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

2018 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

CLEAN WATER LAND & LEGACY AMENDMENT

DEPARTMENT OF NATURAL RESOURCES

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 2018

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February 2020

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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 almost 1,400 timber harvest sites across public and private forest lands since 2000. This report provides results for monitoring that occurred in summer and fall of 2018 and attempts to assess trends in implementation levels over time.

For this reporting period, implementation of site-level guidelines were assessed on 83 sites randomly selected from within three watershed sample units covering eight 8-digit hydrologic unit code (HUC-8) watersheds in the forested portions of Minnesota. Monitored sites had timber harvested at some point in time from late summer of 2016 through summer of 2017. 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 11% by area of detected forest harvest in the watersheds sampled (Table 2).

Overall implementation of key guidelines are similar to the 2016-17 report and show improvement in many areas compared to the last statewide report in 2011. Several key guidelines show fairly high implementation rates when assessed at the statewide scale. These guidelines include riparian management zone (RMZ) implementation, retaining leave trees and snags for wildlife, limiting disturbance in filter strips, minimizing total infrastructure, and occurrence of sites with rutting (primarily on wetland crossings). Guidelines showing improved implementation include mitigating impacts to cultural resources, retaining coarse woody debris, and diversity of leave tree species. Substantial improvement was also documented in the number of sites utilizing the 2012 guideline version which was an item of concern identified in past reports. Guidelines that had relatively low implementation or no improvement over time 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 relatively low. These guidelines have consistently had low levels of implementation with little improvement, and implementation levels should be assessed by the MFRC to determine if they are sufficient to mitigate impacts to forest resources.

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 specific guidelines and audiences where the greatest opportunities for

innovation and improved implementation exist. For example, watersheds with lower filter strip or riparian management zone implementation can be identified, and outreach tailored to local needs. Similarly, watersheds with more challenging hydro-geologic conditions may need specific outreach focused on guidelines for placement of landings and avoidance of unnecessary wetland crossings.

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 RLB watershed sample unit where RMZ compliance was lowest at 50%
- Targeting outreach on avoiding unnecessary wetland crossings in LLP where large numbers of crossing occur (33) and 42% of crossings were viewed as avoidable
- Outreach on a variety of guidelines may improve implementation in LLP and RLB sample units including focus on: infrastructure management, leave tree retention (RLB), managing organic debris on landings, 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, the Sustainable Forestry Education Cooperative, Minnesota Association of County Land Commissioners, MN DNR Private Forest Management, and Minnesota Forest Industries are encouraged to continue their efforts related to these recommendations, and work to develop new educational opportunities to address the specific topics identified above.

Additional implementation monitoring detail can be found via an online interactive reporting tool under development since 2018. This tool provides access to monitoring results recorded since 2009, and incorporates summaries across multiple themes, including watershed sample units, counties, land ownership, and MFRC landscape regions. The beta version of this reporting tool is accessible via: https://forestry.shinyapps.io/gma_minnesota/. Efforts are currently underway to develop needed agency support for an outward facing server capable of running the interactive R Shiny environment needed for this application. Although Resource Assessment is currently seeking similar public facing server capacity to meet its business needs, additional support from the Division of Forestry could help to encourage Minnesota Information Technology Services (MNIT) to provide the needed permissions and administrative information technology assistance.

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List of Acronyms

BMP: Best Management Practice

DOF: MN DNR Division of Forestry

CWD: Coarse Woody Debris

EC: Erosion Control

ETS: Endangered, Threatened, and Special Concern species

FIA: Forest Inventory and Analysis Unit; USDA – Forest Service

FWD: Fine Woody Debris

GIS: Geographic Information System

GMA: Guideline Monitoring Application (A GIS program for data entry)

GMP: Guideline Monitoring Program

HUC-8: 8 digit hydrologic unit code; major watersheds

LLP: Leech Lake - Pine River WSU

LTC: Leave Tree Clump

MFRC: Minnesota Forest Resources Council

MN DNR: Minnesota Department of Natural Resources

MPCA: Minnesota Pollution Control Agency

NASF: National Association of State Foresters

NHD: National Hydrography Dataset

NHIS: Natural Heritage Information System

NIPF: Non-industrial Private Forest

NLCD: National Land Cover Dataset

NOWW: Non Open Water Wetland; a frequently saturated area, either vegetated, or mineral soil

NWI: National Wetlands Inventory

OWW: Open Water Wetland; Lake, River, Stream, or Pond

RA: Resource Assessment, a unit of DOF providing natural resource assessment services

RLB: Rainy River, Little Fork, and Big Fork WSU

RMZ: Riparian Management Zone

ROL: Red Eye, Otter Tail, and Long Prairie WSU

SFRA: Sustainable Forest Resources Act of 1995

TH/FM: Timber Harvest / Forest Management

USDA: United States Department of Agriculture

WCA: MN Wetlands Conservation Act

WRAPS: Watershed Restoration and Protection Strategy

WSU: Watershed Sample Unit; one or more HUC-8s

WQ: Water Quality

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 MFRC 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 DNR's Guideline Monitoring Program (GMP) has monitored guideline implementation at over 1,400 harvest sites since 2000 and has published eight reports summarizing the findings through 2017. 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 major hydrologic unit (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 83 harvest sites in eight HUC-8 watersheds that were monitored during 2018, 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 GMP restructured monitoring efforts to focus on the US Geological Survey defined eight digit hydrologic unit code (HUC-8) watershed scale (81 HUC-8s across Minnesota), where attempts are made to select watersheds that are concurrently evaluated in the Minnesota Pollution Control Agency (MPCA) Watershed Restoration and Protection Plan (WRAPS) process (ex., MPCA 2017a-c).

Sites monitored in 2018 were selected from forest cover changes detected (see below) within three watershed sample units, with each unit consisting of either a single watershed or a cluster of watersheds with similar landscape characteristics. The Appendix and Figures 1 and 2 provide a series of in-depth maps and statistics related to each of the three 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.

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

- **LLP:** Leech Lake - Pine
- **RLB:** Rainy River Headwaters, Little Fork, and Big Fork
- **ROL:** Red-eye River, Otter Tail River, and Long Prairie River

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. For monitoring year 2018, DNR Forestry Resource Assessment (RA) staff detected forest cover change within all major watersheds in Minnesota with greater than 20% forest cover, as determined by National Land Cover Data (NLCD 2011), using Landsat 8 satellite images from summer 2016 – summer 2017. For all three watershed sample units monitored in 2018, RA image analysts visually inspected each area of detected forest change to refine the list of sites and modify their site boundaries as needed. All identified areas of canopy change greater than 2.5 acres (1 hectare) in size were considered for monitoring.

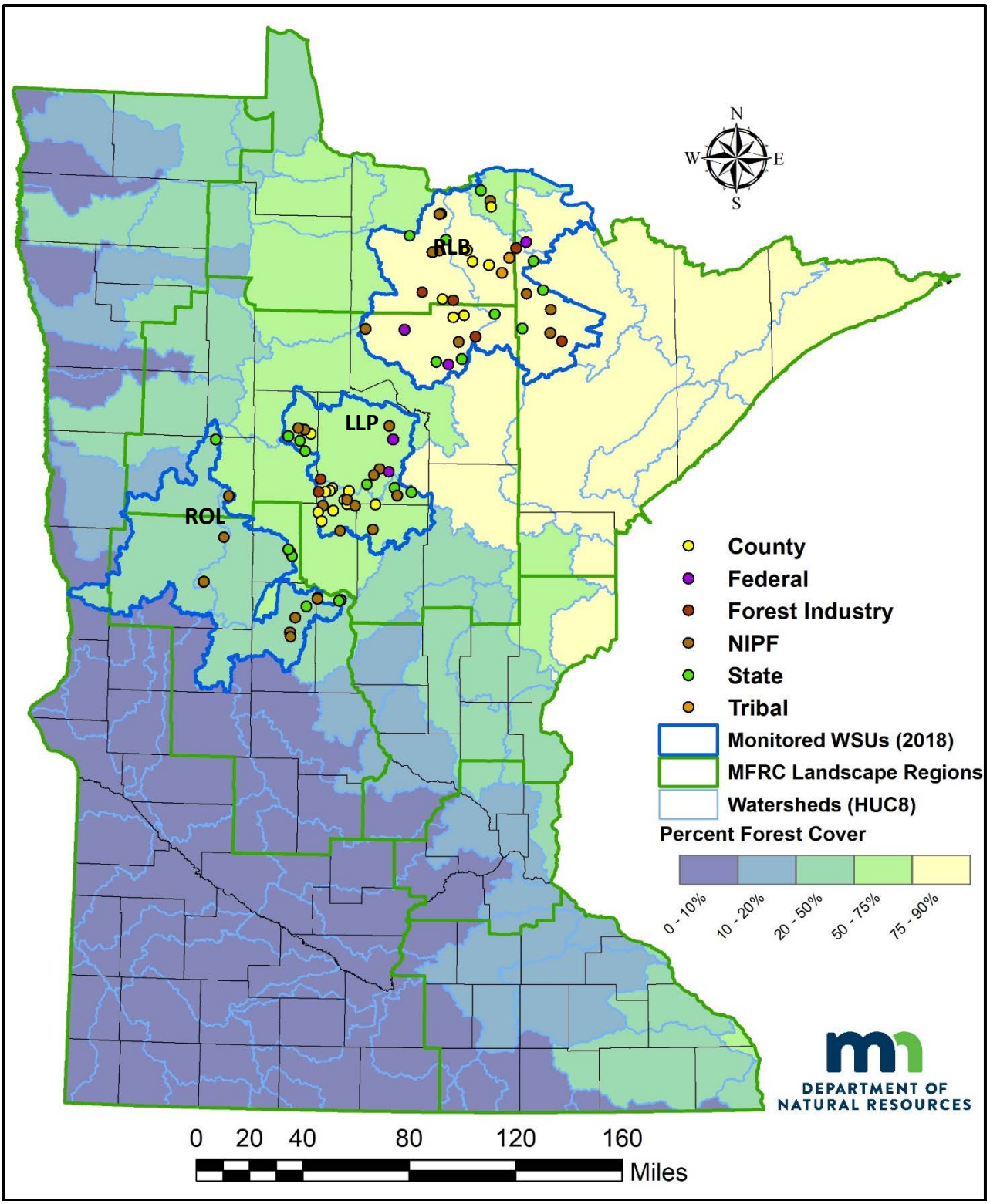


Figure 1. Watersheds and sites where guideline implementation monitoring occurred in 2018. Site locations are displayed by land ownership category. In total, 83 sites were sampled. Percent forest cover by HUC-8 watershed is displayed as blue (less forest cover – in the southwest) to yellow (nearly full forest cover – in the northeast) shading.

Site Selection

A subset of forest cover change sites (confirmed as harvests) were selected for monitoring. Within each WSU, monitoring sites were selected with an 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 ensure selection of sufficient sites (50%) 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 state owned lands;

County: all lands owned or managed by a county;

Federal: all U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, or Army Corps of Engineers lands;

Forest Industry: owned by Blandin Paper, Potlatch, and Molpus Companies;

Nonindustrial Private Forests (NIPF): all privately owned non-industry 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, a cooperative approach was used to contact NIPF landowners and gain permission to access their sites. GMP collaborated with local foresters in the DNR Cooperative Forest Management Program to contact NIPF landowners. The effort yielded substantially higher numbers of cooperating NIPF landowners compared to past monitoring efforts. Because of the success of this approach, the program has achieved a more representative sample of NIPF sites than it has in past years.

Table 1. Watershed units monitored (2018) and number of sites per ownership category.

Watershed Unit	County	Federal	Forest Industry	NIPF & Tribal*	State	Total
LLP	11	2	2	11	6	**32**
RLB	7	3	5	11	10	**36**
ROL	0	0	0	8	7	**15**
Total	**18**	**5**	**7**	**30**	**23**	**83**

*Two tribal sites were monitored in RLB.

Monitoring Data Collection

GMP staff used monitoring protocols similar to those in the previous monitoring report (Rossman et al, 2018) 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. 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 may be more aware of guideline implementation strategies than the landowner.

Field monitoring for 2018 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 required to complete calibration training with GMP staff prior to the start of field monitoring. On-site monitoring was conducted June – September, 2018.

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. During 2018 monitoring (and in previous field seasons) several limitations of the GMA were observed. Issues related to computing speed, menu and data entry form accessibility, and lack of user customizability resulted in extensive contractor feedback, limited in-field use of the application, and even data loss in a few cases.

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 sources. Information gathered in this manner typically has gaps related to guideline implementation because such strategies are rarely identified in supporting timber harvest documentation.

Results

Data 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 & 2018).

Land and Water Characteristics by Watershed

The Appendix contains a wealth of information related to the three WSUs. 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 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 82% in RLB to a low of 26% in ROL. Not surprisingly, ROL had the highest percentage of crop/pasture lands at 32%, compared to 1% or less in LLP and RLB. In terms of water-related features, LLP has the highest percent cover of lakes and ponds (27%) primarily due to surface waters of Leech Lake, followed by ROL (11%) with many smaller lakes and ponds. RLB has lower percent cover of lakes and ponds (3.5%), but has the longest total length of rivers and streams (3,757 miles) and the highest proportion of trout streams. Despite low forest cover and lesser amount of lakes and ponds in ROL, the high number of miles of rivers and streams (3,395 miles) implies that disturbances will likely be relatively close to, or upslope from water features.

Forest Disturbances and Distance to Water Features

Statewide, the average forest canopy disturbance detected between 2013 and 2017 was 83,310 acres per year (roughly 0.45% of the total forested land identified by NLCD). This estimate of disturbance is likely low, given our 2.5 acre minimum mapping unit and comparison with USDA-Forest Inventory and Analysis (FIA) figures related to cutting/harvests on forestlands in Minnesota. FIA data indicate that for the 5-year period ending in 2018, approximately 146,938 acres of clearcut removals occurred annually. Given average annual harvests of 2.95 million cords (MNDNR 2019) reported between 2012 and 2016, this equates to an average yield of approximately 19.5 cords per acre across the state; very close to accepted norms. It is important to note that the NLCD threshold for identifying woodlands (10% canopy) differs from that used by USDA – FIA (25% canopy), resulting in the higher total forested land. (18.5 million acres vs. 17.6 million acres).

Changes detected between summers 2016 and 2017 were used to identify sites sampled in 2018. Disturbance estimates are depicted visually in Figure 2 and as annual averages in Table 2. Of the three WSUs sampled in 2018, RLB (12.5 million acres) had the highest number of disturbed sites (676 annually) and the highest percent of forest cover disturbed (1.1% annually), though the average disturbance size was small (33.9 acres). Such high levels of harvest are consistent with the predominantly aspen forest type present in the RLB unit (36%), and increased harvests of tamarack and black ash related to recent insect outbreaks in the region. The ROL watershed unit (2.36 million acres) had the lowest number of disturbances and the lowest percent of forest cover disturbed (0.15%). The LLP watershed unit (1.36 million acres)

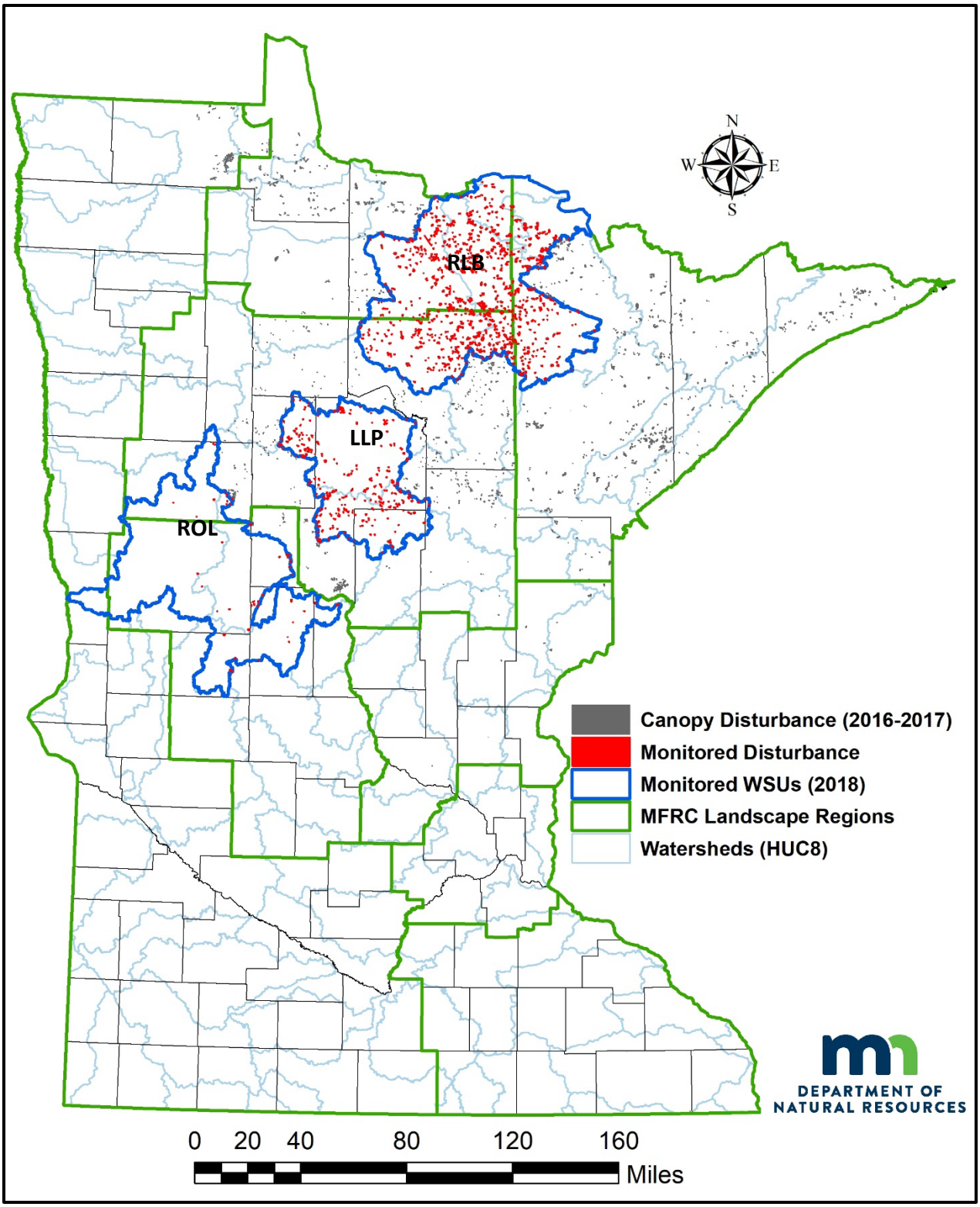


Figure 2. Two-year forest canopy disturbance map. Statewide, canopy disturbance observed between 2016 and 2017 is shown as gray patches. Within watershed sample units monitored in 2018, canopy disturbance is shown as red patches. Note the concentration of canopy disturbance in the RLB unit.

Table 2. Forest cover disturbance statistics by watershed (2016-2017).

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 Disturbance
LLP	160	35.5	45.0	5,674	0.4%	0.63%	20.0%
RLB	676	33.9	41.8	22,920	0.9%	1.10%	5.3%
ROL	24	44.9	51.3	1,079	0.05%	0.15%	63.0%

*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. These figures may differ slightly from 5-year averages presented in the Appendix.

was intermediate at 160 sites totaling 0.63% of existing forest canopy disturbed. Although the target sampling rate was approximately 30 harvest sites per WSU, sampling intensity varied substantially by WSU due to large regional differences in forest cover/land use, proximity to timber markets, and resulting harvest intensity.

Additional analyses have been done to summarize the relative proximity of forest cover disturbances (2.5 acre minimum mapping unit) to a public waters feature (ex., river/stream, lake/pond, open water wetland; source: the national hydrography dataset - NHD, MN DNR hydrography data layer, and the national wetlands inventory - NWI). 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.

For watersheds monitored in 2018, the average distance to any hydrologic feature was between 640 and 1,280 feet. About 8% of all canopy change occurred on or adjacent to a hydrologic feature. 85% of all change detected occurred within 0.5 miles of a water feature, underscoring the importance of forest management to maintaining water quality. 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 40.1 acres, which is lower than the 50.2 acres reported in 2016-17 and higher than the 34 acres reported in 2011. There are clear differences in mean harvest size among the watershed units ranging from 25.1 to 49 acres, similar to previous reports. Although not a

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)
LLP	32	10.2	495.4	49	85.4	1,567
RLB	36	6.4	253.6	38.5	48.5	1,386
ROL	15	7.8	51.1	25.1	13.3	376
Overall	**83**	**6.4**	**495.4**	**40.1**	**62.2**	**3,328**

guideline in itself, site size may influence implementation of other guidelines such as managing site infrastructure and acreage of leave tree clumps.

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 (191 of 321), while the majority of open water wetlands (OWW – 24 of 29) and perennial streams (21 of 38) 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. 87% of all monitoring sites (72 of 83) 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 83% (321) of the total.

There were a greater number of water bodies found per site in LLP (eight) vs. RLB and ROL (four and three, respectively). It is also worth noting that only one trout stream (RLB) and one trout lake (LLP) were identified during the 2018 monitoring. These differences reflect the characteristics of watersheds monitored. Most OWWs (87%) and streams (96%) occurred in the LLP and RLB sample units where higher numbers of waterbodies across sites may create greater challenges in implementing water quality guidelines relative to the ROL sample unit.

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

Type	LLP	RLB	ROL	Total
Non-open Water Wetland*	181	104	36	**321**
Trout Stream	0	1	0	**1**
Non-trout Stream	9	44	2	**55**
Intermittent Stream	2	16	0	**18**
Open Water Wetland	17	1	3	**21**
Lake	6	1	1	**8**
Total Waterbodies (n)	211	135	42	**388**
Sites w/Water (n)	26	32	14	**72**
Sites w/out Water	6	4	1	**11**

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

Harvest Methods and Planning

The percent of sites that were clear-cut with reserves remains similar to past reports at 83%. Other harvest methods reported include thinning, single tree and group selection, seed tree, 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

About 42% of sites were harvested predominantly during the winter season (Dec. 16 – March 15) (Table 5) compared to 37% in the 2016-2017 reporting period, and similar to the 2011 statewide value. Substantial variability in harvest timing 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. Differences between reporting periods may also be associated with variable pressure to access and harvest wood during non-frozen seasons, resulting from poor operating conditions in years like 2016-2017 with mild, wet, and shorter than average winters. Regional variation in acceptable operating practice (social norms) are also likely related to watershed location and physical characteristics, and result in different levels of BMP implementation.

Table 5. Distribution of harvest by season for sites in monitored watershed sample units.

Watershed Unit	Season of Harvest	Sites (n) with Harvest in Season	Percent of Site Area Harvested in Season	Sampled Acres Harvested in Season	Percent of Unit Harvest by Season
LLP	Spring	4	34.7%	205.5	13.2%
LLP	Summer	16	74.0%	773.5	49.5%
LLP	Fall	10	46.7%	143.4	9.2%
LLP	Winter	13	94.3%	439.4	28.1%
RLB	Summer	7	47.7%	210.8	15.7%
RLB	Fall	10	59.2%	375.2	27.9%
RLB	Winter	24	81.7%	758.9	56.4%
ROL	Spring	7	57.1%	81.1	21.6%
ROL	Summer	3	100%	88.7	23.6%
ROL	Fall	3	89.0%	80.6	21.4%
ROL	Winter	6	89.5%	125.7	33.4%
Combined	***Spring***	***11***	***8.7%***	***286.6***	***8.7%***
Combined	***Summer***	***26***	***32.7%***	***1,073.0***	***32.7%***
Combined	***Fall***	***23***	***18.3%***	***599.2***	***18.3%***
Combined	***Winter***	***43***	***40.3%***	***1,324.1***	***40.3%***
Total	**All**	**103***	**100.0%**	**3,282.8**	**100.0%**

*Total number of entries exceeds the number of sites because some harvests spanned multiple seasons.

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 (federal) 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 and 1 federal site indicated that they chose not to use the guidelines. Five additional NIPF sites chose not to respond to the question about which guideline version was used. 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 prior reporting periods 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. While it is difficult to prove that forest management plans result in better BMP implementation, it is generally recognized that processes like forest certification, periodic audits, and stewardship planning tend to result in generally high levels of BMP use (NASF 2015, 2019). Stewardship plans should spell out long and short-term goals and objectives, resource values to be maximized, strategies and concerns associated with achieving resource objectives, silvicultural approaches associated with specific objectives, and specific BMPs to be implemented on-site and where needed.

Harvest plans (including site maps) were developed for nearly all county, federal, forest industry and state sites. For the 25 NIPF sites that had a completed pre-site questionnaire (89% of all NIPF sites); landowners reported that approximately 64% had a written general forest management plan for their property with most also having a written timber harvest plan for the site. Almost all written plans (15) were prepared by a forestry consultant or natural resource professional. One written plan was prepared by the logger. Of the 25 NIPF sites responding to the pre-site questionnaire, nine indicated no written plan was developed. This emphasizes that for many NIPF harvests (nine of 25 with no written plan), the logging professional may be the sole source informing landowners about site-level guidelines and implementing BMPs 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. A focus on the importance of written management plans could also facilitate greater BMP implementation across NIPF sites. However, variability in landowner objectives may preclude substantial progress on this measure of stewardship planning.

On-site Guideline Implementation Results

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. 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 soil exposure throughout the filter strip. Concentrated soil exposure is to be avoided. 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 433 total filter strips observed across sites, detailed filter strip data were recorded for 72 filter strips that triggered expanded data collection. Most (78%) filter strips for which detailed observations were recorded were located adjacent to NOWW, 15% were adjacent to streams, and only 7% were adjacent to OWW. For all filter strips recorded, 2.5% 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 0.2% of filter strips (one strip) had erosion occurring within the filter strip, resulting in sediment being deposited into the adjacent non-open water wetlands (Table 6). Overall, 99% of filter strips met the minimum disturbed soil recommendations of no concentrated soil exposure or less than 5% dispersed soil exposure. LLP watershed sample unit had the highest compliance rate at 87% while ROL had the lowest at 81%. This compliance is slightly lower than figures from the previous report and may demonstrate either difficulties with filter strip implementation in landscapes composed substantially of NOWW (e.g., RLB and LLP), differences in weather related soil conditions, differences in timing of harvest among units, or differences in filter strip management among WSUs.

Table 6. Filter soil exposure, erosion, and sediment reaching a waterbody. Note that most filter strips not meeting guidelines had a road, skid trail, or landing within the filter strip.

WSU	Total Filter Strips (n)	No Soil Exposure	> 5% Exposed Soil	Erosion in Filter Strip	Road or Skid Trail in Filter Strip	Landing in Filter Strip	Strips w/Sediment to Waterbody
LLP	218	28		2	13	15	1
RLB	172	31	2		6	28	0
ROL	43	9			3	7	0
Total	**433**	**68**	**2**	**2**	**22**	**50**	**1**

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. Unfortunately, for 50 filter strips that had landings located within the filter strip, contractors were unable to determine if these landings could have been located outside of filter strips. [1] Overall, 90% of sites met the disturbed soil minimums as well as the recommendations for avoiding landings within filter strips where possible (Table 6). Continued emphasis should be placed on avoiding location of infrastructure within filter strips and wetlands where practical.

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 of 60 ft^2 for all types. RMZ compliance was based on the 2012 revised guidelines.

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)
- Undisturbed forest (no apparent harvest)
- Partially harvested forest (harvest retained partial canopy)
- Clear-cut (for remaining recommended RMZ width)

1 These observations appear to have not been recorded for the 2018 monitoring due to a shortcoming of the GMA software. It was reported by contractors that several of the triggered question screens were inaccessible, so responses could not be recorded.

Compliance was based on the combined width of 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 combined non-forest, undisturbed, and partially harvested portions based on the minimum recommended basal area of 60 ft^2. RMZs meeting 95% or more of recommended 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 50 RMZs were identified on or adjacent to 35 sites monitored in 2018. Overall, 36 of 50 (72%) RMZs met guideline recommendations for width and basal area of forest retention. These results are lower than the previous report of 79% total compliance and 17% partial compliance respectively.

From a watershed perspective, compliance for RMZ implementation is highest for the ROL watershed sample unit. ROL had 100% compliance on all RMZs adjacent to OWWs and streams (both trout and non-trout waters) (Table 7), while LLP was totally compliant on trout streams, lakes and OWW. RLB had lower compliance for streams, but 100% compliance for lakes & OWWs (Table 7). Outreach including the importance of RMZ management in RLB sample units may improve awareness and implementation of RMZ guidelines for streams.

RMZs provide direct shade to streams and lakes as well as shade 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 67% which is lower than last reporting period (83%).

Guidelines also recommend retention of coarse woody debris (CWD) within RMZs where partial harvest is occurring. For thirty-one sites that conducted partial harvest (but still retained >60BA) within RMZs, nineteen retained four or more CWD/acre within the RMZ as recommended by the guidelines. Of the remaining twelve sites, eight did not retain any CWD within the partially harvested area of the RMZ, and four retained fewer than the recommended four logs per acre. 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 7. 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%)
LLP	32	15	25	100%	80%	100%	80%	12%
RLB	36	15	18	50%	50%	100%	50%	22%
ROL	15	5	7	N/A	100%	100%	100%	N/A
Overall	**83**	**35**	**50**	**67%**	**72%**	**100%**	**72%**	**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 (60%) occurred as a result of skid trials, with most crossings (78%) occurring on NOWW (Table 8).

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 23% of observed crossings could have been avoided (Table 9), with most instances due to skid trails crossing NOWWs. Six of the 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. Fourteen of 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.

All watershed sample units had avoidable crossings identified. The LLP sample unit had 42% of all crossings identified as avoidable (Table 9). Remaining sample units had from 10-57% of crossings identified as avoidable. This highlights a continuing need for focused outreach addressing the importance of avoiding crossings and techniques for identifying wetlands. A continued focus on wetland identification and avoidance of unnecessary crossings would serve to leverage existing outreach resources while producing real water quality benefits.

Table 8. Number of crossings by infrastructure component, watershed sample unit and waterbody type with avoidance potential.

WSU	Infra-structure	Crossings (n)	Stream	Mineral Soil Wetland or Seasonal Pond	Peatland	Average Length (feet)	Avoidable (n)	Impede Fish (n)
LLP	Forest road	5	1	4	0	37.6	0	0
LLP	Skid trail	28	5	22	1	66.8	14	1
LLP	***Subtotal***	***33***	***6***	***26***	***1***	***62.4***	***14 (42%)***	***1***
RLB	Forest road	36	7	27	0	283.8	1	0
RLB	Skid trail	31	5	26	0	104.6	6	0
RLB	***Subtotal***	***67***	***12***	***53***	***0***	***200.9***	***7 (10%)***	***0***
ROL	Forest road	1	0	1	0	40	0	0
ROL	Landing	1	0	1	0	40	1	0
ROL	Skid trail	5	1	4	0	100	3	0
ROL	***Subtotal***	***7***	***1***	***6***	***0***	***82.9***	***4 (57%)***	***0***
Total	**Total**	**107**	**19**	**85**	**1**	**96.1**	**25**	**1**

From a watershed perspective, RLB and ROL had the highest and the lowest mean number of crossings per site, and bracketed the median for percent of avoidable crossings at 10% and 57% respectively (Table 9). The ROL sample unit had the highest percent of avoidable crossings (57%) but the lowest number of crossings per site (Table 9). 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, ROL had few crossings identified as avoidable and a low mean number of crossings per site due to differences in watershed characteristics. However, operational habits and awareness of wetland locations by equipment operators may contribute to successful avoidance as much as watershed hydrologic characteristics. 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. Existing data (NWI 2019) and wetland identification (Board of Water and Soil Resources - BWSR) could serve this need.

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. For example, Table 4 shows 181 NOWW in the LLP WSU, while Table 9 shows a total of 26 NOWW crossings within LLP.

Table 9. Non-open water wetland (NOWW) crossings by watershed sample unit.

WSU	Infra-structure	Total Sites (n)	Sites w/ Crossings (n)	Crossings (n)	Mean Crossings per Site When Present	NOWW Crossings (n)	Avoidable (n)	Rutted (n)
LLP	Forest road	32	3	5	1.7	4	0	0
LLP	Skid trail	32	12	28	2.3	22	14	3
LLP	***Subtotal***	***32***	***12***	***33***	***2.8***	***26***	***14***	***3***
RLB	Forest road	36	17	36	2.1	27	1	2
RLB	Skid trail	36	18	31	1.7	26	6	1
RLB	***Subtotal***	***36***	***24***	***67***	***2.8***	***53***	***7***	***3***
ROL	Forest road	15	1	1	1.0	1	0	0
ROL	Landing	15	1	1	1.0	1	1	0
ROL	Skid trail	15	4	5	1.3	4	3	2
ROL	***Subtotal***	***15***	***4***	***7***	***1.8***	***6***	***4***	***2***
Total	**Total**	**83**	**56**	**107**	**1.9**	**85**	**25**	**8**

Rutting on Non Open Water Wetland Crossings

NOWW are the most frequently crossed wetlands during harvesting operations in Minnesota. During this reporting period, 85 NOWW crossings were observed. Rutting occurred on only 9.4% of all NOWW crossings. All instances of rutting were attributed to logging operations and not to recreation or other non-logging activities. Of the crossings that were rutted (8), approximately half (5) 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 92% of all rutted crossings with the remaining instances occurring on forest access roads or landings. 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 13 sites. Eight crossings were associated with forest roads, and eleven were from skid trails. None of these stream crossings were deemed as avoidable, indicating 100% 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 209 approaches were identified and evaluated by monitoring contractors. The vast majority (94.5%) of these approaches were in good condition and did not require further erosion control practices for sediment control (Table 10), 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, relatively level topography, etc.). However, for the 12 approaches where EC was deemed necessary, only four (33%) had practices appropriately

Table 10. Erosion control and occurrence on approaches (APPs) for all water features by watershed unit.

Watershed Unit	Total Sites	Sites with APPs	Total APPs (#)	# APPs Needing EC	# APPs with EC Installed	# APPs with Erosion	# APPs Sediment Reached Waterbody
LLP	32	12	66	6	2	3	1
RLB	36	24	131	4	0	1	0
ROL	15	4	12	2	2	0	0
Total	**83**	**40**	**209**	**12**	**4**	**4**	**1**

installed, which is slightly higher than what was reported in the two previous reports, but still an area for improvement. More importantly, erosion was frequently (50%) observed when EC practices were needed but not installed. Additionally, in 25% of instances when erosion was occurring on approaches, contractors found evidence of sediment reaching the associated waterbody (Table 10). 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, McEachran et al. 2018).

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, all of the watershed units had sites with approaches needing EC (Table 11). Targeted outreach 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.

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 (4.8%) 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 11). Most (eight of nine) WQ segments occurred on skid trails, likely due to challenges associated with logging operations in warmer winters for sites with many NOWW. In one of the four 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 waterbodies like approaches are. Although there is clearly a need to focus efforts on improving EC use in

Table 11. 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*	*Sites with WQ Segments*	*# WQ Segments*	# Segments with EC Installed	# Segments with Erosion	# Segments with Sediment to Waterbody
LLP	32	1	5	5	2	1
RLB	36	2	2	0	1	0
ROL	15	1	2	0	1	0
Total	**83**	**4**	**9**	**5**	**4**	**1**

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.

Fewer approaches needing EC were identified in 2018, and fewer WQ segments were monitored. Approaches needing EC represented 7.2% of all approaches monitored in 2016-2017, and 5.7% of all approaches observed in 2018. WQ segments were monitored for 75% of approaches needing EC in 2018. For 2016-2017, this figure was 94%, possibly indicating more lax monitoring of WQ segments during the 2018 monitoring season.

Infrastructure

Equipment traffic can compact and rut soil. It can also damage or remove vegetation and associated root systems, which 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 3.4% (Figure 3) higher than the 2.9% reported in the previous report, but still reflecting a 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 0.93 acres, down from the 1.1 acres reported in 2016-2017. Mean on-site road acreage for this reporting period is 0.35 acres, down from the previous report and also down from past reports.

From a watershed perspective: The mean percent infrastructure by watershed sample unit ranged from a low of 2.9% in ROL to a high of 4.3% in RLB. The RLB 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 ROL are typically rolling upland terrain providing relatively flat areas available for landing locations, the RLB is nearly level topography dominated by wetlands and offering few good landing opportunities.

Overall, 74% of sites monitored in 2018 met the recommended infrastructure amounts based on 2012 guidelines (Table 12). This is lower than the 2016-2017 report (77%) but considerably higher than previous reports. When comparing on-site infrastructure with site size, compliance was highest for sites averaging 47 acres or more. Compliance was lowest for sites less than 24 acres. Mean site size (40 acres) was smaller for watersheds in this report compared to the long-term average of 55 acres, but overall compliance was similar.

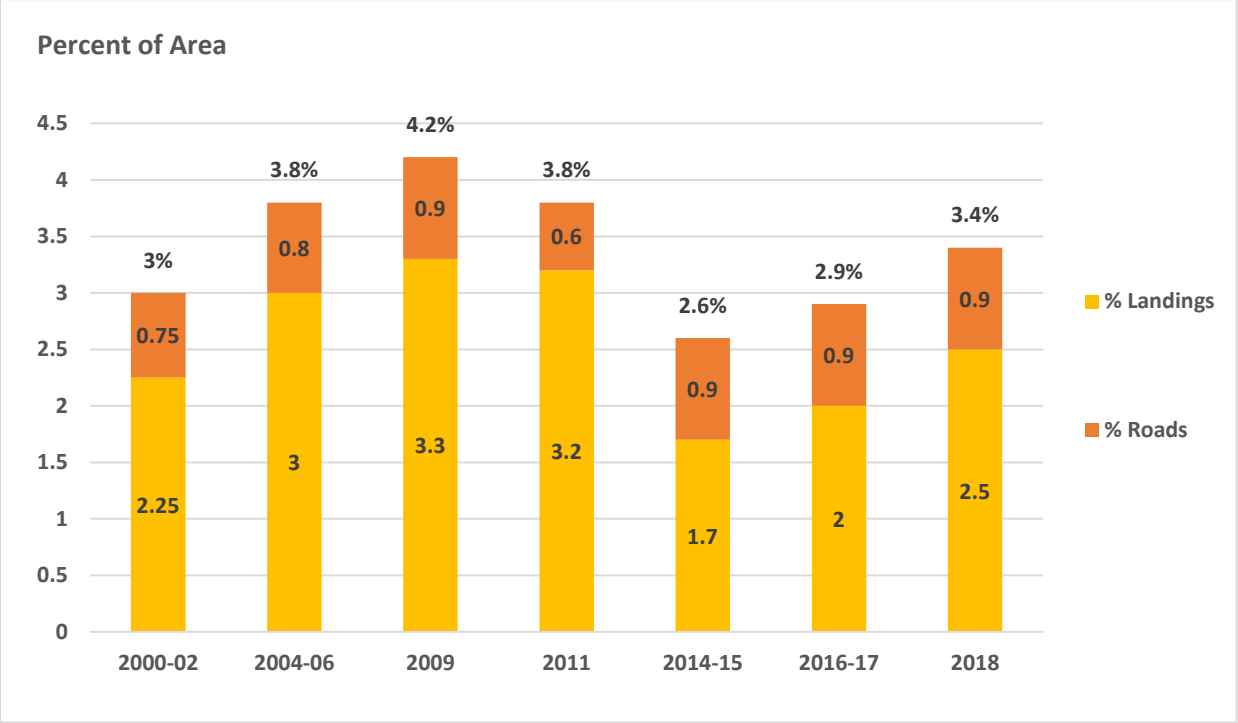


Figure 3. Mean percent infrastructure by reporting period.

Table 12. Acreage of on-site infrastructure by watershed sample unit.

WSU	Sites w/Infra-structure (n)	Percent Meeting Infra-structure Guidelines*	Average Acres	Standard Deviation (Acres)	Average Infra-structure Acres	Average Landing Acres	Average Road Acres
LLP	31	71.9%	49	85.4	1.80	1.40	0.40
RLB	35	55.6%	38.5	48.5	1.66	1.05	0.61
ROL	11	93.3%	25.1	13.3	0.39	0.34	0.05
Total	**77**	**73.6%**	**37.5**	**62.2**	**1.28**	**0.93**	**0.35**

* For sites with on-site infrastructure

As indicated above, the watershed units represent a wide range of hydro-geomorphology, with RLB falling within the nearly level and water rich Agassiz lake plain in the far north, and ROL falling within the morainal landscapes of west-central Minnesota (e.g., Pine Moraines & Outwash Plains and Hardwood Hills subsections). Differences in compliance may be a reflection of the ease at which landings can be located and developed in the relatively upland topography of ROL as opposed to RLB.

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, 64 landings (20.4% of total) were located at least partially in a wetland or filter strip (primarily NOWWs). Typically, 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. In 2018, software limitations precluded responses related to landings located within wetlands and/or filter strips, and none were judged to have upland locations available for placement. For 2016-17 an overall implementation rate of 80% for locating landings outside of wetlands and filter strips when possible was observed. Similar results were observed for 2014-15 and for 2011. From these past reports, it is clear that 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.

The LLP 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. However, the RLB sample unit had the highest percentage of landings located within wetlands or filter strips (29%). Comparatively, ROL had the lowest total number of wetlands and waterbodies on sites as well as the lowest per site mean. Interestingly, LLP had the lowest percentage (10%) of landings located in wetlands, waterbodies or filters strips. It appears that while the density of surface water and wetlands may influence the relative times when landings are located in a wetland or filter strip, local practices and operational norms, as well as upland availability, may also play a role in implementation of BMPs related to landing 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. Many landings (40%) were more than 50% vegetated and only 10% had little or no vegetation at the time of monitoring. Overall, almost 90% of landings had greater than 5% vegetative cover. Although not a specific guideline, re-vegetated landings are less susceptible to erosion. Only one landing had indication of erosion occurring. No landings had any visible trash on them. These results are all similar to last report, demonstrating high compliance for related guidelines.

Similarly, no landings had signs 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 2018, 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 258 observed landings, 62% 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, 9% of the time the source was identified as chipping debris, and 26% of the time the source was identified as saw dust. From a watershed perspective, the highest occurrence of dense organic debris covering the landing was in RLB where 73% of landings had 50% or more of the landing occupied by dense debris, followed by LLP where 54% of landings fell in the same category. Landings in ROL had fewer occurrences of dense slash covering half or more of the landing (29%).

The occurrence of harvest related fill-originating from landings located within a wetland was not thoroughly evaluated at this time, due to incomplete data related 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 Minnesota Wetlands Conservation Act (WCA). 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 83 sites monitored, only eight sites had rutting identified somewhere on the site, and two of these had rutting identified at more than one feature type. Although somewhat

difficult to determine exactly, all but one site with rutting had less than 5% total rutted surface area. The one site with substantial rutting had 25% of the upland harvest area rutted.

From the watershed perspective; some rutting occurred in all watersheds. The number of sites with rutting ranged from two each in LLP and ROL, to four in RLB. 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.

Visual Quality

Associated with 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. One caveat is that the online only visual sensitivity maps have not been updated in many years, and are incomplete with respect to recreational trails, waterways, and even some surface roads.

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 70 monitoring sites located within the eight counties with established visual sensitivity ratings. Rated sites were entirely from the RLB and LLP watershed units. For these 70 sites, 51 (73%) indicated awareness of the visual sensitivity rating. For agency and industry sites, awareness of the visual sensitivity rating was 88%, with dramatically lower awareness for NIPF sites (30%). For 52% of the rated sites, land mangers indicated the correct visual sensitivity rating. This observation contrasts with about 72% identifying the correct visual quality rating in the previous report.

For sites that did not accurately identify the correct visual sensitivity rating, almost 43% of incorrect visual sensitivity responses were related to surface streets or public roads. Most (57%) were due to incorrect responses related to features such as recreational trails, and waterways. Many of these features 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 as well as available maps may improve understanding of site visual sensitivity ratings.

Cultural Resources

Cultural and historic resources such as Native American (mostly Anishinaabe – Chippewa and Ojibwe, or Dakota – Sioux, depending on the region) camp or village sites, human burial sites,

old homesteads, and logging camps 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 96% overall for agency and industry sites (53) 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 check for 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, DNR staff checked monitoring sites against the archeological site inventory maintained by the state archaeologist's office. Only one site was flagged as having known cultural and historic resources on or near the site; an historic logging camp noted in the 1874 Corps of Engineers survey of the Leech Lake River. This cultural resource site was on NIPF land, and the landowner indicated that a check for cultural resources had been done. However, based on the landowner's knowledge and/or sources checked, it was not known if any cultural resources were present on the site. One additional cultural resource, a historic ice road, was identified by the landowner on a state administered site. In this instance, the landowner excluded the cultural resources from the operational area of the project.

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, 100% reported that they checked for known ETS prior to initiating activities, higher than the 85% in the last report. Land managers reported that six of 53 agency and industry sites reported known ETS species on or adjacent to the harvest site. Management activity was modified on three of these six 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 83 sites monitored in 2018, GMP staff independently queried the DNR's Natural Heritage Information System (NHIS) to determine if monitoring sites had known ETS species 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 having a known ETS species within or adjacent (within 660 ft.) to the site. For these 14 sites, all said they checked for ETS, four indicated knowledge of the species existence and took appropriate actions, and 10 checked for known ETS species but did not find any species on, or adjacent to, the site.

Of the 10 sites failing to identify the presence of ETS species known to NHIS on, or directly adjacent to, the site, four were state, two were forest industry, two were federal, and one was county owned. The remaining site was NIPF. Five of the 10 sites were located in the RLB sample unit, while four were from the ROL unit.

The reasons for disparity between sites that indicated checking appropriate sources for known ETS species, and the ability to correctly identify the presence of ETS species found 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 harvest activity 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 check for known ETS species “on or near” management sites. DNR Natural Heritage staff currently recommend checking within a one mile buffer of management sites, while local managers may only be considering areas on-site and directly adjacent to sites. Clarifying guideline intent (i.e., defining what “near” means) may improve implementation.

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. Additionally, a more publically accessible version of NHIS providing simple presence / absence information for the broad class of ETS species would help greatly in making these checks easier to accomplish for stewards not directly connected to the DNR Natural Heritage Program. Simply knowing that an ETS is present would go a long way towards justifying the additional effort involved with contacting Natural Heritage staff for additional information.

Biomass, Slash Management & Fine Woody Debris Retention

Slash or fine woody debris (FWD) retained on harvest sites helps to sustain soil productivity, and also provides habitat for small mammals, amphibians, and other organisms. Guidelines recommend practices that allow for dispersed slash on the site if it does not conflict with management objectives, rather than piling slash. For this report, 74 of 83 sites had slash more or less evenly distributed on the site representing an 89% implementation rate to this guideline.

Fifteen sites utilized slash as a biomass product. All sites utilizing slash as biomass retained an estimated 1/3 or more of fine woody debris on site.

From the watershed perspective, the LLP and RLB units had six and three 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 concentrated in the LLP WSU with twelve sites reporting utilization. Biomass utilization outside of LLP was minimal, with ROL reporting two and RLB only one site where biomass was utilized.

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 88% of the time (Table 13), slightly lower than last reporting period but substantially higher than numbers reported in earlier 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 RLB (Avg. = 23 logs per acre) and LLP (Avg. = 26 logs per acre) sample units appeared to have higher number of recorded CWD on site. Seventeen sites had 40 or more pieces of CWD per acre. Implementation of this guidelines continues to be high.

Table 13. Number of sites with indicated ranges of CWD pieces per acre in general harvest area.

Watershed Unit	0	0-2	2-5	5-20	20-30	30-40	40-50	>=50	Total Sites
LLP	3	1	3	15	5	1	3	4	35
RLB	1	2	1	9	8	7	6	2	36
ROL	3		2	4	2		1		12
Total	**7**	**3**	**6**	**28**	**15**	**8**	**10**	**6**	**83**

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" diameter at breast height (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. Due to enhanced wind firmness and more favorable wildlife habitat characteristics, 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 83 sites monitored, 68 sites were evaluated for implementation of the leave tree guidelines. Of the 83 sites monitored, 68 sites were evaluated for implementation of the leave tree guidelines. Of the remaining 15 sites, 11 were managed with selection harvests, thinning, seed tree or shelterwood harvests. These silvicultural prescriptions retain abundant vertical structure and were therefore not evaluated for leave tree guideline compliance. One harvest site indicated no leave trees were retained, and three sites did not respond to the question.

Overall, 56 (82%) of the 69 sites monitored for implementation of leave tree guidelines had adequate leave trees remaining on site to meet recommended guidelines. Additionally one site identified specific forest management applications (e.g., genetic considerations for seed) as a reason for applying an exception to the leave tree guidelines. Compliance to leave tree guidelines for watersheds sampled in this report are slightly higher than those watersheds sampled in 2016 and 2017 (Table 14). Statewide, a total of 12 sites (18%) did not meet the leave tree retention guidelines.

Overall, 69% of sites met the retention guidelines utilizing leave tree clumps and/or RMZs and 9% utilized scattered leave trees alone. 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 47 sites that utilized the leave tree clump strategy, 32 fully met the guideline via RMZs and 20 fully met the guideline via stand-alone LTCs. Five sites fully met the guideline via both methods, and 15 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.

Table 14. 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%
2018	68	9%	69%	82%	11	82%

Table 15. 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**
LLP	30	27	5	20	3	19	81%
RLB	36	30	1	32	2	18	66%
ROL	17	11	0	10	0	10	85%
Total	**83**	**68**	**6**	**62**	**5**	**47**	**77%**

* **# sites using these strategies to retain leave trees**

At the watershed scale, rates of implementation ranged from a high of 85% in ROL to a low of 66% in RLB. LLP had 81% of sites meeting the leave tree guidelines. Many sites fully met both scattered and clumped leave tree guidelines (doubling up). When looking at results by watershed unit, all three WSUs utilized LTCs more frequently than scattered as a leave tree strategy (Table 15). Considering these results, targeted outreach on leave tree guidelines to the RLB and LLP watersheds may increase implementation of leave tree guidelines in these areas.

Leave Tree Clump Characteristics

Contractors identified and evaluated 86 leave tree clumps (LTCs) on 35 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 the two most recent reports exceed the number of sites utilizing scattered leave trees (Table 15). Blowdown occurred in only 8% of LTCs with an average of 6.4% of trees within LTCs being impacted. We currently do not have needed data to compare blowdown of scattered leave trees vs. blowdown in LTCs. For upcoming monitoring, additional data on blowdown of scattered leave trees will be collected.

In this reporting period, contractors noted when leave tree clumps were used to protect or enhance sensitive feature on the harvest site. Approximately half of the LTCs were used to protect or enhance non-open water wetlands by being located in or around these features, while another 10% were used to protect or enhance a stream or river, open water wetland, or visual quality corridor.

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 16 shows the frequency of the most common mature tree species identified in LTCs. Eight 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 half 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

Table 16. Common species identified in LTCs by frequency of occurrence, across all monitored sites.

Species	# of LTCs with Species as Most Common	# of LTCs with Species in Top 5	% of LTCs with Species Present	Wildlife Rating for Tree Species
Aspen	39	65	75.6	Excellent
Norway Pine	10	32	37.2	Good
Northern Red Oak	9	25	29.1	Excellent
Black Ash	6	17	19.8	Excellent
Paper birch	6	51	59.3	Fair
Red Maple	5	42	48.8	Good
Basswood	3	16	18.6	Excellent
Jack pine	3	7	8.1	Fair
Balm of Gilead	1	3	3.5	Excellent
Northern White Cedar	1	5	5.8	Good
Burr Oak	1	12	13.9	Excellent
White pine	1	5	5.8	Excellent
White spruce	1	5	5.8	Good
Balsam Fir	0	12	13.9	Fair
Elm	0	3	3.5	Excellent
Sugar maple	0	16	18.6	Excellent
Black spruce	0	3	3.5	Fair
Tamarack	0	1	1.2	Good

are 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, and black ash.

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 one to three (low to high respectively) with a statewide mean of 1.45, indicating that on average species with fair to excellent wildlife characteristics are being retained at all watershed units. The maximum wildlife rating for leave tree species was three in all watersheds. Both species richness and presence of large trees retained were variable across watershed units, being

greatest in the LLP and RLB, and less in the ROL sample unit. Statewide estimates are similar to those from previous years for which data is available (Table 17). 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 eight feet tall and ≥6 inches DBH. Snags were commonly recorded at nearly all harvest sites, ranging from a mean of 0.8 to 1.1 per acre across watersheds monitored this cycle (Table 17). 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 an active area of research. 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 lower than in previous reports, but it is difficult to determine if snag retention is trending lower at this time.

Table 17. Scattered leave tree and snag characteristics (parentheses show 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
LLP	1.8 (1.3)	0-5	4.1	0-5	1.4	0-3	0.7 (0.1)	0-1.0
RLB	2.3 (2.5)	0-10	4.3	0-5	1.2	0-3	0.6 (0.1)	0-1.0
ROL	1.8 (1.7)	0-5.5	4.6	0-5	1.7	0-3	0.7 (0.1)	0-1.0
2018	2.0 (1.8)	0-10	4.3	0-19	1.43	0-3	0.7 (0.1)	0.2-1.0
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
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
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 2016-17 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, 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. Landowners, managers, and logging operators should strive to improve implementation of these guidelines, given the critical role that they play in mitigating impacts to water quality, wildlife, and soil productivity. 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 (e.g., MFRC's Regional Landscape Committees and the Minnesota Pollution Control Agencies' Watershed Restoration and Protection Strategies process), to coordinate efforts, develop strategic partnerships, organize local events, and acquire additional funding needed for this level of outreach.

Rainy Headwaters, Little Fork, and Big Fork watersheds (RLB):

Nearly half of the Rainy Headwaters, Little Fork, and Big Fork watersheds are dominated by wooded wetlands. These hydric woodlands are made up of black spruce, tamarack, northern white-cedar, and black ash forest types with a mixture of aspen and other upland species complementing the bottomlands dominated by wetland conifers. To the south and north, these watersheds are bordered by lakes with well-developed rivers and streams running south to north. This unit is comprised of 82% forested cover types and has little land development (1.7%) and almost no intensive agriculture (0.2%). Substantial components of scrub/shrub (4.6%) and wetland (4.9%) habitat, with lesser amounts of grassland (2.4%) round out the land cover in this watershed unit.

Of the three watershed units sampled in 2018, RLB (12.5 million acres) had the highest number of disturbed sites (676 sites, 16,463 acres annually) and the highest percent of forest cover disturbed (1.1% annually), though the average disturbance size was small (33.9 acres). This level of harvest is consistent with the predominantly aspen forest type present (36%), and increased harvests of tamarack and black ash related to recent insect outbreaks in the region. Eastern larch beetle and emerald ash borer both pose an increasing threat to the black ash (8.1%) and tamarack (10.1%) forests common in the RLB sample unit.

Sites in RLB had high compliance to guideline recommendations in several categories including: minimizing soil exposure on filter strips (99%), RMZ management on lakes and OWW (100%), locating landings outside of wetlands and filter strips (84%), avoidance of wetland crossings (90%), leave tree retention (94%), coarse woody debris retention (92%), and installation of EC on approaches where needed. Opportunities for improvement include infrastructure management (56%), riparian management along streams (both trout and non-trout - 50%), avoidance of dense debris accumulation on landings (37%), and retaining more preferred leave tree species for wildlife (down slightly from previous reports).

Leech Lake and Pine watersheds (LLP):

Located in the Northern Minnesota Drift and Lake Plains, the Leech Lake and Pine watersheds (1.36 million acres) are dominated by complex surface geology composed of deep glacial till and outwash plains, moraines, drumlin fields, and outwash channels. This unit has the most

complex geology and most surface water (16% of surface area) of the three sample units monitored in 2018. LLP also had the highest number of hydrologic features associated with monitored sites (211 features on 26 of 32 sites), with the vast majority of identified hydrologic features being non-open water wetlands (181).

This unit has approximately 66% forest land with an additional 7.5% in wetlands. Forest cover (899,554 acres) includes a strong component of aspen (36%), oak-hickory (12%), northern hardwoods (8%), lowland black ash (6%) and tamarack (6%), and a mix of other forest types. Forest disturbance in LLP was observed at 160 sites (5,674 acres) annually totaling 0.63% of existing forest canopy.

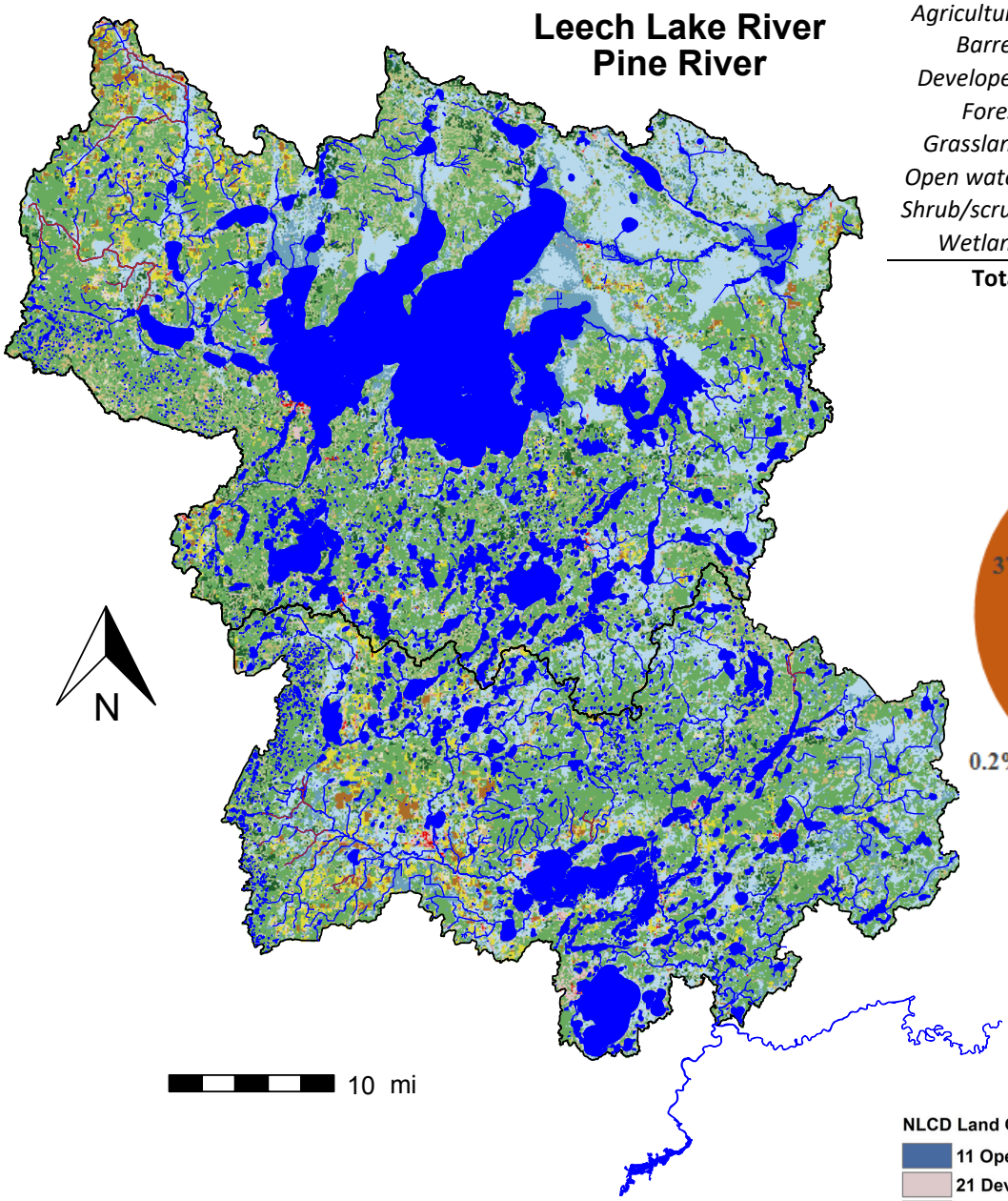
Sites in LLP had high compliance to guideline recommendations for RMZ management (80%), coarse woody debris retention (89%), leave tree retention (81%), locating landings outside of wetlands and filter strips (90%), and filter strip management (87%). Opportunities for improvement include: avoidance of unnecessary wetland crossings (58% compliant), infrastructure management (72%), using winter harvests on frozen ground (28%) to avoid rutting and erosion on skid trails and crossings of NOWW, and installation of EC on approaches where needed (33%).

Red Eye, Otter Tail, and Long Prairie watersheds (ROL):

These watersheds encompass a 2.36 million acres of west central Minnesota containing a mixture of mainly hardwood forests (26%) and agriculture (32%) with substantial surface water (10%) and wetland (13%) resources. The watershed unit falls on the transition between the Pine Moraines and Outwash Plains ecological subsection and the Hardwood Hills subsection. The ROL unit has both high percent cover of lakes and ponds (10%), and extensive rivers and streams (2,093 miles) with some trout streams present (97 miles). The ROL watershed unit had the lowest number of disturbances (24) and the lowest percent of forest cover disturbed (0.15%), which is not surprising given the characteristics of the unit, and distance from major timber markets.

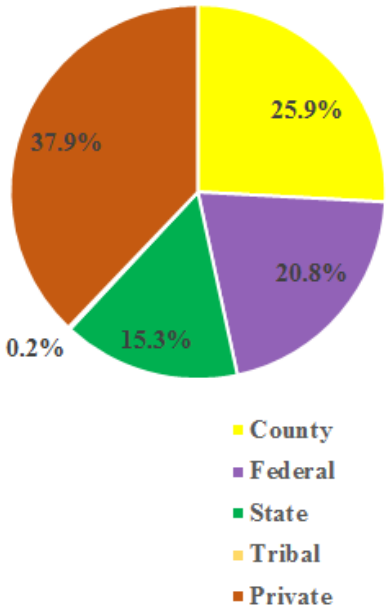
Sites in ROL had high compliance to guideline recommendations in several categories including: RMZ management (100%), use of EC on approaches, avoidance of rutting (87%), infrastructure management (93%), locating landings outside of wetlands and filter strips (91%), and leave tree retention (85%). Opportunities for improvement include filter strip implementation (77%), avoidance of wetland crossings (74%), coarse woody debris retention (75%), and use of EC on roads and skid trails.

Appendix

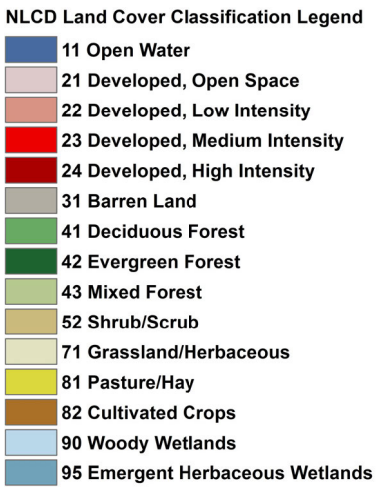


Land cover	Acres
Agriculture	14,449
Barren	1,031
Developed	40,379
Forest	899,554
Grassland	59,114
Open water	221,801
Shrub/scrub	20,539
Wetland	101,980
Total	**1,358,846**

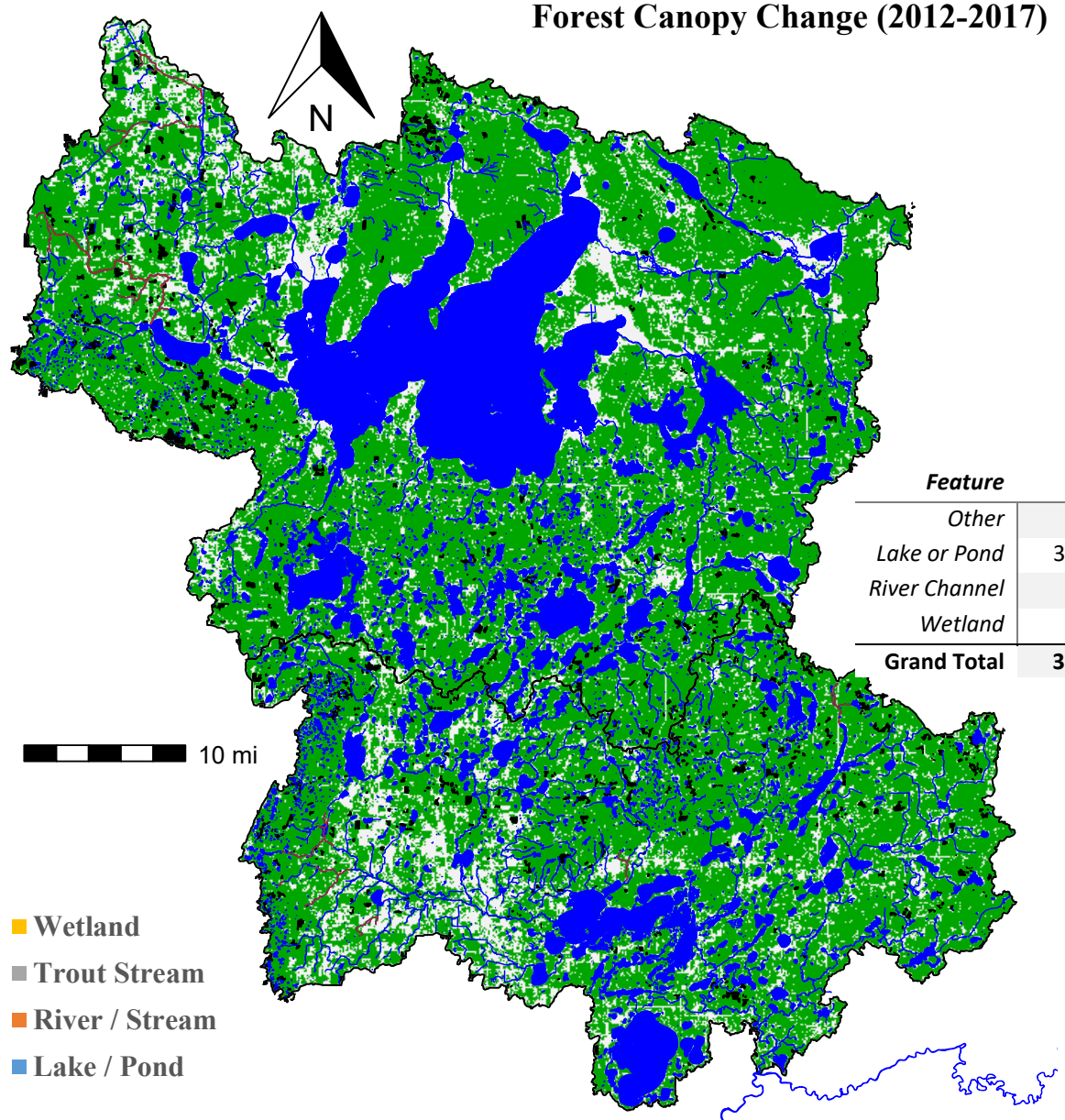
Forest Ownership



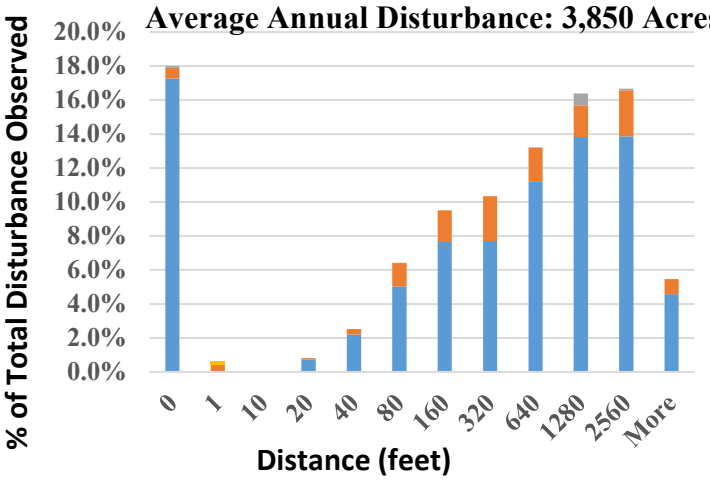
Forest Cover	Acres	Percent
Aspen	321,447	35.7%
Black ash	52,329	5.8%
Northern hardwoods	69,772	7.8%
Other	236,725	26.3%
Paper birch	59,804	6.6%
Tamarack	52,329	5.8%
Oak - hickory	107,149	11.9%
Total	**899,554**	**100.0%**



Forest Canopy Change (2012-2017)

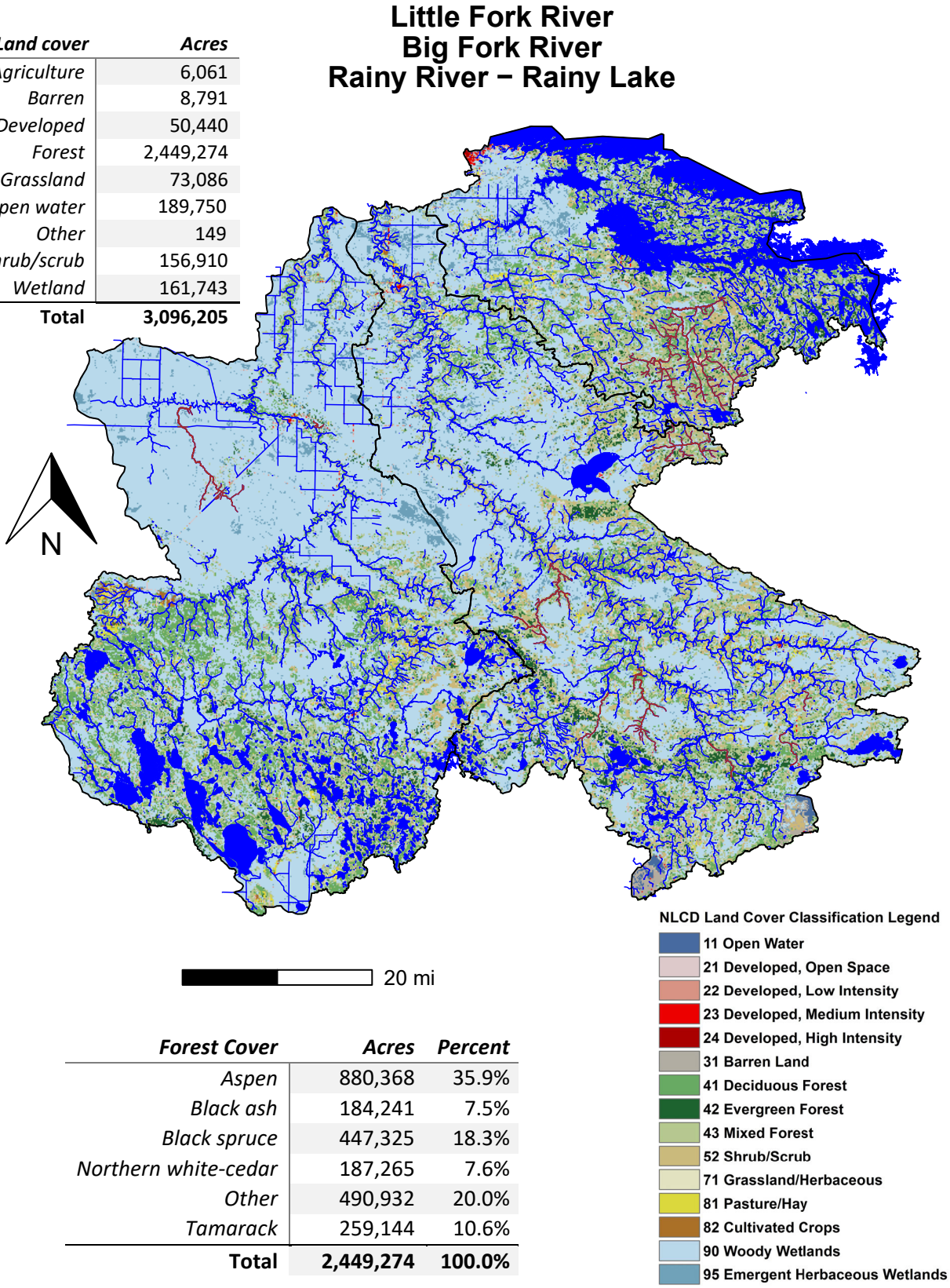


Feature	Acres
Other	5,477.5
Lake or Pond	361,488.7
River Channel	18,359.6
Wetland	5,140.3
Grand Total	**394,644.2**



Stream Type	Stream Miles	n
River	226.7	80
Other	514.5	920
Drainage ditch	75.7	146
Stream	796.1	1359
Trout Stream	77.6	41
Grand Total	**1,690.6**	**2546**

Land cover	*Acres*
Agriculture	6,061
Barren	8,791
Developed	50,440
Forest	2,449,274
Grassland	73,086
Open water	189,750
Other	149
Shrub/scrub	156,910
Wetland	161,743
Total	**3,096,205**

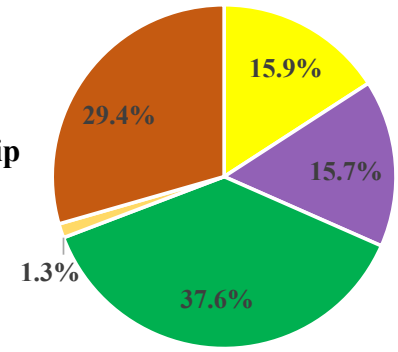


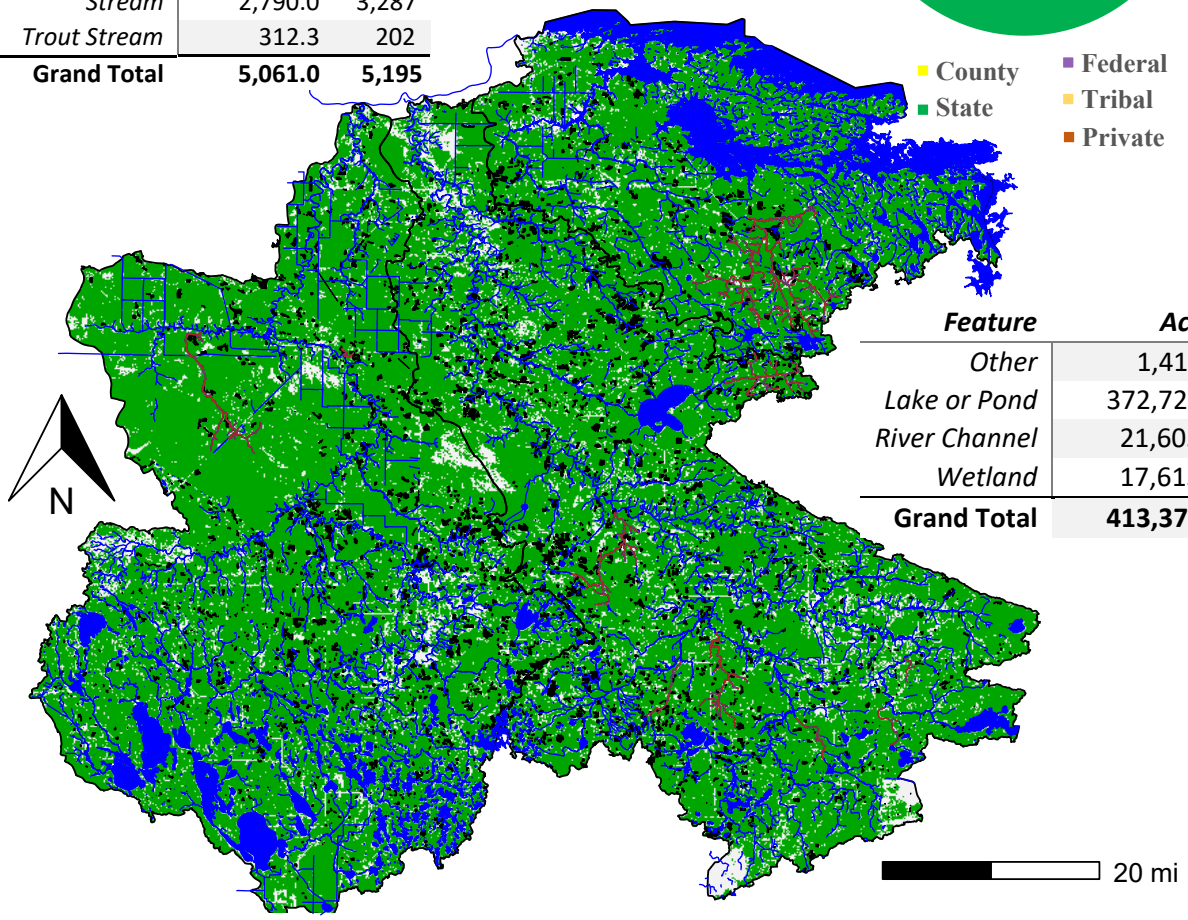
Forest Cover	*Acres*	*Percent*
Aspen	880,368	35.9%
Black ash	184,241	7.5%
Black spruce	447,325	18.3%
Northern white-cedar	187,265	7.6%
Other	490,932	20.0%
Tamarack	259,144	10.6%
Total	**2,449,274**	**100.0%**

Forest Canopy Change (2012-2017)

Stream Type	Stream Miles	n
River	1,026.6	397
Other	531.0	929
Drainage Ditch	401.1	380
Stream	2,790.0	3,287
Trout Stream	312.3	202
Grand Total	**5,061.0**	**5,195**

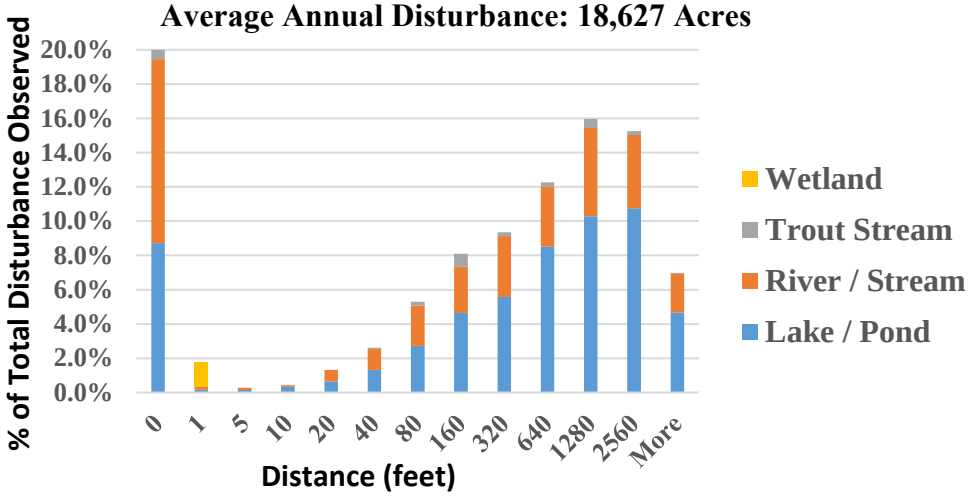
Forest Ownership





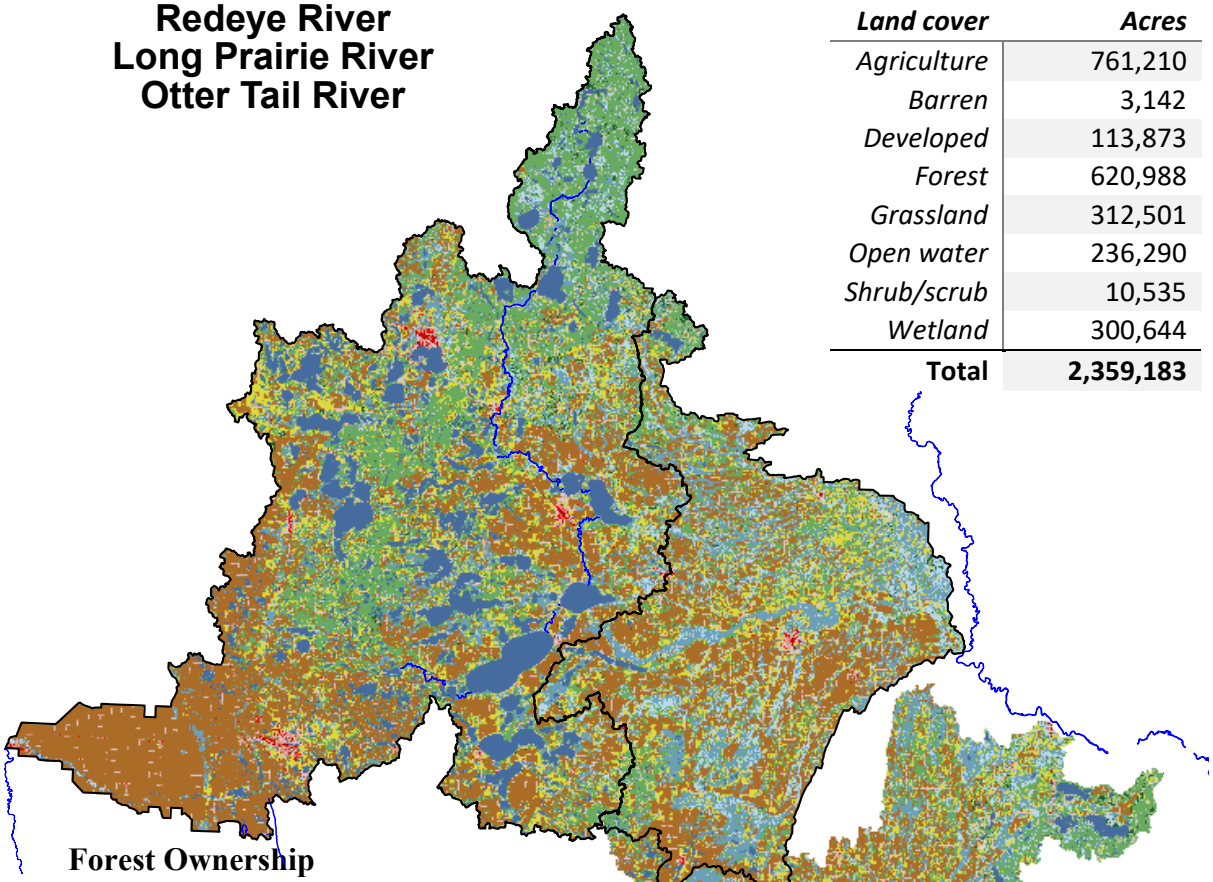
Feature	Acres
Other	1,414.0
Lake or Pond	372,728.3
River Channel	21,605.4
Wetland	17,613.5
Grand Total	**413,371.2**

Average Annual Disturbance: 18,627 Acres

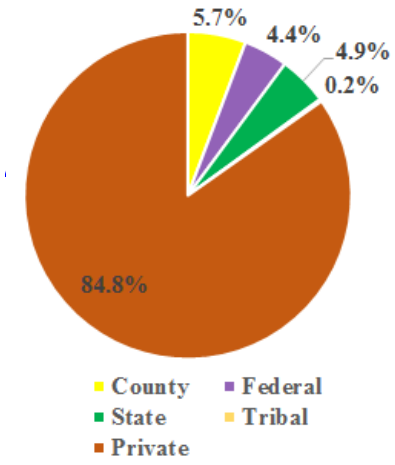


Redeye River
Long Prairie River
Otter Tail River

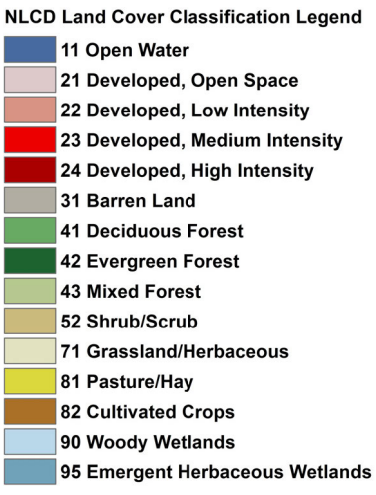
Land cover	*Acres*
Agriculture	761,210
Barren	3,142
Developed	113,873
Forest	620,988
Grassland	312,501
Open water	236,290
Shrub/scrub	10,535
Wetland	300,644
Total	**2,359,183**



Forest Ownership

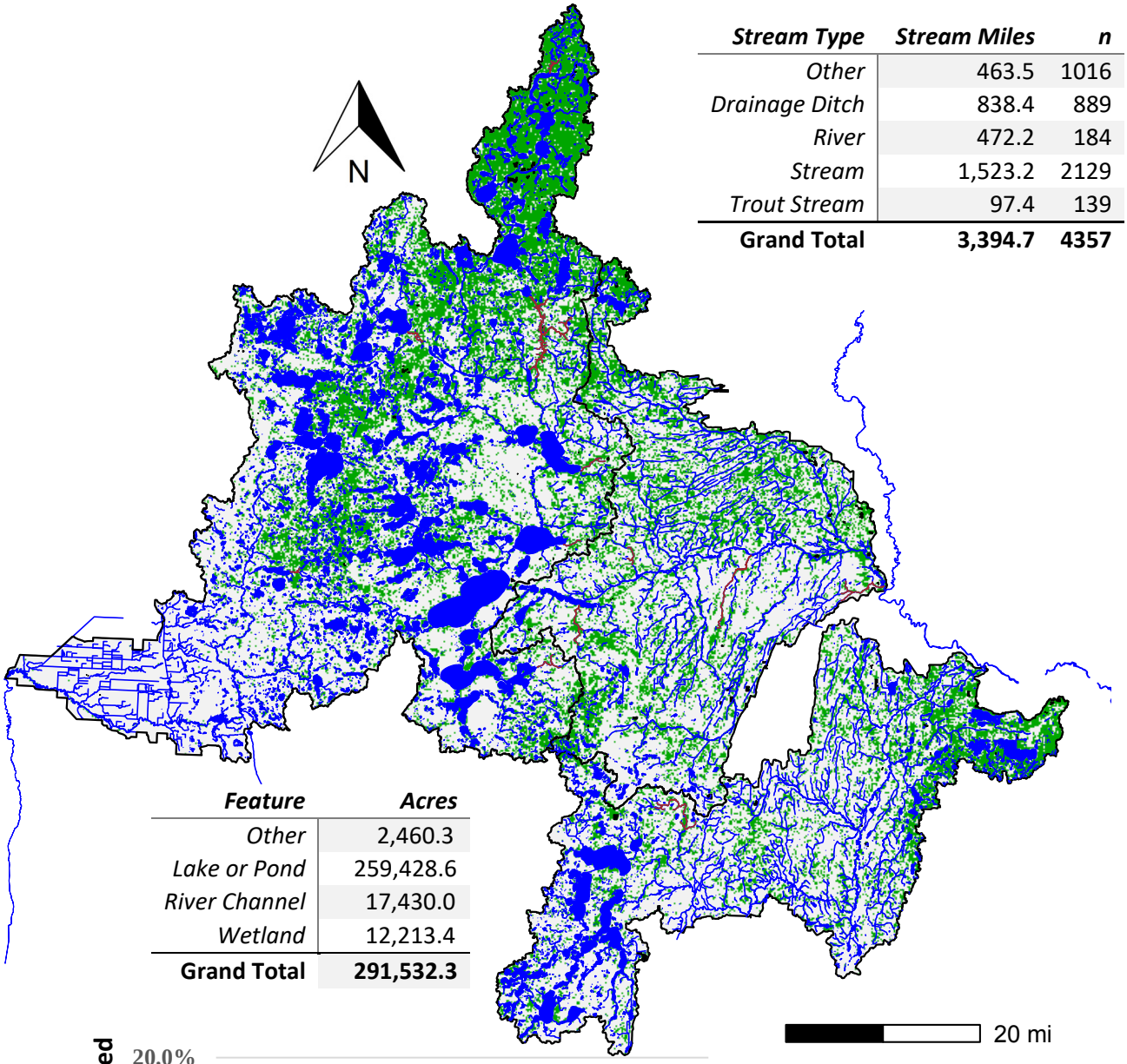


Forest Cover	*Acres*	*Percent*
Aspen	117,996	19.0%
Black ash	36,035	5.8%
Central hardwoods	58,060	9.3%
Northern hardwoods	93,022	15.0%
Other	144,079	23.2%
Oak - hickory	171,795	27.7%
Total	**620,988**	**100.0%**

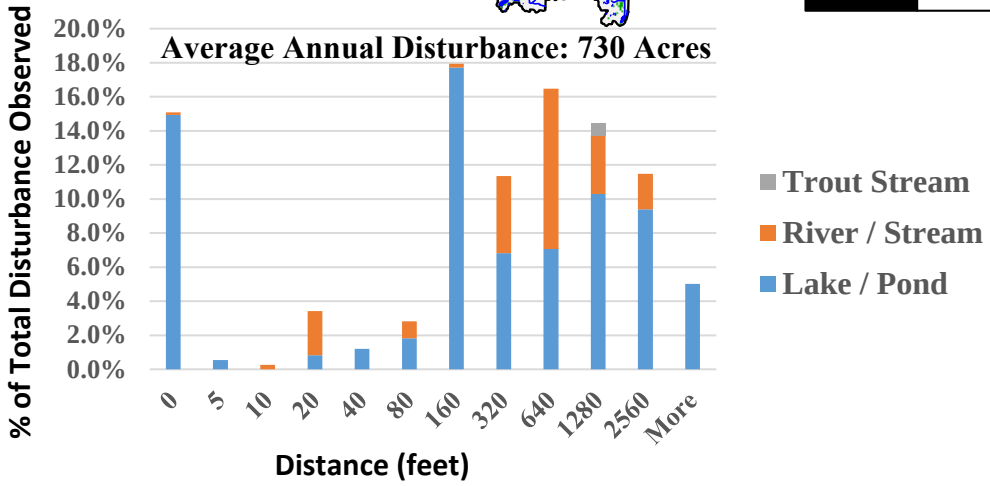


Forest Canopy Change (2012-2017)

Stream Type	Stream Miles	n
Other	463.5	1016
Drainage Ditch	838.4	889
River	472.2	184
Stream	1,523.2	2129
Trout Stream	97.4	139
Grand Total	**3,394.7**	**4357**



Feature	Acres
Other	2,460.3
Lake or Pond	259,428.6
River Channel	17,430.0
Wetland	12,213.4
Grand Total	**291,532.3**



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