Timber Harvesting and Forest Management Guidelines on Public and Private Forest Land in Forested Watersheds in Minnesota

2016 and 2017 Monitoring Implementation Results

A report by the Minnesota Department of Natural Resources,
Forest Management Guideline Implementation Monitoring Program
Respectfully submitted to the Minnesota Forest Resources Council

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Timber Harvesting and Forest Management Guideline Implementation on Public and Private Forest Land in Forested Watersheds in Minnesota

Monitoring for Implementation 2016 & 2017

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February 2018

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Executive Summary

The Minnesota Forest Resources Council's (MFRC) *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers,* establishes best management practices (guidelines) for timber harvesting and forest management (TH/FM) on forested lands in Minnesota. Implementation monitoring of these guidelines has been conducted on over 1300 timber harvest sites across public and private forest lands since 2000. This report provides results for monitoring that occurred in summer and fall of 2016 and 2017 and attempts to assess trends in implementation levels over time.

For this reporting period, implementation of site-level guidelines were assessed on 179 sites randomly selected from within 6 watershed sample units (18 HUC-8 watersheds) in the forested portions of MN. Monitored sites had timber harvest occurring at some point in time from late summer of 2014 through summer of 2016. The distribution of sites among the primary ownership categories was in approximate proportion to the acres of timber harvest for each based on forest disturbance analysis for the same time window. Overall, guideline monitoring sites represented approximately 18% by area of detected forest harvest in the watersheds sampled (Table 2) (14% for northern forest units).

Overall implementation of key guidelines are similar to the 2014_15 report and show improvement in most areas compared to the last statewide report in 2011. Several key guidelines show continuous or substantial improvement when assessed at the statewide scale including RMZ management, retaining leave trees and snags for wildlife, limiting disturbance in filter strips, minimizing total infrastructure, condition and location of landings, occurrence of sites with rutting (primarily on wetland crossings), managing cultural resources, retaining coarse woody debris, and diversity of leave tree species. Substantial improvement was documented in the number of sites utilizing the 2012 guideline version which was an item of concern identified in the last report. Guidelines that demonstrate lower or no improvement of implementation include avoidance of wetland crossings, use of erosion control on approaches where needed, retention of fine woody debris on biomass harvest sites, and awareness of visual quality sensitivity ratings. Checking for known endangered, threatened or special concern species was reported as high by managers, but accurately identifying the presence of known species in site documentation was low.

Conducting guideline monitoring at the watershed scale has proven valuable for the program by increasing understanding of the variation in guideline implementation across the state, and also provides increased efficiency and cost savings in the monitoring process. Implementation data at the watershed scale continues to reveal interesting results and relationships not previously identified with statewide estimates. This additional information will help target outreach efforts to topics and audiences where the greatest opportunities for innovation and improved implementation exist.

Recommendations for targeted outreach at the watershed scale include the guidelines with lower implementation levels mentioned above, as well as a variety of guidelines specific to

localized watersheds. Several examples are offered where targeted outreach to land managers and loggers in specific watersheds may improve future compliance including:

- Outreach on the importance of riparian management zones to all landowners in the LRRR and the SE MN watershed sample units where all RMZs were adjacent to streams and compliance was lowest at 71% and 67% respectively.
- Targeting outreach on avoiding unnecessary wetland crossings in CWR and MRBS watershed sample units where implementation was well below the statewide mean
- Outreach on a variety of guidelines may improve implementation in LRRR and SCKS sample units including focus on: infrastructure management, leave tree retention, locating landings outside of filter strips and wetlands, avoiding wetland crossings, and wetland identification, where implementation rates are below the statewide mean

Additional opportunities for improved implementation at the watershed scale are noted throughout this report. Recommendations include more introductory training opportunities for new foresters and loggers, targeted training related to wetland identification to aid in avoidance of wetland crossings, and identification of situations where water diversion and erosion control practices need to be implemented. Continuing education programs, such as Minnesota Logger Education Program and the Sustainable Forestry Education Cooperative, are encouraged to continue their efforts related to these recommendations, and work to develop new educational opportunities to address the specific topics identified above.

Contents

List of Figures

List of Tables

Introduction

This report is an update to the Minnesota Forest Resources Council (MFRC) and forest management stakeholders on the implementation of sustainable forest management practices as required by the Sustainable Forest Resources Act (SFRA). The MFRC was established under the SFRA to resolve important forestry policy issues through collaboration among a broad set of forest stakeholders. The SFRA requires the Council to develop and periodically revise voluntary guidelines for use on public and private forestland in Minnesota to minimize negative impacts of timber harvest and other forest management activities. This report summarizes the results of monitoring for the implementation of these guidelines.

The timber harvest and forest management (TH/FM) guidelines are a set of recommended voluntary practices designed to mitigate harvest-related impacts on water quality, wildlife, soil productivity, cultural resources, biodiversity, visual quality, and other forest resources. These guidelines were initially published in 1999 in the guidebook *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers* (MFRC 1999). The guidelines have been revised twice since their inception, and new guidelines related to biomass harvesting were added in 2007. Substantial changes in recommendations related to riparian management zones (RMZs), allowable infrastructure, leave trees, and others, were made in the most recent revision (MFRC 2012).

The SFRA (89A.07, subd. 2.) requires the Minnesota Department of Natural Resources (DNR) to monitor implementation of the TH/FM guidelines on public and private forestlands. The DNRs Guideline Monitoring Program (GMP) has monitored guideline implementation at over 1,300 harvest sites since 2000 and has published seven reports summarizing the findings through 2015. Prior to 2014, monitoring sites were randomly selected from all harvest sites across the state and findings were summarized to estimate statewide implementation levels. In 2013, the program was significantly modified by 1) focusing harvest site monitoring at the HUC-8 watershed scale compared to a statewide sample, and 2) incorporating forest disturbance estimates into the assessment, recognizing that the local level of disturbance and its configuration influences interpretation of implementation estimates. The overall objective of this new approach is to use the new assessment to conduct more targeted and effective education and outreach for improved guideline implementation.

This report summarizes the monitoring data for 179 harvest sites in 18 HUC-8 watersheds that were monitored during 2016-17, with emphasis on key guidelines and topics identified as opportunities for improvement in previous reports. Statewide estimates calculated from the mean among watersheds are also presented for comparison to previous years and for application to statewide policy development.

Methods

This section outlines the forest cover change detection, site selection, and monitoring data collection methods for monitoring the implementation of forest management guidelines.

Watershed Sample Units

Starting in 2014, the guideline monitoring program (GMP) restructured monitoring efforts to focus on the US Geological Survey defined hydrologic unit code 8 (HUC-8) watershed scale, where attempts are made to select watersheds that are concurrently evaluated in the Minnesota Pollution Control Agency (MPCA) watershed Restoration and Protection Plan (WRAP) process.

Sites monitored in 2016 and 2017 were selected from forest cover changes detected (see below) within six watershed sample units, with each unit consisting of either a single watershed or a cluster of watersheds with similar landscape characteristics. The Appendix and Figure 1 provide a series of in-depth maps and statistics related to each of the 6 watershed sample units. Where appropriate, results have been reported by watershed sample unit. Where no substantial difference in implementation data is observed, results may be presented in statewide summaries. The Appendix provides a series of in-depth maps and statistics related to each of the 6 watershed sample units.

Throughout this document, watershed sample units are abbreviated as follows:

- **CWR:** Crow Wing River watershed
- **LRRR:** Lake of the Woods, Rapid River, Roseau River and Rainy River
- **MRBS:** Mississippi River – Brainerd and Sartell
- **SCKS:** Upper St. Croix, Kettle and Snake River watersheds
- **SCN:** St. Louis, Cloquet and Nemadji River watersheds
- **SE MN:** SE Minnesota watersheds including: Root River, Zumbro River, and Mississippi River – La Crescent, Lake Pepin, Reno, and Winona

Forest Cover Change Detection

As in other years, forest cover change detection was performed to 1) identify recent harvest sites for field monitoring (see below), and 2) provide overall estimates of forest disturbance by major watershed to provide additional context for field monitoring findings. Two periods of time for forest change detection were utilized in this reporting period. For monitoring year 2016, DNR Forestry Resource Assessment (RA) staff detected forest cover change within three watershed sample units only (which included MRBS, SCN, and SE MN). For these watersheds, RA conducted change detection using Landsat 8 imagery acquired between summer 2014 and summer 2015. For monitoring year 2017, RA staff detected forest cover change within all major watersheds in Minnesota with greater than 20% forest cover, as determined by NLCD 2011, using Landsat 8 satellite images from summer 2014 – summer 2016. For all six watershed

sample units monitored in 2016 and 2017, RA image analysts visually inspected each area of detected forest change to refine the list of sites and modify their site boundaries as needed.

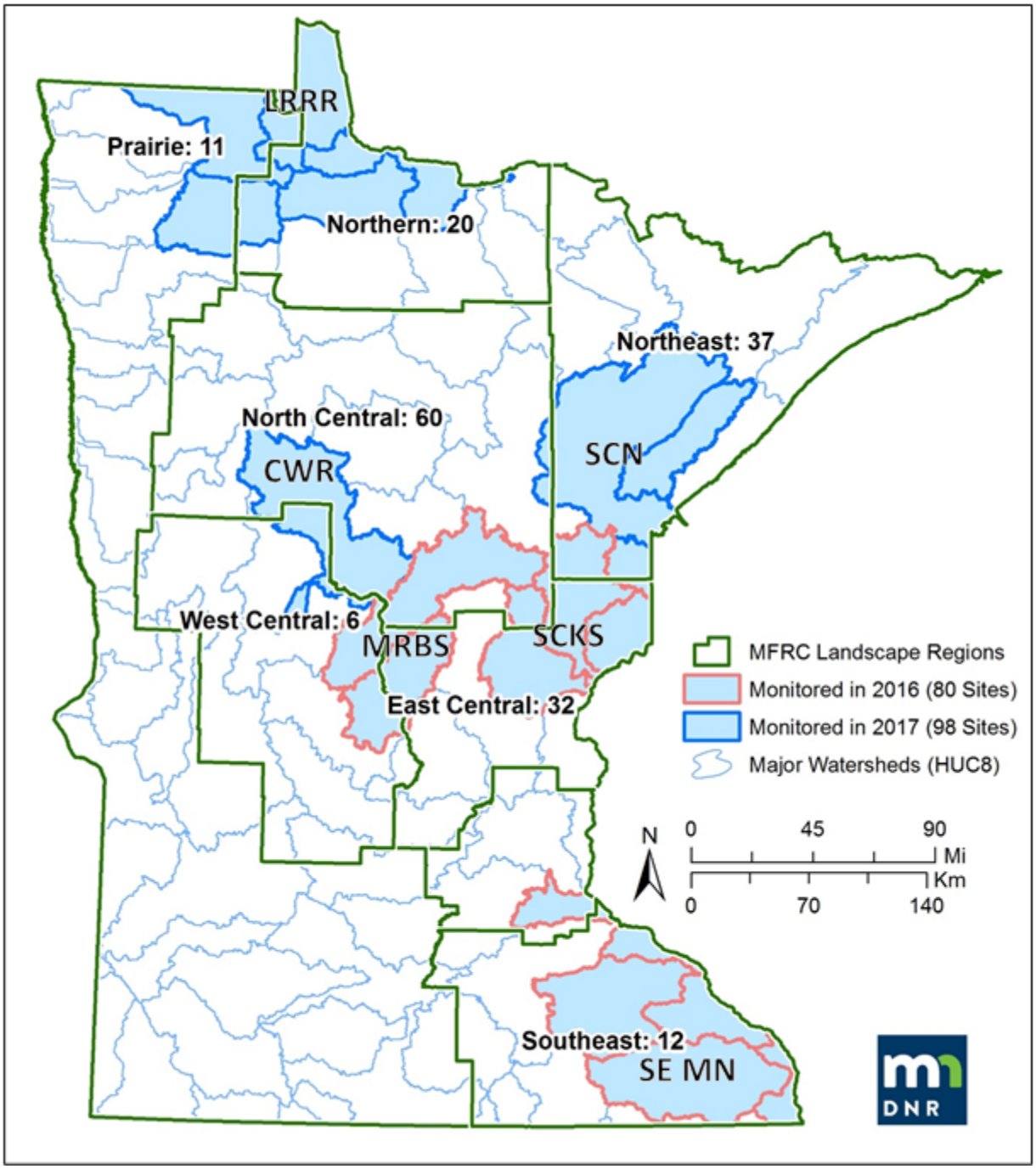


Figure 1. Watersheds where guideline implementation monitoring occurred in 2016 and 2017, and the relative number of sites per MRFC Landscape Region.

Site Selection

For both monitoring years, a subset of detected forest cover change sites (confirmed as harvests) were selected for monitoring. Within each watershed unit, monitoring sites were selected with effort to represent the relative proportion of harvest activity by ownership categories. In an effort to monitor an adequate number of sites near open water, stratified sampling was used in each ownership category to increase the number of sites with harvest activity within 200 feet of a known open water feature. Monitoring sites were selected from all forest ownership categories. For purposes of this report, the ownerships have been grouped into the following categories: State: All lands owned by the state; County: All lands owned or managed by a county; Federal: All lands owned by the U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, or Army Corps of Engineers; Forest Industry and Corporate: Lands owned by Blandin Paper, Potlatch, and Molpus and Rajala Companies; Nonindustrial Private Forests (NIPF): All privately owned non-industry lands and tribal lands.

Landowner and/or manager contact was attempted for every potential monitoring site to verify that harvest occurred within target dates, verify that harvest was completed, and secure permission to access the site. Final monitoring sites were selected from this initial pool. Alternate sites were selected to account for instances where sites had to be dropped for unanticipated reasons. A breakdown of site ownership per watershed unit is shown in Table 1 and site distribution across the seven MFRC Landscape Regions is shown in Figure 1.

In an effort to increase participation by NIPF landowners, the GMP utilized two new approaches to contact NIPF landowners and gain permission to access their sites. In 2016 the program contracted with local Soil Water Conservation Districts, and in 2017 collaborated with local foresters in the DNR Cooperative Forest Management Program to contact NIPF landowners. Both efforts yielded substantially higher numbers of cooperating NIPF landowners compared to past monitoring efforts. Because of the success of these new approaches, the program has achieved a more representative sample of NIPF sites than it has in past years.

Table 1: Watershed unit monitored and number of sites per ownership category.

Watershed Unit	Year	Land Ownership Category					
		County	Federal	Forest Industry & Corporate Lands	State	NIPF & Tribal*	Total
CWR	**2017**	8	0	3	11	9	31
LRRR	**2017**	2	0	2	20	9	33
MRBS	**2016**	8	0	1	7	18	34
SCKS	**2016**	8	0	0	9	17	34
SCN	**2017**	11	1	9	6	8	35
SE MN	**2016**	0	0	0	12	0	12
Total		**37**	**1**	**15**	**66**	**60**	**179**

*Four tribal sites were monitored in LRRR and 1 in MRBS

From a watershed perspective, all sites sampled in SE MN were state land sites. Fourteen potential NIPF sites were originally identified in the site selection process, however ten of these were forest land conversions to other land use, and GMP staff were unable to obtain permission to access the remaining four sites. In the SCN sample unit, the GMP sampled a relatively high number of forest industry lands in a collaborative effort with the DNR legacy program. Data gathered on these sites satisfied both program monitoring needs. This collaboration was only done in watersheds and on ownerships that had substantial conservation easements enrolled in the legacy program. Only 1 federal (USFS) site was monitored in this reporting period located in SCN. This is a result of random site selection and harvest activity in the specific watershed sample unit. Federal lands were heavily sampled in adjoining watersheds during the 2014 & 15 monitoring period.

Monitoring Data Collection

For both field years represented in this report, GMP staff used monitoring protocols similar to those in the previous monitoring report (Rossman et al,, 2016) utilizing the guideline monitoring application (GMA) software and SurfacePro3 Tablets. Prior to field monitoring, GMP staff contacted agency, industry and tribal land managers to gather critical background information on the "pre-site data questionnaire" including information about timber harvest planning, harvest practices, season of harvest, and various guideline implementation strategies. The pre-site form provides the opportunity for landowners and managers to relate critical information on how guidelines were implemented on a site. Without this information, GMP staff and field contractors may not be aware of specific reasoning or strategies for guideline implementation. In order to improve the pre-site information obtained on NIPF sites, future program goals include interviewing loggers who conducted the harvests on NIPF sites because they may be more aware of guideline implementation strategies than the landowner.

Field monitoring for both 2016 and 2017 was accomplished through a competitive bid contract. Bidding contractors were required to provide one or more teams of at least two people each, who collectively met several criteria including expertise and educational background in forestry, soil science, water resources science (including wetland delineation), and GIS and/or remote sensing skills. Contractors were also required to complete calibration training with GMP staff prior to the start of the 2016 field monitoring. On-site field monitoring was conducted between June-September in both 2016 and 2017.

Monitoring contractors collected detailed information while on-site and delineated spatial features utilizing field observations, air photos, and site documentation. Data collection generally involved a ground survey of the entire site, with detailed measurements recorded for key features including leave trees, roads and landings, riparian management zones (RMZs), filter strips, surface water and wetlands, crossings, and others. On-site observations were entered into the GMA for analysis.

Quality Control

Both in-office and in-field review of site data was conducted by the GMP Coordinator on randomly selected monitoring sites to evaluate consistency and compliance with monitoring protocols. This process confirmed that data were being properly collected and provided useful insight for determining whether monitoring forms and field procedures needed additional modification. Where appropriate, changes were made to data based on quality control findings.

For sites without completed pre-site information, GMP staff attempted to gather relevant information through timber sale documents, maps and other public source evidence. Information gathered in this manner typically has gaps related to strategies used for guideline implementation because strategies are rarely identified in supporting timber harvest documentation.

Results

Data referenced from previous monitoring reports may be found in Dahlman and Phillips (2004), Dahlman (2008), Dahlman and Rossman (2010), Rossman 2012, and Rossman et al. (2016).

Land and Water Characteristics by Watershed

The Appendix contains a wealth of information related to the characteristics of the six watershed sample units. Watershed characteristics such as frequency and types of streams and wetlands, lakes, developed acreage, and percent slope ultimately relate to the number of harvest sites and influence the need for specific BMPs or guidelines such as RMZs, filter strips, and erosion control on crossings, etc. Forest cover (including forested wetlands) varied considerably between watershed units from a high of 72% in SCN to a low of 20% in SE MN. Not surprisingly, SE MN and MRBS had the highest percentages of crop/pasture or urban/open/barren lands at 58% and 37%, respectively, compared to 4% in SCN. These land cover types have been shown to have greater water quality impacts relative to forested land use, and both the SE MN and MRBS watersheds may be at higher risk of water quality degradation for this reason. In terms of water-related features, the LRRR unit has the highest percent cover of lakes and ponds (10%) primarily due to surface waters of Lake of the Woods, followed by CWR (6%) with many smaller lakes and ponds. The SE MN unit has one of the lowest percent cover of lakes and ponds (2%), but has the longest total length of rivers and streams (9874 miles) and the highest proportion of trout streams. Despite the low forest cover and relatively low amount of lakes and ponds in SE MN, the higher number of miles of rivers and streams imply that the majority of disturbances in that unit will be relatively close to water features or upslope from water features.

Forest Disturbances and Distance to Water Features

Forest cover change detection was done between summer 2014 – summer 2015 in the MRBS, SCN, and SE MN watershed units, and between summer 2014 – summer 2016 in the CWR, SCKS,

and MRBS watershed units. As a result of the longer time frame for change detection in the CWR, SCKS, and MRBS watershed units, the disturbance estimates for those units described here and in Table 2 are presented as annual averages for comparison purposes.

Of all the watershed units, MRBS and CWR had the highest number of disturbed sites and the highest percent of forest cover disturbed, though the average disturbance size was small (41.2 and 34.6 acres, respectively). The SE MN watershed unit had the lowest number of disturbance sites and the lowest percent of forest cover disturbed (2%), which is not surprising given the characteristics of the SE MN sample unit. A significant high wind event in Crow Wing County during July of 2016 appears to have contributed substantially to harvest activity in the CWR sample unit.

Table 2. Annual forest cover disturbance statistics by watershed.

Watershed Unit	Number of Detected Forest Disturbances	Mean disturbance Area (ac)	Standard Deviation of Area (ac)	Total Area (ac)	Disturbed Percent of Unit Area	Disturbed Percent of Unit Forest Cover	Monitored Percent of Disturbances
CWR	165	34.6	33.7	5,713	0.5%	0.9%	16%
LRRR*	156	42.4	45.9	6,594	0.2%	0.5%	10%
MRBS	173	41.2	49.8	7,125	0.4%	1.1%	18%
SCKS*	99	76.7	86.7	7,560	0.5%	0.8%	15%
SCN*	152	57	69.3	8,631	0.4%	0.5%	11%
SE MN	31	42.9	45.5	1,331	0.05%	0.2%	39%

*Number of detected disturbances, total area, disturbed percent of total area, and monitored percent of disturbances are presented as an annual average base on a two-year window of change detection

Additional analyses have been done to summarize the relative proximity of forest cover disturbances to a public waters feature (ex., river/stream, lake/pond, open water wetland; source: the National Hydrography Dataset, MN DNR Hydrography data layer, and the National Wetlands Inventory). The shortest Euclidean distance (as the bird flies) between boundaries of a forest disturbance area and the nearest waterbody was calculated by using the “Near Tool” in ArcGIS. When a waterbody occurs within or is touching the boundary of a disturbance, the distance between them is zero. There are a few caveats to this analysis, including the reliance on the precise mapping location of water features (which is not historically very precise at the site scale) and the Euclidean distance measure of the Near Tool. Given these caveats, it is important to use the following analyses as a relative comparison and not replace site specific analyses.

The watershed unit that has the highest percent of waterbodies within or nearest to disturbance features is the SE MN unit, where 75% of the 31 disturbance sites have a water feature that is within 40 feet of the boundary of a disturbance and 87% of all the SE MN disturbances are within 160 feet of a waterbody (the majority of which are rivers and streams).

The SE MN unit has the highest length of rivers and streams and also the highest slopes and standard deviation of slope, where both measures are indicative of the complex bluff land terrain for which the area is well-known. However, these landscape characteristics are what make the Near Tool not as effective for this type of analysis.

As expected based on the land cover characteristics described previously, the units with the next highest percent of disturbances nearest water features are SCN and MRBS where 40% and 24% respectively, have a water feature that touches or intersects the boundary, and about 50% within 160 feet. The LRRR watershed unit had the fewest disturbances near water features, where only 12% of the disturbances have a water feature that touches or intersects the boundary and only about 26% of the disturbances are within 160 feet. Histograms of these proximity analyses per watershed unit can be found in the Appendix.

Monitoring Site Characteristics

Monitoring Site Sizes

Table 3 reports statistics on monitoring site size and total monitored area by watershed. Mean site area was 52.2 acres, which is considerably higher than the 37 acres reported in 2016 and 34 acres reported in 2011. There are clear differences in mean harvest size among the watershed units ranging from 25 to 82.1 acres, similar to previous reports. Although not a guideline in itself, site size may influence implementation of other guidelines such as managing site infrastructure and acreage of leave tree clumps.

Table 3: Monitoring site size by watershed sample unit.

Watershed Unit	Number of Sites	Min Area (ac)	Max Area (ac)	Mean Area (ac)	Standard Deviation of Area (ac)	Total Area (ac)
CWR	31	8.9	122.6	35.3	23.6	1093
LRRR	33	6.8	245.2	41.6	43.2	1374
MRBS	34	8	96.5	37.4	25.6	1271
SCKS	34	7.1	300	82.1	69.3	2793
SCN	35	5.3	246.5	71.9	65.9	2518
SE MN	12	3.5	41	25	10.8	300
Total	**179**	**3.5**	**300**	**52.2**	**51.8**	**9348**

Type and Distribution of Waterbodies

The types and numbers of waterbodies or wetlands associated with the monitoring sites are shown in Table 4. The majority of non-open water wetland (NOWW) types were located on-site, while the majority of open water wetlands (OWW) and perennial streams were located adjacent to harvest sites, which may indicate that most harvests are designed to go around or avoid surface water features rather than containing them within the harvest boundaries. Over 87% of all monitoring sites had at least one waterbody or wetland on, adjacent, or along the

logging road accessing the site. NOWW were more common than any other waterbody or wetland type accounting for 84% (831) of the total of which 48 were seasonal ponds located primarily in CWR, MRBS and SCKS sample units.

There were considerably higher numbers of non-trout perennial streams and OWWs compared to the previous report, but also substantially fewer trout streams. These differences reflect the characteristics of the watersheds that were monitored compared to the last report. Most (87%) OWWs occurred in the CWR and MRBS sample units. Higher numbers of waterbodies across sites may create greater challenges in implementing water quality guidelines.

Table 4: Number of waterbodies by type and watershed sample unit.

Type	CWR	LRRR	MRBS	SCKS	SCN	SE MN	Total
NOWW*	145	104	153	317	108	4	831
Intermittent Streams	0	1	3	1	5	0	10
Perennial Streams – Non-trout	3	13	9	10	27	10	72
Perennial Streams - Trout	0	0	0	0	3	3	6
OWW	17	0	10	4	0	0	31
Lakes	6	0	5	2	11	0	24
Total Waterbodies (#)	171	118	180	334	155	27	985
Sites with Waterbodies (#)	18	30	34	34	33	9	157
Sites with No Waterbodies (#)	13	3	0	0	2	3	21

*Includes Mineral soil wetlands, shallow peat wetlands, seeps and springs, beaver ponds, season ponds, wetlands or waterbodies where just a filter strip is recommended.

Harvest Methods and Planning

The percent of sites that were clear-cut remains similar to past reports at 89%. Included in this number were 11 salvage harvests. Other harvest methods reported include thinning, single tree and group selection, and shelterwood. Some sites utilized mixed harvest methods. Almost all clear cuts included some reserve or leave trees on or adjacent to the harvest area.

Season of Harvest

Only 37% of sites were harvested predominantly during the winter season (Dec. 16th – March 15th) (Table 5) compared to 58% in the last reporting period, but that estimate is similar to the 2011 statewide value. Substantial variability was reported among watershed sample units likely due to differences in access opportunities during frozen and non-frozen seasons based on physical characteristics of the watersheds. The differences from the last report may also be associated with increased pressure to access and harvest wood during non-frozen seasons, or result from poor operating conditions in recent mild winters.

Table 5: Number of sites with 75% or more of harvest occurring in listed season.

Watershed Unit	Number of Sites	Summer	Fall	Winter	spring	Mixed season
CWR	31	11	2	3	3	12
LRRR	33	2	2	16	1	12
MRBS	34	9	5	12	0	8
SCKS	34	6	1	18	1	9
SCN	35	12	4	8	0	10
SE MN	12	0	1	9	0	2
Total #	**179**	**40**	**15**	**66**	**5**	**53**
Total %	**100%**	**22%**	**8%**	**37%**	**3%**	**30%**

Guideline Version Used

All agency and industry lands responding to the pre-site questionnaire indicated awareness that the site-level guidelines were revised in 2012. Only one site (tribal) reported that they were unaware of the 2012 revisions. Fourteen sites reported that the 2012 version was not used due to the fact that the harvest was put under contract prior to the January 2013 publishing date of the revised guidelines and therefore used the previous (2005) version. Finally, 1 (NIPF) site indicated that they chose not to use the guidelines. Overall, greater than 90% of those responding to the pre-site questionnaire indicated that they used the 2012 guideline version. This is a substantial improvement over the last reporting period indicating either greater acceptance, higher awareness, or incorporation into operational practice with time.

For sites monitored in this reporting period, the 2012 revised version of the site-level guidelines was used as the standard of measure when reporting compliance.

Pre-harvest Planning

The TH/FM guidelines recommend the development of written plans for all forest management activities, including timber harvest. Harvest plans (including site maps) were developed for nearly all county, federal, forest industry and state sites. For the 52 NIPF sites that had a completed pre-site questionnaire (87% of all NIPF sites); landowners reported that approximately 33% had a written general forest management plan for their property with most also having a written timber harvest plan for the site. All written plans were prepared by a forestry consultant or natural resource professional. Of the NIPF sites without written plans, 12 indicated an oral harvest plan developed for the site either by the logger or a resource professional. Remaining sites indicated that no plans were developed. This emphasizes that for many NIPF harvests, the logging professional is key to informing landowners about site-level guidelines and also implements those guidelines on the site. Targeted outreach to loggers in watersheds with high NIPF harvest activity would be an effective approach to increase implementation of site-level guidelines.

Guideline Implementation Results

Visual Quality

Connected to the development of visual quality BMPs in 1995, visual sensitivity classification maps were developed for the 16 northern counties with land departments and can be found at Visual Sensitivity Classifications Link. These maps and narratives identify features such as roads, rivers, lakes, or recreational trails that are rated as "most," "moderately," or "less," visually sensitive. Visual quality guideline implementation was based on these ratings.

Monitoring contractors rated sites for visual quality when components of a harvest site could be viewed from a location frequented by the public including roads, trails, lakes, navigable streams, or campgrounds. Visual quality guidelines were evaluated on 141 monitoring sites located within the 16 counties with established visual sensitivity ratings. For these 141 sites, 99 (70%) agency and industry sites indicated awareness of the visual sensitivity rating and for 72% of the rated sites, land mangers indicated the correct visual sensitivity rating. For sites that did not accurately identify the correct visual sensitivity rating, most (77%) were due to incorrect responses related to features such as recreational trails and navigable streams that are not mapped on the county visual sensitivity maps. These features are generally listed in the county visual sensitivity narratives. Greater awareness of the need to review county visual sensitivity narratives may improve understanding of site visual sensitivity ratings. These results are very similar to the previous report.

Cultural Resources

Cultural and historic resources such as old homestead sites, logging camps, human burial sites, and American Indian camp or village sites may be susceptible to damage from forest management. Guidelines recommend that landowners and resource managers check inventories and records for the presence of known cultural and historic resources and/or cultural resource potential before beginning forest management activities. Additionally guidelines recommend visually checking for the presence of these resources on management sites.

The proportion of sites for which landowners or resource managers reported checking records for cultural and historic resources has generally increased over time to 88% overall for agency and industry sites monitored in this report. This represents a trend of continuous improvement since first assessed in 2000. Checking records for cultural and historic resources on NIPF lands is unknown due to the simplified pre-site questionnaire and intermittent response by NIPF landowners. Because the majority of NIPF sites monitored do not have a resource professional assisting the landowner, the burden of initiating the checking of known cultural resources often falls to the logging professional. Inclusion of this topic in upcoming guideline implementation training would serve to remind loggers of this guideline and ensure that resources and procedures are understood.

As part of the monitoring assessment, the state archaeologist's office checked all monitored sites against the archeological site inventory. Only five sites were flagged as having known cultural and historic resources on or near the site. All five sites were on state administered lands. Four of the five sites checked appropriate inventories, were aware of the cultural resources or potential, and took appropriate actions to protect cultural resources on the management sites. One of the sites reported not checking cultural resource inventories for known resources, was not aware of the cultural resources on the site, and therefore took no action for protection. Cultural resources on this site were subsurface and likely not impacted. Landowners and resource managers did not identify any additional "unknown" cultural resources other than what was reported by the state archaeologists' office.

Endangered, Threatened and Special Concern Species

TH/FM guidelines recommend checking for the presence of endangered, threatened, or special concern species (ETS), sensitive communities, or sensitive sites on or near management sites prior to the initiation of activities. Additionally, the guidelines recommend that appropriate actions are taken to protect known occurrences. For agency and industry lands, 85% reported that they checked for known ETS prior to initiating activities, lower than the 92% in last report. Land managers reported that 11 of 106 agency and industry sites had known ETS species on or adjacent to the harvest site. Management activity was modified on six of these 11 sites with remaining instances either not needing modification or situations where the species was off-site and not impacted by harvest activity. Checking for the presence of ETS species is unknown for NIPF lands because the abbreviated pre-site questionnaire for this group did not include a similar question.

For the 99 sites monitored in 2017, GMP staff independently queried the DNR's Natural Heritage Information System (NHIS) to determine if monitoring sites had known ETS species (and other special concern sites) present. The NHIS is a collection of databases that provides information on Minnesota's rare plants, animals, native plant communities, and other rare features. This query identified 14 monitoring sites with having a known ETS species within the harvest site boundaries and 8 sites with known ETS species adjacent (within 660 ft.) to the site. Four of these sites had known threatened species adjacent to the harvest, and 18 sites had species of special concern. For these 22 sites, only 6 indicated knowledge of the species existence and took appropriate actions, four did not check prior to activity, and 12 checked for known ETS species but did not correctly identify any species on or adjacent to the site.

The reasons for disparity between sites that indicated checking appropriate sources for known ETS species, and the ability to correctly list species identified in the GMP query of NHIS database is unknown. DNR staff that manage the NHIS database indicated that this database is continually being updated, and there may be a time lag between species identification in the field and entry into the database. Because of this, staff recommend a second review of the NHIS database just prior to activity beginning if it has been more than one year since the initial review. Additionally, there may be differences in the interpretation of guideline language recommending managers to check for known ETS species "on or near" management sites. The DNR Natural Heritage staff currently recommend checking within a one mile buffer of

management sites, whereas local managers may only be considering on-site and directly adjacent to sites. Clarifying guideline intent may improve implementation rates.

The NHIS contains a wealth of information for landowners who utilize it. Outreach to land owners, land managers and loggers is recommended to improve use of the NHIS and implementation of related guidelines.

Wetlands and Waterbodies

A major focus of the TH/FM guidelines is protecting wetlands and waterbodies, including non-open-water wetlands (NOWW), open-water wetlands (OWW), perennial and intermittent streams, lakes, seasonal ponds, and seeps and springs. The filter strip and RMZ guidelines are the primary tools for protecting wetlands and waterbodies by defining specified areas adjacent to a wetland or waterbody where management activities are to be less intrusive than in the general harvest area. See Table 4 for reference to the types and numbers of waterbodies found on monitoring sites.

Filter Strips

The function of a filter strip adjacent to a waterbody is to trap and filter out suspended sediment, and potential pollutants attached to sediment, before it reaches surface water resources. The guidelines recommend establishment of filter strips adjacent to all water features. The recommended width of a filter strip is 50 feet with an additional 2 feet for each 1% increase in slope over 10%, to a maximum of 150 feet. Harvesting and other forest management activities are permitted in a filter strip as long as the integrity of the filter strip is maintained and mineral soil exposure is kept to a minimum (MFRC 2012). The guidelines recommend limiting soil disturbance to less than 5% dispersed (no concentrated) soil exposure throughout the filter strip. Guidelines further recommend locating landings, roads and other infrastructure outside of filter strips in order to maintain the integrity or functionality of the filter strip.

During field monitoring, detailed filter strip information is recorded for only those filter strips where contractors observed disturbance(s) that potentially resulted in a compromised filter strip function. All other filter strips are counted and labelled as meeting guideline recommendations. Of 1042 total filter strips observed across sites, detailed filter strip data were recorded for 147 filter strips that triggered expanded data collection. Most (83%) filter strips were located adjacent to NOWW, 12% were adjacent to streams, and only 5% were adjacent to OWW. For all filter strips recorded, 3% had exposed mineral soil within the filter strip at the time of field visits with most of these due to presence of roads or landings within the filter strip. Only 1% of filter strips had erosion occurring within the filter strip, and only four (0.4%) filter strips were associated with sediment being deposited into the adjacent non-open water wetlands (Table 6). Overall, 97% of filter strips met the minimum disturbed soil recommendations of no concentrated soil exposure or less than 5% dispersed soil exposure. SCN watershed sample unit had the highest compliance rate at 100% while SE MN had the

lowest at 90%. This compliance is nearly identical to the previous report and demonstrate a continuing high level of filter strip guideline implementation.

Table 6: Soil exposure, erosion, and sediment reaching a waterbody observed in filter strips with and without roads, skid trails, or landings.

Condition	Total Filter Strips	Filter Strips without Roads, Skid Trails, or Landings	Filter Strips with Roads, Skid Trails, or Landings	Filter Strips with Erosion	Filter Strips with Sediment Reaching a Waterbody
No Soil Exposure	1012	904	116	0	0
<5% Dispersed	1	0	1	1	1
<5% Concentrated	5	2	1	3	0
≥5% Dispersed	5	0	3	1	0
≥5% Concentrated	19	1	14	7	3
Total	**1042**	**907**	**135**	**13**	**4**

Avoiding placement of infrastructure within filter strips is an important preventative measure to avoid exposed or otherwise impacted soils that may reduce the effectiveness of filter strip functions. Of the 108 filter strips that had landings located within the filter strip, contractors determined that the majority (65%) of these landings could have been located outside of filter strips. Overall, 91% of sites met the disturbed soil minimums as well as the recommendations for avoiding landings within filter strips were possible (Table 7). Continued emphasis should be placed on avoiding location of infrastructure within filter strips where practical.

Table 7. Soil exposure, erosion, and sediment reaching a waterbody observations, and overall compliance rates of filter strips per watershed unit.

Watershed Unit	Total Filter Strips	Filter Strips w/ concentrated or ≥5% dispersed Soil Exposure	Strips w/ avoidable landings & No soil exposure	Filter Strips with Erosion	Filter Strips w/ Sediment Reaching a Waterbody	Compliance* (%)
CWR	170	3	5	0	0	96%
LRRR	152	6	24	0	0	80%
MRBS	178	9	11	9	3	89%
SCKS	350	8	28	3	1	90%
SCN	162	0	1	0	0	99%
SE MN	30	3	1	1	0	87%
Total	1042	29	70	13	4	91%

* Non-compliance based on filter strips having ≥5% dispersed exposed soil or any concentrated exposed soil as well as locating landings within filter strips that could have been located outside of filter strips.

Riparian Management Zones

Riparian area is defined as the area of land and water forming a transition from aquatic to terrestrial ecosystems along streams, lakes, and open water wetlands. RMZ guideline recommendations were modified in 2012 resulting in generally wider, but simplified RMZ recommendations. Current width recommendations for RMZs are based on type and size of waterbody, with a standard recommended residual basal area for all types. In this reporting period, RMZ compliance was based on the 2012 revised guidelines with the exception of 2 RMZs where contracts were established in 2011.

For each RMZ, data were collected from three representative cross sections to characterize the composition of the full recommended RMZ width based on type and size of waterbody. Basal area (BA) within the RMZ was determined using a variable plot with 10 factor prism. Linear distances and BA were recorded for:

- Non-forest (sedge, brush, and scattered trees with a BA less than 25 ft^2/acre)
- Undisturbed forest (no apparent harvest with BA greater than 25 ft^2/acre)
- Partially harvested forest (harvest retained at least 25 ft^2/acre BA)
- Clear-cut (harvest retained less than 25 ft^2/acre BA) for the rest of the recommended RMZ width for the specific type and size of waterbody

Compliance was based on the combined width of the non-forest, undisturbed forest, and partially harvested forest (where reserve trees met the BA recommendations) from the water's edge landward. Basal area compliance was evaluated for the partially harvested portion based on the minimum recommended basal area of 60 ft^2. RMZs meeting 95% or more of recommendation width and basal area are within the margin of error and considered compliant. Some RMZs had significant areas of non-forest vegetation (i.e., grass, sedge, brush, or shrubs) adjacent to water, while others were composed entirely of forest.

A total of 104 RMZs were identified on or adjacent to 71 sites monitored in 2016 and 2017. Overall, 82 of 104 (79%) RMZs met guideline recommendations for width and basal area of forest retention. Additionally 18 RMZs managed 50% or more of the recommended RMZ width and basal area representing an additional 17% of RMZs with significant partial compliance (Table 8). These results are very similar to the previous report of 80% and 13% respectively.

From a watershed perspective, compliance for RMZ implementation is widely variable across watershed sample units. SCN had 100% compliance on all RMZs adjacent to OWWs and trout streams and 80% on other perennial streams - the highest overall compliance despite having substantially more RMZs than any other sample unit (Table 8). SCKS had the lowest compliance for lakes & OWWs but the highest compliance for RMZ adjacent to non-trout streams were 11 of 12 met recommendations (Table 8). All 14 RMZs in LRRR were adjacent to non-trout streams and achieved 71% compliance. All 3 RMZs in SE MN were on trout streams and had 67% compliance. Outreach including the importance of RMZ management in CWR, LRRR and SE MN sample units may improve awareness and implementation of RMZ guidelines.

RMZs provide direct shading to streams and lakes as well as shading to soils and ponded water that result in cooling or maintaining temperatures in runoff and internal drainage that is particularly important for cold water habitats. Compliance on trout streams was 83% which is slightly lower than last reporting period of 93%. Five of six trout streams (SCN and SE MN) met recommended guideline for RMZ width and BA while the remaining RMZ met just over 50% of the recommended width (Table 8).

Guidelines also recommend retention of coarse woody debris (CWD) within RMZs where partial harvest is occurring. For six sites that conducted partial harvest (but still retained >60BA) within RMZs, five retained four or more CWD/acre within the RMZ as recommended by the guidelines. The remaining site did not retain any CWD within the partially harvested area of the RMZ. Retaining CWD within RMZs can sometimes be confused with guidelines that recommend avoiding placement of slash within filter strips. Clear communication in guideline training could contribute to improved implementation.

Table 8. RMZs meeting guideline recommendations by watershed sample unit.

Watershed Unit	Total Sites	Sites with RMZs	Total RMZs (#)	Trout Streams (%)	Non-trout Streams (%)	Lakes & OWW (%)	Total Compliance (%)	Partial Compliance (>50%)
CWR	31	11	24	-	60%	79%	75%	13%
LRRR	33	12	14	-	71%	-	71%	29%
MRBS	34	13	17	-	83%	73%	76%	24%
SCKS	34	11	16	-	92%	50%	81%	13%
SCN	35	22	30	100%	80%	100%	87%	13%
SE MN	12	2	3	67%	-	-	67%	33%
Grand Total	179	71	104	83%	79%	78%	79%	17%

Crossings

Crossings are sections of roads or skid trails, and in some instances landings, where equipment crosses a wetland or waterbody. Logging equipment crossings are the forest management features that have the greatest potential for disturbing wetlands and waterbodies. The types and relative proportion of waterbodies and wetlands crossed changed little compared to the previous report. The majority of crossings (64%) occurred as a result of skid trials, with most crossings (92%) occurring on NOWW (Table 9).

One of the key guidelines to avoiding impacts to wetlands and waterbodies is to avoid crossings whenever practical. Contractors were asked to determine whether a crossing could have been avoided without unreasonable costs or reduced safety. Contractors reported that overall 28% of observed crossings could have been avoided (Table 9), with most instances due to skid trails crossing NOWWs. These results are nearly identical to the last report and higher than the 18% reported in 2011. The majority (~75%) of avoidable crossings were documented in situations where contractors determined the operator could have easily driven around a wetland (i.e.

where logging operators cut across the tip of a wetland rather than driving fully around), or crossed small isolated wetlands that could easily have been avoided. The remaining avoidable crossings occurred where contractors judged that there were two or more crossings were one crossing would have been sufficient. Improved avoidance of unnecessary crossings will reduce wetland impacts and improve overall guideline implementation.

Table 9. Number of crossings by infrastructure component and waterbody type with avoidance potential.

	Crossings (#)	NOWW	Beaver Pond	OWW	Dry wash	Stream	Could Have Been Avoided
Roads	115	101	-	-	3	11	24
Landings	6	6	-	-	-	-	4
Skid trails	214	200	-	-	6	8	66
Total	**335**	**307**	**-**	**-**	**9**	**19**	**95**

Only one watershed sample units (SCN) had no avoidable crossings identified by monitoring contractors. In contrast, the MRBS sample unit had 52% of all crossings identified as avoidable (Table 10). Remaining sample units had from 25-33% of crossings identified as avoidable. This highlights a continuing need for focused outreach addressing the importance of avoiding crossings and techniques for identifying wetlands.

From a watershed perspective, LRRR and SE MN had the highest and the lowest mean number of crossings per site, but both fell near the median for percent of avoidable crossings at 28% and 25% respectively (Table 10). The MRBS sample unit had the highest percent of avoidable crossings (56%) but fell near the median for number of crossings per site (Table 10). These observations suggest that the number of crossings per site appears to be only partially related to the implementation rate or ability to avoid unnecessary crossings. This may reflect the fact that it is as much the size and characteristic of wetlands as it is the number of wetlands that dictates the number of crossings created and ability to avoid unnecessary crossings. Notably, SCN had no crossings identified as avoidable and a low mean number of crossings per site despite having similar watershed characteristics as other northern watersheds, and may suggest that operational habits and awareness of wetland locations by equipment operators may contribute substantially to successful avoidance. This highlights an opportunity for focused outreach in watersheds having high percentages of avoidable crossings. Avoidance of crossings where possible appears to be a continuing opportunity for improvement. Outreach should include both techniques for avoiding crossings as well as identification of wetlands and wetland edges.

The relationship between the number of wetlands on or adjacent to harvest sites and the number of crossings is dependent on both the geomorphology of the watershed, as well as care in avoiding crossing wetlands by operators. In most cases the number of crossings is much lower than the number of NOWWs observed, indicating that many of the observed wetlands were not crossed and likely avoided.

Table 10. Non-open water wetland **(NOWW)** crossings by watershed sample unit.

Watershed Unit	# Sites	# Sites with Crossings	Total # of crossings Observed	Mean Crossings per site when present	# of NOWW Crossings	# of Avoidable NOWW Crossings	# of NOWW Crossings Rutted
CWR	31	10	24	2.8	21	7 (33%)	1
LRRR	33	19	104	8.8	104	29 (28%)	4
MRBS	34	22	54	3.5	50	28 (56%)	4
SCKS	34	29	114	5.7	109	28 (26%)	4
SCN	35	19	29	2.5	24	0	2
SE MN	12	5	10	2.3	8	2 (25%)	0
Total	**179**	**104**	**335**	**4.3**	**316**	**94 (30%)**	**15**

Figure 2 below is a common example where one of two crossings was determined to be avoidable. The red line indicates the harvest site boundary, the blue polygon with hash marks indicate wetland boundaries. Two crossings are identified by FID:CRS5451 and FID:CRS5452.

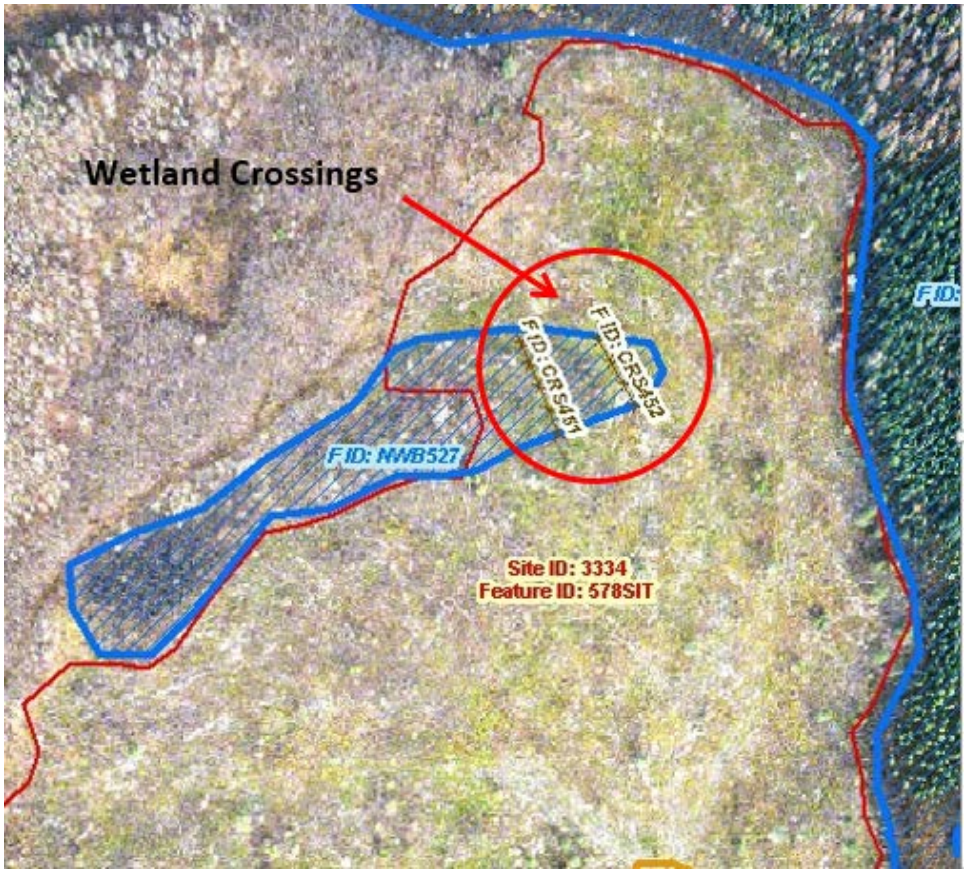


Figure 2. Example of multiple crossings of a wetland.

Rutting on Non Open Water Wetland Crossings

Non open water wetlands (NOWW) are the most frequently crossed wetlands during harvesting operations in MN. During this reporting period, 308 NOWW crossings were observed. Rutting occurred on only 5% of all NOWW crossings, down substantially from the 33% reported in the 2011 report as well as the 13% from the last report. All instances of rutting were attributed to logging operations and not to recreation or non-logging activity. Of the crossings that were rutted, approximately half were identified as having rutting exceeding 50% of the width of the wetland. This level of rutting increases the likelihood that shallow subsurface flow of water will be restricted, potentially altering wetland hydrology. Skid trail crossings accounted for 74% of all rutted crossings with the remaining instances occurring on forest access roads. Avoidance of rutting in wetland crossings appears to be an area of substantial improvement in recent reports.

Stream Crossings

Implementation of guidelines that protect water quality is particularly important at stream crossings due to the potential to directly impact stream water quality. During this reporting period, contractors recorded 19 stream crossings occurring on 14 sites. Eleven crossings were associated with forest roads, and eight were from skid trails. Only one of these stream crossings (a skid trail in MRBS) was deemed as avoidable, indicating 95% compliance in avoiding stream crossings where possible. Additional stream crossings may have been avoided through site planning that are not documented here given that most streams were adjacent to harvest sites and were not crossed.

Approaches and Segments

Recommendations on the use of erosion control have been a primary component of the forest management guidelines related to maintaining water quality. In particular, use of erosion control (EC) at areas in close proximity to water resources is important in minimizing sedimentation of wetlands and streams. Approaches are the portion of a skid trail or road immediately leading into a wetland or waterbody, making them a key feature when assessing the use of erosion control because of potential to funnel surface water, sediment, organic debris, and contaminants into the water. Guidelines recommend that water diversion/erosion control practices be installed immediately when approaches are created and then maintained until the location is stabilized.

A total of 659 approaches were identified and evaluated by monitoring contractors. The vast majority (95%) of these approaches were in good condition and did not require further erosion control practices for sediment control (Table 11), similar to what has been observed in previous reports (Rossman 2012, Rossman et al. 2016). Generally, EC is not needed on approaches that have low slope (<2%), little or no exposed mineral soil, or where natural roughness and/or breaks in terrain negate the need. The high estimate of approaches not needing EC may reflect high levels of guideline implementation through good selection of crossing locations, or may be associated with the relatively forgiving operating conditions that occur in the state (ex., winter

harvesting, level topography, etc.). However, for the 32 approaches where erosion control (EC) was deemed necessary, only eight (25%) had practices appropriately installed, which is slightly higher than what was reported in the two previous reports, but still an area for improvement. More importantly is that erosion was frequently (75%) observed when EC practices were needed but not installed. Additionally, in over 70% of instances when erosion was occurring on approaches, contractors found evidence of sediment reaching the associated waterbody (Table 11). Utilization of soil and slash water bars or scattered slash on approaches would reduce potential impacts to wetlands and surface water, but the establishment of vegetation appears to play an even larger role in minimizing erosion (Slesak et al. 2016). Regardless, the results reinforce the need to emphasize the importance of EC practices on approaches to minimize erosion potential, and a need to identify when EC practices are needed during training programs for loggers, land managers, and landowners. For example, half of the watershed units (MRBS, SCKS and SE MN) commonly had sites with approaches needing EC (Table 11), which is likely associated with differences in slope or soils. Targeted outreach to these watersheds on how to identify the need for EC installation, and what practices to install, would help to increase guideline implementation and reduce the potential for water quality impacts.

Table 11. Erosion control and occurrence on approaches (APPs) for all water features by watershed unit.

Watershed Unit	Total Sites	Sites with APPs	Total APPs (#)	For Sites with APPs Needing Erosion Control			
				# APPs Needing EC	# APPs with EC Installed	# APPs with Erosion	# APPs Sediment Reached Waterbody
CWR	31	9	48	1	1	0	0
LRRR	33	19	205	2	0	2	2
MRBS	34	21	108	9	0	8	6
SCKS	34	29	220	6	0	6	2
SCN	35	16	58	3	2	1	0
SE MN	12	5	20	11	5	8	8
Total	**179**	**99**	**659**	**32**	**8**	**25**	**18**

During the monitoring field assessments, contractors documented segments of roads and skid trails with slope steepness and length that had potential for erosion to occur. For the majority of these segments, contractors simply documented whether erosion was occurring or not. For those segments near wetlands or surface water that have a higher potential to impact water quality compared to other portions of the harvest site, contractors collected more detailed data. Because of their proximity, these “water quality (WQ) segments” may impact water quality if erosion control practices are not properly installed.

Only a small number of sites (11%) had WQ segments present, which may reflect proper locating of roads and skid trails away from wetlands and surface water. However, similar to approaches, those WQ segments that needed EC installed generally did not have it and the occurrence of erosion in those situations was common (Table 12). Most (23 of 39) WQ segments occurred on roads, likely due to challenges associated with stabilizing road surfaces –

especially for active roads. In four of the 31 WQ segments with erosion occurring, sediment reached the associated waterbody. This is lower than documented for approaches, likely because WQ segments are not a direct conduit to wetlands and waterbody's like approaches are. Notably, the MRBS and SCKS watersheds had both the highest number of WQ segments as well as the lowest number with EC practices installed, making these geographically close units prime candidates for targeted efforts to improve EC use and application. In contrast, the SE MN watershed sample unit had a relatively high number of WQ segments with most having EC practices installed. Although there is clearly a need to focus efforts on improving EC use in general, the small number of times that sediment reaches a wetland or waterbody from approaches and WQ segments limits water quality impacts associated with forest harvesting.

Table 12. Use of erosion control and erosion occurrence on skid trail and road segments that have potential to impact water quality (WQ) by watershed unit.

Watershed Unit	***Total Sites***	***Total number segments***	***Sites with WQ Segments***	***For Sites with WQ Segments Present***			
				# WQ Segments	**# with EC Installed**	**# with Erosion**	**# Sediment Reached Waterbody**
CWR	*31*	83	*3*	*6*	1	5	0
LRRR	33	2	0	0	0	0	0
MRBS	34	20	7	10	0	9	1
SCKS	34	40	5	14	0	13	3
SCN	35	3	0	0	0	0	0
SE MN	12	63	4	9	7	4	0
Total	**179**	**211**	**19**	**39**	**8**	**31**	**4**

Infrastructure

Equipment traffic can compact and rut soil, damage or remove vegetation whose root systems hold the soil in place, reduce movement of air and water into and through the soil, and redirect surface water flow. These impacts restrict plant root growth, reduce the availability of nutrients and moisture for plant growth, increase the potential for erosion, and can change surface and subsurface hydrology.

One way to minimize impacts of traffic on soil productivity during timber harvest operations is to limit the amount of high traffic area in roads and landings (i.e., infrastructure). Site-level guidelines recommend:

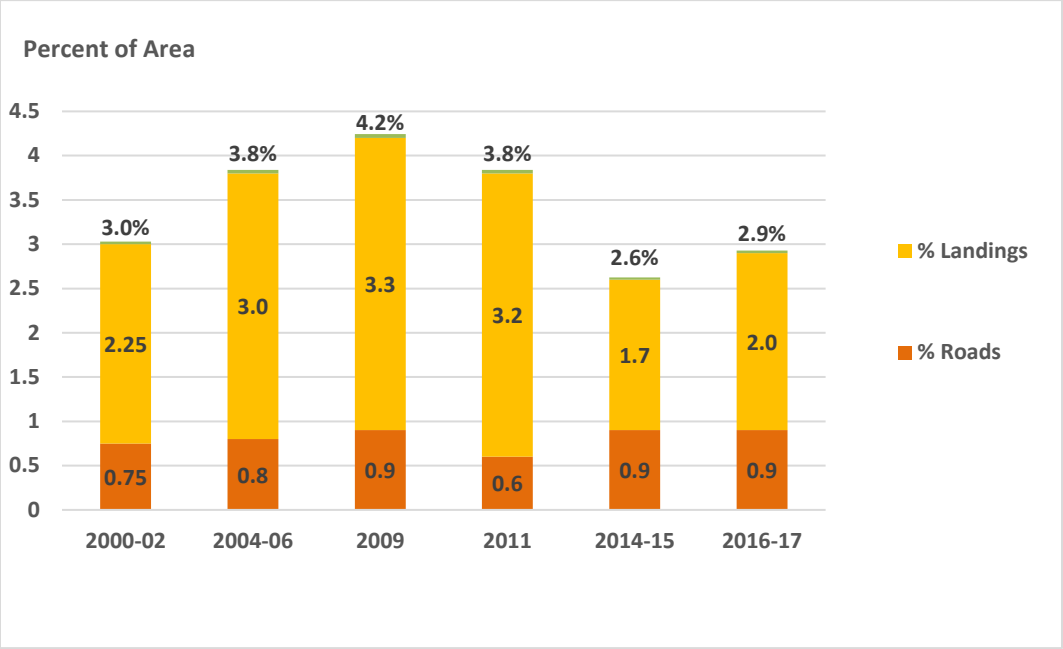
- *Sites less than 20 acres should have 1 acre or less of the harvest site in infrastructure.*
- *Sites 20-30 acres should have less than 5% of the harvest area in infrastructure.*
- *Sites greater than 30 acres should have 3% or less of the harvest area in infrastructure.*

Monitoring contractors determined total on-site infrastructure by measuring area occupied by landings and roads within the site. The estimated mean infrastructure per site for is 2.9% (Figure 3) similar to the 2.6% reported in the previous report and a sharp decrease in infrastructure since the reported high of 4.2% in 2009. The variability in percent infrastructure from past reports appears to occur primarily in landing infrastructure, with road infrastructure remaining relatively stable ranging from 0.6 to 0.9 percent while percent landing infrastructure has ranged from a high of 3.3% to a low of 1.7%.

Mean on-site landing area per site in this reporting period is 1.1 acres, up from the 0.76 acres report in the last report, but down from the 2009 and 2011 reports. Mean on-site road acreage for this reporting period is 0.5 acres, equal to the previous report and also down from past reports.

From a watershed perspective: The mean percent infrastructure by watershed sample unit ranged substantially from a low of 0.7% in SE MN to a high of 5.2% in LRRR. The LRRR watershed sample unit had both the highest mean percent of sites in roads as well as landings. These two sample units represent very different terrain and challenges for managing landings. Where sites in SE MN are typically steep terrain providing relatively small flat areas available for landing locations which are often off-site, the LRRR is nearly level topography offering many landing opportunities and perhaps enabling operators to create larger and more frequent landings.

Figure 3. Mean Percent Infrastructure by reporting period.



Overall, 77% of sites monitored in 2016 and 2017 met the recommended infrastructure amounts based on 2012 guidelines (Table 13). This is lower than the 2014_15 report (82%) but considerably higher than previous reports. Both SE MN and SCN had high compliance of 100%

and 94% respectively, while LRRR had the lowest compliance at 52%. When comparing on-site infrastructure with site size, highest compliance to infrastructure guidelines was achieved on sites ≤20 acres in size (100% compliance), followed by sites in the 20-30 acre range (90% compliance), and finally sites greater than 30 acres (63% compliance). Mean site size was substantially higher at 52 acres for watersheds in this report compared to 37 acres in the previous report, but overall compliance was similar.

Table 13: Acreage of on-site infrastructure by watershed sample unit.

Watershed Unit	Sites Meeting Infrastructure Guidelines (%)*	*Total # Sites with On-site Infrastructure	*Mean site Size (ac)	*Mean On-site Infrastructure (ac)	*Mean On-site Landing Size (ac)	*Mean On-site Roads (ac)
CWR	84%	26	38	1.1	0.8	0.3
LRRR	52%	32	43	2.2	1.6	0.6
MRBS	78%	29	41	1.3	0.9	0.4
SCKS	70%	32	87	2.3	1.5	0.8
SCN	94%	31	80	1.5	0.9	0.6
SE MN	100%	5	28	0.2	0.1	0.1
Total	**77%**	**155**	**56**	**1.6**	**1.1**	**0.5**

* For sites with on-site infrastructure

As indicated above, the watershed units represent a wide range of geomorphology, with LRRR falling within the nearly level Agassiz lake plain in the far north, and SE MN falling within the valleys and bluffs of SE Minnesota. Differences in compliance may be a reflection of the ease at which landings can be located and developed in the relatively flat topography of LRRR as opposed to SE MN.

Landing Location

In addition to limiting the area occupied by landings within reasonable safety and operational limits, guidelines recommend locating landings outside of wetlands, filter strips, and RMZs to maintain water quality, even in winter operations. Operating on landings under frozen conditions reduces the potential for some impacts, but may not reduce the risk of depositing landing debris (i.e. slash, culls, and chipping debris) onto frozen wetland surfaces and subsequently into the wetland itself. Additionally, fueling, maintaining equipment, or leakage from equipment that often occurs on landings, increases the potential to place contaminants directly into frozen wetland surfaces. Reduced vegetation growth on landings can last for decades, and will occur regardless the harvest season (Slesak and Kaebisch 2016).

Overall, 144 landings (32% of total) were located at least partially in a wetland or filter strip (primarily NOWWs). In addition to documenting landing locations, monitoring contractors judged whether suitable upland area was available for alternative location of landings that would still accomplish the site objectives without unreasonable costs or reduced safety. Of those landings located within wetlands and/or filter strips, 91 were judged to have upland locations available for placement, indicating an overall implementation rate of 80% for locating

landings outside of wetlands and filter strips when possible (Table 14). This result is the same as reported in the 2014_15 report and similar to the previous 2011 report (76%). The most common (over half) avoidable situations occurred where landings were located in filter strips. When evaluating this information at the site scale, 33% of all sites had at least one landing located in a filter strip or wetland where an alternative upland location was deemed available, indicating a site compliance rate of 67%. Several sites had multiple landings with only one within a wetland or filter strip. These results are also very similar to the results reported in the 2014_15 report.

Table 14: Landing (LND) location related to wetlands and filter strips.

Watershed Unit	**Total # Sites**	**Total # LND**	**LNDs Located in Wetlands or Filter Strips where Upland Available**	**Sites with a LND Located in Wetlands or Filter Strips where Upland Available**
CWR (2017	32	55	9%	16%
LRRR (2017)	33	140	24%	39%
MRBS (2016)	34	59	20%	32%
SCKS (2016)	34	96	34%	65%
SCN (2017)	35	90	7%	20%
SE MN (2016)	12	11	9%	8%
Total	**179**	**451**	**20%**	**33%**

At the watershed scale: the SCKS watershed sample unit had substantially lower (35%) compliance than the mean for locating landings outside of filter strips and wetlands where uplands were available. SE MN, SCN and CWR performed substantially higher than the mean compliance value for this guideline. The SCKS sample unit had the highest total number of waterbodies observed on or adjacent to monitoring sites (Table 4) as well as the highest mean number per site. This sample unit also had the highest percentage (lowest compliance) of landings located within wetlands, waterbodies or filter strips where alternatives were available (Table 14). Comparatively, SE MN had the lowest total number of wetlands and waterbodies on sites as well as the lowest per site mean. SE MN also had the lowest percentage of landings located in wetlands, waterbodies or filters trips where upland options were available. It appears that the density of surface water and wetlands may influence the relative times when landings are located in a wetland or filter strip where upland alternatives are available.

Assessing the reasons why operators located landings in filter strips or wetlands when uplands were available in difficult to ascertain. Monitoring contractors were asked to identify a reason if they were able determine while on site. For just over half (56%) of these instances contractors indicated that it was unknown or they were unsure; the next most common response (25%) was “landing expansion” or “landing sprawl”; and remaining miscellaneous reasons included “ease of operation” or “convenience of location”.

It is unknown if landing location is related to ability to identify wetlands under variable harvest conditions, watershed characteristics, or harvest site planning and operations. Outreach

addressing wetland identification tips and the importance of locating landings away from wetlands and waterbodies may improve awareness and implementation of guidelines in all watersheds.

Landing Conditions

Landings were generally in good condition. Most (69%) landings were more than 50% vegetated and only 7% had little or no vegetation at the time of monitoring. Although not a specific guideline, re-vegetated landings are less susceptible to erosion. Only 11 landings had indication of erosion occurring, with one instance where a trace amount of sediment was reaching a non-open water wetland. Only six landings had any visible trash on the landings with four of those apparently from logging and two from non-logging sources. One landing had evidence of rutting. These results are all similar to last report, demonstrating high compliance for related guidelines.

Only three landings had evidence of fueling and equipment maintenance activity as evidenced by visible oil/petroleum product stains (oil spots) on landings. Guidelines recommend keeping equipment in good repair, and that spills up to five gallons be thin spread over the upland part of a site, with spills over five gallons reported to MPCA duty officer for recommended action. Lack of observable evidence of spills on landings suggests high compliance to these guidelines.

Accumulation of organic debris on landings

In 2016 & 2017, monitoring contractors were asked to document occurrences of dense organic debris accumulation on landings. Contractors were asked to identify the portion of landings that were covered by concentrations of organic debris sufficient to inhibit regeneration of woody vegetation. Contractors also identified the type of the material (slash, chips, saw dust, etc.) as well as the origin related to upland or wetland if possible. The goal was to evaluate situations when dense debris accumulation on landings potentially represents a loss of productivity for this area of the site. Additionally, for landings in wetlands, this data may provide insight into situations where this dense slash represents “fill” and may give indication of how often this is occurring. Contractors were instructed to only document situations where the accumulation of organic debris is dense and thick enough to inhibit woody vegetation.

Of the 451 observed landings, 32% had half or more of the landing surface area covered in dense organic debris. In nearly all instances at least part of the source of debris was from slash, 32% of the time the source was identified as chipping debris, and 18% of the time the source was identified as saw dust.

From a watershed perspective, the highest occurrence was in LRRR where just over half of landings had 50% or more of the landing occupied by dense debris, followed by SCKS with approximately 1/3 of landings in the same category. Lowest occurrence was in SE MN, likely due to operational differences and utilization of the primary species being harvested in that region.

The relationship between this data and occurrence of fill in wetlands was not thoroughly evaluated at this time primarily due to incomplete data related to specifically where the debris was located within the landing itself. It should be noted however, that dense deposition of slash and debris in this manner is considered fill in wetland regulations and is not exempt from wetland replacement in the MN Wetlands Conservation Act. Additionally, it was observed that creation of a dense slash mat masks wetland edges and may contribute to landing expansion into wetlands.

Although not addressing a specific guideline per se, this information may provide insight into an emerging issue and suggests need for further study.

Rutting Analysis at the Site Level

The TH/FM guidelines recommend minimizing rutting on roads, skid trails, and landings, and avoiding rutting in the general harvest area. Rutting occurs when tires or tracks of equipment displace and compact soil and tears the root mat when the soil is not strong enough to support the vehicle load.

The presence or absence of rutting ≥6 inches deep was recorded for a variety of features. In previous reports we have focused on the occurrence of rutting by various feature types (such as crossings, approaches, landings) across all sites. For this report, we also assessed the cumulative amount of rutting identified on all features of sites including the general harvest area. As in past reports the frequency of rutting was highest in NOWW skid trail crossings, however, the highest surface area of rutting at the site scale occurs when there is rutting identified in skid trails within the general harvest area (not associated with any one feature such as a crossing). This suggests that these sites have soils or soil conditions conducive to rutting (too wet for operations or weak soils) and often have rutting associated with crossing features as well.

When evaluated at the site level, rutting is clearly focused on a minority of monitored sites. Even then, sites that had some rutting identified had minor amounts when compared to the entire site. Of the 179 sites monitored, only 14 sites had rutting identified somewhere on the site, and six of these had rutting identified at more than one feature type. Although somewhat difficult to determine exactly, all sites with rutting had less than 2% total rutted surface area. These results are substantially lower for incidence of sites with rutting than previous reports.

From the watershed perspective; some rutting occurred in all watersheds. The number of sites with rutting ranged from 1 in CWR, SE MN and SCN, to 3 in MRBS, and 4 in LRRR and SCKS. The MFRC has established no threshold for guidelines related to the percent rutting on a site or specific features on a site. Guidelines recommend avoiding rutting through careful planning related to season of operation and monitoring of day to day conditions. Anecdotally, operations on sites with rutting at multiple feature locations (especially in general harvest area) likely occurred because operating conditions were conducive to rutting. In these situations, guidelines recommend changing operations or curtailing operations until conditions improve.

Biomass, Slash Management & Fine Woody Debris Retention

Retaining slash or fine woody debris (FWD) on harvest sites helps to sustain soil productivity, and also provides habitat for small mammals, amphibians, and other organisms. Guidelines recommend favoring practices that allow for dispersed slash on the site if it does not conflict with management objectives, rather than piling slash. For this report period, 117 of 179 sites had slash more or less evenly distributed on the site representing a 65% implementation rate to this guideline.

Thirty one sites utilized slash as biomass product of which 23 (74%) retained an estimated 1/3 or more of fine woody debris on site. Eight sites did not retain the recommended 1/3 FWD including three sites that retained only incidental breakage (less than 33%) and four sites that did not retain either slash or incidental breakage.

From the watershed perspective, the MRBS and LRRR units had 20 and 12 sites that did not have slash more or less evenly distributed back on to the site. For these sites, slash was either piled at the landing, scattered in dense layers in close proximity to the landing, or utilized as biomass. Biomass utilization was distributed throughout all WSUs (except for the SE MN unit) with SCKS having the highest number of biomass harvest sites at eight.

Wildlife Habitat

Coarse Woody Debris

Coarse woody debris (CWD) provides important habitat for forest animals and plants. The site-level guidelines recommend creating or retaining two to five bark-on down logs (pieces >6 ft. long and > 6 inches diameter) per acre in the general harvest area and at least four bark-on down logs per acre in riparian areas. General harvest areas met the guideline of two or more "sound" down logs per acre 96% of the time (Table 15), slightly lower than last reporting period but substantially higher than numbers reported in 2011 and previous reports. Higher results may be partially due to a change in plot measurement protocols in 2014 for CWD which includes large branches as CWD rather than just logs (boles). Just over half of the sites monitored fell into the range of 5-30 pieces of CWD/ acre in the general harvest area. From the watershed perspective, sites in the LRRR sample unit appeared to have higher number of recorded CWD on sites with over half reporting 50 or more pieces of CWD per site. Implementation of this guidelines continues to be high.

Leave Tree Distribution

The TH/FM guidelines recommend retaining mature, live trees on clear-cut timber harvests to provide vertical structure and habitat for wildlife while harvested stands regenerate. The

guidelines provide two options for meeting the leave tree (or green tree retention) recommendations:

- Scattered - retain six or more scattered individual trees greater than 6" DBH per acre in the harvest area (scattered leave trees).
- Leave tree clumps (LTC) - retain at least 5% of a clear-cut harvest area in patches at least ¼ acre.

In both cases (scattered and LTC) leave trees should be at least six inches DBH. Leave tree clumps are the preferred method and ideally would be located on site; however, areas adjacent to a harvest may be considered in evaluating leave tree acreage. Adjacent leave tree clumps are typically located between the harvest site, and an adjacent non-forested wetland, or previously harvested area, as a visual screen, or where the leave tree clump is not large enough to be economically manageable by itself. In the 2012 revisions to the site-level guidelines, the MFRC modified the guidelines to include the area managed within RMZs as leave tree clumps. Of the 179 sites monitored, 158 sites were evaluated for implementation of the leave tree guidelines. The remaining 21 sites included selection harvests, thinning, seed tree and shelterwood harvests that retain abundant vertical structure and were therefore not evaluated for leave tree guideline compliance.

Table 15. Number of sites with indicated ranges of CWD pieces in general harvest.

Watershed Unit	0-2	2-5	5-20	20-30	30-40	40-50	≥50	Total Sites
CWR	1	1	9	6	5	0	9	31
LRRR	-	-	5	2	1	6	19	33
MRBS	2	1	6	11	4	7	3	34
SCKS	2	3	17	7	1	1	3	34
SCN	2	3	19	7	2	2	0	35
SE MN	0	0	4	6	0	2	0	12
Total	**7**	**8**	**60**	**39**	**13**	**18**	**34**	**179**

Overall, 123 (78%) of the 158 sites monitored for implementation of leave tree guidelines had adequate leave trees remaining on site to meet recommended guidelines. Additionally three sites identified silvicultural or safety reasons for not retaining leave trees such as managing dwarf mistletoe (*Arceuthobium pusillum*) in black spruce stands or Insect & disease concerns with harvesting fire damaged trees. Considering these sites, the estimated overall compliance to leave tree retention guidelines was 80%. Compliance to leave tree guidelines for watersheds sampled in this report are slightly less than those watersheds sampled in 2014 and 2015 and also show a slight decrease compared to numbers reported in 2011 (Table 16). Statewide, a total of 32 sites (20%) did not meet the leave tree retention guidelines. Of these sites all but 2 had some leave trees retained, with 12 of these 32 sites retaining 50% or more of the recommended leave trees by one or both methods.

Leave tree clumps are the preferred method of leave tree retention as recommended by the site-level guidelines. Overall, 49% of sites met the retention guidelines utilizing leave tree clumps and 44% utilized scattered leave trees. These results mark the first monitoring report where LTCs were used more commonly than scattered leave trees. The increase in reported utilization of leave tree clumps is likely due to the revisions made to the guidelines in 2012 that widened RMZs and included forested portions of RMZs as qualifying for the 5% goal of LTC retention. Of the 77 sites that utilized the leave tree clump strategy, 46 of those fully met the guideline via RMZs, 36 fully met the guideline via stand alone LTCs, 11 fully met the guideline via both methods, and 6 utilized a combination of the two. The inclusion of the generally wider RMZs as qualifying leave trees has substantially increased the number of sites meeting the guideline via leave tree clumps.

At the watershed scale, rates of implementation ranged from a high of 100% in SE MN to a low of 65% in LRRR and 69% in SCKS, both substantially below the statewide average. Despite having the lowest compliance rates, over a third of these sites in LRRR and SCKS fully met both scattered and clumped leave tree guidelines (doubling up). When looking at results by watershed unit, four of six WSUs utilized LTCs more frequently than scattered as a leave tree strategy, with MRBS and SE MN utilizing scattered leave trees more (Table 17). Considering these results, targeted outreach on leave tree guidelines to the LRRR and SCKS watersheds may increase implementation of leave tree guidelines in these areas.

Table 16. Percent of sites that meet or exceed leave tree guidelines.

Monitoring Year	Number of Sites for Which Guidelines Apply	Sites With ≥ 6 Scattered Leave Trees / Acre	Sites With ≥ 5% of Site in Leave Tree Clumps or RMZs	Sites with ≥ 6 Scattered Leave Trees/ Acre or ≥ 5% of Site in Leave Tree Clumps, both, or in Combination	Additional Sites Citing Silvicultural or Safety Reasons	Total
2000-02	293	49%	31%	61%	-	61%
2004-06	266	41%	13%	47%	-	47%
2009	74	50%	22%	61%	2	61%
2011	71	55%	32%	83%	1	83%
2014-15	158	47%	38%	82%	3	84%
2016 -17	158	44%	49%	78%	3	80%

Table 17. Number (%) leave tree compliance by watershed sample unit.

Watershed Unit	**Total Sites**	**Sites Evaluated for LTs**	***Scattered**	***LTC & RMZ**	***Met both ways**	***Met using combination**	**% Sites Meeting Guidelines**
CWR	31	27	12	15	4	1	89%
LRRR	33	31	13	16	9	0	65%
MRBS	34	28	15	9	4	2	82%
SCKS	34	29	14	12	7	1	69%
SCN	35	34	6	22	3	2	85%
SE MN	12	9	9	3	3	0	100%
Total	**179**	**158**	**69**	**77**	**30**	**6**	**80%**

*** # sites using this strategies used to retain leave trees**

Leave Tree Clump Characteristics

Contractors identified and evaluated 177 leave tree clumps (LTCs) on 69 sites during this monitoring cycle. Additionally, the forested portions of RMZs also function as clump retention and satisfied leave tree recommendations. Since 2004, the percentage of monitored sites utilizing LTCs to satisfy leave tree retention guidelines has increased steadily, and in this report exceed the number of sites utilizing scattered leave trees (Table 17). Blowdown occurred in only 7% of LTCs with an average of 10% of trees within LTCs being impacted.

In this reporting period, contractors noted when leave tree clumps were used to protect or enhance sensitive feature on the harvest site. Approximately 1/3 of the LTCs were used to protect or enhance non-open water wetlands by being located in or around these features.

Guidelines recommend that a mix of species is desirable for retention as leave trees and that preference should be given to particular species for their longevity, wind firmness, cavity potential and value to wildlife species, recognizing that it is necessary to work with what is available on a particular site. Table 18 shows the frequency of the most common mature tree species identified in LTCs. Six of the top ten species listed as the most common species found in an LTC are ranked as having excellent or good value to wildlife. Nearly 1/3 of the LTCs had aspen as the most common species in the LTC and may reflect recent outreach emphasizing the importance of retaining aspen. Several species including paper birch, red maple, and balsam fir are very frequently found in LTCs but not as frequently as the main species in the LTC. Other common species included white pine, burr oak, white spruce, basswood, tamarack, white cedar, white ash and hickory.

Table 18. Common species identified in LTCs by frequency of occurrence, across all monitored sites.

Species	# of LTCs with Species Listed as the most common species in LTC	# of LTCs with Species Listed as a component w/in 5 Most Frequent Species	% of LTCs with species as component	Rating of Species for Value to Wildlife
Trembling aspen	58	67	38%	Excellent
Black ash	27	42	24%	Excellent
N. Red oak	17	48	27%	Excellent
Black spruce	16	10	6%	Fair
Balsam fir	8	36	20%	Fair
Paper birch	7	78	44%	Fair
Sugar maple	7	17	10%	Excellent
Red maple	6	70	40%	Good
Red pine	6	12	7%	Good
Jack pine	5	9	5%	Fair

Scattered Leave Tree Characteristics

In addition to documenting presence or absence of scattered leave trees on monitoring sites, species composition of leave trees was also noted as well as additional characteristics including presence of cavity trees (or trees with rot in stem), and presence of dominant / co-dominants as leave trees (indicating that the larger trees were retained).

Scattered leave tree characteristics related to diversity, preference for wildlife suitability, and relative size were estimated from plot data at each site and averaged to determine mean values per watershed unit. A leave tree species preference metric for wildlife ranged from 1.8 to 2.6 with a statewide mean of 2.2, indicating that on average species with good or excellent wildlife characteristics are being retained at all watershed units. Both species richness and presence of large trees retained were variable across watershed units, being greatest in the SCKS and SE MN, and lowest in SCN. The high values for all metrics in SE MN may reflect that regions greater species diversity or different harvesting practices from the northern portion of the state. Statewide estimates are similar to those from previous years for which data is available (Table 19). The data generally indicate that a range of species and sizes are being retained as leave trees across much of the state.

Snag Distribution

Snags provide habitat for wildlife requiring tree cavities, perches, and bark foraging sites. For monitoring purposes a snag is defined as a dead tree stem standing at least 8 feet tall and $\geq$6 inches DBH. Snags were commonly recorded at nearly all harvest sites, ranging from a mean of 1.5 to 3.5 per acre across watersheds monitored this cycle (Table 19). MFRC guidelines generally recommend leaving all snags possible, but also have recommendations to remove

snags for visual quality concerns in some instances. The suitability of these most recent estimates is not clear, as the level of snag density needed to support snag-dependent wildlife populations is unknown. Based on recent FIA data, mean snag density for timberland in Minnesota is 18 per acre, indicating that these levels are lower than what exists in intact stands. Statewide estimates from this monitoring cycle are also approximately 40% lower than the previous report, but it is not possible to determine if snag retention is trending lower at this time.

Table 19. Scattered leave tree and snag characteristics (values in parentheses are standard error of the mean)

Watershed Unit	Snags (# acre[1])		Species Richness (#) [a]		Species Preference Index [b]		Proportion of large trees [c]	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
CWR	2.2 (0.2)	0.2-5.3	3.7 (0.4)	0-7	2.3 (0.2)	0-3	0.6 (0.1)	0-1.0
LRRR	3.5 (0.5)	0.2-11.5	3.8 (0.4)	0-9	2.0 (0.1)	0-3	0.5 (0.1)	0-1.0
MRBS	1.8 (0.3)	0-7.6	4.3 (0.6)	0-13	2.1 (0.2)	0-3	0.5 (0.1)	0-1.0
SCN	2.3 (0.3)	0-7.2	2.6 (0.3)	0-7	1.8 (0.2)	0-3	0.4 (0.0)	0-0.9
SCKS	1.5 (0.2)	0-6.3	5.0 (0.5)	1-11	2.6 (0.1)	1.8-3	0.6 (0.1)	0.1-1.0
SE MN	1.8 (0.4)	0.6-5.1	7.0 (0.4)	5-9	2.6 (0.1)	2.1-3	0.8 (0.1)	0.2-1.0
Statewide 2016-17	2.2 (0.1)	0-11.5	4.1 (0.2)	0-13	2.2 (0.1)	0-3.0	0.6 (0.1)	0-1.0
Statewide 2014-15	3.6 (0.3)	0-19.7	5.0 (0.2)	0-14	2.3 (0.1)	0-3.0	0.6 (0.0)	0-1.0
Statewide 2011	N/A	N/A	4.2 (0.3)	0-9	2.4 (0.1)	0-3.0)	0.5 (0.0)	0-1.0

[a] mean total number of species listed at each site

[b] calculated as the mean preference value per tree at each site, with values of 1, 2, and 3 corresponding to the categories “fair”, “good”, and “excellent” shown in Table GG-3 of the FMG Guidebook

[c] the proportion of measurement plots at a given site where contractors indicated dominant or co-dominant trees were present

Conclusions and Recommendations

Similar to the 2014_15 report, overall guideline implementation has improved in most of the focal areas when compared to the last statewide report in 2011. Results from this report show that implementation of many guidelines is generally high with many reflecting continuous or substantial improvement including those related to managing RMZs, retaining leave trees and snags for wildlife, limiting disturbance in filter strips, minimizing total infrastructure, condition and location of landings, occurrence of sites with rutting (primarily on wetland crossings), managing cultural resources, retaining coarse woody debris, and diversity of leave tree species. Substantial improvement was documented in the number of sites utilizing the 2012 guideline version which was an item of concern identified in the last report.

Five guideline topics were found to show consistently low or decreasing level of implementation at the statewide scale including wetland crossings that could have been avoided, use of water diversion/erosion control on approaches where needed, retention of FWD on biomass harvest sites, ETS species considerations, and awareness of visual quality sensitivity. Given the critical role that the above guidelines play in mitigating impacts to water quality, wildlife, and soil productivity, landowners, managers and logging operators should strive to improve implementation to avoid negative impacts on Minnesota's forest resources. In particular, use of erosion control continues to be inadequate and there is a need for concerted effort to implement erosion control practices when potential impacts to water quality are high (i.e.., on approaches and segments near wetlands and surface water). Two focal areas (checking of known ETS species and awareness of visual sensitivity ratings) could benefit from language clarifications in the site- level guidelines in addition to specific outreach on the subject. The following recommendations are intended to be used as a framework to improve the overall level of guideline implementation.

Outreach and Education Statewide

Outreach is one of the primary tools available for improving guideline implementation and is essential to successful voluntary implementation. Future outreach should acknowledge successes in guideline implementation and focus on areas where opportunity for improved implementation exists. Continued effort to make available and update the on-line introduction to site-level guidelines course will assist with this, but additional in-depth programs targeting specific guidelines should also be considered. Specific topics to consider for focused training could include 1) introduction of site-level guidelines to new land managers and loggers, 2) continued training for improved wetland identification, especially related to avoidance of crossings and landing locations, 3) methods of effective water diversion and erosion control practices and how to recognize when these practices are needed, and 4) awareness on where and how to check for visual sensitivity ratings related to streams, trails, and other non-road features. Additionally, clarification of guideline language related to checking for known ETS species and the meaning of "near" may improve implementation of ETS species guidelines. The

above topics are recommended for all watershed units. Outreach efforts should include NIPF landowners, loggers who work on NIPF lands, and natural resource professionals who advise NIPF landowners.

Summaries and Opportunities for Improvement at the Watershed Scale

The use of watershed scale monitoring introduces a structure to focus outreach and education efforts in localized areas with the highest opportunities for improved implementation. The following summaries provide an overall review of guideline implementation and opportunities for focused outreach for each watershed unit. Potential exists for Council staff, GMP staff, and others to work with local partners and efforts (e.g., MFRC's Regional Landscape Committees and the Minnesota Pollution Control Agencies' Watershed Restoration and Protection plans) to develop strategies and acquire funding for this outreach.

Crow Wing River Watershed (CWR):

The Crow Wing watershed encompasses part of the popular Brainerd lakes area and is dominated by forests and lakes with localized areas of intensive agriculture. This unit is 49% forested cover and has the second highest percent cover in lakes at 6%. CWR had the second highest percent of forest cover disturbed (0.9%) during the target window, though the average disturbance size was small at ~35 acres. A severe wind event in July of 2016 may have substantially increased the observed disturbance for this watershed.

Sites in CWR had high or improving compliance to guideline recommendations in several categories including: filter strip implementation (96%), RMZ management (75%), infrastructure management (84%), locating landings outside of wetlands and filter strips (91%), and Leave tree retention (89%), and installation of EC on approaches were needed. Opportunities for improvement include avoidance of wetland crossings (67%)

Lake of the Woods, Rapid, Roseau, and Rainy River watersheds (LRRR):

Located in the broad flat Agassiz Lake plain, these watersheds are dominated by low relief, organic soils, and sandy beach ridges with some bedrock controlled topography in the eastern portion. This unit is the largest of the six sample units and contains some of the most remote (most Roadless) regions of MN with the western portions more highly developed with agriculture. This unit has approximately 42% forest land with an additional 22% in sparsely forested wetlands. Forest disturbance in LRRR was estimated at 0.5% of the forested area which is slightly lower than the statewide median.

Sites in LRRR had high or improving compliance to guideline recommendations for filter strip implementation (80%) and installation of EC on approaches where needed. Opportunities for improvement include: RMZ management (71%), avoidance of wetland crossings (72%), locating landings outside of wetlands and filter strips (76%), infrastructure management (52%), and leave tree retention (65 %).

Mississippi River – Brainerd and Sartell (MRBS):

These watersheds encompass the third and fourth segments on the Upper Mississippi River and transition from predominantly forested landscape in the north to increasing development and agricultural influences further south. A recent monitoring and assessment report of the upper Mississippi River indicates that the water quality of the Mississippi river in north end of this sample unit is high, but is degraded substantially at the more developed southern part of the sample unit due to agricultural runoff carried in by tributaries from the west (MPCA 2017). MRBS had the second highest percentage of crop/pasture or urban/open/barren lands at 37%, which was heavily concentrated in the southern part of the unit. This unit had the highest number of disturbed forest sites and the highest percent of forest cover disturbed (~1.1%), though the average disturbance size was small (41 acres).

Sites in this sample unit had high or improving compliance to guideline recommendations in several categories including: filter strip implementation (89%), locating landings outside of wetlands and filter strips (80%), and leave tree retention (82%). Opportunities for improvement include: avoidance of wetland crossings (44%), RMZ management (76%), and infrastructure management (78%).

Upper St. Croix, Kettle and Snake River Watersheds (SCKS):

This sample unit has the second highest percent of forested lands (59%) for watersheds monitored in this cycle. This unit has a relatively low total stream length (2692 miles) and low percent lakes (2%). Forest disturbance in SCKS was below the mean for number of disturbances but highest for average disturbance size (~77 acres) resulting in ~0.8% of forest cover disturbance in the 1 year target window.

Sites in SCKS had high compliance to guideline recommendations for filter strip implementation (90%), and RMZ management (81%). There are several opportunities for improvement including avoidance of wetland crossings (74%), infrastructure management (70%), locating landings outside of wetlands and filter strips (66%), and leave tree retention (69%).

St. Louis, Cloquet, and Nemadji River Watersheds (SCN):

Located in the heart of the iron range and extending south of Duluth, this sample unit is comprised of a variety of geomorphic features including lake plain, dissected lake plain (Nemadji) and rolling till plains and moraines. This unit has the highest percent of forest cover (72%) and the lowest percent crop/pasture at 4%. This unit had a relatively high number of disturbance sites as well as high mean disturbance area resulting in a 0.5% forest cover disturbance.

Sites in SCN had high or excellent compliance to guideline recommendations in several categories including: filter strip implementation (99%), RMZ management (87%), avoidance of wetland crossings (100%), infrastructure management (80%), locating landings outside of

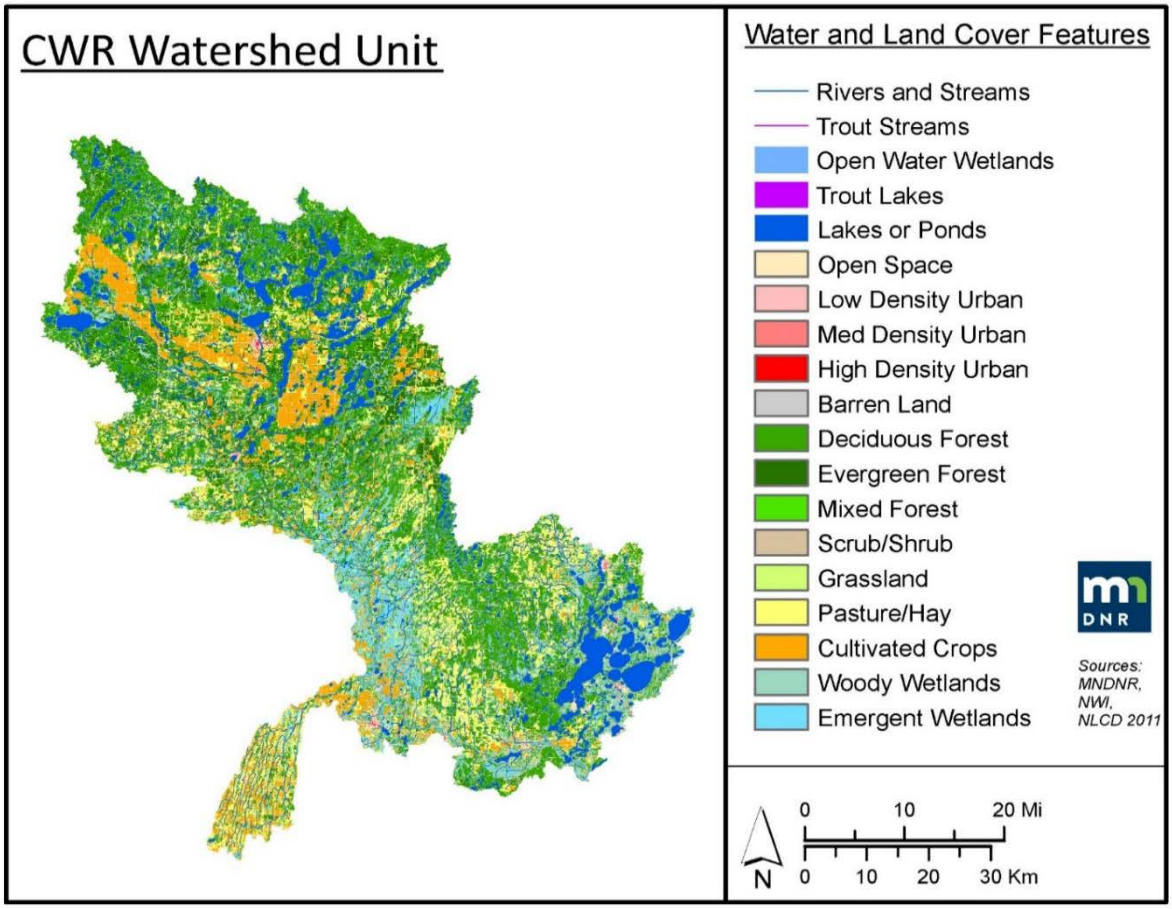
wetlands and filter strips (93%), and leave tree retention (85%). For several of these categories SCN had highest compliance rate of any sample unit.

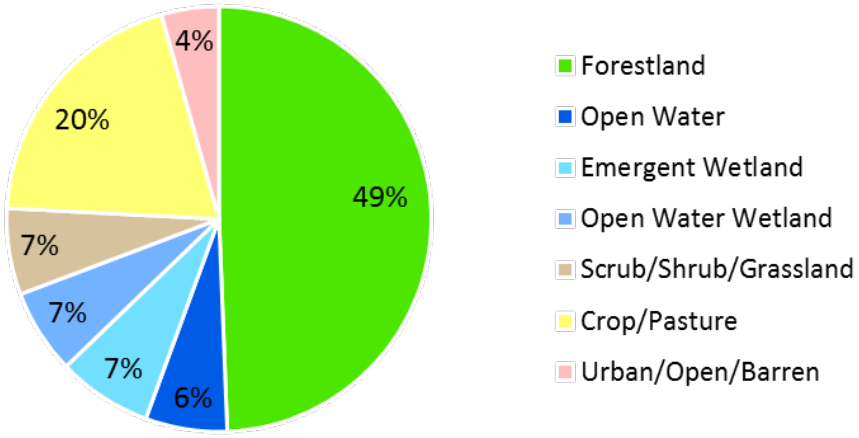
Root River, Zumbro River, and Mississippi River at Lake Pepin, Reno, Winona, and La Cresent (SE MN):

These watersheds encompass the forested area of SE Minnesota known for its scenic bluffs and steep river valleys containing a mixture of hardwood forests and agriculture. The SE MN unit has one of the lowest percent cover of lakes and ponds (2%), but has the longest total length of rivers and streams (9874 miles) and the highest proportion of trout streams (28%). The SE MN watershed unit had the lowest number of disturbance sites and the lowest percent of forest cover disturbed (2%), which is not surprising given the characteristics of the unit.

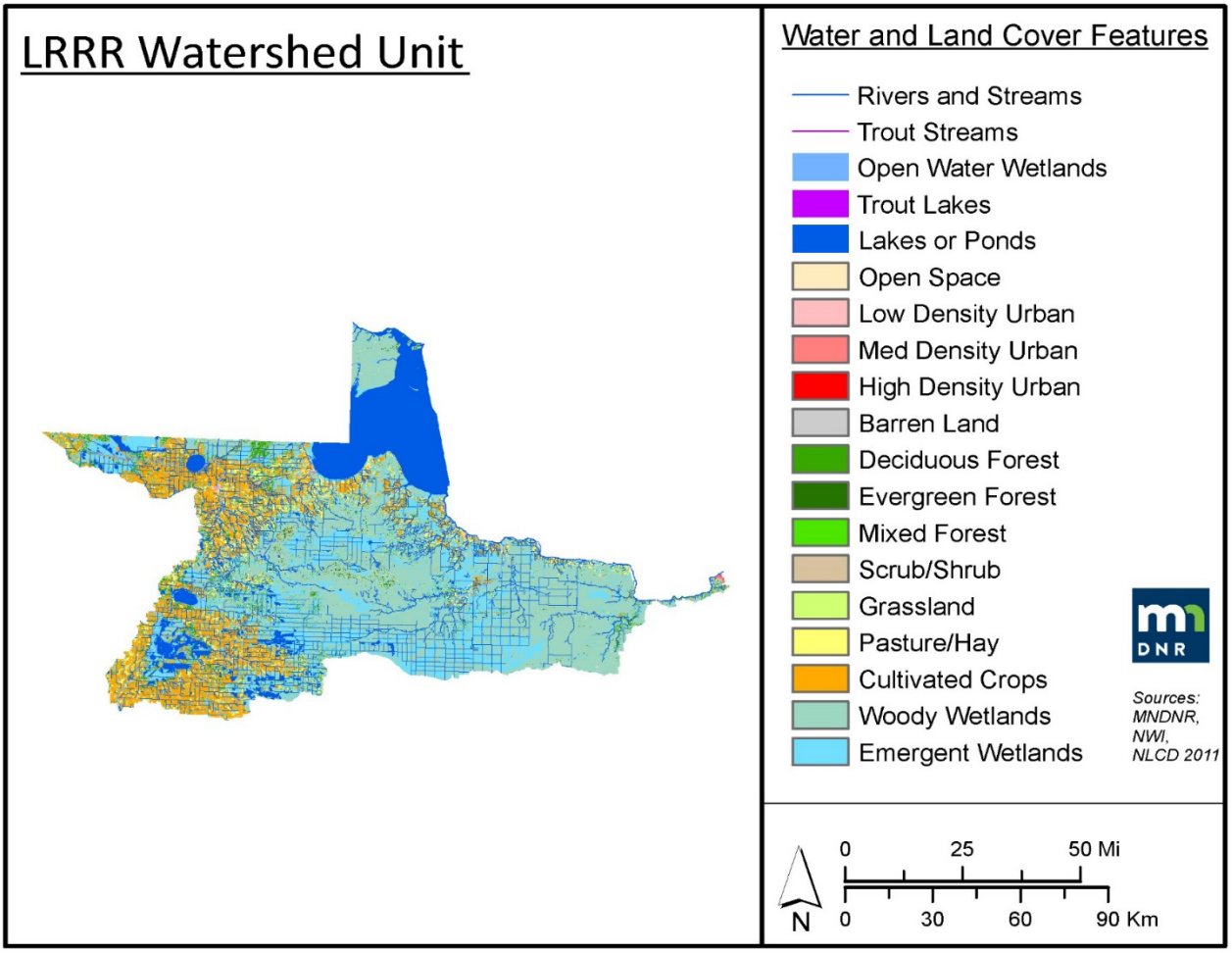
Sites in SE MN had high or improving compliance to guideline recommendations in several categories including: filter strip implementation (87%), avoidance of wetland crossings (75%), infrastructure management (92%), locating landings outside of wetlands and filter strips (91%), and leave tree retention (100%). Opportunities for improvement include RMZ management (67%) where two of three RMZs met recommendations.

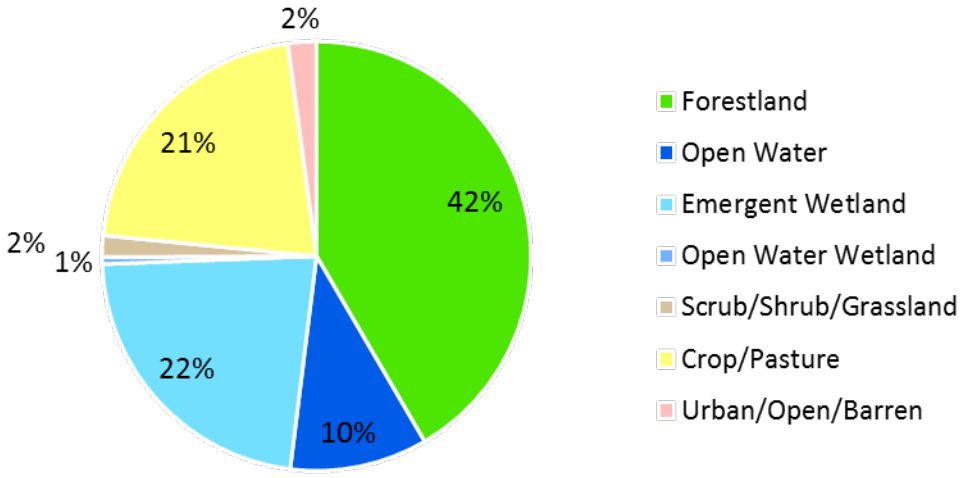
Appendix



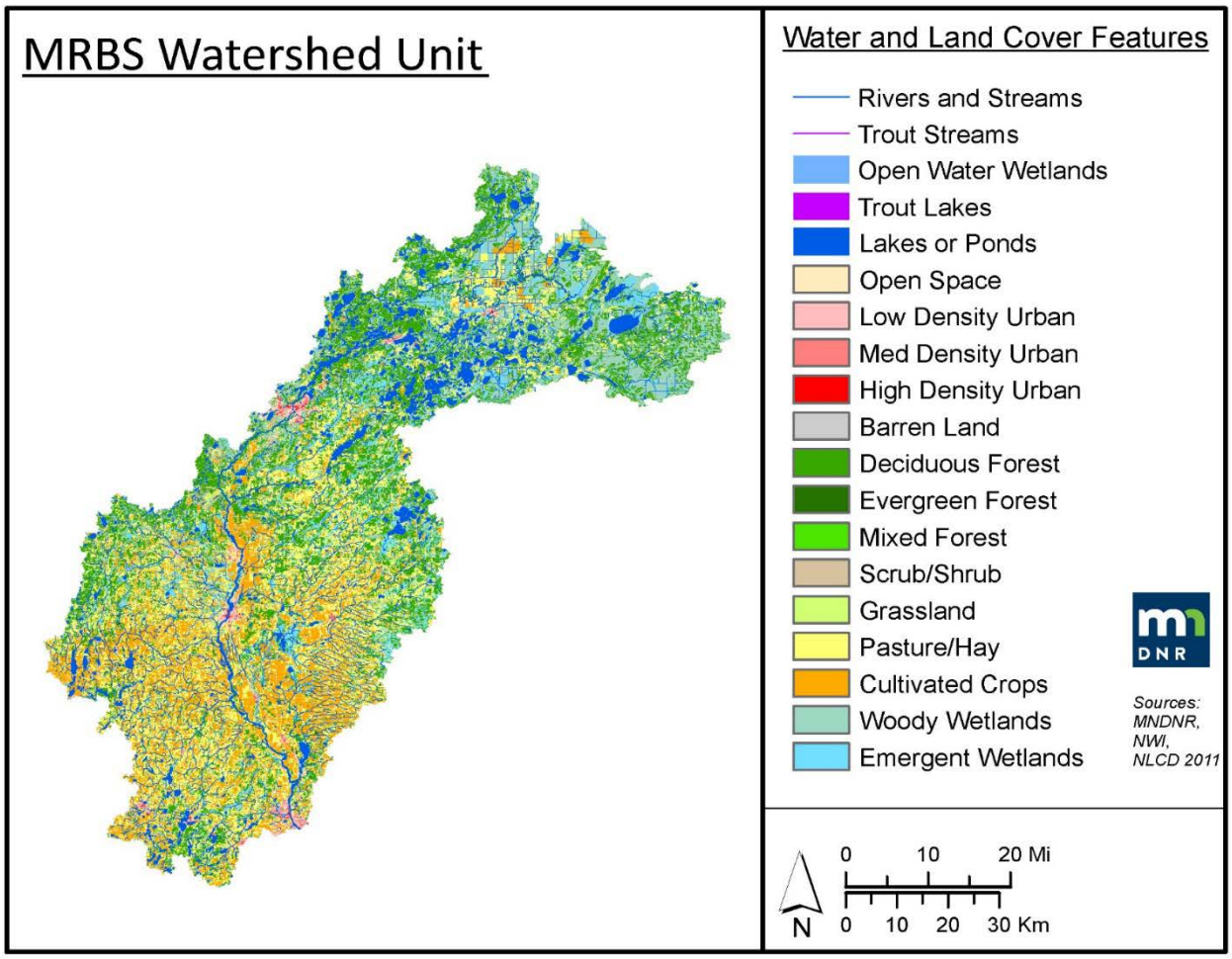


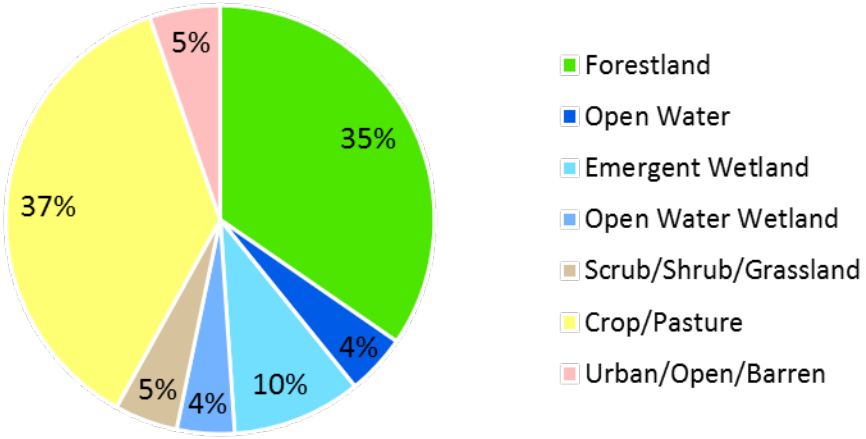
Total Area of Unit (acres)	1,268,959
Slope (%; Mean, Standard Deviation)	4.9, 6.3
Rivers & Streams (length, mi)	1,886
Trout Lakes & Ponds (%)	7.4
Trout Rivers & Streams (%)	1.9
DOT/State Forest Roads (length, mi)	9,436
Forest Access Routes (length, mi)	1,136



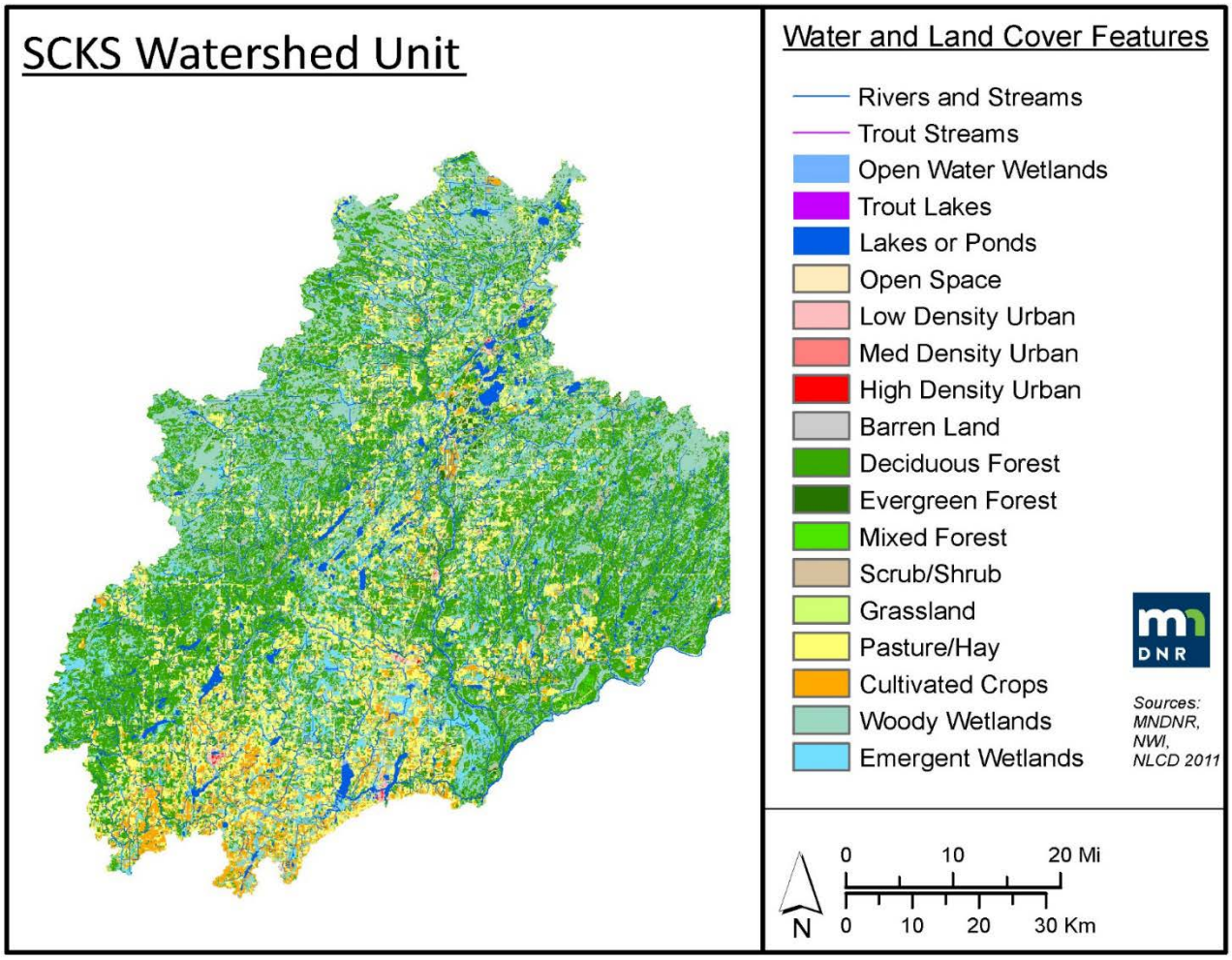


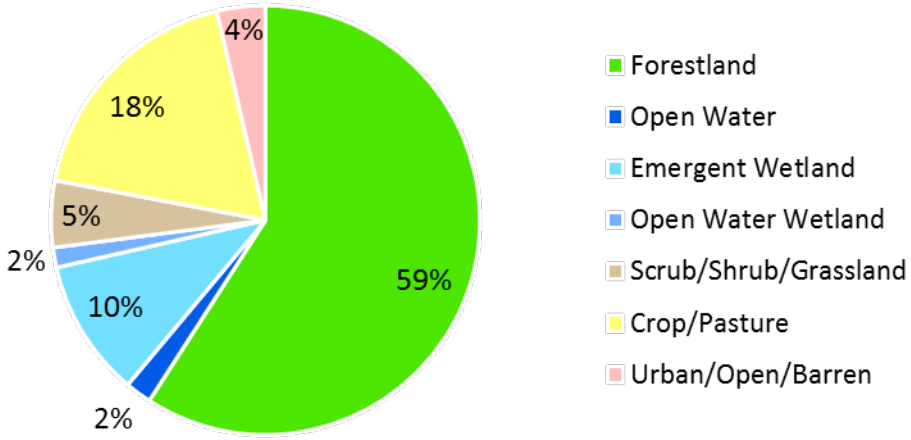
Total Area of Unit (acres)	3,217,211
Slope (%; Mean, Standard Deviation)	1.4, 2.3
Rivers & Streams (length, mi)	5,754
Trout Lakes & Ponds (%)	0.3
Trout Rivers & Streams (%)	0.3
DOT/State Forest Roads (length, mi)	12,045
Forest Access Routes (length, mi)	1,692



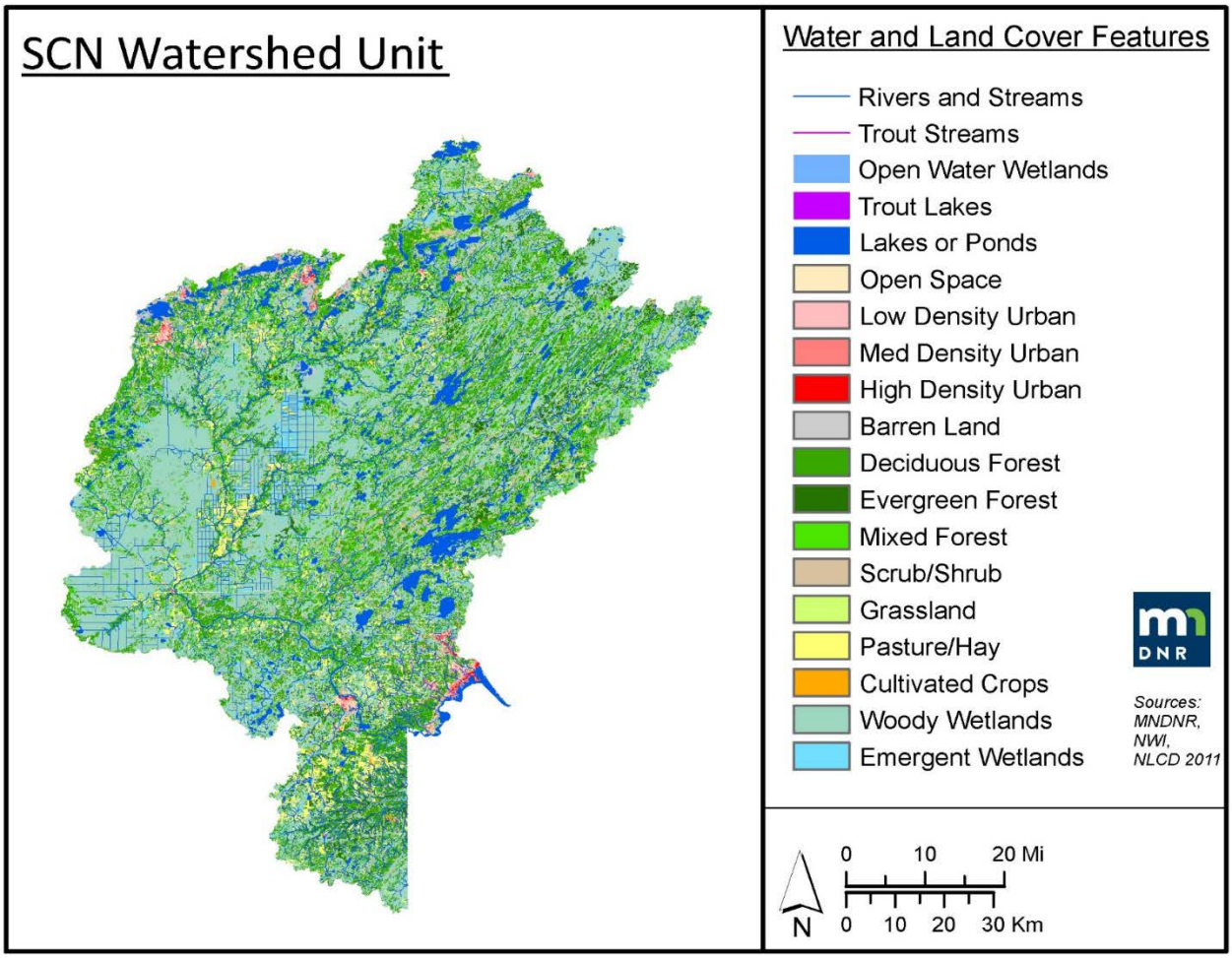


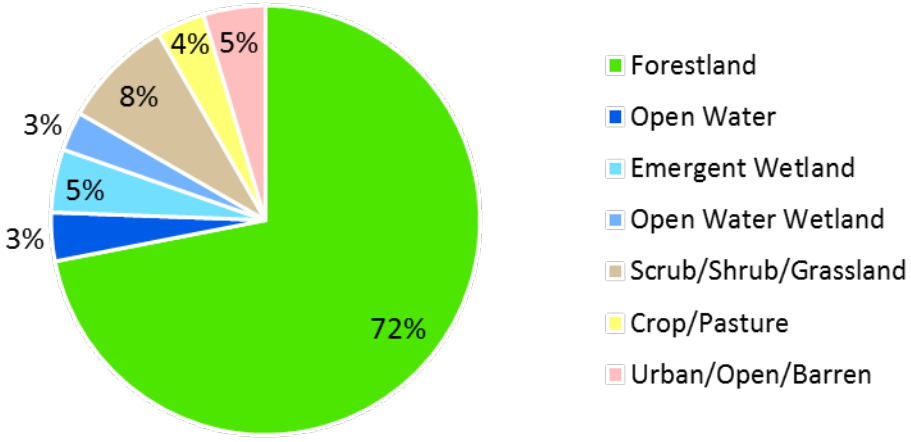
Total Area of Unit (acres)	1,732,415
Slope (%; Mean, Standard Deviation)	4.2, 5.5
Rivers & Streams (length, mi)	3,200
Trout Lakes & Ponds (%)	8.1
Trout Rivers & Streams (%)	1.1
DOT/State Forest Roads (length, mi)	14,059
Forest Access Routes (length, mi)	317



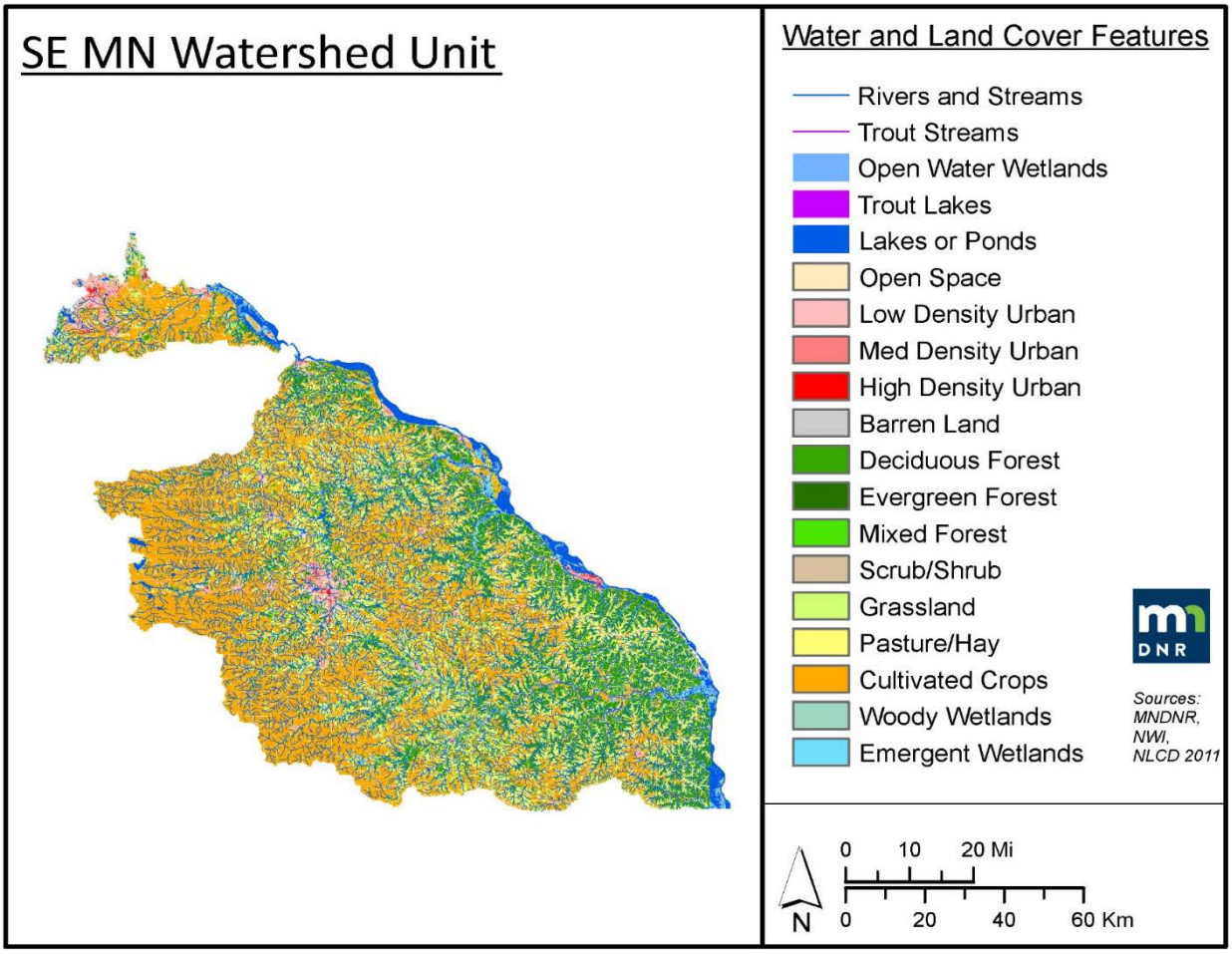


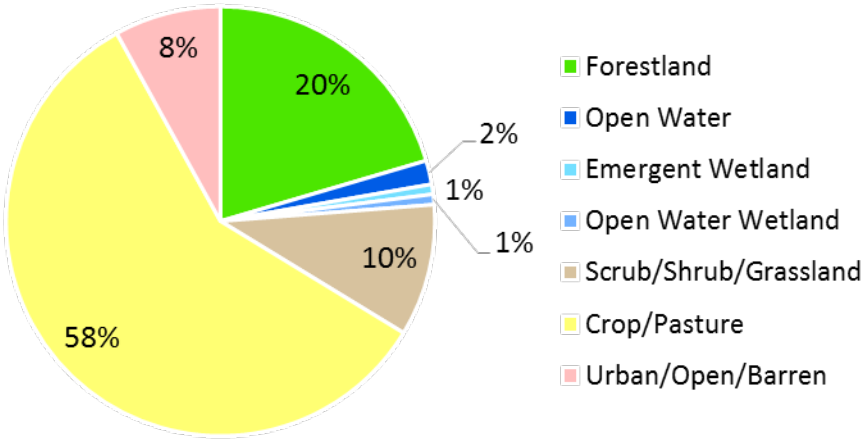
Total Area of Unit (acres)	1,664,192
Slope (%; Mean, Standard Deviation)	3.7, 4.5
Rivers & Streams (length, mi)	2,692
Trout Lakes & Ponds (%)	3.4
Trout Rivers & Streams (%)	1.8
DOT/State Forest Roads (length, mi)	10,032
Forest Access Routes (length, mi)	913



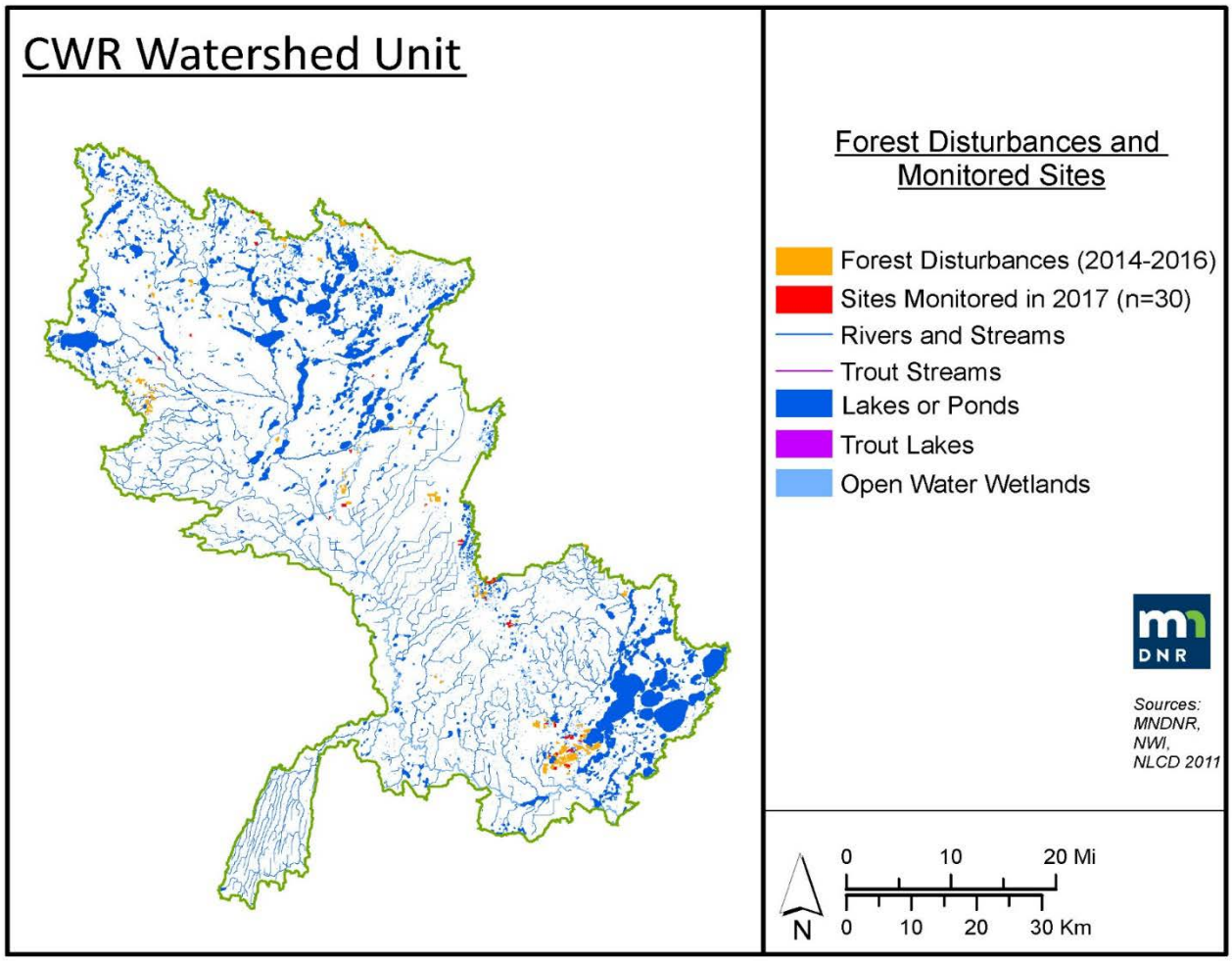


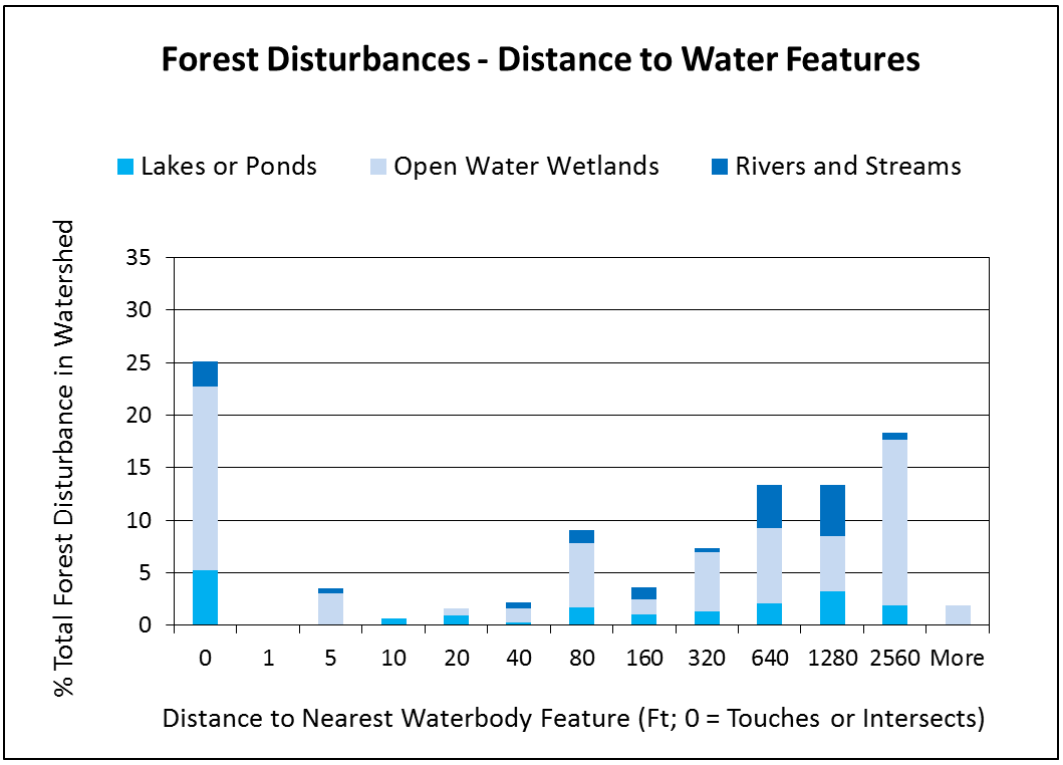
Total Area of Unit (acres)	2,515,881
Slope (%; Mean, Standard Deviation)	4.5, 7
Rivers & Streams (length, mi)	4,419
Trout Lakes & Ponds (%)	5.7
Trout Rivers & Streams (%)	15.0
DOT/State Forest Roads (length, mi)	13,274
Forest Access Routes (length, mi)	1,832

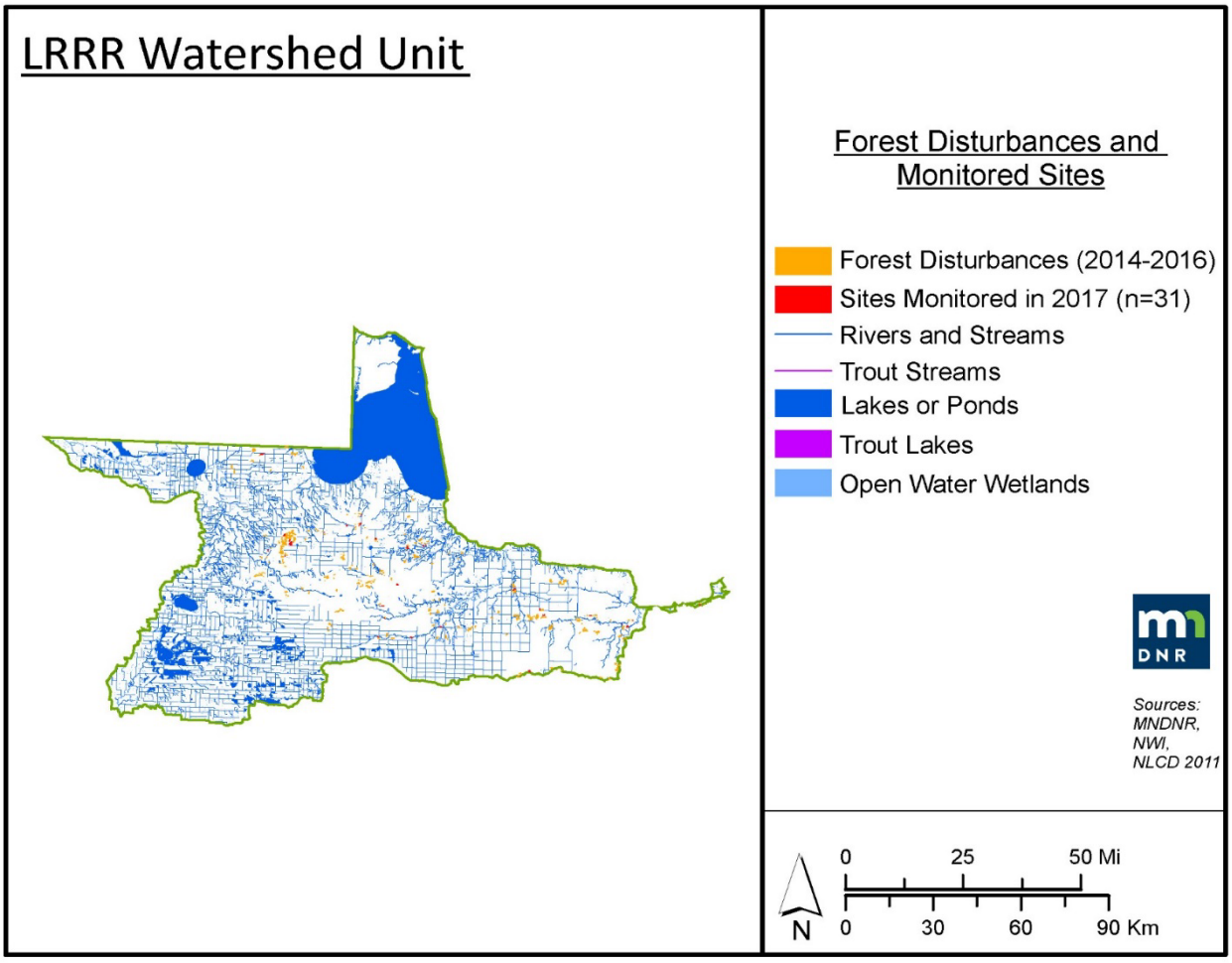


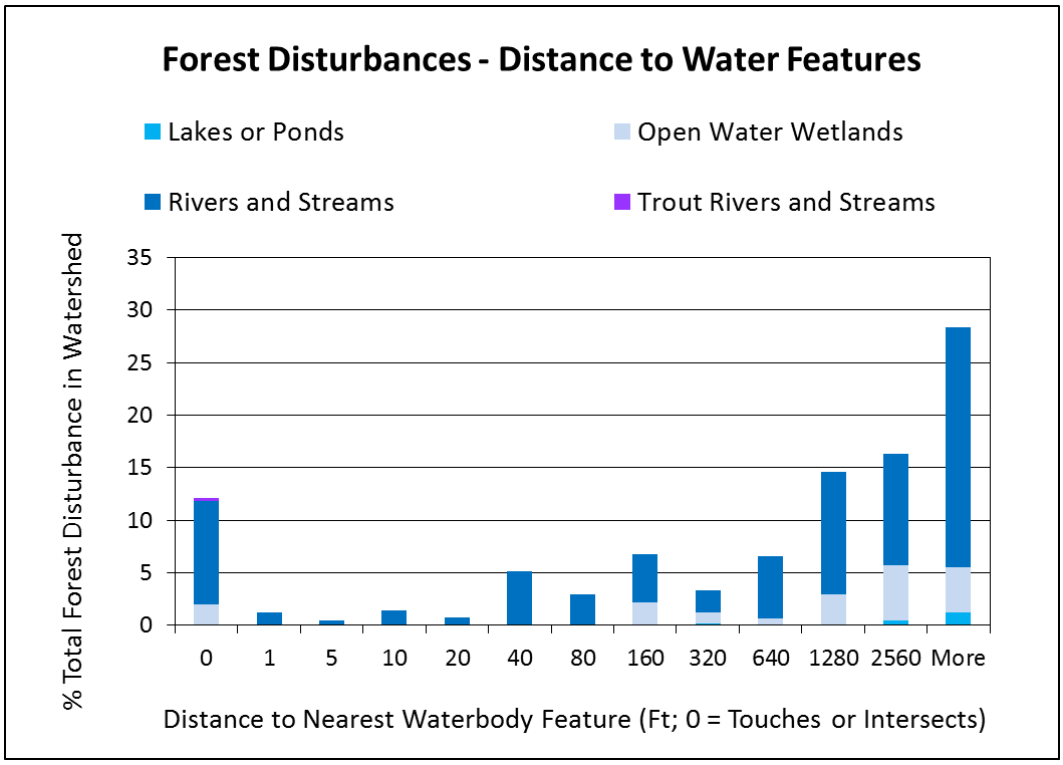


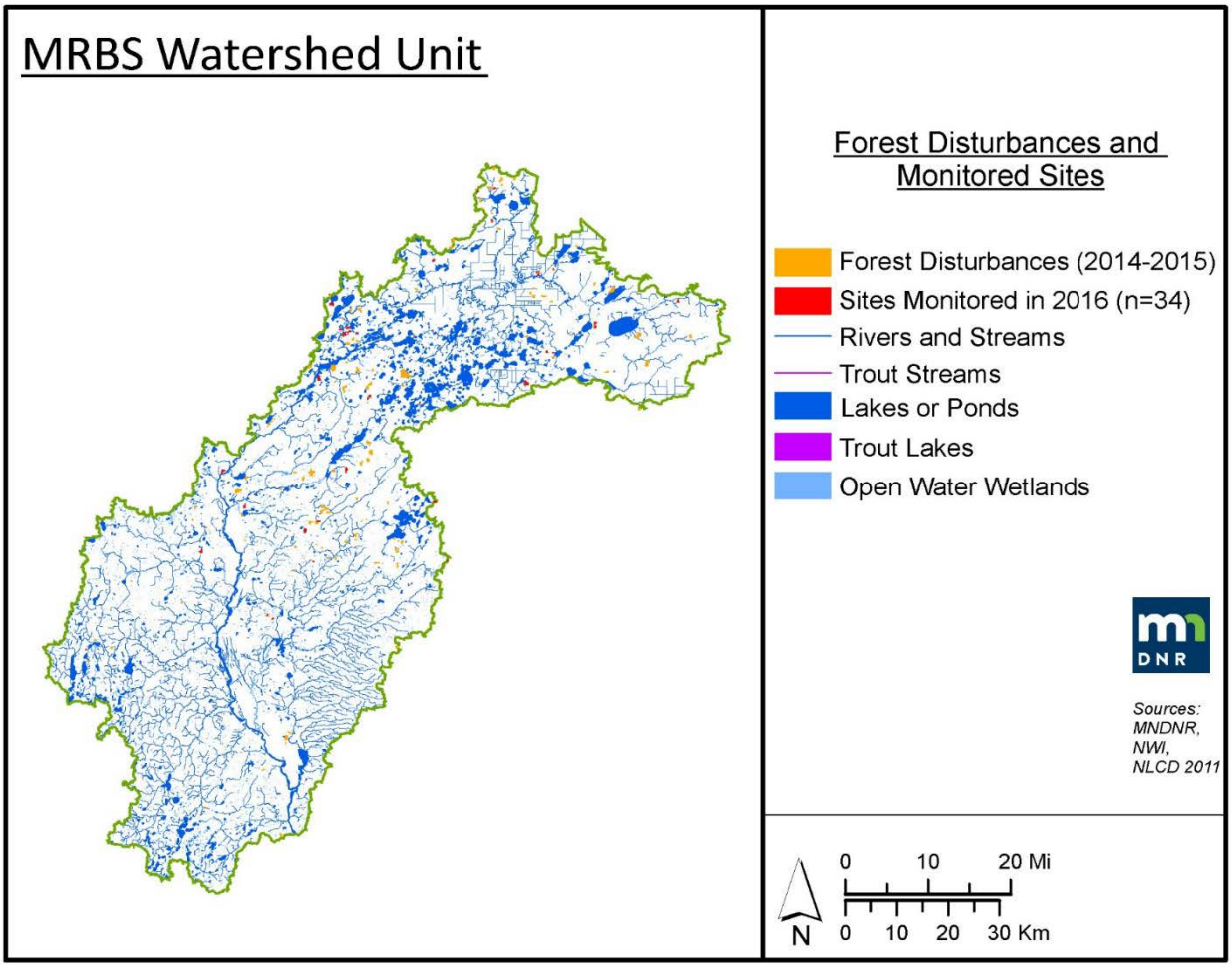
Total Area of Unit (acres)	2,950,852
Slope (%; Mean, Standard Deviation)	10.4, 12.7
Rivers & Streams (length, mi)	9,874
Trout Lakes & Ponds (%)	0.1
Trout Rivers & Streams (%)	28.4
DOT/State Forest Roads (length, mi)	30,861
Forest Access Routes (length, mi)	284

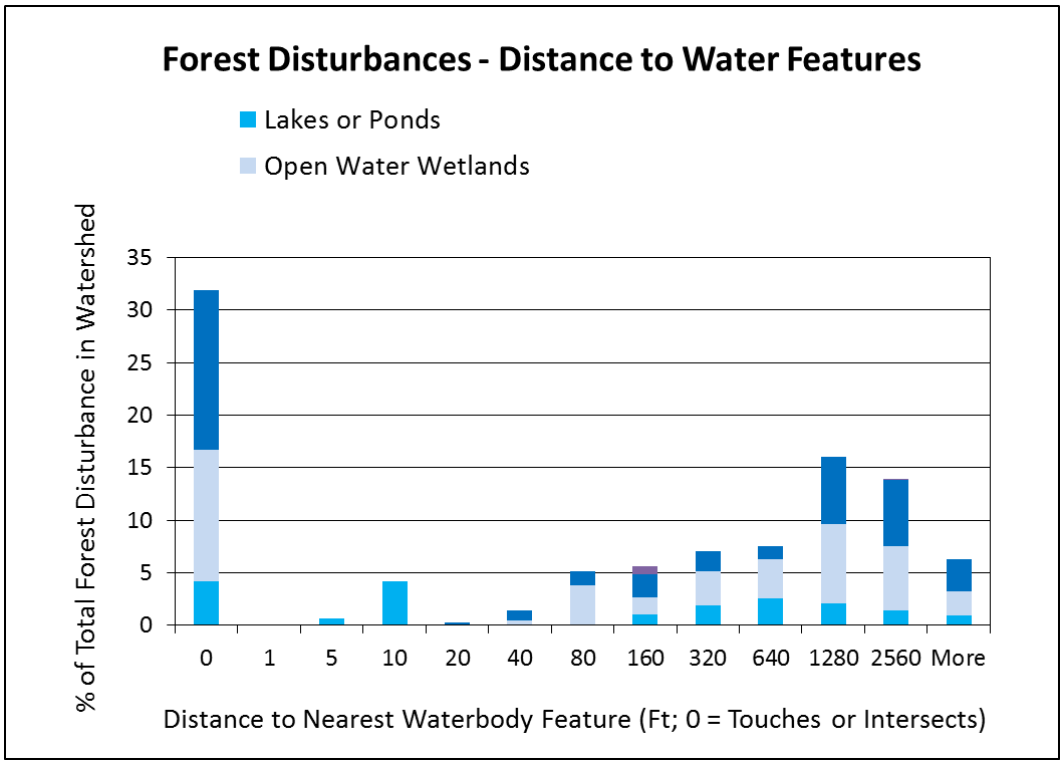

CWR Watershed Unit
Forest Disturbances and Monitored Sites
Forest Disturbances (2014-2016)
Sites Monitored in 2017 (n=30)
Rivers and Streams
Trout Streams
Lakes or Ponds
Trout Lakes
Open Water Wetlands
DNR
Sources: MNDNR, NWI, NLCD 2011
N
0 10 20 Mi
0 10 20 30 Km

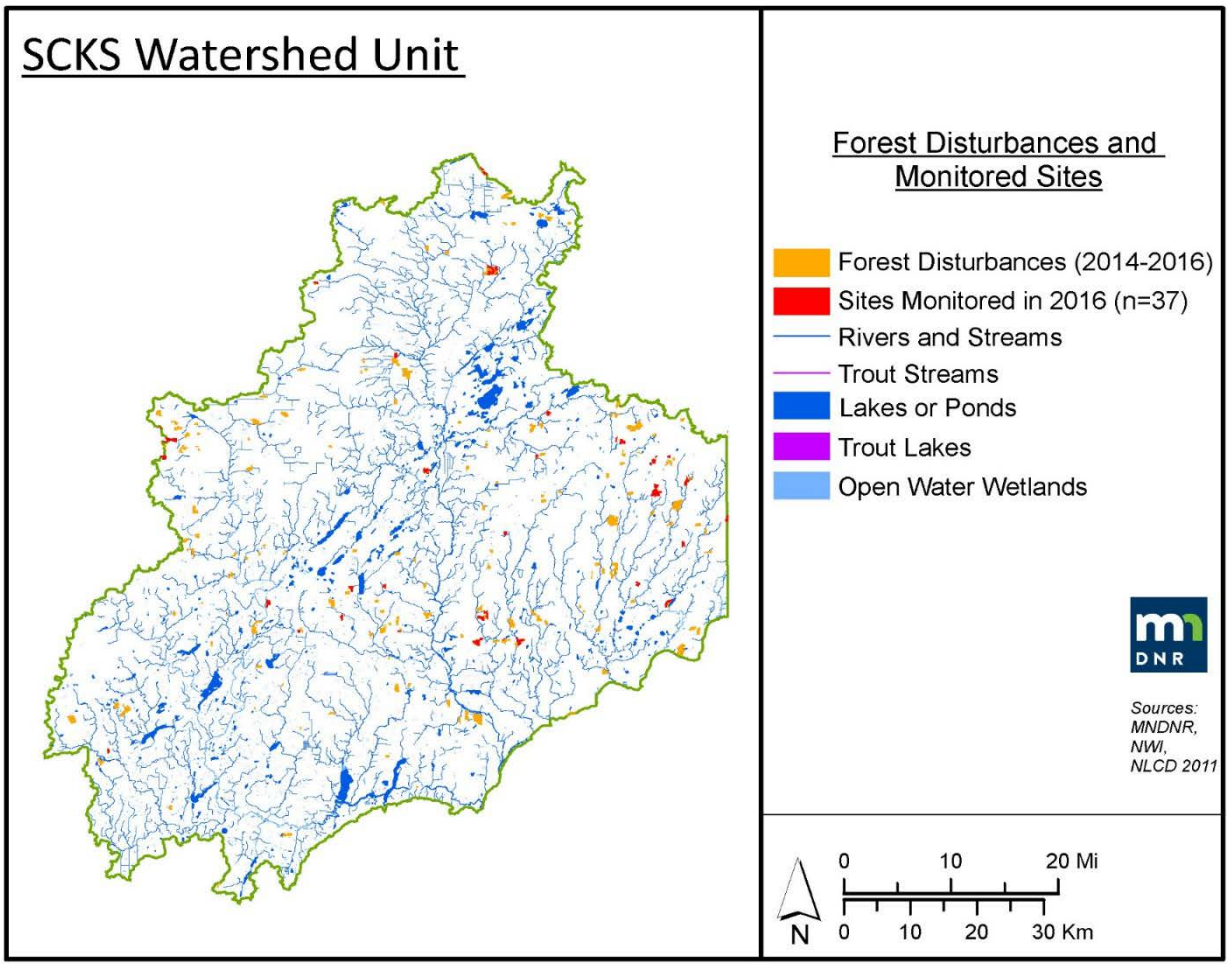

Forest Disturbances - Distance to Water Features
Lakes or Ponds
Open Water Wetlands
Rivers and Streams
% Total Forest Disturbance in Watershed
35
30
25
20
15
10
5
0
0 1 5 10 20 40 80 160 320 640 1280 2560 More
Distance to Nearest Waterbody Feature (Ft; 0 = Touches or Intersects)

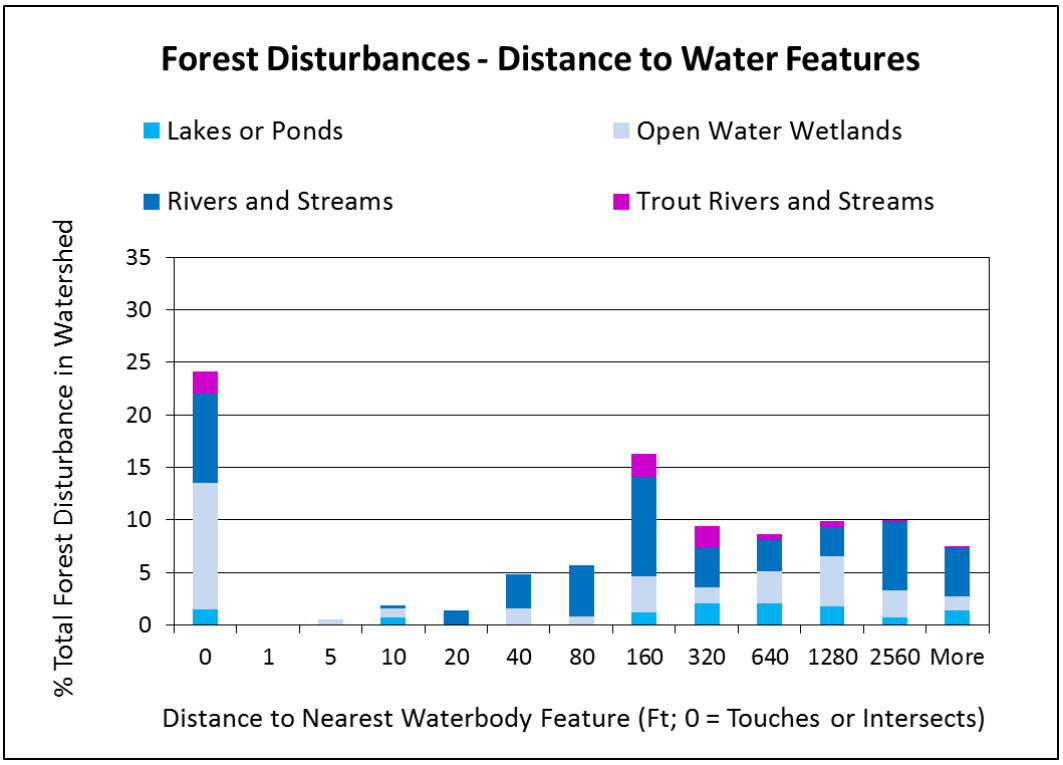

LRRR Watershed Unit
Forest Disturbances and Monitored Sites
Forest Disturbances (2014-2016)
Sites Monitored in 2017 (n=31)
Rivers and Streams
Trout Streams
Lakes or Ponds
Trout Lakes
Open Water Wetlands
DNR
Sources: MNDNR, NWI, NLCD 2011
N
0 25 50 Mi
0 30 60 90 Km

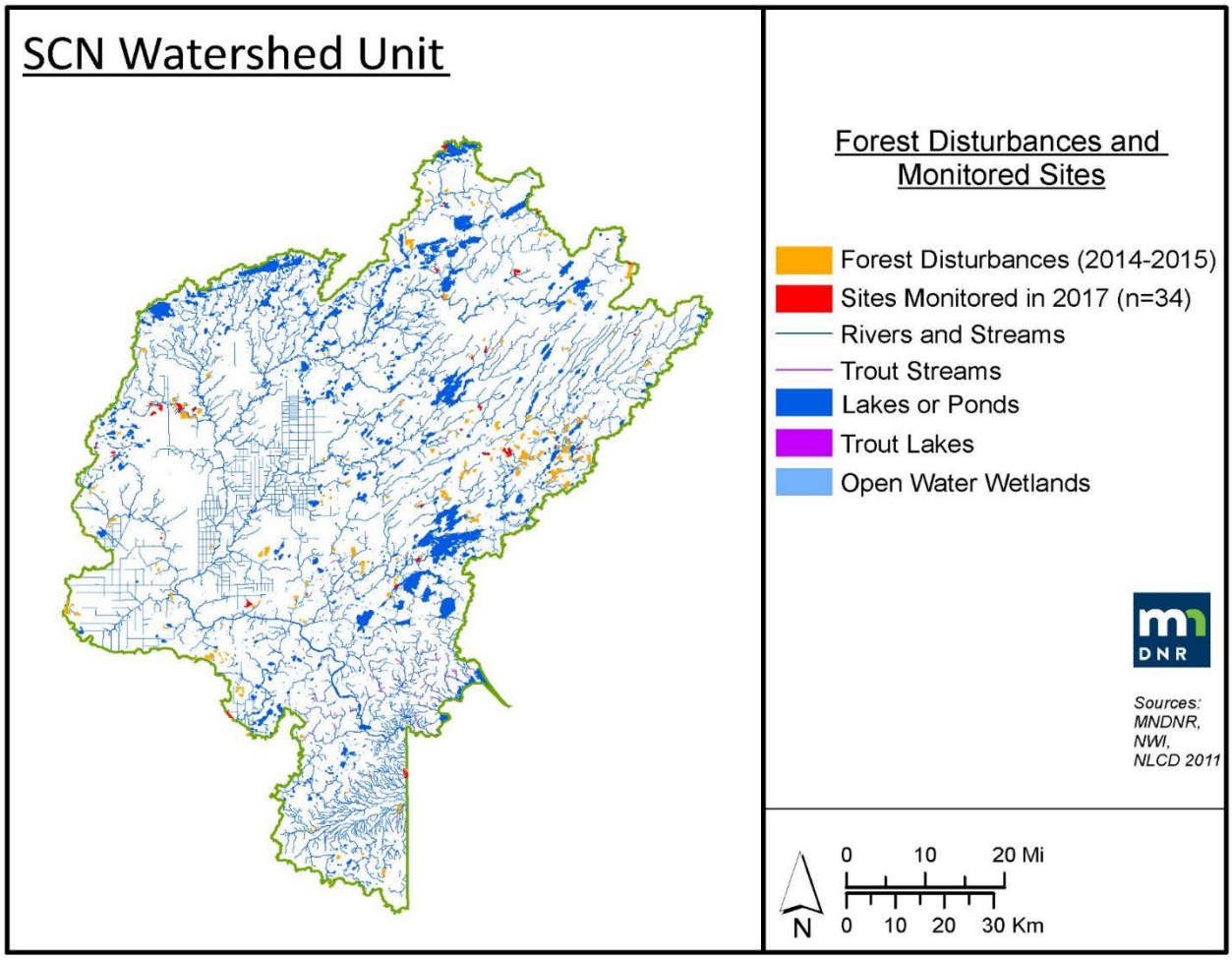

Forest Disturbances - Distance to Water Features
Lakes or Ponds
Open Water Wetlands
Rivers and Streams
Trout Rivers and Streams
% Total Forest Disturbance in Watershed
35
30
25
20
15
10
5
0
0 1 5 10 20 40 80 160 320 640 1280 2560 More
Distance to Nearest Waterbody Feature (Ft; 0 = Touches or Intersects)

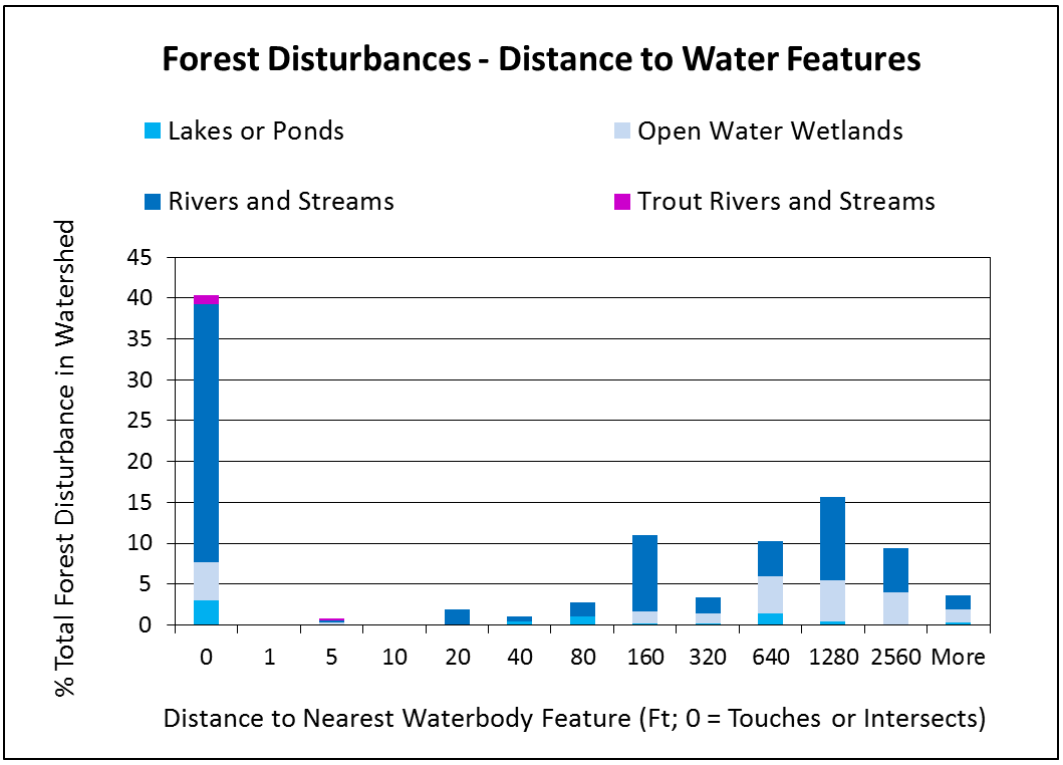

MRBS Watershed Unit
Forest Disturbances and Monitored Sites
Forest Disturbances (2014-2015)
Sites Monitored in 2016 (n=34)
Rivers and Streams
Trout Streams
Lakes or Ponds
Trout Lakes
Open Water Wetlands
DNR
Sources: MNDNR, NWI, NLCD 2011
N
0 10 20 Mi
0 10 20 30 Km

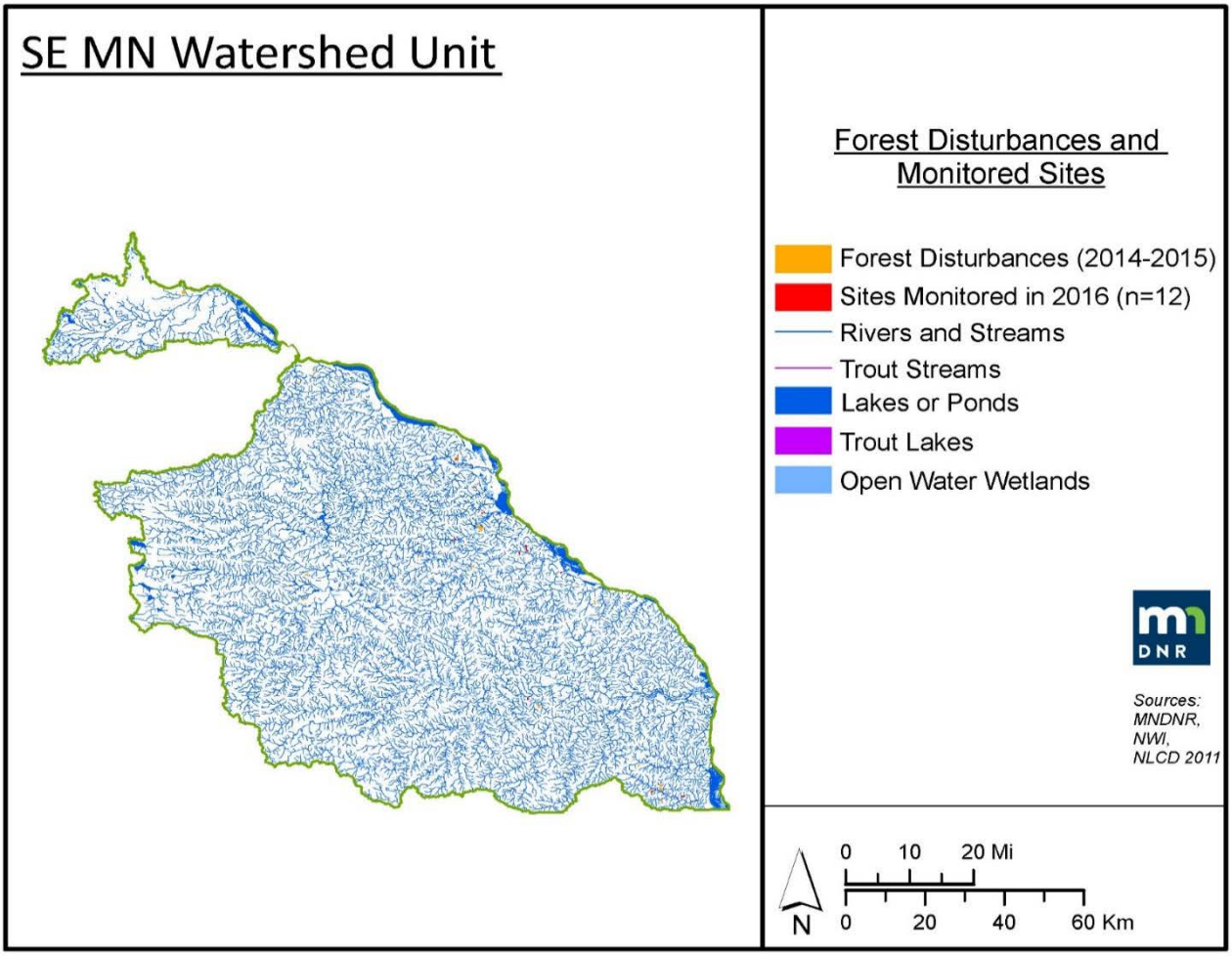

Forest Disturbances - Distance to Water Features
Lakes or Ponds
Open Water Wetlands
% of Total Forest Disturbance in Watershed
35
30
25
20
15
10
5
0
0 1 5 10 20 40 80 160 320 640 1280 2560 More
Distance to Nearest Waterbody Feature (Ft; 0 = Touches or Intersects)

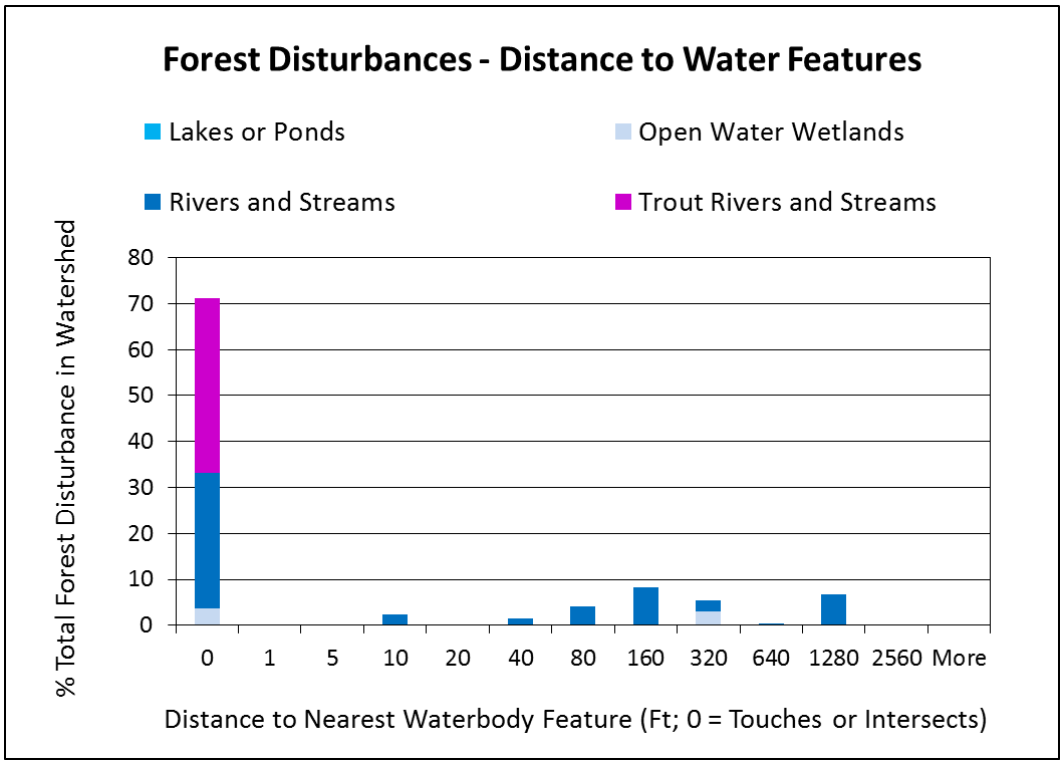

SCKS Watershed Unit
Forest Disturbances and Monitored Sites
Forest Disturbances (2014-2016)
Sites Monitored in 2016 (n=37)
Rivers and Streams
Trout Streams
Lakes or Ponds
Trout Lakes
Open Water Wetlands
DNR
Sources: MNDNR, NWI, NLCD 2011
N
0 10 20 Mi
0 10 20 30 Km


Forest Disturbances - Distance to Water Features
Lakes or Ponds
Open Water Wetlands
Rivers and Streams
Trout Rivers and Streams
% Total Forest Disturbance in Watershed
35
30
25
20
15
10
5
0
0 1 5 10 20 40 80 160 320 640 1280 2560 More
Distance to Nearest Waterbody Feature (Ft; 0 = Touches or Intersects)


SCN Watershed Unit
Forest Disturbances and Monitored Sites
Forest Disturbances (2014-2015)
Sites Monitored in 2017 (n=34)
Rivers and Streams
Trout Streams
Lakes or Ponds
Trout Lakes
Open Water Wetlands
DNR
Sources: MNDNR, NWI, NLCD 2011
N
0 10 20 Mi
0 10 20 30 Km


Forest Disturbances - Distance to Water Features
Lakes or Ponds
Open Water Wetlands
Rivers and Streams
Trout Rivers and Streams
% Total Forest Disturbance in Watershed
45
40
35
30
25
20
15
10
5
0
0 1 5 10 20 40 80 160 320 640 1280 2560 More
Distance to Nearest Waterbody Feature (Ft; 0 = Touches or Intersects)


SE MN Watershed Unit
Forest Disturbances and Monitored Sites
Forest Disturbances (2014-2015)
Sites Monitored in 2016 (n=12)
Rivers and Streams
Trout Streams
Lakes or Ponds
Trout Lakes
Open Water Wetlands
DNR
Sources: MNDNR, NWI, NLCD 2011
N
0 10 20 Mi
0 20 40 60 Km


Forest Disturbances - Distance to Water Features
Lakes or Ponds
Open Water Wetlands
Rivers and Streams
Trout Rivers and Streams
% Total Forest Disturbance in Watershed
80
70
60
50
40
30
20
10
0
0 1 5 10 20 40 80 160 320 640 1280 2560 More
Distance to Nearest Waterbody Feature (Ft; 0 = Touches or Intersects)

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