

Update to the Minnesota Forest Resources Council on Progress of the Site Level Committee's Revision of Minnesota's Forest Management Guidelines (FMGs)

Executive Summary

Prepared August 8th, 2022, by Anna Stockstad and MFRC's Site Level Committee

The Minnesota Forest Resources Council (MFRC) Site Level Committee has implemented a three-prong approach to the review of the Minnesota voluntary site-level forest management guidelines (FMGs). First, a survey of stakeholder perceptions was conducted during the summer of 2020 and spring of 2021. Secondly, results of guideline monitoring from the 2014-2018 and 2020-2021 monitoring periods were used to evaluate field implementation of the FMGs. Thirdly, a comprehensive literature review, which was open for citation submission from the public through April 2022, was carried out to identify advances in research related to the FMGs. **The Site Level Committee has completed the three-prong review process and is now pivoting to creating recommendations for FMG revisions, clarifications, and education/training improvements.**

During June-August, 2022, the Site Level Committee and MFRC staff compiled and evaluated the information collected through the three-prong FMG review process with the objective to determine appropriate actions for each topical section of the FMGs (e.g., no action, improve education or minor updates, modify). At this time, no topical sections have been identified as needing major modifications. However, some sections require further investigation and review as identified through the review process. Further investigation of these topics may require additional consultation with specialists on the topic(s) and/or the ad hoc committee on climate change and carbon. The results of monitoring suggest that insufficient training/education contribute to lower implementation/compliance of some FMGs, not the content of the FMGs as written. In particular, a need to re-emphasize FMG education programs to practicing foresters was identified in addition to emphasizing field training opportunities when possible. **The summarized recommendations by the Site Level Committee for each topical section are outlined below. The full document with the summarized survey, monitoring, and literature review results is attached below following the Executive Summary.**

Filter strips

Decision: No major revisions. Strengthen guideline training related to placement of filter strips and investigate adding photos of filter strips along with training. Training should emphasize the need to avoid placing infrastructure in filter strips.

Justification: Majority of survey respondents did not recommend revision; monitoring results showed that compliance was lower due to placement of landings, skid trails, and roads within landings; literature review showed that post-2012 research supports current filter strip FMGs.

Riparian Management Zones (RMZs)

Decision: Further investigation and review is needed.

Justification: Higher percentage of survey respondents suggested need for revision; monitoring results showed overall high compliance and implementation; literature review showed that post-2012 research supports current RMZ FMGs.

Visual quality

Decision: No major revisions, but help guide other partners/agencies to update visual sensitivity information/maps along with improving access to full sensitivity ratings.

Justification: Some survey respondents suggested that visual sensitivity databases need to be updated; there has been high compliance during monitoring periods and FMG content as written for the sensitivity ratings was less of a concern. Current local/county-level visual sensitivity information and maps originated before MFRC/FMGs, any update efforts should remain at the local level rather than MFRC.

Cultural resources

Decision: No major revisions. Improve education/training related to cultural resources, specifically the identification of cultural resources in the field.

Justification: Majority of survey respondents reported that cultural resource guidelines do not need to be modified, but suggestions from survey respondents included improving field training, especially training focused on identifying cultural resources.

Spill kits

Decision: No major revisions.

Justification: Majority of survey respondents reported that spill kit guidelines do not need to be modified, frequency of visible spills during monitoring was low.

Seasonal ponds

Decision: No major revisions, but education and field training on the identification and ecology of seasonal ponds is needed.

Justification: Survey respondents suggested need for improved training on identification of seasonal ponds (especially in winter); implementation of filter strips is high, so it can be assumed that implementation of FMGs related to seasonal ponds/NOWW is also high; literature review showed that post-2012 research supports current seasonal pond FMGs.

Leave trees

Decision: Further investigation and review is needed.

Justification: Higher percentage of survey respondents reported that these guidelines should be modified in some way; monitoring found high implementation and compliance of leave tree

FMGs; literature review showed that post-2012 research supports current leave tree FMGs; leave tree suitability ratings may need to be updated to consider long-term performance with potential climate change and forest pest impacts.

Invasive species

Decision: Follow up on previous invasive species FMG work by Rob Slesak during 2012 revision, and leverage this previous work to improve education and resources on invasive species. More consideration is needed to decide if additional content related to invasive species is needed in the current FMGs.

Justification: Most survey respondents reported that FMGs are sufficient in effectiveness, but enhanced education and resources are needed to improve identification of invasive species.

Endangered, threatened, and special concern (ETS) species

Decision: No major revisions. Update all information related to ETS species in FMGs to be current.

Justification: Survey respondents reported that ETS classifications and issues of concern need to be updated; monitoring showed high implementation and compliance on agency and industry owned sites; literature review supported need for updates due to new ESA listings and the development of new HCPs in MN.

On-site infrastructure

Decision: No major revisions. Improve and implement education/training that could be used to improve implementation of filter strip FMGs in relation to on-site infrastructure, specifically related to the placement of infrastructure within filter strips and NOWW crossings.

Justification: Majority of survey respondents reported sufficient effectiveness and that current guidelines do not need to be modified; monitoring showed lower compliance in smaller sites and when infrastructure is placed within filter strips.

Rutting/compaction

Decision: No major revisions. Education should emphasize avoiding rutting in non-open water wetland skid trail crossings, especially in relation to non-frozen site conditions.

Justification: Majority of survey respondents reported sufficient effectiveness and that current guidelines do not need to be modified; monitoring showed that frequency of rutting was highest in non-open water wetland skid trail crossings; post-2012 research in the literature review supports current FMGs related to rutting/compaction.

Erosion control

Decision: No major revisions, but education should be enhanced to improve implementation while acknowledging the pre-harvest planning requirements and costs associated with erosion

control implementation. Education improvements should include emphasis on the importance of erosion control and how to cost-effectively implement erosion control practices.

Justification: Majority of survey respondents reported sufficient effectiveness and that these guidelines do not need to be modified; implementation of erosion control practices were relatively low and evidence of erosion was observed; post-2012 research in the literature review supports current FMGs related to erosion control. The current guidelines are sufficient, but enhanced education on erosion control would improve implementation and compliance.

Biomass harvest/slash management

Decision: No major revisions. Carbon issues related to biomass harvesting are separate from the biomass FMG content.

Justification: Majority of survey respondents reported sufficient effectiveness and that these guidelines do not need to be changed; sites where a biomass harvest occurred during monitoring had high compliance; post-2012 research in the literature review supports CWD and FWD retention strategies as outlined by the FMGs.

Climate change and carbon

Decision: Further investigation and review is needed, defer to the ad hoc climate change and carbon committee for specific recommendations and guidance on climate change and carbon issues.

Justification: A guidebook on climate adaptation for forest managers already exists through NIACS, and planning when and where to harvest based on climate projections is beyond the scope of the guidelines. Changes to the current guidelines could be in the form of an addendum and/or the addition of a "climate smart" or similar logo to indicate FMGs that mitigate climate change impacts and that support long-term climate change goals.

2022 Revision of MN FMGs: Recommended actions and justification

Prepared and edited June 27th, 2022, by Anna Stockstad, Dick Rossman

Revised and prepared for Minnesota Forest Resources Council August 16th, 2022

Survey language and results from Hannah Friesen, Kristyn Beutow

Monitoring report language and results (2014-2018, 2020-2021) from David Wilson, MN DNR

As requested by the Site-Level Committee in June 2022, the objective of this document is to present a summarized report of the stakeholder survey, monitoring reports, and literature review results and to provide **broad guidance** on next steps for the 2022 revision of Minnesota’s voluntary site-level forest management guidelines (FMGs).

The following report summarizes all available results to date related to the 2022 revision of the FMGs. Each section below contains results from the stakeholder survey (summer 2020 – spring 2021), site-level monitoring reports (2014-2018, 2020 – 2021), and literature review (winter 2021 – spring 2022). The 2014-2018 monitoring report is a **statewide** report, meanwhile only **six watersheds** were monitored during the 2020-2021 period. Only a summary of results is included here, so we advise that the Site-Level Committee reviews the full monitoring report documents for more detail.

Potential actions, justified based on the results of the survey, monitoring reports, and literature review, are included for each section of the guidelines to help to streamline decision-making for the Site-Level Committee during the revision process. **Proposed actions are not intended as recommendations for specific changes, but instead to serve as a guide for the decision-making of the Site-Level Committee during the revision process.**

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Filter Strips and Water Quality

Changes implemented in 2012 revision

No changes were implemented related to filter strips and water quality.

Survey results

- 79% reported sufficient or better effectiveness of the FMGs related to filter strips/water quality
- 61% of respondents reported that these FMGs do not need to be modified, and 23% reported that they should be modified.
- 7% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: clarify differences between guidelines related to filter strips and RMZs, review and reassess harvest guidelines within filter strips, widen filter strip requirements, clarify how soil impacts quality of filter strip, educate on watersheds, include photos of the “do’s and don’ts”.

Monitoring report results

For all filter strips recorded in the statewide report, 2.6% had exposed mineral soil within the filter strip at the time of monitoring visits, with most of these due to presence of roads or landings within the filter strip. Only 0.26% of filter strips (six strips) resulted in sediment being deposited into the adjacent wetland. Overall, 97.4% of filter strips met the minimum disturbed soil recommendations of no concentrated soil exposure or less than 5% dispersed soil exposure. However, infrastructure placement reduced overall compliance on filter strip implementation to 83.3%; mostly due to placement of landings, skid trails, or roads within the filter strip (often with an alternative upland site available).

2014-2018 Statewide Site-Level Monitoring Report Table 13. Filter strip performance, soil exposure, erosion, and sediment reaching a waterbody.

WSU	Filter Strips (n)	Strips w/ Soil Exposure	Strips w/ Landing & No Soil Exposure	Road or Skid Trail on Strip	Strips w/ Erosion	Strips w/ Sediment to Waterbody	Percent Compliant*
CWR	170	1	8	8	0	0	92.4%
LLP	218	7	14	21	1	1	87.2%
LRRR	151	4	39	22	0	0	51.7%
MGR	139	2	9	3	2	1	89.2%
MH	126	5	9	7	0	0	81.7%
MRBS	178	8	12	11	4	3	82.6%
RLB	172	4	24	7	0	0	80.2%
RLCW	114	0	11	2	0	0	88.6%
ROL	43	0	7	5	0	0	76.7%

RR	162	0	3	0	0	0	98.1%
SCKS	350	7	35	13	2	1	86.6%
SCN	163	0	6	0	0	0	96.3%
SEMN	30	3	1	7	1	0	66.7%
SUP	149	6	7	7	0	0	85.2%
VRR	147	13	24	15	1	0	59.9%
Total	2,312	60	209	128	11	6	83.3%

Recommendations

- Future training should include implementation of water diversion or erosion control on all roads, whether new or existing.
- Emphasis should continue to be placed on avoiding location of skid trails and landings within filter strips where practical.

Literature review results

Three references related to filter strips and water quality were submitted to the online bibliography. A literature review by Cristan et al. (2016) summarized the effectiveness of forestry best management practices (BMPs) related to water quality across the United States. Overall, this review found that BMPs can minimize erosion and sedimentation, but high implementation rates (compliance) and quality are critical for maximizing the effectiveness of BMPs in improving water quality by reducing erosion and sediment yield. The authors emphasized the importance of pre-operation planning, logger training, and landowner knowledge of forestry BMPs to improve implementation. The review highlighted specific BMP guidelines that maximize water quality, such as drainage structures and erosion control on forest roads, sediment control structures, the application of these BMPs during forest operations instead of afterwards, effective skid trail closure practices (waterbars and/or applying slash or mulch) and improving stream crossings.

Another review by Edwards et al. (2016) synthesized the effectiveness of BMPs related to forest roads in the context of protecting water quality. The use of various types of filter strips (termed buffer strips in the paper), both in forest and agricultural settings, was reviewed. The current MN filter strip FMG (General Guidelines page 25) agreed with the guidelines determined to be effective in the review (Edwards et al. Table 28).

Slesak et al. (2018) presented a framework for monitoring of BMP implementation and water quality as applied in Minnesota (used for 2020-2021 Site-Level Monitoring Report).

Recommended action and justification

Decision: No major revisions. Strengthen guideline training related to filter strips and investigate adding photos of filter strips along with training. Training should emphasize the need to avoid placing infrastructure in filter strips.

Justification: Majority of survey respondents did not recommend revision; monitoring results showed that compliance was lower due to placement of landings, skid trails, and roads within landings; literature review showed that post-2012 research supports current filter strip FMGs.

1. Original proposed action: **Strengthen education/training**
 - a. Justification:
 - i. Monitoring report suggested the inclusion of water diversion/erosion control implementation on all roads in future training.
 - ii. Monitoring report suggested that training should continue to emphasize not placing landings and skid trails within filter strips, where practical.
 - iii. Add pictures to guidelines along with training.
 - b. Economic CBA: None required.

Riparian Management Zones

Changes implemented in 2012 revision

- Allow RMZ area to count towards recommended 5% leave tree area
- Simplification of RMZ width categories (reduced to three)
- Modification of RMZ width depending on stream or lake characteristics (Table GG-2)
- Modification of RMZ residual basal area (standardized to 60 ft² for all RMZs)

Survey results

- 76% reported sufficient or better effectiveness
- 50% of respondents reported that FMGs in this topic do not need to be modified, 28% reported that they should be modified
- 10% indicates that FMGs related to this topic are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: clarify and simplify the types of surface water around which RMZ guidelines are applied, review impacts of 2012 revision which allowed RMZ areas to be counted towards total reserve land, reduce clauses, education on what riparian zones are, enhance formatting, shift from one-size-fits-all to a more flexible approach

Monitoring report results

Overall, there is a continuing trend of generally good RMZ guideline implementation. For all watershed units during the statewide 2014-2018 monitoring period, total compliance of RMZs guidelines was 72%. Compliance on trout streams was 87% during this monitoring period. In those watersheds reported in the 2020-2021 monitoring period, 73% of observed RMZs in the six observed watershed units met guideline recommendations for width and basal area of forest retention. Compliance on trout waters was 64% for the same reporting period. The lowest level of compliance was in the SUP watershed on county and NIPF land during this period.

Recommendations

- Increase outreach targeting county and NIPF landowners in the SUP watershed with emphasis on the benefits of RMZ implementation to increase compliance in this watershed
- Clarify communication of CWD retention in RMZ guidelines (often confused with guidelines that recommend avoiding placement of slash within filter strips) to improve implementation

2014-2018 Statewide Site-Level Monitoring Report Table 18. Riparian management zone implementation in monitored watershed units.

WSU	Sites (n)	Sites w/RMZ (n)	RMZs (n)	Average RMZ Width (ft)	Average Guideline Width (ft)	Totally Compliant	Partially Compliant	Mean Partial Compliance*
CWR	31	12	24	180	216	75%	12%	57%

LLP	32	15	25	182	209	80%	12%	92%
LRRR	31	13	14	137	151	64%	36%	78%
MGR	29	13	16	231	257	69%	19%	60%
MH	35	9	14	277	286	86%	14%	83%
MRBS	34	13	17	251	268	76%	24%	71%
RLB	36	15	18	128	160	50%	22%	82%
RLCW	24	4	4	142	155	75%	25%	82%
ROL	15	5	7	189	196	100%	0%	0%
RR	28	4	9	-	50	22%	44%	73%
SCKS	34	11	16	214	229	81%	12%	67%
SCN	37	22	30	280	286	87%	13%	78%
SEMN	12	2	3	191	243	67%	33%	52%
SUP	30	16	17	169	171	88%	12%	87%
VRR	26	12	29	193	227	48%	24%	66%
Overall	434	166	243	196	218	71.6%	18.4%	74.9%

*Average level of compliance with width and BA recommendation on partially compliant sites.
(Partial Compliance * Mean Partial Compliance = Weighted Partial Compliance)

2020/2021 Site-Level Monitoring Report Table 7. RMZs meeting guideline recommendations by watershed sample unit.

Watershed Unit	Total Sites	Sites with RMZ	Total RMZs (#)	Trout Streams (%)	Non-trout Streams	Lakes & OW W	Total Compliance (%)	Partial Compliance (>50%)
MH	33	4	7	-	100%	100%	100%	-
SUP	33	24	45	62%	68%	-	66%	24%
RR	23	8	10	-	67%	50%	67%	33%
MGR	34	11	20	100%	71%	86%	76%	-
VRR	33	10	13	100%	90%	100%	91%	9%
RLCW	25	5	13	-	67%	50%	67%	22%
Total	181	62	108	68%	75%	79%	73%	17%

Literature review results

One citation related to RMZs was submitted to the online bibliography. Kastendick et al. (2012) investigated the impacts of upland clearcutting on soil nutrients when combined with uncut and partially harvested RMZs. This study found that RMZs sustain riparian soil nutrient availability and found that the nutrient pulse post-harvesting in the upland does not move far into the uncut RMZ. The RMZ specifications used in this study reflected the MN Site-Level FMGs (at the time of publication), and the results support the effectiveness of these guidelines. It is important to note that this study occurred prior to the 2012 revision and therefore implemented pre-2012 RMZ guidelines.

Recommended action and justification

Decision: Further investigation and review is needed.

Justification: Higher percentage of survey respondents suggested need for revision; monitoring results showed overall high compliance and implementation; literature review showed that post-2012 research supports current RMZ FMGs.

1. Original proposed action: **Further investigation and review needed**
 - a. Justification:
 - i. 28% of respondents reported that guidelines should be modified.
 - ii. Slope should be inserted as a significant determinant of RMZ width.
 1. In some steep slope situations, minimum RMZ's allow for cutting right to the edge of the bluff.
 - iii. RMZ widths should be increased for streams that have natural floodplain that is wider than current RMZ recommendations suggest.
 1. Larger rivers tend to have larger floodplains, and larger river floodplains also serve as important wildlife travel corridors.
 - iv. Remove the ability to harvest within RMZ's when adjacent to trout streams, with reasonable exemptions
 1. Harvesting within the RMZ decreases shade and the supply of woody debris to the stream.
 - b. Economic CBA: **Required** (changes amount of harvestable wood).

Visual Quality

Changes implemented in 2012 revision

No changes were implemented related to visual quality.

Survey results

- 81% reported sufficient or better effectiveness
- 53% of respondents reported these FMGs do not need to be modified, 19% reported that they should be modified
- 6% of respondents indicated that FMGs are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: update sensitivity classifications based on current use and development, create more user-friendly tools for accessing visual sensitivity ratings, clarify and simplify guidelines for various sensitivity ratings, opportunities for education regarding proper forest management, inclusion of slash piles and removal in guidelines, update baseline and GIS data. Many respondents commented that they find the visual quality standards unnecessary because they feel it hides what they are doing from the public, which is something that should be considered when revising the guidelines.

Monitoring report results

Average compliance for the 16 northern counties with visual quality guidelines during the statewide 2014-2018 monitoring period was 81.4%. Visual quality guidelines were met for ~66% of sites that had one or more visually sensitive features (vistas) during the 2020-2021 monitoring period. Guidelines were not met in these cases due to apparent harvest size exceeding guideline recommendations, slash piles being visible from vistas, or landings being located within roads or trails.

Literature review results

No citations related to visual quality were submitted to the online bibliography.

Recommended action and justification

Decision: No major revisions, but help guide other partners/agencies to update visual sensitivity information along with improving access to full sensitivity ratings.

Justification: Some survey respondents suggested that visual sensitivity databases need to be updated; there has been high compliance during monitoring periods and FMG content as written for the sensitivity ratings was less of a concern. Current local/county-level visual sensitivity information and maps originated before MFRC/FMGs; any update efforts should remain at the local level rather than MFRC.

1. Original proposed action: **Update information and educate**
 - a. Justification:
 - i. Some survey respondents suggested that sensitivity classifications should be updated based on current use and development.
 - ii. Survey results also recommended the need for more user-friendly tools for accessing visual sensitivity ratings.
 - iii. Survey respondents reported that the baseline and GIS data need to be updated.
 - iv. Some survey respondents suggested that guidelines for various sensitivity ratings need to be clarified and simplified.
 - v. Survey results showed potential need for more education related to visual quality, particularly slash piles and removal.
 - b. Economic CBA: None required.

Cultural Resources

Changes implemented in 2012 revision

No changes were implemented related to cultural resources.

Survey results

- 86% reported sufficient or better effectiveness
- 67% of respondents reported that these FMGs do not need to be modified, 14% reported that they do need to be modified
- 3% of respondents indicated that these FMGs are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: Enhance education and improve access to information concerning locating and identifying cultural resources, simplify and clarify existing guidelines, provide field training to aid the identification of CRs, consider expanding CRs to include ecosystem resources

Monitoring report results

Cultural resources FMG implementation was not reported.

Literature review results

One citation related to cultural resources was submitted to the online bibliography. Chamberlain et al. (2019) synthesized the state of knowledge and emerging issues related to nontimber forest products in the United States. The authors stressed the importance of the inclusion of traditional and local ecological knowledge, community-guided collaboration, and innovative institutional arrangements when managing/sustaining nontimber forest products. This review also emphasized the importance of integrating nontimber species into forest research and the effective monitoring of these resources to maintain sustainable use and health of forest ecosystems.

Recommended action and justification

Decision: No major revisions. Improve education/training related to cultural resources.

Justification: Majority of survey respondents reported that cultural resource guidelines do not need to be modified, but suggestions from survey respondents included improving field training, especially training focused on identifying cultural resources.

1. Original proposed action: **Improve education/training**
 - a. Justification:
 - i. Survey respondents suggested that education and access to information related to locating and identified CRs should be improved.
 - ii. Survey respondents suggested that field training could be provided to improve the identification of CRs.
 - b. Economic CBA: None required.

Spill Kits

Changes implemented in 2012 revision

- Updated requirements related to the reporting and handlings of petroleum spills

Survey results

- 79% reported sufficient or better effectiveness.
- 62% of respondents reported that these FMGs do not need to be modified, 13% reported that they should be modified.
- 6% of respondents indicated that these FMGs are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: prescribe a minimum spill kit for enhanced compliance and to help meet certification standards, describe what an adequate spill kit includes, increasing access to spill kits by requiring them in more on-site machinery, and more training.

Monitoring report results

Implementation of spill kit guidelines were not explicitly measured during monitoring. It was reported that during the 2020-21 monitoring period, 3.4% of all landings had evidence of fueling and equipment maintenance activity as evidenced by visible oil/petroleum product stains (oil spots) on the landing. The lack of observable evidence of spills on landings suggests high compliance to spill kit guidelines.

Literature review results

No citations related to spill kits were submitted to the online bibliography.

Recommended action and justification

Decision: No major revisions.

Justification: Majority of survey respondents reported that spill kit guidelines do not need to be modified, frequency of visible spills during monitoring was low.

1. Original proposed action: **No major revisions**
 - a. Justification:
 - i. 79% of respondents reported sufficient effectiveness, 62% reported guidelines do not need to be modified
 - ii. The monitoring report suggested that there was high compliance to spill kit guidelines (only 3.4% of landings with visible oil stains).
 - b. Economic CBA: None required.

Seasonal Ponds

Changes implemented in 2012 revision

No changes were implemented related to seasonal ponds.

Survey results

- 72% reported sufficient or better effectiveness
- 52% of respondents reported that these FMGs do not need to be modified, 26% reported that they do need to be modified.
- 11% of respondents indicated these FMGs are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: clarify the description of seasonal ponds, improve education on identification of seasonal wetlands during different seasons (e.g., difficult to identify during winter when snow covered), emphasize the ecological importance of these features, implement training on how to identify seasonal ponds, include new science and research

Monitoring report results

For the purposes of implementation monitoring, seasonal ponds fall into the general category of non-open water wetlands (NOWW). Out of 2,166 total waterbodies observed during the 2014-2018 monitoring period, 1,797 were classified as NOWW. Out of 846 total waterbodies observed during the 2020-2021 monitoring period, 718 were classified as NOWW. Due to the high compliance of filter strips, it can be assumed that the application of these guidelines to seasonal ponds would also be high. 85.4% of skid trail crossings occurred on NOWW during the 2014-2018 monitoring period. Rutting occurred on 14% of all NOWW crossings during the 2020-2021 monitoring period.

Literature review results

Five citations related to seasonal ponds were submitted to the online bibliography. Bischof et al. (2013) found that timber harvesting may rapidly modify canopies over seasonal ponds and change litter inputs to seasonal ponds, which supports the use of filter strips around seasonal ponds and avoiding disturbances within the seasonal pond.

The results of the literature review by Calhoun et al. (2014) suggested that an adaptive approach is the most effective way to manage seasonal ponds.

The literature review by Hofmeister et al. (2022) supports the use of harvest buffer around seasonal ponds. The authors listed challenges related to the conservation of seasonal ponds, such as inconsistent definitions, lack of thorough inventories, limited regulatory protections, and landowner attitudes toward pond conservation.

Mui et al. (2016) investigated the seasonal landscape connectivity for Blanding's turtles and the results support the use of a harvest buffer around seasonal ponds to protect the habitat of this species.

Previant & Nagel (2014) emphasized the importance of seasonal ponds as a critical landscape component and the maintenance of tree species diversity surrounding seasonal ponds. The authors recommend that FMGs not only focus on minimizing disturbance to the seasonal pond, forest floor, and canopy, but also to focus on maintaining a diverse forest surrounding the seasonal pond.

Recommended action and justification

Decision: No major revisions. Education and field training on the identification and ecology of seasonal ponds is needed.

Justification: Survey respondents suggested need for improved training on identification of seasonal ponds (especially in winter); implementation of filter strips is high, so it can be assumed that implementation of FMGs related to seasonal ponds/NOWW is also high; literature review showed that post-2012 research supports current seasonal pond FMGs.

1. Original proposed action: **Improve education/training**
 - a. Justification:
 - i. Survey respondents suggested that the description of seasonal ponds needs to be improved.
 - ii. Survey respondents also suggested that training should be improved to include the identification of seasonal ponds (including during the winter when snow covered), the need to emphasize the ecological importance of seasonal ponds and should include new research related to seasonal ponds.
 - iii. 82.7% of leave tree clumps associated with on-site features were used on non- open water wetlands which include seasonal ponds.
 - b. Economic CBA: None required.

Leave Trees

Changes implemented in 2012 revision

- Clarification that scattered and clumped leave trees can be used in conjunction to achieve recommended retention levels
- Emphasis on utilizing a leave tree configuration which achieves a desired future condition
- Allow consideration of economic value when choosing which leave trees to retain

Survey results

- 74% reported sufficient or better effectiveness
- 53% of respondents reported that these guidelines do not need to be modified, 30% reported that they should be modified
- 10% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly in the forest
- Suggestions from survey respondents: clarify 5% language in guidelines as a *minimum* retention rate, encourage reserve patches over individual leave trees to address windthrow, provide additional guidance on maintaining reserves that are representative of the stand and healthy (this section would emphasize the ecological benefits of leaving live trees at sites, as many survey respondents voiced that they find this FMG unnecessary in the recommendations section).

Monitoring report results

Leave tree distribution

Total compliance across watershed units during the statewide 2014-2018 monitoring period was 95%, with the lowest compliance in the LRRR watershed. Total compliance across the six watershed units during the 2020-2021 monitoring period was 76%, and net compliance (weighted by acreage) was 90%. During the 2020-2021 monitoring period, 109 out of 146 observed sites had adequate leave trees to meet recommended guidelines. Outreach on leave tree guidelines to the MGR and VRR watersheds targeting smaller harvests would likely increase statewide implementation of leave tree guidelines.

2020/2021 Site-Level Monitoring Report Table 16. Percent of sites that meet or exceed leave tree guidelines.

Monitoring Year	Number of Sites for Which Guidelines Apply	Sites With ≥ 6 Scattered Leave Trees / Acre	Sites With $\geq 5\%$ of Site in Leave Tree Clumps (at least $\frac{1}{4}$ acre)	Sites with ≥ 6 Scattered LTs/ Acre or $\geq 5\%$ of Site in LT Clumps, both, or in combination	Sites Citing Silviculture 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%
2014-18	373	54%	28%	92%	13	95%
2020-21	146	42%	51%	75%	2	76%

2014-2018 Statewide Site-Level Monitoring Report Table 23. Watershed scale compliance with leave tree guideline recommendations.

WSU	Total Sites (n)	Total Acres	Sites w/Leave Tree Retention (n)	Scattered Leave Trees per Acre (n)	Percent of Site in Leave Tree Clumps	Percent of Site in RMZ	Percent Net Compliance
CWR	31	800	22	5.01	5.45	12.24	96.1
LLP	32	1,449	28	6.08	8.01	6.93	96.1
LRRR	31	1,059	26	5.29	5.51	6.71	82.9
MGR	29	922	27	2.79	2.05	7.85	86.6
MH	35	981	30	28.11	2.05	6.17	97.8
MRBS	34	882	26	8.15	5.12	9.36	95
RLB	36	1,323	30	5.79	2.7	7.1	96.1
RLCW	24	746	23	9.41	3.97	2.96	100
ROL	15	272	10	7.47	10.2	2.86	100
RR	28	342	17	19.72	3.3	2.16	97.8
SCKS	34	2,021	25	6.63	4.53	3.65	87.7
SCN	37	2,578	34	2.59	3.65	14.4	96.2
SEMN	12	263	9	10.58	2.09	4.37	100
SUP	30	872	22	7.58	5.04	12.35	97.1
VRR	26	1,196	24	3.6	6.73	9.65	92.6
Total	434	15,708	353	8.6	4.7	7.2	93.8

2020/2021 Site-Level Monitoring Report Table 17. Number (%) leave tree compliance by watershed sample unit. **Weighted by site acres.**

WSU	Total Sites	Sites Evaluated for LTs	Scattered LTs	LTC	Both	Combo	% Site Acres Meeting Guidelines	% Net Compliance (Acres)
MH	33	26	23	13	11	1	79%	86%
SUP	33	30	30	21	21	2	98%	99%
RR	23	12	10	2	2	1	78%	88%
MGR	34	25	23	12	11	1	67%	77%
VRR	33	29	29	12	12	3	71%	88%

RLCW	25	22	22	12	12	1	92%	97%
Total	181	144	137	72	69	9	83%	90%

Leave tree clump characteristics

The percentage of sites utilizing leave tree clumps to meet retention guidelines was at 51% in the 2020-2021 monitoring period, with less than blowdown events of less than 5% occurring in 96% of the clumps (average blowdown in clumps ~2.7%). Three of the five most frequently occurring species in leave tree clumps are ranked as having excellent or good value to wildlife during the statewide 2014-2018 and 2020-2021 monitoring periods.

2014-2018 Statewide Site-Level Monitoring Report Table 25. 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
<i>Aspen</i>	106	179	28.96	Excellent
<i>White Cedar</i>	92	101	16.34	Good
<i>Elm</i>	90	99	16.02	Excellent
<i>Black Ash</i>	79	119	19.26	Excellent
<i>Jack pine</i>	73	88	14.24	Fair
<i>Red pine</i>	35	76	12.3	Good
<i>N. Red Oak</i>	28	87	14.08	Excellent
<i>Black</i>	16	32	5.18	Fair
<i>Red maple</i>	15	122	19.74	Good
<i>Sugar maple</i>	14	80	12.95	Excellent
<i>Paper birch</i>	13	138	22.33	Fair
<i>White pine</i>	13	22	3.56	Excellent
<i>White Ash</i>	8	12	1.94	Excellent
<i>Balsam Fir</i>	8	57	9.22	Fair
<i>White</i>	7	29	4.69	Good
<i>Basswood</i>	5	35	5.66	Excellent
<i>Tamarack</i>	4	15	2.43	Good
<i>Hickory</i>	3	9	1.46	Good
<i>Pin Oak</i>	3	12	1.94	Excellent
<i>Other</i>	3	12	1.94	N/A
<i>Balm of</i>	1	11	1.78	Excellent
<i>Burr Oak</i>	1	23	3.72	Excellent
<i>Tag alder</i>	1	1	0.16	Excellent
<i>Black cherry</i>	0	10	1.62	Excellent
<i>Hackberry</i>	0	1	0.16	Good
<i>White oak</i>	0	8	1.29	Excellent

Literature review results

Leave tree distribution

Two citations related to leave tree distribution were submitted to the online bibliography. The literature review by Corace (2018) suggested that BMPs should focus on the management of the forest as a whole, not the management of a particular species, so forest management should encompass management of bird habitat. Forest-bird habitat management should account of spatial and temporal variation, so leaving a variety of species, distributions, and clumps of leave trees supports bird habitat.

The results of Grinde et al. (2020) support the benefit of leave trees for birds and small mammals. In this study, tree retention treatments (dispersed tree retention, aggregated tree retention) increased biodiversity of small mammal and breeding bird communities at 7-8 years post-harvest, and the authors found no effect of biomass removal on bird and small mammal communities.

Leave tree clump characteristics

Three citations related to leave tree clump characteristics were submitted to the online bibliography, and four citations were submitted in the letter by Ted Dick (DNR F&W), with recommendations below.

Berg et al. (2020) investigated the role of local cavity tree density in the selection of den sites by female fishers in northern MN. This study found that fishers exclusively use cavities in large diameter trees, which supports the retention of snags and large diameter cavity trees in high density patches (clumps).

Roth et al. (2014) found that retaining leave trees greater than 16cm in diameter created the highest densities of mal golden-winged warblers in aspen forests, which supports the retention of a higher density of large diameter leave trees to support wildlife habitat.

Recommended action and justification

Decision: Further investigation and review is needed.

Justification: Higher percentage of survey respondents reported that these guidelines should be modified in some way; monitoring found high implementation and compliance of leave tree FMGs; literature review showed that post-2012 research supports current leave tree FMGs; leave tree suitability ratings may need to be updated to consider long-term performance with potential climate change and forest pest impacts.

1. Proposed action: **Further investigation and review needed**

a. Justification:

- i. Include language on leave trees in timber harvesting section of guidelines
- ii. Stress importance of sizes available prior to management in leave tree decisions during training
- iii. Monitor sizes of leave trees in monitoring efforts
- iv. Bolster information on sizes of trees suggested for leave trees that encourage habitat for woodpeckers
- v. Add information about northern long eared bat habitat requirements as related to leave trees (pending HCP recommendations)
- vi. Include direction on how long leave trees need to remain unharvested and strongly suggest a method for identification and documentation of leave trees in training so that future managers will not harvest leave trees "before their time"
- vii. Change ash suitability classification to "fair" due to presence of EAB.
- viii. Incorporate language changes stressing consideration of factors affecting long-term presence of leave trees at a landscape level in site level leave tree decisions, particularly in heavily managed aspen-dominated landscapes.

b. Economic CBA: None required.

Invasive species

Changes implemented in 2012 revision

- New information on the threat of invasive species, related laws and regulations, and useful resources

Survey results

- 63% reported sufficient or better effectiveness
- 48% of respondents reported that these FMGs do not need to be modified, 19% reported that they should be modified.
- 10% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: enhance education regarding the identification of invasive species, emphasize the importance of cleaning equipment between sites (mirror DNR's "Clean, Play, Go" messaging for recreational vehicles), provide more resources for identifying potential invasives prior to management and for reporting invasives encountered during management activities, format invasive species section better (information difficult to find)

Monitoring report results

Invasive species FMG implementation was not reported.

Literature review results

No citations related to invasive species were submitted to the online bibliography.

Recommended action and justification

Decision: Follow up on previous invasive species FMG work by Rob Slesak during 2012 revision, and leverage this previous work to improve education and resources on invasive species. More consideration is needed to decide if additional content related to invasive species is needed in the current FMGs.

Justification: Most survey respondents reported that FMGs are sufficient in effectiveness, but enhanced education and resources are needed to improve identification of invasive species.

1. Proposed action: **Further investigation of previous work. Improve education, resources, and format**
 - a. Justification:
 - i. Draft invasive species FMGs were already drafted by Rob Slesak during 2012 revision – leverage this previous work to improve education and resources.
 - ii. Survey respondents suggested the following:
 1. Enhance education regarding identification of invasive species
 2. Emphasize cleaning of equipment between sites
 3. Provide more resources for identifying invasives
 4. Reformat invasive species section (respondents reported that the information was difficult to find)
 - b. Economic CBA: None required.

Endangered, Threatened, and Special Concern (ETS) Species

Changes implemented in 2012 revision

No changes related to ETS species were implemented in the 2012 revision.

Survey results

- 72% reported sufficient or better effectiveness
- 56% of respondents reported that these FMGs do not need to be modified, 21% reported that they should be modified
- 6% of respondents indicated that FMGs are not being implemented well or are being implemented too narrowly
- Suggestions for survey respondents: update to reflect current ETS classifications and issues of concern, enhance education on ETS species identification and how to avoid impacts on ETS species, highlight species that are vulnerable to forest management, create a more user-friendly database to check if species is classified as ETS.

Monitoring report results

During the statewide 2014-2018 monitoring period, over 90% of agency and industry owned sites reported that they checked for ETS prior to initiating activities. Only 5.9% of NIPF owned sites reported that they checked for ETS prior to initiating activities during this monitoring period.

2014-2018 Statewide Site-Level Monitoring Report Table 27. Sites checked for threatened and endangered species (ETS) listed by ownership.

<u>Ownership</u>	<u>Sites (n)</u>	<u>% Checked</u>	<u>% Protected</u>
County	112	87.5	42.9
Federal	29	93.1	100
Industry	33	90.9	0
NIPF	119	5.9	0
State	130	93.1	83.3
Tribal	11	81.8	100
Total	434	67.3	55

During the 2020-2021 monitoring period, self-reported checking for ETS during the planning process was high (99%) for agency and industry lands, and 25% for NIPF lands. For federal, state, county, and industry sites, appropriate management actions were taken to protect the ETS in 89% of cases. For 18 monitoring sites identified as having known ETS species adjacent to the site, 11 indicated checking appropriate sources and 7 of these failed to identify any known ETS species identified in the NHIS query. The disparity between sites that indicated checking appropriate sources for known ETS species, and the ability to correctly list species identified in

the NHIS database may be due to a time lag between species identification in the field and entry into the database.

Recommendations

Outreach to NIPF landowners and loggers is recommended to improve use of the NHIS and implementation of related guidelines. A more publicly accessible version of NHIS providing simple presence/absence information for the broad class of ETS species would help in making these checks easier to accomplish for stewards not directly connected to DNR Natural Heritage Program. Simply knowing that an ETS is present in the vicinity of a harvest would go a long way towards justifying the additional effort involved with contacting Natural Heritage staff for additional information.

Literature review results

Five citations related to ETS species were submitted to the online bibliography. Two of these citations provided information and guidance for the rusty-patched bumblebee (*Bombus affinis*) which has been listed as federally endangered since the 2012 revision. The US Fish and Wildlife Service recommends avoiding removal of foraging habitat greater than 2 acres.

Two of the citations are relevant to the northern long-eared bat (*Myotis septentrionalis*), which is currently listed as federally threatened (proposal to classify as endangered as of March 2022) and of special concern in MN. One of these citations (Johnson & King, 2018) provide guidance on habitat consideration for bats affected by white-nose syndrome (which includes northern long-eared bat, little brown bat – special concern in MN).

The fifth citation is the Minnesota Wood Turtle Conservation Plan (MN DNR 2020). This plan recommends increasing terrestrial habitat connectivity to promote wood turtle habitat. The wood turtle is not a federally listed species, but it is widely considered a species at risk and is under consideration for federal listing in 2023. The wood turtle is listed as globally endangered by the IUCN and is ranked as vulnerably in the United States. The wood turtle is listed as threatened in Minnesota.

Recommended action and justification

Decision: No major revisions. Update all information related to ETS species in FMGs to be current.

Justification: Survey respondents reported that ETS classifications and issues of concern need to be updated; monitoring showed high implementation and compliance on agency and industry owned sites; literature review supported need for updates due to new ESA listings and the development of new HCPs in MN.

1. Proposed action: **Update with current ETS listings and references**
 - a. Justification:
 - i. Survey respondents indicated that ETS guidelines should be updated with current listings.
 - ii. 72% reported sufficient effectiveness.
 - iii. Rusty patched bumblebee has been federally listed as endangered since 2012
 - iv. Northern long-eared bat is federally threatened and of special concern in MN, acknowledge Aitkin-Carlton HCP for northern long-eared bat.
 - v. DNR F&W suggested that Pesticide Use guidelines should reference care needed in use on rare plant communities.
 - b. Economic CBA: None required.

On-site Infrastructure

Changes implemented in 2012 revision

- Modification of the maximum allowable infrastructure amount based on harvest size (Table TH-1)

Survey results

- 88% reported sufficient or better effectiveness
- 73% of respondents reported that these FMGs do not need to be modified, 10% reported that they should be modified
- 5% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly.
- Suggestions from survey respondents: limit landing and/or road size, increase emphasis on safety, improve education on culvert placement and proper erosion control to meet MN Wetland Conservation Act requirements and forestry exemption criteria, address the design and usage of seasonal roads (e.g., ice roads, winter-use roads)

Monitoring report results

During the statewide 2014-2018 monitoring period, the estimated mean infrastructure per site was 2.97%. Overall, 78.6% of sites monitored from 2014-2018 met the recommended infrastructure amounts based on 2012 guidelines. During this period, 35% of sites had a landing in a wetland, filter strip, or RMZ where an alternative upland site was available.

During the 2020-2021 monitoring period, the mean infrastructure per site was estimated to be 2.1%, which continues the decline since 2009. On the site level, 22% of sites in the 2020-2021 period had at least one landing located in a filter strip or wetland where an alternative upland location was deemed available – several sites had multiple landings with only one within a wetland or filter strip. Most sites (81%) with landings located within wetlands were harvested during winter operations during this period. Landings were generally in good condition, with 44% of landings being more than 50% vegetation observed during this period. 8 landings had evidence of rutting, with the rutting occupying less than 10% of the landing area in all but one case. Most landings (74%) had greater than 10% of the landing covered with organic debris during the 2020-2021 period.

2014-2018 Statewide Site-Level Monitoring Report Table 14. Infrastructure installation, percent area, and compliance with guideline recommendations on monitored sites.

Watershed Sample Unit	Total Sites (n)	Sites w/ Infrastructure (n)	Average Acres	Standard Deviation	Total Acres	Average Infrastructure Acres	Average Landing Acres	Average Road Acres	Percent Compliant
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CWR	31	26	35.3	23.6	1,093	0.92	0.67	0.25	83.9
LLP	32	31	49	85.4	1,567	1.8	1.4	0.4	71.9
LRRR	31	30	41	43.4	1,270	2.22	1.63	0.59	45.2
MGR	29	24	31.8	32.8	922	0.79	0.46	0.33	82.8
MH	35	31	33.1	35.8	1,158	1.27	0.67	0.61	74.3
MRBS	34	29	37.4	25.6	1,270	1.1	0.78	0.31	73.5
RLB	36	35	38.5	48.5	1,386	1.66	1.05	0.61	55.6
RLCW	24	23	32.3	21.5	774	1.01	0.58	0.43	83.3
ROL	15	11	25.1	13.3	376	0.38	0.34	0.05	93.3
RR	28	16	34.8	70.9	976	0.41	0.28	0.13	96.4
SCKS	34	32	82.1	69.3	2,793	2.16	1.41	0.75	67.6
SCN	37	33	70.9	64.8	2,622	1.32	0.77	0.56	94.6
SEMN	12	5	25	10.8	300	0.08	0.05	0.03	100
SUP	30	24	41.4	37.7	1,243	1.04	0.66	0.38	80
VRR	26	24	49.1	38.6	1,276	1.53	1.05	0.48	76.9
Total	434	374	41.8	50.9	19,025	1.18	0.79	0.39	78.6

2020/2021 Site-Level Monitoring Report Table 12. Acreage of on-site infrastructure by watershed sample unit.

Watershed Unit	Sites Meeting Infrastructure Guidelines (%)*	Total # Sites with On-site Infrastructure	Mean On-site Infrastructure	Mean On-site Landing Acres	Mean Onsite Road Acres	Mean Harvest Acres
MH	51.5%	33	2.76	2.13	0.63	80
SUP	66.7%	33	2.61	1.98	0.63	112
RR	73.9%	22	1.26	0.85	0.41	43
MGR	70.6%	34	1.81	1.08	0.73	79
VRR	45.5%	33	2.54	1.71	0.84	85
RLCW	76.0%	25	1.76	1.08	0.68	68
Total	64.0%	180	2.12	1.47	0.65	78

*Compliance is based on 2012 infrastructure guidelines.

2014-2018 Statewide Site-Level Monitoring Report Table 15. Landing location and Monitoring Year: Upland Site (US) or Wetland/Filter strip/RMZ (WFR),

Watershed Sample Unit	Monitoring Year	Total Sites (n)	Total Landings (n)	Landings in WFR (n)	# in WFR Where US available	% WFR where US available	% Sites w/landing in WFR where
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US
available

CWR	2017	31	72	12	NA	NA	NA
LLP	2018	32	125	13	NA	NA	NA
LRRR	2017	31	199	75	NA	NA	NA
MGR	2015	29	95	30	15	15.79	37.9
MH	2014	35	137	22	15	10.95	22.9
MRBS	2016	34	25	25	13	52	35.3
RLB	2018	36	157	47	NA	NA	NA
RLCW	2015	24	73	20	13	17.81	45.8
ROL	2018	15	30	6	NA	NA	NA
RR	2014	28	48	14	10	20.83	32.1
SCKS	2016	34	49	45	35	71.43	67.6
SCN	2017	37	99	18	NA	NA	NA
SEMN	2016	12	3	3	0	0	0
SUP	2014	30	85	9	6	7.06	16.7
VRR	2015	26	135	67	41	30.37	61.5
Total	2014-2018	434	1,332	406	335*	25.14	35.53

2020/2021 Site-Level Monitoring Report Table 13. Landing location related to wetlands and filter strips.

Watershed Unit	Total # Sites	Total # Landings	Landing Located in Wetlands or Filter Strips where Upland Available	Sites with a Landing Located in Wetlands or Filter Strips where Upland Available
MH	33	61	4.9%	9.1%
SUP	33	57	19.3%	24.2%
RR	25	27	18.5%	21.7%
MGR	34	63	14.3%	23.5%
VRR	33	93	12.9%	27.3%
RLCW	25	57	19.3%	32.0%
Total	181	358	14.2%	22.1%

Recommendations

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.

Literature review results

Two citations related to on-site infrastructure were submitted to the online bibliography. Slesak & Kaebisch (2016) found that landings had reduced vegetation growth compared to the general harvest area, and season of harvest had no effect. This supports FMG recommendations to minimize the total amount of infrastructure on site.

Lee et al. (2021) found that landings support pollinator habitat because landings had higher densities of pollinators than timber harvest interiors, and timber harvests with diverse vegetation structure support pollinator habitats. This supports recommendations to revegetate landings if possible following a harvest.

Recommended action and justification

Decision: No major revisions. Improve and implement education/training that could be used to improve implementation of filter strip FMGs in relation to on-site infrastructure.

Justification: Majority of survey respondents reported sufficient effectiveness and that current guidelines do not need to be modified; monitoring showed lower compliance in smaller sites and when infrastructure is placed within filter strips.

1. Proposed action: **Improve education/training.**

a. Justification:

i. Survey respondents suggested the following:

1. Increase emphasis on safety
2. Improve education on proper culvert installation and erosion control to meet MN Wetland Conservation Act requirements and forestry exemption criteria
3. Address the design and usage of seasonal roads

ii. Monitoring report recommendations:

1. Outreach addressing wetland identification tips, importance of locating landings away from wetlands and waterbodies

b. Economic CBA: None required.

Rutting/Compaction

Changes implemented in 2012 revision

No changes related to rutting/compaction were implemented in the 2012 revision.

Survey results

- 81% reported sufficient or better effectiveness of the FMGs related to this topic
- 63% of respondents reported these FMGs do not need to be modified; 18% reported that they should be modified
- 7% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly
- Suggestions from survey respondents: improve/clarify the definitions of rutting and compaction (including setting measurable levels), improve enforcement of guidelines, emphasize avoidance of saturated soils and provide tools/information for identifying prime opportunities for management activities (e.g., soil maps, frost depth information), adapt guidelines to warming winters and the impacts of climate change.

Monitoring report results

At the site level, sites that had some rutting identified had minor amounts when compared to the entire site. Of the 181 sites monitored during the 2020-2021 monitoring period, 64 sites had rutting identified somewhere on the site, and two thirds of these (40 sites) had rutting identified on more than one feature type. The frequency of rutting was highest in NOWW skid trail crossings, but the highest surface area of rutting occurs when there is rutting identified in skid trails within the general harvest area (not associated with any one feature). Rutting occurred on 4.6% of all NOWW crossings during the 2020-2021 monitoring period (14% of sites), which is down from 13% during the 2014-2018 period.

2020/2021 Site-Level Monitoring Report Table 14. Rutted sites and features with mean percent of feature rutted (rutting six inches deep or deeper).

WSU	Sites	Sites Rutted	Water-body	Crossing	Landing	Skid Trail	Road	Filter Strip	Total Features	Mean % Rutting(SD)
MH	33	3	0	2	1	1	1	0	5	16.9(19)
SUP	33	16	10	22	1	5	4	9	51	10.8(18)
RR	23	4	4	5	1	1	1	1	13	13.9(22)
MGR	34	15	5	13	2	6	8	4	38	16.7(19)
VRR	33	13	6	9	1	6	3	1	26	4.8(4)
RLCW	25	13	10	19	2	7	5	2	45	10.9(16)
Total	181	64	35	70	8	26	22	17	178	12.3(4)

Recommendations

Focusing outreach on techniques to avoid rutting in NOWW crossings such as use of temporary crossing structures may improve future guideline implementation.

Literature review results

In total, there were 6 post-2012 (two citations submitted by DNR Forestry were from 2010) citations related to rutting/compaction submitted to the online bibliography. Two of these citations were the updated Michigan (2018) and Wisconsin (2018) Forest Best Management Practices and Forest Management Guidelines, respectively. These citations are relevant because they may serve as a relevant comparison to MN FMGs during the revision process as they also contain guidelines related to rutting and compaction. The Michigan BMPs includes a helpful table (Table 5) of precautions and actions to address rutting, and a similar format may be helpful in the MN FMGs.

A study by Curzon et al. (2022) found the combination of whole-tree harvest, forest floor removal, and severe compaction at the most productive yielded greater mean biomass production and faster recovery than less disturbed stands at the least productive site. Bulk density increased with increasing amount of compaction, but results indicated that there was recovery of bulk density at the surface but not deeper in the soil surface.

Rittenhouse & Rissman (2015) found that warming winter air temperatures may reduce the period when harvesting can occur with minimal impacts to the soil, which supports the need for climate change adaptations during winter harvesting. The report also summarizes methods for evaluating frozen soil and snow conditions to determine ideal winter operability.

A USDA Forest Service report by Nash et al. (2020) summarized research and management guidelines related to winter timber harvesting to reduce soil impacts and supports the need for climate change adaptations during winter harvesting. The report also summarizes methods for evaluating frozen soil and snow conditions to determine ideal winter operability. This report also had detailed guidance on winter road construction to limit negative impacts to soil.

Recommended action and justification

Decision: No major revisions. Education should emphasize avoiding rutting in non-open water wetland skid trail crossings, especially in relation to non-frozen site conditions.

Justification: Majority of survey respondents reported sufficient effectiveness and that current guidelines do not need to be modified; monitoring showed that frequency of rutting was highest in non-open water wetland skid trail crossings; post-2012 research in the literature review supports current FMGs related to rutting/compaction.

1. Proposed action: **Improve education/training.**
 - a. Justification:
 - i. 81% of survey respondents reported sufficient effectiveness
 - ii. 63% reported that these guidelines do not need to be modified (18% reported that they should be modified)
 - iii. Only 7% of respondents indicated that these guidelines are not being implemented well/are being implemented too narrowly.
 - iv. Sites identified with rutting had small amounts of rutting in comparison to the entire site.
 - v. Monitoring report showed higher frequency of rutting in crossings with NOWWs
 1. Focusing outreach on techniques to avoid rutting in NOWW crossings
 - b. Economic CBA: None required.

Erosion Control

Changes implemented in 2012 revision

- Clarification on when erosion control is “needed and necessary”

Survey results

- 81% reported sufficient or better effectiveness
- 70% of respondents reported that these FMGs do not need to be modified, 12% reported that they should be modified
- 5% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly
- Suggestions from survey respondents: specify how to control road erosion, improve education on the implementation of these guidelines, emphasize how erosion varies across the state based on multiple factors, stronger emphasis on how to use available on-site materials such as slash

Monitoring report results

During the 2014-2018 monitoring period, 94% of approaches were in good condition and did not require further erosion control practices. However, for the 97 approaches where erosion control was deemed necessary, only 24% of these had erosion control practices appropriately installed during this period and erosion was frequently (59%) observed when erosion control practices were needed but not installed. For the 2014-2018 period, in 61% of instances when erosion was occurring on approaches to a waterbody, contractors found evidence of sediment reaching the associated waterbody.

Over 94% of all approaches during the 2020-2021 monitoring period were associated with NOWWs. Of 512 approaches to NOWWs during this same period, 49 required erosion control practices to meet guideline recommendations. Only 14 of these 49 approaches (31%) had erosion control practices installed, which is higher than previous estimates (20% in 2014-2015). Erosion was frequently observed when practices were needed but not installed, although the actual occurrence of sediment delivery to wetlands and streams was small. Only a small number of sites (~20%) have water quality segments present, which may indicate good guideline implementation regarding locating roads and skid trails away from wetlands and surface water. However, similar to approaches, those water quality segments that needed erosion control installed generally did not have it and the occurrence of erosion in those situations was common.

Literature review results

Three citations related to erosion control were submitted to the online bibliography. McEachran et al. (2018) found that the presence of vegetative cover on roads, landings, and skid trails post-

harvest is strongly associated with lower occurrences of erosion on those features. This supports the use of maintaining ground cover to promote erosion control.

Bennett & Frohn (2018) summarized emergency erosion techniques for dealing with severe weather conditions during an active timber harvest. The techniques outlined in this report agree with the recommendations in the current FMGs.

McEachran et al. (2021) provided a conceptual model to identify the direct and indirect effects of harvesting on sediment yield. This study emphasized that the indirect of harvesting on sediment yield must also be considered, in addition to direct effects, when developing best management practices related to erosion.

Recommended action and justification

Decision: No major revisions. Education should be enhanced to improve implementation while acknowledging the pre-harvest planning requirements and costs associated with erosion control implementation.

Justification: Majority of survey respondents reported sufficient effectiveness and that these guidelines do not need to be modified; implementation of erosion control practices were relatively low and evidence of erosion was observed; post-2012 research in the literature review supports current FMGs related to erosion control. The current guidelines are sufficient, but enhanced education on erosion control would improve implementation and compliance.

1. Proposed action: **Strengthen education/training**

a. Justification:

- i. Erosion is frequently observed in monitoring when practices were needed but were not followed/installed.
- ii. Survey respondents suggested:
 1. Specify how to control road erosion
 2. Improve education on implementation of erosion control guidelines
 3. Emphasize how erosion varies across the state based on different factors
 4. Stronger emphasis on how to use on-site materials such as slash

b. Economic CBA: None required.

Biomass Harvest/Slash Management

Changes implemented in 2012 revision

- Allow adjustment (more or less) of FWD retention during biomass harvesting depending on the amount of incidental breakage that occurs
- Allow deviation (more or less) from recommended FWD retention during biomass harvesting to achieve silvicultural objectives
- Modification of slash guidelines to conform with biomass harvesting guidelines

Survey results

- 84% reported sufficient or better effectiveness
- 62% of respondents reported these FMGs do not need to be modified, 16% reported that they should be modified
- 4% of respondents indicated that FMGs related to this topic are not being implemented well or are being implemented too narrowly
- Suggestions from survey respondents: Unnecessary in the absence of a market for biomass, native plant community classification should influence slash retention rates, emphasize slash retention for wildlife as appropriate, use subsidies to draw biomass market to MN, include considerations for fire-dependent sites, include handling of chipping residue, bring in more science to support guidelines

Monitoring report results

During the 2014-2018 monitoring period, biomass harvests occurred on 121 sites (out of 435 total). 41 of these biomass sites had a FWD retention strategy in place. There were 36.5 CWD logs per acre and 2.7 snags per acre across all watershed units during the 2014-2018 monitoring period. General harvest areas met the guidelines of two or more "sound" down logs per acre 96% of the time during this monitoring period.

For the 2020-2021 reporting period, 152 of 169 sites not utilizing biomass had slash relatively evenly distributed on the site. Twelve sites utilized slash as biomass product during this period. Only three sites did not meet the minimum recommended number of CWD. Seven of these sites retained at least 33% of tops and limbs from harvested trees as well as FWD from incidental breakage during harvest operations. The remaining five did not retain the intentional 33% of tops and limbs, but three of these did retain incidental breakage.

Literature review results

In total, eight citations related to biomass harvesting/slash management were submitted to the online bibliography.

The literature review by Berger et al. (2013) summarized the effects of biomass harvesting (whole tree harvesting) on forest productivity. The review found that compared to natural disturbance, structural departure increases in a gradient ranging from conventional harvesting

on one end, to whole tree harvesting in the middle, and to energy wood harvesting on the other end. The authors identified a large gap in knowledge on the impact of the ecological effects energy wood harvesting.

Curzon et al. (2014) found that increased disturbance severity from the removal of harvest residues for bioenergy feedstocks may have negative impacts on structural development and above-ground biomass production in some sites, which supports the need for biomass harvesting guidelines. No intermediate levels of biomass removal were tested in this study.

Fateaux et al. (2012) found that the retention of CWD had positive effects on small mammal species (red-backed voles and deer mice) in clearcuts, partial cuts, and controls (no harvesting). The highest small mammal abundance occurred with high volumes of well decayed CWD. This supports guidelines for CWD retention to support wildlife habitat.

The study by James et al. (2021) provides a meta-analysis of forest residue removals on forest soils. The results suggest that intermediate removals of biomass (<80% removal) using whole tree harvesting with forest floor retention can provide a sustainable source of biomass for bioenergy production without additional soil carbon losses. The most severe losses of soil carbon and nitrogen occurred with forest floor removal. This supports slash retention guidelines.

Lewandowski et al. (2016) found that biomass harvesting with slash retention increased mycorrhizal fungi abundance and nitrogen availability. These results apply specifically to single rotation biomass harvesting in aspen stands and may not be directly applicable to the harvesting of other tree species or multiple rotations. This study supports slash retention guidelines.

Premer et al. (2016) concluded that overstory tree communities were not impacted by residue removal, but understory species richness, diversity, and evenness increased with residue removal. The results showed that residue removal increases the variability in vegetation communities. From these results, the authors suggested that aspen forest vegetation communities on productive soils may be resilient to the removal of residues, although these responses are likely to vary based on soil type.

Premer et al. (2019) found that harvest residues can be removed while sustaining productivity in aspen stands. Residue retention following whole tree harvesting did not appear to alter aboveground productivity of aspen across a range of soil types, but ultimately the effects of removal are site specific.

Finally, a study by Premer & Froese (2018) found that retaining residue during cut-to-length harvesting mitigates soil compaction, but excessive residue can negatively impact aspen regeneration density and height growth. This supports slash retention guidelines but potentially warrants consideration of regeneration during slash management.

Recommended action and justification

Decision: No major revisions. Carbon issues related to biomass harvesting are separate from the biomass FMG content.

Justification: Majority of survey respondents reported sufficient effectiveness and that these guidelines do not need to be changed; sites where a biomass harvest occurred during monitoring had high compliance; post-2012 research in the literature review supports CWD and FWD retention strategies as outlined by the FMGs.

1. Proposed action: **No revisions.**

a. Justification:

- i. 84% reported sufficient effectiveness
- ii. 62% reported that these guidelines do not need to be modified
- iii. Literature review results support slash retention guidelines, guidelines limiting biomass removal
- iv. 152 of 169 sites not utilizing biomass observed during the 2020-2021 monitoring period had slash distributed relatively evenly across the harvest area.

b. Economic CBA: None required.

Climate Change and Carbon

Survey results

- The development of guidelines related to climate change and adaptive forest management was the most cited opportunity for additional FMGs (8 respondents, 22% of responses)

Literature review results

Fourteen post-2012 citations related to a proposed climate adaptation section were submitted by DNR Division of Forestry employees (one citation was published in 2011 and not included here).

Butler et al. (2012) provided a review of climate adaptation strategies and approaches which would provide as a useful reference in the potential development of a climate adaptation section in the MN FMGs.

Duveneck & Scheller (2015) simulated two landscapes (northern MN and northern lower MI) and three climate futures with four management regimes. Of the four management regimes, the climate suitable planting resulted in the greatest resilience under climate change, although the effects of climate change generally outweighed the differences in forest management regimes.

Friesen et al. (2021) investigated the effects of reduced snow cover on soil temperature and frost development in forested peatlands in northern MN. The results suggest that reductions in winter snow cover may result in increased soil frost development in forest peatlands, although this response may be modified by concurrent changes in winter air temperature.

The results of Grinde et al. (2021) indicated the potential for significant large-scale impacts of black ash mortality due to EAB on wildlife, so management strategies should focus on establishing alternative tree species in black ash swamps in order to maintain long-term forest cover, structural complexity, and wildlife diversity.

Handler et al. (2014) summarized current climate change predictions for northern Minnesota. Currently, air temperatures are expected to increase across all seasons, but with dramatic warming during the winter, by 2100. Precipitation is project to increase during winter and spring, but summer precipitation is expected to decrease. More winter precipitation is expected to occur as rain instead of snow. Extreme precipitation events are expected to become more frequent.

Janowiak et al. (2014) proposed a structured approach for making broad adaptation concepts applicable to on-the-ground management strategies. This framework would be relevant in the potential development of climate adaptation guidelines.

Jiang et al. (2014) developed site index models using both climate and soils information to better assess the effect of climate change on site productivity. These models were applied to

eastern forest tree species and Minnesota was included in the model area. Results of these models could be use in the development of climate adaptation guidelines.

McEachran et al. (2021) found no effect of forest harvesting on annual maximum flows.

Ontl et al. (2020) developed the Forest Carbon Management Menu, which translates carbon management concepts into applicable strategies for managers. This would be useful as a reference when structuring a potential climate adaptation section in the FMGs.

Palik et al. (2021a) reported on a large-scale management experiment from Minnesota that included different silvicultural approaches for establishing replacement tree species in black ash forests. Group selection was the silvicultural system that provided the best balance between survival and growth, and American elm had the highest survival across species and treatment combinations.

Palik et al. (2021b) examined the potential for co-occurring tree species to replace black ash, either through gap filling in the overstory or release from the understory. The study found no species capable of replacing black ash in both hydrologic regimes (wet and very wet swamps), indicating there is a low probability of black ash replacement from expansion in the overstory or release in the understory and silvicultural intervention would be needed to replace black ash.

Shannon et al. (2019) provided a menu of tiered adaptation strategies that are focused on Midwest and Northeastern forests to support the integration of climate change considerations in management decisions. This would serve as a useful reference to the development of a potential climate adaptation section in the guidelines.

Swanston et al. (2018) summarized climate change predictions and impacts for forests of the Midwest and Northeast. Northern, boreal, and montane forests were assessed to have the greatest vulnerability due to the predicted decline of dominant tree species under warmer conditions. This is a summary of results presented in Handler et al. (2014).

Windmuller-Campione et al. (2021) quantified the regeneration 5 to 11 years post-harvest in black ash swamps in three silvicultural systems (group selection, clearcut, diameter-limit harvesting). The authors concluded that there could be flexibility in designing treatments for diversification since there were no significant relationships between the basal area of residual overstory trees and density (TPH) of non-ash regeneration. There was a positive relationship between depth of soil much and black ash saplings. Specific silvicultural systems in combination with site quality may be useful to allow for the regeneration of non-ash species in black ash forests.

Recommended action and justification

Decision: Further investigation and review is needed, defer to the ad hoc climate change and carbon committee for specific recommendations and guidance on climate change and carbon issues.

Justification: A guidebook on climate adaptation for forest managers already exists through NIACS, and planning when and where to harvest based on climate projections is beyond the current scope of the guidelines. Changes to the current guidelines could be in the form of an addendum and/or the addition of a “climate smart” or similar logo to indicate FMGs that mitigate climate change impacts and that support long-term climate change goals.

Additional FMG topics from survey and monitoring reports

Additional survey recommendations

The most commonly cited opportunities for additional FMGs included the following:

- Climate change and forest management (8 respondents, 22% of responses)
- Responsible ecosystem management and support the increase of forest biodiversity (5 respondents, 14% of responses)
- Protecting watersheds from riparian soil erosion and runoff (5 respondents, 14% of responses)
- Cost effectiveness and the economics of forest management (5 respondents, 14% of responses)
- Advice on how to reduce soil erosion, rutting, and compaction (4 respondents, 11% of responses)
- How to promote long-term sustainability of forests (4 respondents, 11% of responses)
- How to most effectively close trails to unwanted ATV/recreational use in order to prevent erosion and the spread of invasives (3 respondents, 8% of responses)
- Accommodate and advocate for wildlife preservation during timber harvesting (2 respondents, 5% of responses)
- Educate foresters on carbon markets and carbon sequestration, to incentivize climate solutions (1 respondent, 3% of responses)

Additional feedback on the guidelines included adding consistent page numbers throughout the report, rather than beginning again in each section. In addition, it was suggested that the MFRC find a way to make the guidelines more available to the public in an attempt to educate on the world of timber harvesting.

Additional monitoring report recommendations

Specific forest management guidelines (FMGs) have also been identified as in need of broader implementation, including additional outreach and education to raise awareness of the guidelines and recommended implementation criteria.

- Leave trees provide wildlife habitat and help to intercept precipitation, encourage infiltration of surface water into forest soils, reduce overland flow, and provide a living anchor for forest soils.
- Vegetated filter strips are widely implemented, but not always managed appropriately. These features intercept and slow the movement of sediment from forest soils into surface waters.
- Erosion control measures on approaches and crossings serve to prevent the movement of soil from these high traffic areas to surface waters.
- Avoidance of unnecessary wetland and waterbody crossings serves to limit interaction with surface water and minimize the potential for delivery of sediment downstream.
- Riparian management zones provide vegetative cover in close proximity to water bodies, serve as important wildlife habitat, and provide benefits associated with filter strips and leave trees.

- Rut avoidance is another operational consideration that can help to reduce the movement of sediment into surface waters.