by the State. A total of 10% of sites monitored each year are to be reviewed. This process continued through 2010; however, due to difficulty in finding objective external monitors to participate, this practice has been discontinued. A new system is being considered to resume these external audits. https://www.in.gov/dnr/forestry/files/fo_BMP_2007_3rd_Party_Report-Final.pdf

III. Results

A. Comprehensive BMP Application & Effectiveness

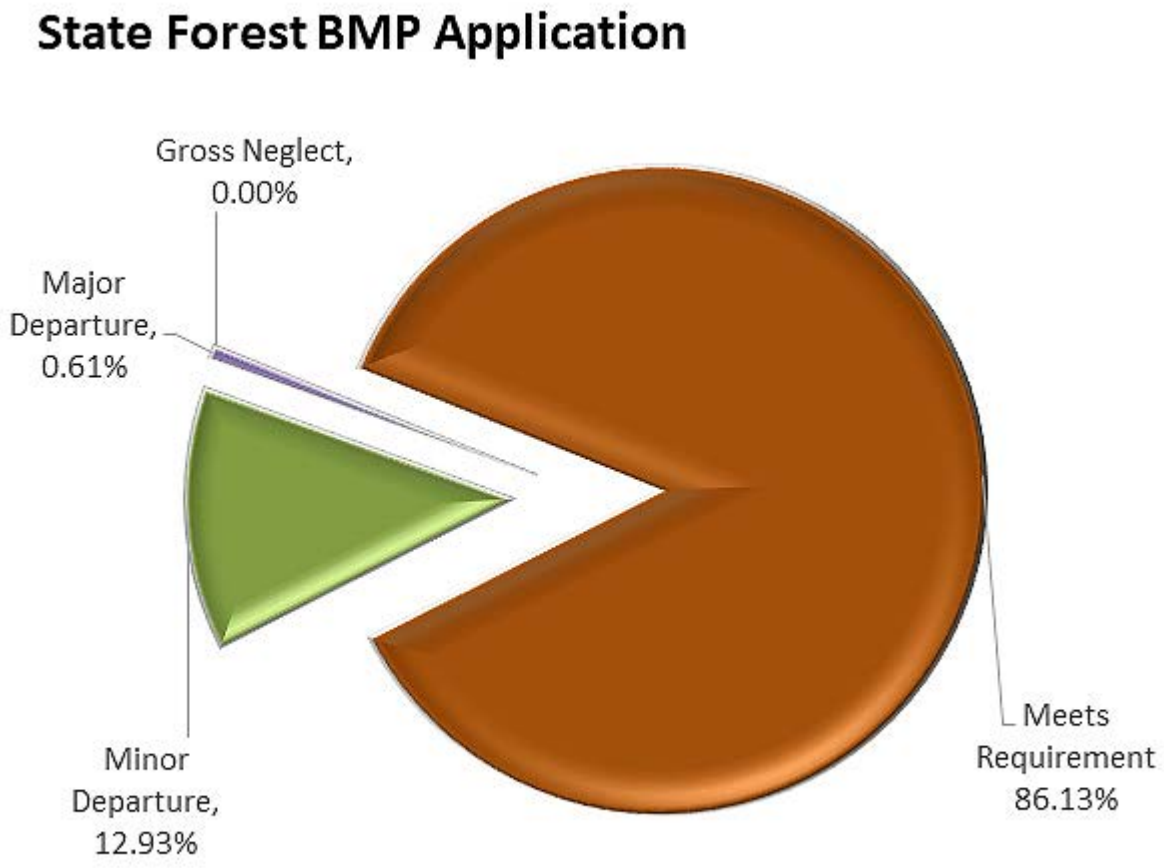


Figure 3. BMP application for 679 State Forest sites monitored from 1996-2019.

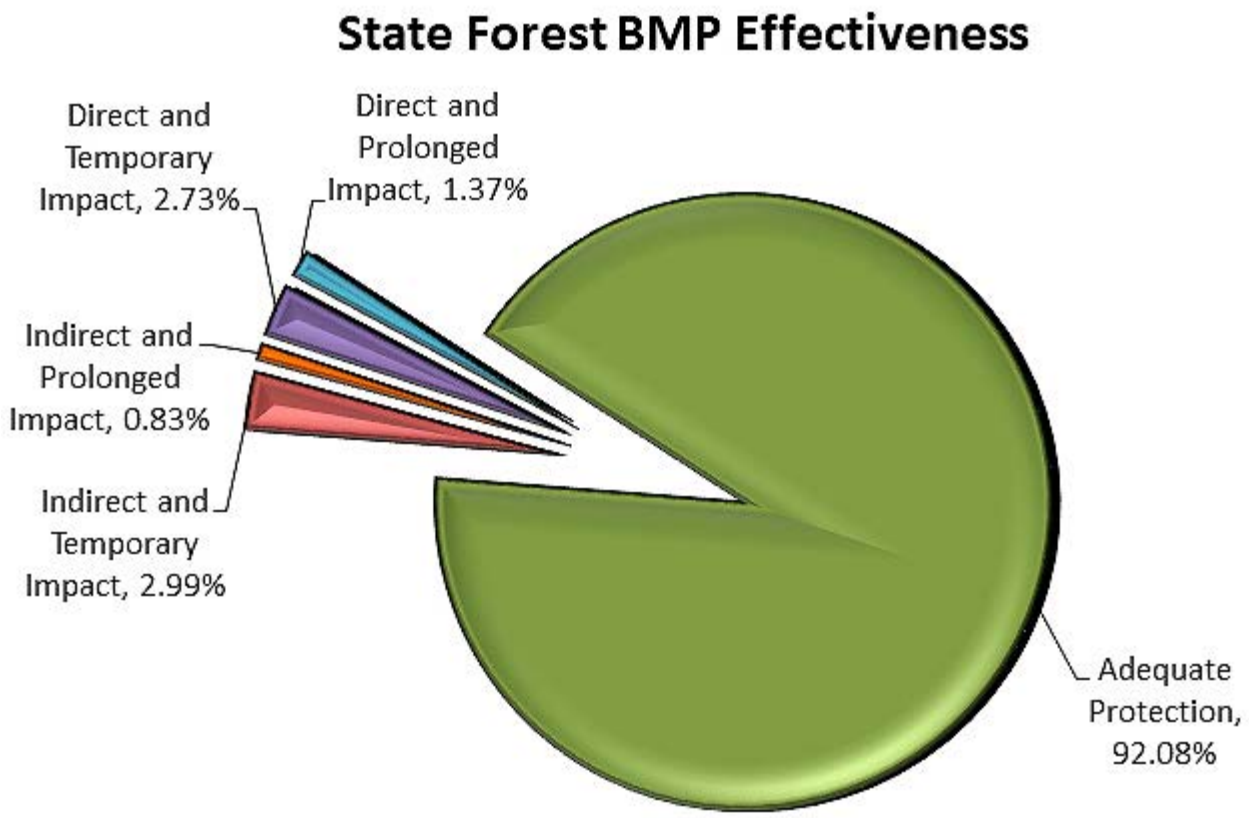


Figure 4. BMP effectiveness for 679 State Forest sites monitored from 1996-2019.

The application and effectiveness rates for BMPs used to protect sites after timber harvests are excellent for the 679 sites monitored since 1996. The overall application rate is 86.13%, and the overall effectiveness rate is 92.08%.

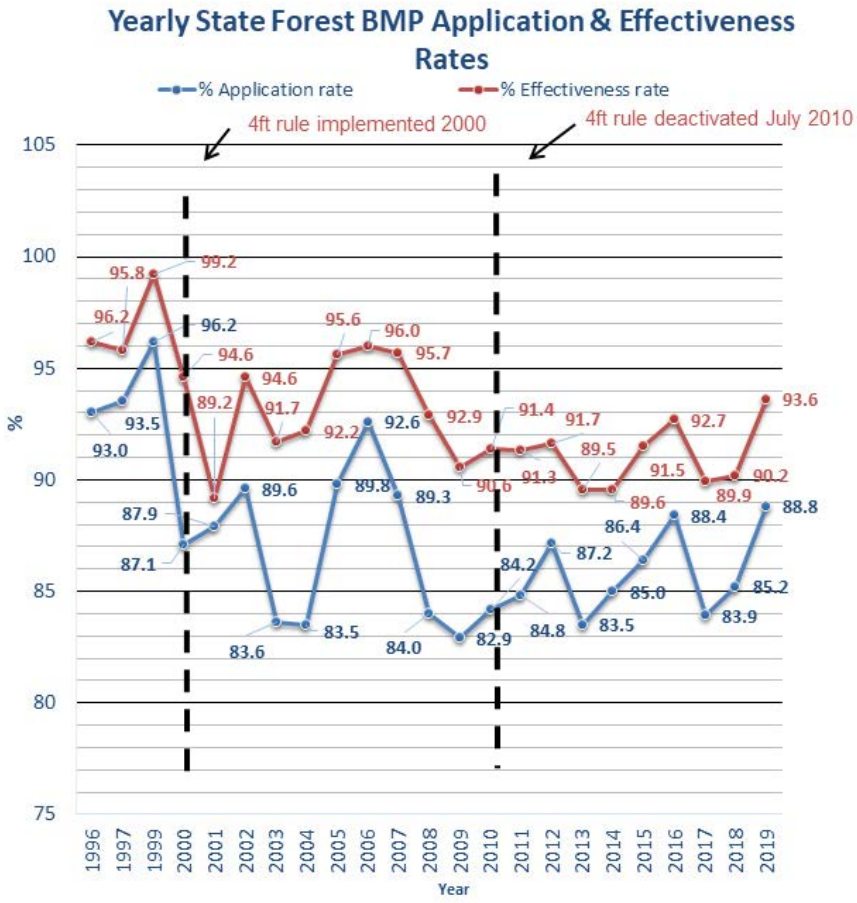


Figure 5. Yearly trends of BMP application and effectiveness on Indiana State Forests for 23 years of monitoring. These percentages are calculated for each year's data separately, not combined with the running totals from previous years.

Access roads and landings are areas of a timber harvest where much of the activity done by machines is concentrated, including that done by over-the-road tractor-trailers, which cannot withstand much variation in terrain when traveling. Therefore, access roads are often well stabilized, are drained well, and are 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 cross streams. Proximity of harvest infrastructure to water increases the chances of sediment reaching water bodies. This is why these two areas typically have lower effectiveness scores than the other three categories.

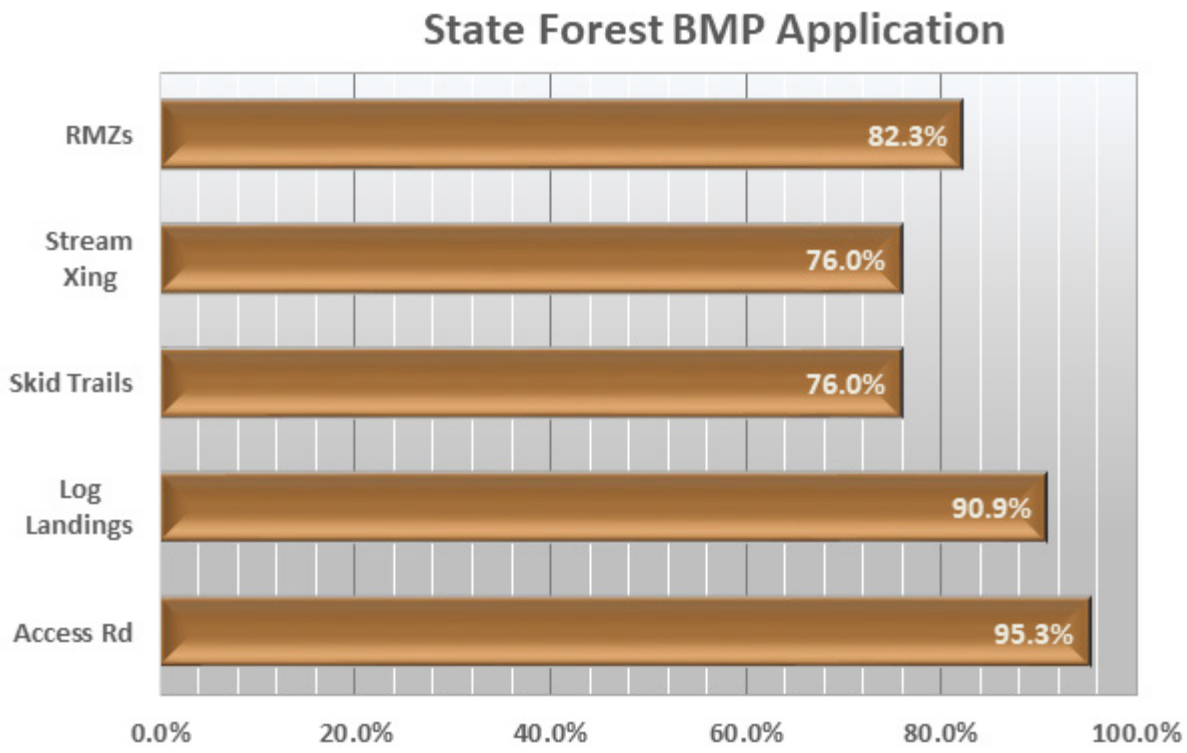


Figure 6. Overall BMP application for each of the five BMP categories.

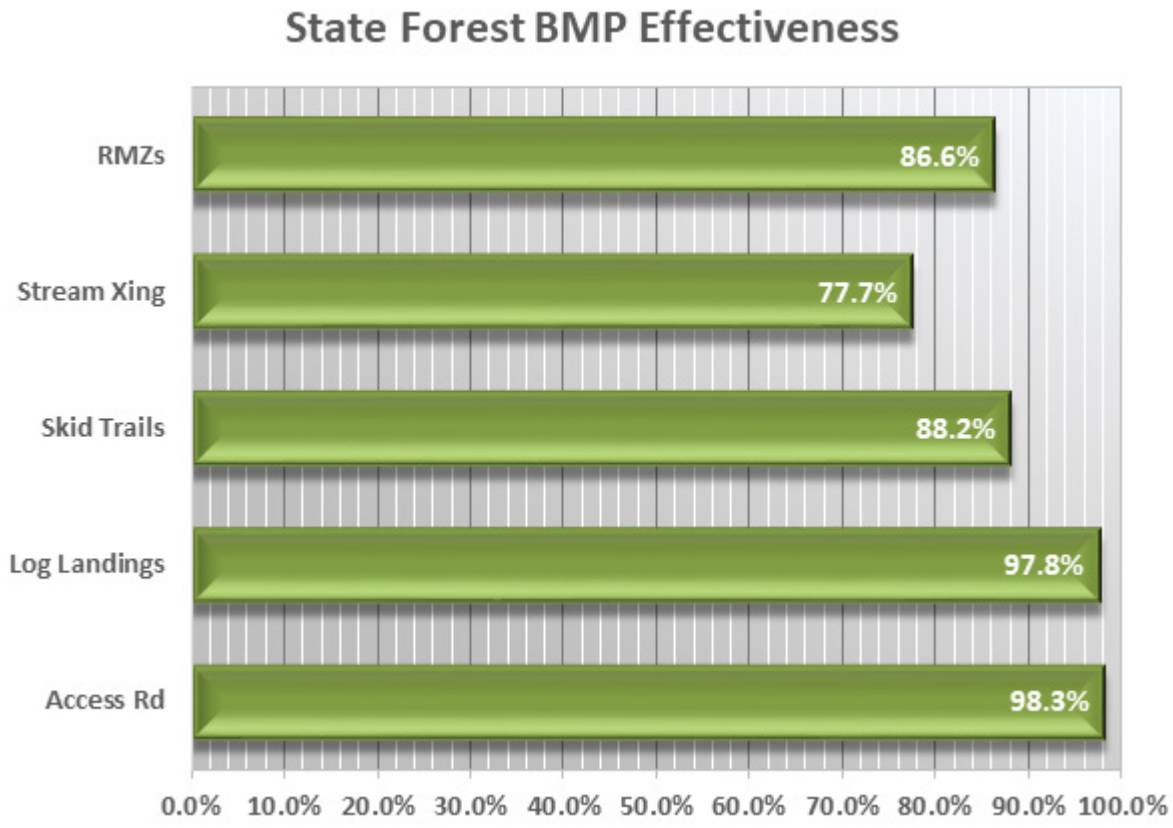


Figure 7. Overall BMP effectiveness for each of the five BMP categories.

The overall BMP application and effectiveness for the five categories, access roads, and log landings were the highest ranked, with access roads having a 95.3% application and a 98.3% effectiveness rate. Log-landing application was 90.9% and effectiveness, 97.8%. The third-highest category was RMZs, with 82.3% application and 86.5% effectiveness rates. Skid trails had the lowest application rate of all categories but was 76% application. Effectiveness is good on skid trails, 88.2%, considering the low application rate. The BMP area with the most difficulty was stream crossings. Because of the direct impact 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 lower effectiveness with more direct impacts to the streams, making this area the most critical and important BMP area. Wet conditions can also lead to large departures in effectiveness of stream crossings. The application of stream crossings across the 23 years of monitoring on state forests is 76% and 77.7% effectiveness.

1. Access Roads

Access roads connect the harvest area to the public road system in order to get the logs to the mills for processing. This connection means vehicles, such as tractor-trailers, need to be able to drive without much difficulty. Often, access roads are stable, with a good base, or are short; therefore, they are often located away from water bodies and are constructed to drain well. Typically, they have higher application and effectiveness scores because they are often covered with rock and are more stable.

Crowning and cutouts promote good drainage and stable permanent access roads. Photo by Duane McCoy, DNR

Table 1. Access road BMP application and effectiveness for all State sites monitored from 1996-2019.

Access Roads	% Application	% Effective
A1. Uses existing routes where appropriate	99.8	99.8
A2. Adequate buffer strip next to watercourses and sensitive areas	94.8	98.5
A3. Avoids unstable gullies, seeps, very poorly drained areas	95.7	99.0
A4. Road grades are within standards	98.0	100.0
A5. Amount of roads minimized	99.8	100.0
A6. Stream crossings minimized	99.8	99.8
A7. Road excavation minimized	98.5	99.8
A8. Excavated and fill materials placed properly	99.2	99.2
A9. Roads constructed to drain well	87.7	97.1
A10. Appropriate road stabilization, drainage and diversions installed	85.4	94.0
A11. Water diversions functioning properly	91.8	96.0
A12. Runoff diverted onto stable forest floor areas	89.4	92.7
A13. Public road drainage system maintained	99.2	99.5
A14. Public road's drainage maintained	99.5	99.8
A15. Traffic barriers installed	91.2	98.8
Overall Access Road	95.3	98.3

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

State access road application areas to improve on are: A9. "Roads constructed to drain well," 87.7%, and A10, "Appropriate road stabilization, drainage and diversions installed," 85.4%. Effectiveness on these areas was still high at 94% and above. Overall application and effectiveness for access roads was high at 95.3% and 98.3%, respectively.

2. Log Landings

LEFT: Log landing that was used during a wet period, causing rutting and not smoothed out and stabilized afterwards. **RIGHT:** A well vegetated log landing several years after harvest. Photos by Duane McCoy, DNR

Log landings are the areas of highest equipment concentration. Equipment brings 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 the piles are loaded onto a truck by either a knuckle boom or loader, and then the truck hauls away 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 all of the equipment comes together in this one area.

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

Log Landings	% Application	% Effective
Y1. Suitable number and size of landings	95.4	99.7
Y2. Landings located outside RMZ	95.3	99.1
Y3. Landings located on stable areas	93.9	99.3
Y4. Excavation of site minimized	93.6	98.7
Y5. Landings avoid concentrating or collecting runoff	75.4	96.1
Y6. Landing's runoff enters stable area	83.8	94.3
Y7. Proper water diversions in working order	89.5	95.4
Y8. Landing smoothed and soil stabilized	88.6	96.4
Y9. Landings free of fuel and lubricant spills and litter	94.3	98.8
Y10. Landing location suitable for equipment fueling and maintenance	99.3	99.9
Overall Log Landings	90.9	97.8

Landings on state forests have many uses. Some are landings that are newly installed and used only for the one tract being harvested. Others have been established for decades and are used for multiple tracts. Those that are older and used for multiple tracts 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 landings Y5 & Y6 were an application challenge on state forests. Y5's application rate was 75.4%, and the A6 application was 83.8%. Both had high effectiveness rates at 96.1% and 94.3%, respectively. Overall log-landing application was 90.9%, and overall log-landing effectiveness was 97.8%.

3. Skid Trails

A skid trail that has well-established vegetative cover. Photo by Duane McCoy, DNR

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, as such, have varying degrees of exposure and compaction. Different equipment can have the same variance concerning soil exposure and compaction. These trails often traverse the roughest terrain on the site with physical obstacles, slopes, water bodies, 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, typically on difficult terrain. This is especially true on state forests. Skid trails often disturb the largest portion of soil and cover ground that has a higher susceptibility to erosion if exposed and compacted; therefore, they are found to have the lower percentage of BMP compliance on a timber harvest with respect to application. Their impact to water quality can vary widely, considering their proximity to water bodies.

LEFT: Skid trail with gully erosion due to lack of water diversions. **RIGHT:** Water-bar outlet conveying runoff on to the stable forest floor. Photos by Duane McCoy, DNR

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	98.2
S2. Adequate buffer strip next to water courses and sensitive areas	67.9	84.6
S3. Avoids steep and long straight grades (>20% for >200')	71.5	96.8
S4. Avoids unstable gullies, seeps, poorly drained areas	79.7	90.3
S5. Amount of skid trails minimized	81.5	94.2
S6. Trail excavation minimized	84.3	93.7
S7. Appropriate drainage and diversions installed	49.8	78.9
S8. Water diversions in working order	77.2	86.3
S9. Runoff diverted onto stable forest floor areas	69.5	75.9
S10. Streams not used as skid trails (except for crossings)	81.8	83.8
Overall Skid Trail	76.0	88.2

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

BMP specifications S2 (67.9%), S3 (71.5%), S7 (49.8%), S8 (77.2%) and S9 (69.5%) 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 78.9% effectiveness rate. S9, "runoff diverted onto stable forest floor," had an effectiveness rating of 75.9%. The comprehensive application rate for all skid trails monitored on state forest properties is 76%, and the effectiveness rate is 88.2%.

4. Stream Crossings

Stream crossings have historically been the most challenging area of BMPs in Indiana. There is little margin of error for crossings. Mistakes are likely to directly affect water quality due to their nearness to 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 will mitigate their impact by decreasing the amount of sediment delivered and hasten the healing process.

LEFT: A metal grate bridge used to cross small unmapped intermittent during a harvest on private land. Photo by Michael Landers, private landowner **RIGHT:** Same stream crossing area over a year after the harvest. Photo 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	88.4	91.2
X2. Crossings minimize disturbance to the natural bed and banks	67.3	69.3
X3. Streambank approaches properly designed and stabilized	59.5	61.5
X4. Water runoff diverted from road prior to crossing	59.2	61.6
X5. Crossing as close to 90 degrees as practicable	87.2	91.8
X6. Crossing does not unduly restrict water flow	81.7	82.9
X7. Soil has not been used as fill in the stream (except culverts)	75.3	76.1
X8. Ford constructed of non-erosive materials	84.9	85.3
X9. Fords have stable banks and streambeds	61.7	61.3
X10. Culverts are properly sized and installed	69.7	72.7
X11. Culverts clear of significant flow obstructions	68.8	71.9
X12. Temporary structures properly anchored	97.6	95.2
X13. Temporary structures and resulting obstructions removed	82.4	78.4
Stream Crossing	76.0	77.7

There are often fewer stream crossings on State sites than on most other sites due to avoidance. Foresters on State sites will often avoid or minimize stream crossings to minimize the impact to water quality. 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. There have been a total of 638 stream crossings reported on state forest harvest sites, and 242 sites had stream crossings. There is an average of 2.8 crossings, per site with a crossing. There were 16 perennial crossings, 373 crossings of mapped intermittent streams and 249 crossings of unmapped intermittent streams; 64% of state forest sites monitored had no stream crossing.

X2, X3 and X4 had low application and effectiveness rates. X2 application rate was 67.3%, and effectiveness rate was 69.3%. X3 application rate was 59.5%, and effectiveness rate was 61.5%, X4 application rate was 59.2%, with a 61.6% effectiveness rate. X9 and X10 were also areas needing further attention, with application rates of 61.7% and 69.7% and effectiveness rates of 61.3% and 72.7%, respectively. X11, culverts clear of significant flow obstructions, was also a problem on State sites, with an application rate of 68.8%. Culverts free of flow obstructions had an effectiveness rate of 71.9%. The state stream-crossing application and effectiveness overall percentages were 76% and 77.7%, respectively.

The number of crossings monitored on state forests since 2010 is seen below in Figure 8. The graph also shows the number of sites per year with at least one crossing, and the percentage of sites with crossings per year. 2014 had an elevated number of crossings due to one site. There was 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 in order to access the area.

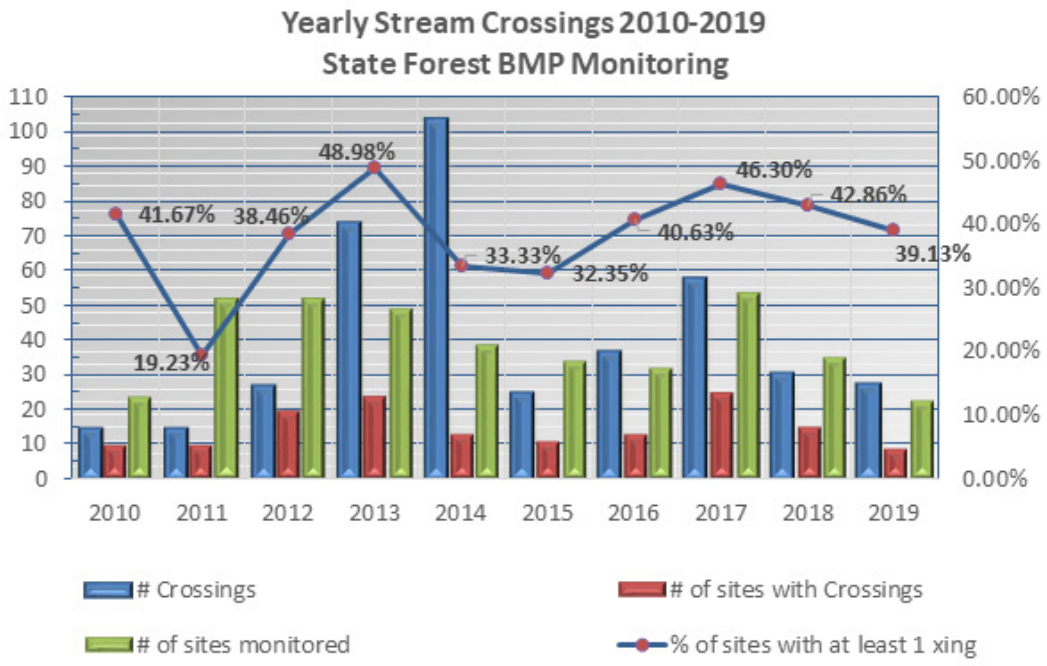


Figure 8. Stream crossing statistics from 2010-2019.

On private lands, a skid trail leading to intermittent stream crossing has no diversions and thus runoff is flowing down the trail and depositing sediment laden runoff into the stream. Photos by Jennifer Sobecki, DNR

LEFT: Waterbars before and after a drainage keep sediment laden water from the harvest entering the streams. Photo by Duane McCoy, DNR **RIGHT:** Soil was used to make a "bridge" for stream crossing on this private site and never removed, creating sediment and erosion problems up and downstream from the crossing. Photo by Jennifer Sobecki DNR

5. Riparian Management Zones

RMZs are somewhat like stream crossings in that they are close to the water; therefore, departures in application are more likely to affect water quality. RMZs are applied to the ground next to water bodies, 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%, 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 BMP Manual for full RMZ width table. http://www.in.gov/dnr/forestry/4588.htm

RMZ in Morgan-Monroe State Forest, marked by forester, debris removed from small intermittent stream. Photo by Jennifer Sobecki, 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	70.5	71.8
Z3. Tree tops and cutoffs placed back from water course to prevent movement into streams during floods	92.1	94.6
Z4. RMZ free of excavated material & debris (other than above)	94.8	97.2
Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings)	96.0	97.3
Z6. Adequate tree stocking in primary RMZ next to perennial streams	99.3	99.2
Z7. RMZ free of roads and landings (except crossing)	64.6	85.5
Z8. Water diverted from roads before entering RMZ	83.7	87.5
Z9. Water diverted onto stable areas of the forest floor	86.7	89.4
Z10. Road and trail surfaces stabilized as needed within RMZ	88.5	89.7
Z11. Ephemeral channels free of excavated material	62.0	63.9
Riparian Management Zones	82.3	86.5

Most state forest sites have a Riparian Management Zone, with 608 of 679 sites having at least one RMZ in the harvest area. Areas of RMZs on state land with challenges were Z2, Z7 and Z11. Obstructing debris in streams (Z2) was a problem, with a 70.5% application rate and 71.8% effectiveness. And 64.6% 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 85.5%. More care is needed in keeping ephemeral channels free of excavated materials. Application was 62%, and effectiveness was 63.9%.

LEFT: Drone captures picture of water diversions on skid trail leading to a stream crossing. Photo by Jamie Winner DNR **RIGHT:** Logging debris in streams can obstruct stream flow, leading to the stream carving a new bank, which results in erosion and sediment going directly into the stream. Photo by Duane McCoy, DNR

IV. Discussion

The overall state forestry BMP application rate is 86.13%. Overall effectiveness is 92.08%. The high application and effectiveness scores show there are many sound practices taking place throughout the state forest harvest sites to maintain the integrity of the soil and water resources. There are many things that are being done well; however, to achieve the most improvement, 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 23 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 95.3% and 98.3%, respectively. Log landings had a 90.9% application and 97.8% effectiveness rating. An area of concern for access roads is their ability to drain well, which may be concerning because of their application rate of 87.7%, even though mitigated with an effectiveness rate of 97.1%. 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 75.4% and 83.8% respectively, but the effectiveness for both is over 94.3% 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 76% and effectiveness of 88.2%. This indicates that although there are some difficulties correctly carrying out BMPs on skid trails, most do not result in large impacts to water quality. 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 78.9% and S9 effectiveness was 75.9%.

Skid trails can have a spectrum of disturbance levels that depend on how often equipment is driven 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 at wet times. 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 (23.4% of skid-trail application scores are minor departures), with little to no effect on water quality.

Overall stream crossing BMP application is 76%, and overall effectiveness is 77.7%. Due to the nature of stream crossings, impacts to water quality are, at times, inevitable; however, the length 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 viable. The largest problem on stream crossings has been and continues to be the diversion of water before the stream crossing, X4. This individual BMP (X4) had an overall application of 59.2% and effectiveness of 61.6%. The proper design and stabilization of stream banks at crossings (X3) was also a problem, with an overall application of 59.5% and effectiveness of 61.5%.

RMZs are much like stream crossings in that they are close to water bodies. If there is a problem, it often directly affects 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 of 82.3%. The effectiveness rate for overall RMZs was 86.5%. The two main areas of RMZs on state forests that needs to be improved is keeping logging debris out of perennial and intermittent streams and keeping ephemeral channels free of excavated materials.

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 importance of diverting water before it concentrates on roads, landings and skid trails, and enters streams and RMZs. These types of BMPs were particularly challenging on private lands; therefore, continuing education for private-lands managers, owners and contractors is of distinct importance.
- Focus on BMP areas that have decreased in application and effectiveness in recent years. Emphasize importance of these during training of foresters and loggers.

Fall colors and a well vegetated log landing on state forest lands. Photo by Jamie Winner

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 the current science.

The DoF wants to use information that is found in reports such as this, and in other similar reports, 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 DoF, and forestry BMPs are the means by which this can be accomplished.

VII. Literature Cited

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