Current Status and Trends of Silvicultural and Forest Health Practices in Minnesota: A 2024 Assessment[1]

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EXECUTIVE SUMMARY

Silviculture is the art and science of supporting and stewarding forest woodland ecosystems from regeneration of a new cohort through regeneration harvest. While the practice of silviculture is based on applied ecological principles, silviculture is also influenced by societal goals and values, as well as markets. Understanding current silvicultural practices provides insight into the ways these factors influence management while also building on previous work to identify trends and changes in values over time. In addition to the ways in which past management has affected present forest conditions, the management of Minnesota's diverse forests is also influenced by regional and global factors. Best management practices and third-party certification standards affect stand-level decisions while harvested wood products are shipped to markets worldwide. Operating within these policy constraints while meeting a wide range of societal and market values requires foresters to address tradeoffs every time they implement treatments.

Thus by quantifying silviculture practices, particularly over the long term, we can identify trends and correlate practices with policy and values, allowing managers and policymakers to consider short- and long-term impacts. The Minnesota silviculture survey represents a unique long-term dataset that has combined societal values and direction with on-the-ground management decisions for large acreage organizations since 1991. This has resulted in a robust dataset that provides the opportunity to link values and goals to site-level forest composition and structure.

The goals for this survey were 1) to understand the implementation of current silvicultural practices and how important drivers such as forest health, markets, and climate smart forestry objectives influence decisions; 2) to compare current silvicultural practices to previous surveys in 2017, 2008, 1996, and 1991; and 3) to assess current and predicted future opportunities and challenges in silvicultural practices. The wording of the questions has remained the same over time to allow for comparison across years, but additional questions have been added over time to reflect changes in societal values. Notably, the 2024 survey includes a question about the type and extent of climate smart forestry practices.

We distributed the survey via email through Qualtrics to 30 forest resource landowners in the state (15 county, 3 national, 1 state, 2 non-profit, 4 forest industry, and 5 tribal nations) who combined manage over two-thirds of the timberland in Minnesota. As in previous years, we did not survey non-industrial private forest owners. Survey respondents were asked to provide responses for calendar year 2024 or their most recent fiscal year for which they have complete data. We asked about all aspects of their silviculture practices including regeneration, tending, and harvesting activities; implementation of Minnesota's voluntary site-level forest management guidelines; climate smart forestry practices; management for forest health threats; and open-ended questions regarding past management considerations and future needs.

Statewide estimates of timberland area and volume harvested were derived by multiplying the respondent silvicultural system acreages by an expansion factor based on the reported statewide harvest level in 2024 divided by the sum of the respondent reported harvests. This approach expanded respondent acreages in silvicultural systems using an expansion factor based on the reported statewide harvest levels divided by the respondent reported harvests (i.e., 2,656,682 cords / 1,436,143 cords = 1.85). The statewide harvest level was estimated from a mill survey conducted by the MN Department of Natural Resources. A key assumption we are making is that we can approximate the harvest level for non-respondents and non-surveyed individuals (family forest owners) from harvest levels acquired in our survey. This approach for estimating statewide harvest levels has been consistent across survey years since its first use in 1996.

The statewide harvest level in 2024 was approximately 2.66 million cords, representing a slight increase from the 2017 figure of 2.51 million cords but still markedly lower than the harvest levels in 2008 (2.9 million cords), 1996 (3.81 million cords), or 1991 (3.5 million cords). Despite this increase in harvest statewide since 2017, harvest intensity (cords harvested per timberland acre) continues a downward trend since 1996 when it was 0.25 cords per acre. In 2008 harvest intensity decreased to 0.2 cords per acre, 0.15 cords per acre in 2017, and reached a new low of 0.137 cords per acre in 2024. This latest decrease could be reflecting in part the loss of softwood pulp markets or an unseasonably warm winter occurring at the beginning of the reporting period.

The clearcut remains the most common regeneration harvest across all ownerships; 51,273 acres were managed with a clearcut regeneration harvest of the 70,703 acres offered, or 72.5%, compared to 72% in 2017. Based on organizations' reported acres, this equates to an estimated 94,849 acres statewide harvested with a clearcut regeneration harvest. This could represent the settling of a trend in declining use of clearcuts relative to other harvest methods since 1991. While there were slight differences between 2024 and 2017 in other even-aged and uneven-aged regeneration harvests (seed tree, shelterwood, and group and single-tree selection), the overall percentage remained unchanged at 11% of harvesting operations equating to a statewide estimate of 14,427 acres.

Commercial thinning occurred on 11,625 acres (21,505 statewide) in 2024. This represents a decrease from thinning in 2017 where 15,266 acres (24,606 statewide) were thinned; this is the lowest total area thinned since 1996, when respondents reported commercial thinning occurring on 10,602 acres. A loss of markets for softwood pulp and logging residues could have affected commercial thinning levels: since the latest iteration of the silviculture survey in 2017, Verso Paper in Duluth closed, along with two biomass energy facilities in Virginia and Hibbing. The reported extent of commercial thinning could also be affected by age class distributions of commercial species such as red pine (*Pinus resinosa*). In either case, the reported decrease in commercial thinning has implications for the viability of tending practices that improve resistance of stands to climate-related forest health concerns such as wildfire, insect or disease threats, and drought.

Respondents were asked to report on the areas regenerated during the survey period, providing both the number of acres as well as the distribution of conifer and hardwood regenerants. A total of 60,111 acres were regenerated across all respondents with a statewide estimate of 95,252 acres. This represents the lowest reported total across all survey years; however, acres of regeneration correlate with acres harvested so fewer acres harvested also mean fewer acres regenerated. It is also important to note that harvested acres will never be an exact match to regenerated acres because of the timing between harvest and regeneration and because intermediate treatments (e.g., thinning) are not regeneration harvests. Across all ownerships, over three-fourths (76.8%) of this regeneration was hardwood species while 23.2% was conifer species. Present markets are generally favorable for aspen (*Populus* spp.) pulpwood and harvesting levels in these forest types can mirror regeneration resulting in large part from the vigorous vegetative reproduction associated with aspen species.

Site preparation treatments remained consistent between 2024 (9,043 acres) and 2017 (8,689 acres). The majority of site preparation acres, 6,837 acres, were treated through mechanical methods with chemical ground treatments in second at 1,954 acres.

Mechanical treatments remain the most common method across all survey years. Prescribed burning remains low with only 196 acres which was less than the 351 acres reported in 2017. However, as noted in the 2017 report, there is continued interest and increased effort in building out the potential to use prescribed fire on timberland as a site preparation and early stand treatment; logistical barriers remain high. Conversely, it is unknown how recent wildfire impacts (e.g., air quality indices over 900 at times in Duluth during the summer of 2026) may affect the public's view of prescribed fire.

Timber stand improvement (TSI) occurred on 13,097 acres in 2024. This represents an increase from 2017 (8,689) but still below acres treated in 2008 and 1996. The vast majority of acres, 10,965 acres, were treated with mechanical or manual release; all organizations used some form of manual release and ranged from 4,887 acres treated on federal lands to 100 acres treated on both Tribal forest lands and NGO owned lands. Unlike other regions of the United States, pre-commercial thinning treatments are rarely used within Minnesota with only 933 acres treated in 2024. This extent is generally consistent with previous survey years: 1,023 acres were treated in 2017 and 1,444 acres in 2008.

A section on climate smart forestry was added in 2024 to quantify the extent of such practices occurring as part of forest management organizations' overstory harvesting prescriptions. Of the 22 usable responses to the question, 16 reported at least a quarter of their prescriptions could be classified as climate-smart forestry with 7 organizations reporting at least 70%. All organizations reported the use of assisted population migration and/or promoting diversity as part of their climate-smart forestry practices. In some cases, organizations prioritized species native to

Minnesota that are adapted to warmer or wetter climates, while others reported simply increasing tree species diversity through artificial regeneration or "thoughtful sale design". Many organizations sought to increase stand vigor and health through decreased planting density as well as both pre-commercial and commercial thinning. Across all ownerships, their responses suggest managers when possible are implementing treatments that favor stand conditions that are more compositionally and structurally diverse. At the same time, respondents' distance and access to markets could limit the extent to which they are able to implement climate smart forestry practices such as increasing vigor through thinning or reducing wildfire risk through understory treatments that decrease ladder fuel density.

As in previous years, the implementation of silviculture practices is dynamic and continually evolving. Almost three-quarters of respondents (74%) reported that their silvicultural practices have changed over the past five years in 2024, up from 55% of respondents in 2017. The most common factors that respondents identified as driving these changes were increasing tree species richness (53%), altering harvest practices such as the size of cutting blocks, improving access, or the type and/or extent of species removal (47%), and an increase in the use of artificial regeneration or assisted migration (29%). Several respondents noted the intersection of multiple factors; furthermore, the extent and impacts of these factors varied across forest management organizations.

Respondents also noted changes in the ways they prepare and administer sales in the last 5 years. A lack of markets for lower quality wood has hindered the capacity for multiple forest management organizations to respond to forest health threats, further compounded by limitations related to the season of harvest as respondents observed shorter, warmer winters. Increasing the size of cutting blocks or having multiple adjacent stands on a permit can limit equipment transportation costs for loggers and potentially provide enough volume to implement necessary silvicultural treatments that may not otherwise be commercially viable when sold on a separate permit.

When asked which site-level guidelines were most difficult for their staff to implement over the past 5 years, 16 respondents (70%) observed challenges with implementing at least one of the site-level guidelines. The most common guidelines mentioned in this context were those regarding infrastructure (n = 6) with concerns about rutting, erosion, and crossings given warmer, wetter winters and large rainfall events during the growing season. One respondent noted that rain storms have resulted in the loss of culverts and replacing the lost structures with a new, larger structure that can withstand flash rain events requires "a vigorous amount of permitting", potentially leading to erosion and water quality concerns. This suggests the need for solutions to climate-related weather considerations at the policy level in addition to changes in silviculture prescriptions at the stand scale.

Looking ahead to the next 5 years, all but four respondents (83%) felt that their silvicultural practices would change in at least some way. Several respondents anticipated increased species diversity, particularly in ash (*Fraxinus nigra*) or aspen covertypes. Some felt that this increased diversity would be the result of upgraded seed collection efforts or natural regeneration in oak (*Quercus* spp.) and pine covertypes while others connected it to increased retention on a given site or an increase in the use of selection and irregular shelterwood silviculture systems. Multiple respondents expressed concerns about winter harvest conditions and other changes connected to poor markets. Despite these present and anticipated challenges, we expect forest management organizations will continue to adapt to these dynamic conditions. This survey has provided insight into the evolving forest management trends in Minnesota and in turn helped inform continuing education opportunities that can aid foresters in their implementation of adaptive management practices.

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1. INTRODUCTION

Silviculture as a discipline and a practice is inherently long-term and intrinsically linked to local, regional, and global societal needs and values (DeRose et al. 2024). Individual foresters are continually managing stands from the previous generation of foresters while at the same time considering how they can ensure future generations of foresters will have options; this type of thinking combines the past, present, and future in terms of management and societal goals and values (Puettmann et al. 2025). Thus, silvicultural practices represent an opportunity to quantify how ecology, disturbance dynamics, societal values, and economic opportunities and constraints are influencing long-term forest composition and structure (Ashton & Kelty 2018, Nyland 2016).

Researchers and managers have prioritized and invested in long-term forestry research within North America (Lindenmayer et al. 2012, Lugo et al. 2006, Wetzel et al. 2011, Pretzsch et al. 2019). This is especially true regionally within the Great Lakes Region of the USA, defined as Michigan, Minnesota, and Wisconsin, and specifically within the state of Minnesota (e.g., Anderson et al. 2020, Young et al. 2017). Minnesota is home to some of the longest running research on red pine (*Pinus resinosa*) growth and yield and silviculture studies. For example, research established on the Cutfoot Experimental Forest within the Chippewa National Forest and the University of Minnesota Cloquet Forestry Center located within the reservation bounds of the Fond Du Lac Band of Lake Superior Chippewa has helped shape our current understanding of red pine growth and yield from seedling through rotation age (e.g., Buckman 1962, Buckman et al. 2006).

However, the direction and goals of these studies have expanded through time as societal goals and values also expanded. For example, the cutting method study documented how different thinning practices resulted in changes in growth and species composition. Originally developed as a growth and yield study, this study, along with other long-term studies in conifer ecosystems, has been expanded to quantify adaptive capacity of conifer ecosystems to increased drought conditions, resulting in new management strategies to maintain growth under changing climatic conditions (Bottero et al. 2017, Powers et al. 2010). This was then tested as a strategy within the first site of the Adaptative Silviculture for Climate Change (ASCC) experiment (Muller et al. 2021).

However, long-term research on management practices and decision making is rarer. For non-industrial private landowners, the National Woodland Owner (NWO) survey is an example of tracking changes in ownership demographic and management practices; the first national woodland survey was conducted in 1978 (Butler 2009). Over the last several decades the NWO survey has documented critical changes in forest landowner decision-making (e.g., Butler et al. 2016, Huff et al. 2019). For example, from 2013 to 2023, private forest landowners are

increasing in age with more landowners participating in preferential property tax, conservation easement, and green certification programs. During the same time period, there was a decrease in landowners' interest in timber production (Butler 2026). Knowledge gained from these surveys can be directly used by organizations and individuals that serve these landowners (e.g., University Extension program development) (Bowler & Butler 2024).

Additionally with increasing technology there have been opportunities to explore land use change and changes in forest structure and composition at regional, national, and global levels (Nitoslawski et al. 2021, White 2016, Xu et al. 2025). Studies using the Forest Analysis and Inventory (FIA) database have highlighted important regional trends for forest health, impacts from herbivory, and changes in forest composition and structure (Glasby et al. 2019, Patton et al. 2021, Tinkham et al. 2018). Satellite imagery has provided the opportunity to quantify these changes over even larger scales and in a more continuous manner (e.g., Vicente-Serrano et al. 2016).

Over the last decade (2016 - 2026) forest ecosystems and organizations that manage them have seen large-scale shifts that have local, national, and international impacts. One of the most drastic events during this decade was the COVID-19 global pandemic which impacted all aspects of forest and natural resource management (Stanturf & Mansuy 2021, Russell 2022). Forestry was considered critical infrastructure with forestry and agriculture workers considered essential employees (Pepke et al. 2020). However, global trade and critical processes related to the forest economy were disrupted and lingering impacts from the pandemic are still affecting the forest industry (e.g., Zhang et al. 2026). At the same time, individuals increasingly spent more time outside recreating, placing greater strain on some of Minnesota's most popular locations (Brown et al. 2021). During this time frame, forest management organizations have also experienced drastic swings in federal funding and direction related to natural resource management and research as well as overall staffing levels (e.g., Inflation Reduction Act (IRA) in 2022 and Department of Government Efficiency in 2025 (DOGE)). Finally, Minnesota has experienced increased wildfire activity, expanding impacts from insects (e.g., emerald ash borer (*Agrilus planipennis* Fairmaire) [EAB], eastern larch beetle (*Dendroctonus simplex* LeConte.) [ELB], and eastern spruce budworm (*Choristoneura fumiferana*)) and diseases (e.g., oak wilt (*Bretziella fagacearum*)), and decreasing average winter frozen ground conditions (MN DNR Forest Health Reports 2020 – 2025).

Understanding and interpreting how these shifting conditions influence forest ecosystem management requires a collective understanding of both the silvicultural activities and the lens through which that silviculture is being practiced. The Minnesota silviculture survey represents a unique long-term dataset that has combined societal values and direction with on-the-ground management decisions for large acreage organizations since 1991 (Windmuller-Campione et al. 2019). This has resulted in a robust dataset that provides the opportunity to link values and goals to site-level forest composition and structure.

2. OBJECTIVES

There were three main objectives for this work:

1. To understand the implementation of current silvicultural practices and how important drivers such as forest health, markets, and climate smart forestry objectives influence decisions,
2. To compare current silvicultural practices to previous surveys in 2017, 2008, 1996, and 1991, and
3. To assess current and predicted future opportunities and challenges in silvicultural practices.

3. METHODS

3.1. QUESTIONNAIRE

The 2024 survey represents the fifth delivery of the silvicultural survey within the state of Minnesota. Detailed information on the history of the surveys can be found in Windmuller-Campione et al. 2020 and citations within.

Following similar methods to the most recent 2017 survey (Windmuller-Campione et al. 2019), the 2024 iteration was developed to quantify silvicultural and forest management practices during calendar year 2024 or using the most recent fiscal year for which respondents had data. Individual respondents defined their most recent fiscal year; this resulted in reported data beginning from late 2023 for some respondents to the full calendar year 2024 for most others. The survey was approved by the Institutional Review Board at the University of Minnesota (Appendix A).

To maintain consistency across surveys, the same questions were used as much as possible. Common names of species were updated (e.g., Spongy moth [*Lymantria dispar*]). The survey consisted of eight sections including an additional section on climate smart forestry. The eight sections included (1) annual forest management operations, (2) silvicultural activities, (3) biofuels harvests, (4) regeneration methods, (5) site preparation methods, (6) forest health, (7) climate smart forestry, and (8) open-ended questions on trends in silvicultural practices. Prior to distribution, the survey was reviewed by local experts to ensure readability and clarity on questions.

The survey was administered following the Dillman (2011) method and was conducted through the survey software Qualtrics with an option for respondents to complete the survey through a fillable PDF form. We distributed the survey (Appendix A) via email through Qualtrics to 30 forest resource landowners in the state (15 county, 3 national, 1 state, 2 non-profit, 4 forest

industry, and 5 tribal nations) who combined manage over two-thirds of the timberland in Minnesota. Two weeks prior to distributing the survey we sent an initial email letter to each recipient requesting their participation (Appendix B). The email described the purpose, funding source, and importance of high participation rates for the study, as well as the ways in which respondents would be able to access and complete the survey. On June 2, 2025 we distributed the survey through Qualtrics, including a link to the fillable PDF survey and a glossary of terms used in the survey.

The email described the voluntary nature of the survey, the general nature of the questions, and informed participants that submitted data would be kept confidential. Using Qualtrics, we tracked respondents' survey completion to facilitate follow-up emails and phone calls. We sent a follow-up email to all nonrespondents approximately five weeks after the initial distribution of the survey. After the August 1, 2025 submission deadline had passed, we sent an additional inquiry email and made phone calls to remaining nonrespondents. Due to an extensive blowdown event affecting north-central Minnesota in the summer of 2025 and two federal government shutdowns, we extended our submission window for survey data into the spring of 2026 which allowed an additional four respondents to complete the survey.

3.2. SURVEY ANALYSIS

Due to changes in both the survey methods and the wording of questions from the previous surveys, we have focused on the general trends without statistical comparisons. There is still great value in the trends and comparison across years. Statewide estimates of timberland area and volume harvested were derived by multiplying the respondent silvicultural system acreages by an expansion factor based on the reported statewide harvest level in 2024 divided by the sum of the respondent reported harvests. This approach expanded respondent acreages in silvicultural systems using an expansion factor based on the reported statewide harvest levels divided by the respondent reported harvests (i.e., 2,656,682 cords / 1,436,143 cords = 1.85). The statewide harvest level was provided by Dr. Ram Deo, MN Department of Natural Resources.

A key assumption we are making is that we can approximate the harvest level for non-respondents and non-surveyed individuals (family forest owners) from harvest levels acquired in our survey. Accounting for survey nonrespondents—particularly those from tribal nations and forest industry—our reported harvest levels by forest management organizations are similar to those reported by Deo and Fauskee (2026). This approach for estimating statewide harvest levels has been consistent across survey years since its first use in 1996 (Puettmann & Ek, 1996). However, there are some caveats when interpreting these statewide estimates of silvicultural practices for family forest owners.

The type and extent of silvicultural practices across Minnesota's estimated 200,000 family forest ownerships are influenced by a variety of factors (Butler et al., 2016). For example, family forest owners with access to diverse sources of information are more likely to implement forest

management activities; however, implementation of these activities can also be affected by parcel size or whether they have a management plan (Sagor & Becker, 2014). Although a fraction of Minnesota family forest owners seek professional assistance (e.g., private forest management foresters employed by the MN Department of Natural Resources), these family forest owners are more likely to actively manage their land (Sagor et al., 2022). Regardless of their motivations for timber production (Butler, 2026) family forest owners are subjected to the same market constraints as the forest management agencies we surveyed. However, the diversity in family forest owner objectives, knowledge, and technical service provider assistance suggest our statewide estimates of silviculture practices on family forest ownerships may not be representative.

4. RESULTS AND DISCUSSION

Twenty-three forest management agencies stewarding over 10.5 million acres of timberland throughout Minnesota responded to the survey. Forest management organizations represented federal, state, county, tribal nations, forest industry, and non-profit entities. The level of participation in the 2024 survey is broadly consistent with that of the survey from 2017 (22 respondents; 10.4 million acres); while earlier iterations of the silviculture survey in 2008 or 1996 featured higher respondent rates, the 2024 survey represents the largest timberland acreage. However, participation from some county and forest industry entities could have been negatively impacted by an extensive blowdown in June in north-central Minnesota (one agency in the region noted a need to prioritize implementing salvage harvests). A lower tribal nations response rate may have been influenced by limited staffing capacity (Dockry et al., 2023) as well as a shifting job and funding landscape at the federal level. While extending the submission window for the survey allowed for more respondents, these issues may have nonetheless impacted the number of non-respondents.

The respondent ownership covered 10,508,706 acres of timberland (Table 1) and individual respondent acreages ranged from several thousand to several million acres. The total reported acreage in this survey represented 66% of the state's 15.81 million acres of timberland (Deo & Fauskee, 2026). A total of 67,581 acres across 1,491 sales were harvested during the reporting period. The vast majority of sales (92%) that were offered were sold. The 127 sales unsold represent 3,121 acres not managed during the reporting period. Counties reported 76 unsold sales (11.0% of sales offered); state, 37 (4.5%); federal, 6 (15.0%); and tribal, 8 (61.5%); forest industry reported no unsold sales.

The statewide harvest level in 2024 was approximately 2.66 million cords, representing a slight increase from the 2017 figure of 2.51 million cords but still markedly lower than the harvest levels in 2008 (2.9 million cords), 1996 (3.81 million cords), or 1991 (3.5 million cords). Despite this increase in harvest statewide since 2017, harvest intensity (cords harvested per timberland

acre) continues a downward trend since 1996 when it was 0.25 cords per acre. In 2008 harvest intensity decreased to 0.2 cords per acre, 0.15 cords per acre in 2017, and reached a new low of 0.137 cords per acre in 2024. This latest decrease could be reflecting in part the loss of softwood pulp markets or an unseasonably warm winter occurring at the beginning of the reporting period.

4.1. SILVICULTURAL SYSTEMS

The clearcut remains the most common regeneration harvest across all ownerships; 51,273 acres were managed with a clearcut regeneration harvest of the 70,703 acres offered, or 72.5%, compared to 72% in 2017. Based on organizations' reported acres, this equates to an estimated 94,849 acres statewide harvested with a clearcut regeneration harvest. This could represent the settling of a trend in declining use of clearcuts relative to other harvest methods since 1991 (Table 2). Strip clearcuts continue to represent a small fraction of all harvested acres, with only 5 total acres in 2024 compared to 25 total acres in 2017. The average clearcut size has increased from 17 acres in 2017 to 20.6 acres in 2024 but still remains lower than the average size in 2008 (29 acres) or 1996 (24 acres). This represents a small scale of disturbance relative to young forage requirements for wildlife such as moose (*Alces alces*) who preferentially browse large volumes of early-successional species such as aspen and other hardwoods (Moen et al., 1997; Pastor et al., 1998).

The percentage of area or number of acres harvested with a clearcut regeneration harvest varied across ownership types, from 60% by federal ownerships to 87% by tribal entities (Table 3). Forest industry prescribed a clearcut regeneration harvest on 62.6% of their acres in 2024, compared to 78% in 2017 and 68% in 2008 but well below a reported figure of 97% in 1996. While the use of a clearcut regeneration harvest was lower on federal ownerships compared to other organizations, there was an increase in the use of a clearcut regeneration harvest to 60% of acres in 2024 from 48% of acres in 2017; tribal nations also reported using a clearcut regeneration harvest on 87% of regeneration harvests in 2024 compared to 76% in 2017. For state and county respondents there were limited changes in percentage of acreage treated in a clearcut regeneration harvest between 2017 and 2024. It should be noted that outside of the exception of forest health concerns, all clearcut regeneration harvests have residual trees (Minnesota Forest Resources Council, 2025). While multiple organizations noted some difficulty in meeting recommended leave tree targets, other organizations noted the need to better understand how to ensure leave trees continue to stand after harvest.

While there were slight differences between 2024 and 2017 in other even-aged and uneven-aged regeneration harvests (seed tree, shelterwood, and group and single-tree selection), the overall percentage remained unchanged at 11% of harvesting operations equating to a statewide estimate of 14,427 acres. The use of uneven-aged regeneration harvests remains consistent between survey periods with 5% reported in 2024 and 6% in 2017. With the exception of tribal forest management organizations, all other ownerships reported using some type of uneven-aged regeneration harvest. Among ownerships implementing uneven-aged regeneration harvests, the

proportion of acres experiencing a group selection regeneration harvest ranged from 2.1% (federal) to 4.1% (forest industry). The reported range for single-tree selection systems was much broader: forest industry did not report any use of single-tree selection while federal ownerships implemented single-tree selection on 9% of their harvested acres.

The consistent use of non-clearcut regeneration harvests since 2017 may be related to middle-aged or mature forest composition and structure present in both northern hardwoods and oak (*Quercus* spp.) forest types. The wide range of diameters and species can provide foresters with a variety of commercially viable options to use uneven-aged management techniques. The highest acreages of the northern hardwoods cover type is concentrated in the 61-100-year age range for counties statewide and skews slightly older for the state ownership, ranging from 71-100 years (Deo & Fauskee, 2026). The oak forest type is likewise concentrated around middle-aged to mature age classes, ranging from 71-90 years for both state and county ownerships (Deo & Fauskee, 2026). Organizations within Minnesota have been actively stewarding both of these ecosystems with the goal of maintaining function and increasing economic quality (personal communication, Aitkin County). Additionally, management organizations have noted proactive harvests in black ash (*Fraxinus nigra*), including using a group selection harvest in black ash to diversify this ecosystem as EAB continues to spread (Looney et al., 2015).

Commercial thinning occurred on 11,625 acres (21,505 statewide) in 2024. This represents a decrease from thinning in 2017 where 15,266 acres (24,606 statewide) were thinned; this is the lowest total area thinned since 1996, when respondents reported commercial thinning occurring on 10,602 acres. A loss of markets for softwood pulp and logging residues could have affected commercial thinning levels: since the latest iteration of the silviculture survey in 2017, Verso Paper in Duluth closed, along with two biomass energy facilities in Virginia and Hibbing. The reported extent of commercial thinning could also be affected by age class distributions of commercial species such as red pine. Federal forest management organizations reported the highest proportion of commercial thinning relative to other harvests (21%), followed by the state with 19%. Across their timberland acreages, federal and state ownerships also have the highest distribution of red pine in the 31-60-year range (Deo & Fauskee, 2026).

A subset of organizations further defined their thinning into the different types of thinning by percentage (e.g., thin from below, row thin). Of the 18 respondents who reported some level of commercial thinning, thinning from below was most frequently implemented and ranged from 30% of acres for federal organizations to 100% of acres for tribal nations. Row thinning (28%) was the next most common with 11 respondents implementing the practice. Free thinning (18%) and thinning from above (5%) were less commonly implemented.

Logger select thinning was implemented on approximately 4,500 acres or 39% of thinned stands. Within logger's selection, loggers made cutting decisions based on predetermined selection criteria and desired post-harvest stand conditions rather than individually marked trees.

The use of logger select varied heavily based on organization. Both state and forest industry respondents reported use of logger select on half (50%) of their commercial thinning harvest acres, while counties reported 37%. One federal respondent reported 100% use of logger select using timber designation by prescription (DxP) while another federal respondent did not use logger select at all. The survey reporting period ended prior to the April, 2025 memo from the Deputy Chief of the National Forest System authorizing the increased use of timber designation by description (DxD) and DxP on all harvests (French, 2025); therefore, the use of logger select on national forest lands in Minnesota could be expected to increase.

4.2. REGENERATION

Respondents were asked to report on the areas regenerated during the survey period, providing both the number of acres as well as the distribution of conifer and hardwood regenerants. A total of 60,111 acres were regenerated across all respondents with a statewide estimate of 95,252 acres. This represents the lowest reported total across all survey years (Table 2). However, acres of regeneration correlate with acres harvested so fewer acres harvested also mean fewer acres regenerated. It is also important to note that harvested acres will never be an exact match to regenerated acres because of the timing between harvest and regeneration and because intermediate treatments (e.g., thinning) are not regeneration harvests.

Across all ownerships, over three-fourths (76.8%) of this regeneration was hardwood species while 23.2% was conifer species (Table 5). During the 2024 survey, respondents were asked for the second time to report the distribution of hardwoods and conifers across their regenerated acres. Compared to the 2017 survey, the hardwood regeneration component has increased from 64%. Hardwood regeneration represented the vast majority of regeneration on county ownerships (87.2%), up from 66% in 2017. Forest industry organizations likewise reported an increase in the hardwood regeneration component, from 58% in 2017 to 70% in 2024. The proportion of hardwoods in 2024 on state and federal ownerships was reported as 80% and 55.7% respectively; compared to 2017 this represented a slight decrease for the state (87%) and a steep decrease for federal respondents (75%). Present markets are also generally favorable for aspen pulpwood and harvesting levels in these forest types can mirror regeneration resulting in large part from the vigorous vegetative reproduction associated with aspen species.

Of the 60,111 acres reported as regenerated by respondents, vegetative natural regeneration occurred on 36,533 acres (60%), down from 66% in 2017. Multiple hardwood species occurring in Minnesota are able to regenerate vegetatively, although aspen is by far the most common species managed on timberland acreages as evidenced by almost all respondents (19; 83%) reporting some level of vegetative natural regeneration. All organizations that reported regeneration activity likewise used artificial regeneration, amounting to 13,866 acres. Conifer species represented the vast majority (84.6%) of artificial regeneration, with the other 15.4% in hardwood species.

Other regeneration methods included cuttings (5 total acres), direct seeding (3,082 acres), and natural regeneration from seed (4,935 acres). Four respondents reported a total of 1,690 acres required two or more years of successive planting; this was more than double the 897 acres requiring replanting in 2017. Early growing season drought conditions could explain some of this reported extent: following low snowpack, almost the entire state (98.6%) was experiencing some level of drought designation in early April (National Drought Mitigation Center, 2024).

Herbivory continues to be ever-present on the landscape. Forest management organizations shared the use of an herbivory protection method on a total of 16,780 acres in 2024, down from 27,265 acres in 2017. Respondents' reported extent of herbivory ection in 2024 represents about 28% of 60,111 total acres regenerated compared to 37% of 74,180 acres reported in 2017. Budcapping remained by far the most common method for protecting regenerants, occurring on 14,694 acres (87.6% compared to 74.4% in 2017). Cages around individual trees were used on 2,085 acres (14.1% compared to 2% in 2017), while no respondents reported the use of fences around larger areas in 2024 (compared to only 9 acres total in 2017). Sprays or repellents were only used on 1 acre. The decrease in herbivory protection suggests organizations may be concentrating their herbivory protection efforts on certain tree species or forest types. Present deer densities in Minnesota's forests as a whole are estimated to be at or even slightly below desired levels (Michel & Giudice, 2024), although the need for protection from herbivory can nonetheless vary geographically (e.g., disproportionately high deer populations on the Lake Superior Highlands [Cornett et al., 2000]). The use of herbivory protection measures may also be influenced by desired future conditions with regards to stand composition and the extent to which regenerants are preferred deer browse.

Respondents were asked to report in their own words which tree species their forest management organizations were currently having the most difficulty regenerating. A total of ten distinct species were listed (Table 6); 18 or 78% of the organizations responded to this question. Eastern white pine (*Pinus strobus*) was reported by the most respondents as a difficult species to regenerate (10 respondents) followed by jack pine (*Pinus banksiana*) (6) and northern white cedar (*Thuja occidentalis*) and northern red oak (*Quercus rubra*) (5 each). Most respondents included an explanation as to why a species was difficult to regenerate: as in 2017, deer browse was the primary reported issue, although respondents in 2024 also observed challenges related to competing vegetation, insect pests and disease, and drought. Some respondents reported whole forest types, noting challenges such as increasing the non-aspen hardwood component in aspen stands, reforesting tamarack stands in the face of eastern larch beetle (e.g., Graham et al., 2026; McKee et al., 2022), perpetuating non-ash species in wet forests ahead of EAB (e.g., Looney et al., 2015), or early-growing-season drought conditions.

4.3. SITE PREPARATION, TIMBER STAND IMPROVEMENT, & INTERMEDIATE TREATMENTS

Site preparation treatments remained consistent between 2024 (9,043 acres) and 2017 (8,689 acres). However, site preparation acreage was well below the 2008 and 1996 numbers. The majority of site preparation acres, 6,837 acres, were treated through mechanical methods with chemical ground treatments in second at 1,954 acres.
Mechanical treatments remain the most common method across all survey years. Prescribed burning remains low with only 196 acres which was less than the 351 acres reported in 2017. However, as noted in the 2017 report, there is continued interest and increased effort in building out the potential to use prescribed fire on timberland as a site preparation and early stand treatment; logistical barriers remain high.

Timber stand improvement (TSI) occurred on 13,097 acres in 2024. This represents an increase from 2017 (8,689) but still below acres treated in 2008 and 1996. The vast majority of treated acres—10,965 acres—were treated with mechanical or manual release; all organizations used some form of manual release and ranged from 4,887 acres treated on federal lands to 100 acres treated on both Tribal forest lands and NGO-owned lands. As noted in the regeneration section, management organizations are increasingly using artificial regeneration to increase species diversity through enrichment or supplemental plantings. This is especially prevalent within the aspen forest type where managers, when appropriate given the ecological classification system (ECS) and logistical constraints (e.g., access to roads), are planting white spruce (*Picea glauca*) after an aspen clearcut regeneration harvest (Semper et al.
2025). The white spruce are then released 3 to 5 years after planting; this represents a manual release. Additionally, many forest management organizations are partnering with The Nature Conservancy (TNC) in planting and subsequent manual release of planted seedlings. Enrichment planting of eastern white pine and northern red oak represent opportunities to increase long-lived species.

Unlike other regions of the United States, pre-commercial thinning treatments are rarely used within Minnesota with only 933 acres treated in 2024. This extent is generally consistent with previous survey years: 1,023 acres were treated in 2017 and 1,444 acres in 2008. Only six respondents reported precommercial thinning activities, and county ownerships and tribal nations reported the lowest levels of precommercial thinning with only 15 and 18 acres treated, respectively.

Salvage harvest operations occurred on 1,285 acres across 7 organizations in 2024. This represents a decrease from 2017 with 5,852 acres but an increase from 210 acres treated in 2009. The majority of salvage operations were reported on state lands (713 acres) followed by federal (361 acres) and county lands (210 acres). As noted in the forest health section, salvage harvests

are a common treatment in response to both forest health impacts and windthrow. If our survey was one fiscal year later, we likely would have captured the impact from the large blowdown affecting the Bemidji area.

4.4. CLIMATE SMART FORESTRY

A section on climate smart forestry was added in 2024 to quantify the extent of such practices occurring as part of forest management organizations' overstory harvesting prescriptions. Climate smart forestry was defined as the implementation of specific silvicultural practices intended to enhance the forest's resistance to climate-driven change in composition, structure, or extent, resilience to climate-driven weather and disturbance patterns, or to reduce the forest's susceptibility to canopy loss due to wildfire, extreme wind, ice storms, drought, flooding (or other weather-related phenomena), insects and disease, and other threats. Additional information on climate smart forestry was provided in the glossary (Appendix A).

Respondents quantified the percentage of overstory harvesting prescriptions that were classified as "climate smart forestry" as one of <25%, 25-70%, or >70% (Figure 1). Of the 22 usable responses to the question, 16 reported at least a quarter of their prescriptions could be classified as climate-smart forestry with 7 organizations reporting at least 70%. Two of the three non-responses did not implement a commercial harvest during the reporting period. All forest management organizations provided further context for their response through an additional short-answer question that asked respondents to elaborate on these practices, including if there were specific forest types on which they were incorporating practices more than others.

All organizations reported the use of assisted population migration and/or promoting diversity as part of their climate-smart forestry practices. In some cases, organizations prioritized species native to Minnesota that are adapted to warmer or wetter climates, while others reported simply increasing tree species diversity through artificial regeneration or "thoughtful sale design". Many organizations sought to increase stand vigor and health through decreased planting density as well as both pre-commercial and commercial thinning. Red pine plantations and aspen stands were forest types commonly prioritized for these climate-smart practices, although some organizations felt that implementing climate-smart forestry in stands managed on short rotations was more challenging than stands with greater components of longer-lived species like oak or eastern white pine. Wet forests were another priority for some organizations, particularly as a target for assisted migration efforts and potentially novel species assemblages. Across all ownerships, these responses suggest stand conditions that are more compositionally and structurally diverse.

One of the respondents reporting limited applications of climate-smart forestry noted that their harvests follow Minnesota's Voluntary Site-level Forest Management Guidelines (Minnesota Forest Resources Council, 2025) and Sustainable Forestry Initiative (SFI) certification

requirements. Others noted that they were promoting species diversity or engaging in assisted range expansion. A lower proportion of reported climate smart forestry practices on a given land base may be due to similar practices but different labels–in the case of following best management practices or third-party certification requirements–as well as access to seed sources. Market considerations may be another factor, however. Respondents' distance and access to markets could limit the extent to which they are able to implement climate smart forestry practices such as increasing vigor through thinning or reducing wildfire risk through understory treatments that decrease ladder fuel density.

4.5. BIOMASS & SLASH DISPOSAL

Total acres of biofuels dropped by almost 80% in 2024 compared to 2017 and 2008. Only 1,628 acres were harvested across 6 organizations for biofuels compared to 7,592 and 7,642 acres in 2017 and 2008, respectively. No biofuels were removed on a second entry in 2024 compared to 21% in 2008. There was a decrease in biofuels harvested as roundwood and sold in 2024 (10%) compared to a high in 2017 (26%). Sub-merchantable and hard snags harvested for biofuels continue to decrease over the survey periods.

Slash disposal prior to collection decreased across all options. The greatest decrease across survey periods was in the piles at the landing which represented 75% of slash before it was collected in 2008 and represented only 9.2% in 2024.

Since the 2017 survey, there has been a shift in biomass public policy and subsequent closures in biomass plants (e.g., Benson Power). This has resulted in a loss of market for mill residues and low-value or poor quality wood. Emerging markets within Minnesota and neighboring Wisconsin for sustainable aviation fuel (SAF) may bolster biomass and low-value markets in the future.

4.6. FOREST HEALTH

Emerald ash borer (EAB) continues to remain the most dominant forest health issue across organizations with 44% of forest management organizations rating it as one of their top three biggest forest health issues in 2024 (Table 7); consistent with the 43% rating it as their highest threat in 2017. There is greater concern regarding impact of spruce budworm (*Choristoneura fumiferana*) and oak wilt (22% each) in 2024 compared to 10% of respondents in 2017. Prioritization of impact of eastern larch beetle (ELB) fell to only 1 organization rating it as their biggest forest health threat.

The spatial distributions of forest health concerns were mapped and correlate with major forest types within the region (Figure 2). Since 2017, EAB has continued to expand its distribution within northern counties of Minnesota. While proactive management and underplanting have

been occurring, there is no single species that can be used for a replacement for black ash (Davenport et al. 2026, Palik et al. 2025). Additionally, there remain larger logistical and economical barriers for replanting or underplanting in black ash stands (D'Amato et al. 2018). Spruce budworm continues to impact forest communities across Minnesota; organizations who were highly concerned and impacted by spruce budworm were in the Arrowhead Region which has consistently had high levels of balsam fir mortality caused by spruce budworm (Figure 2). Additionally, with lagging and closing markets and increased frequency of drought conditions and an associated increase in potential fire risk, managers are continually being creative in how to manage dead and dying balsam fir (*Picea abies*). For example, many organizations have used partners or developed FireWise management plans to reduce fuel loads. However, fire risk and susceptibility during extreme drought conditions or within a wildfire occurs at the landscape scale (Frank et al. 2015). The Greenwood fire in summer of 2021 is an example of a fire in Minnesota that burned across public and private forest lands and into the Wildland Urban Interface (WUI) destroying homes (Minnesota Incident Command System [MNICS], 2022). Forest managers and community members within the WUI will need to increasingly work together to decrease fuel loads to increase potential resiliency to wildfire.

Forest management organizations are continuing to use a diverse set of management techniques to support forest health. Management organizations are actively thinning and using salvage harvests and clearcut regeneration harvests to reduce impact or remove infected trees. These types of silvicultural treatments generally follow broad forest health management strategies. The use of thinning to shift growing space and reduce remaining tree stress has consistently been applied in Minnesota and across the globe for numerous forest health threats, especially bark beetles. The use of a clearcut regeneration harvest removes large overstory trees that are often more likely to be impacted by insects and disease to support new regeneration. In addition, salvage or partial salvage can reduce immediate impact. Finally, a consistent trend that was also highlighted in other sections is supporting mixed species regeneration.

Thirteen invasive terrestrial plants were identified as being actively managed in 2024; this is an increase from 7 invasive terrestrial plants managed in 2017 (Figure 3). Over 60% of organizations are actively managing buckthorn (*Rhamnus cathartica* and *Frangula alnus*), up from ~37% in 2017. Fewer organizations were actively managing knapweed (*Centaurea* spp.), wild parsnip (*Pastinaca sativa*), and thistle (*Cirsium* spp.) in 2024 compared to 2017. In 2024 organizations added managing reed canary grass (*Phalaris arundinacea*), Oriental bittersweet (*Celastrus orbilatus*), black locust (*Robina pseudoacacia*), knotweed (*Reynoutria japonica)*, Japanese barberry (Berberis thunbergii), honeysuckle (*Lonicera* spp), and other additional noxious weeds.

While not a forest health impact, impacts from windstorms and windthrow had management implications for a large proportion of natural resource organizations in Minnesota. Over 60% of

management organizations completed some level of partial salvage harvest due to windthrow in the 2024 survey. Managers increasingly note how severe windthrow used to be rarer events, something that you would need to deal with within your career but not something that is happening every few years (personal communication). Changes in seasonal precipitation events (e.g., ice storms, slush crush) and intense windstorms are increasingly needing to be considered within organizations. Unlike conventional forest health threats, an early or late ice storm can equally impact a 25-year-old red pine stand and a 65-year-old red pine stand resulting in economic loss, especially of wood that is pre-merchantable, and increase potential impacts of forest health issues (e.g., bark beetles). A potential challenge facing management organizations is determining how to incorporate the increased occurrence of windthrow events into their landscape level plans.

4.7. TRENDS IN SILVICULTURAL PRACTICES

Almost three-quarters of respondents (74%) reported that their silvicultural practices have changed over the past five years in 2024, up from 55% of respondents in 2017 (Table 6). The most common factors that respondents identified as driving these changes were increasing tree species richness (53%), altering harvest practices such as the size of cutting blocks, improving access, or the type and/or extent of species removal (47%), and an increase in the use of artificial regeneration or assisted migration (29%) (Table 7). Several respondents noted the intersection of multiple factors; for example, in the context of the ongoing spruce budworm outbreak in northeastern Minnesota, one respondent observed "[the] market has been poor for spruce/fir/birch pulpwood since the Verso plant shut down, and we are having trouble selling sales." The responses to some of the observed challenges are likewise multifaceted: increased tree species richness can address economic, ecological, and climate-smart forestry objectives alike.

Respondents noted changes in the ways they prepare and administer sales in the last 5 years. A lack of markets for lower quality wood has hindered the capacity for multiple forest management organizations to respond to forest health threats, further compounded by limitations related to the season of harvest as respondents observed shorter, warmer winters. The extent and impacts of these factors varied across forest management organizations, however. For example, one respondent noted they were "leaving more residual trees post-harvest to promote species diversity and climate considerations" while another respondent described efforts to increase both commercial species composition and sale size as well as improving access to increase the marketability of sales. Increasing the size of cutting blocks or having multiple adjacent stands on a permit can limit equipment transportation costs for loggers and potentially provide enough volume to implement necessary silvicultural treatments that may not otherwise be commercially viable when sold on a separate permit.

When asked which site-level guidelines were most difficult for their staff to implement over the

past 5 years, 16 respondents (70%) observed challenges with implementing at least one of the site-level guidelines. The most common guidelines mentioned in this context were those regarding infrastructure (n = 6) with concerns about rutting, erosion, and crossings given warmer, wetter winters and large rainfall events during the growing season. One respondent noted that rain storms have resulted in the loss of culverts and replacing the lost structures with a new, larger structure that can withstand flash rain events requires "a vigorous amount of permitting", potentially leading to erosion and water quality concerns. Other respondents mentioned challenges around leave trees and retention guidelines (n = 5), raising concerns about the longevity of individual residuals or snags; in the latter case, safety was a particular concern when returning to the stand post-harvest for site preparation or planting activities. One respondent noted a potential disconnect between marking clusters of residuals in the field and tracking those clusters in their inventory software, while another respondent felt that reserve tree design and implementation that was compatible with silviculture prescriptions was an ongoing training need for their field staff.

Looking ahead to the next 5 years, all but four respondents (83%) felt that their silvicultural practices would change in at least some way. Several respondents anticipated increased species diversity, particularly in ash or aspen covertypes. Some felt that this increased diversity would be the result of upgraded seed collection efforts or natural regeneration in oak and pine covertypes while others connected it to increased retention on a given site or an increase in the use of selection and irregular shelterwood silviculture systems. Multiple respondents expressed concerns about winter harvest conditions and other changes connected to poor markets: "I expect that the aging logging community along with warm winters [will] lead to less difficult-to-access areas being harvested". Others expected an increase in the average size of sales as it may be harder to attract loggers to "traditional timber sales". These seasonal impacts, coupled with respondents anticipating a greater level of sanitation and salvage harvests in ash cover types or systems with budworm-killed spruce-fir, further reinforce the need to identify and develop markets to ensure Minnesota's forests remain vigorous and resilient to an uncertain future.

5. CONCLUSIONS

As in previous survey years, this 2024 survey captures the ongoing adaptive management practices implemented by forest management organizations that reflect shifts in societal values, markets, and management goals. Climate smart forestry practices were more directly quantified in this latest survey, providing insights into the ways in which respondents made decisions given current and projected climatic conditions, market considerations, and policy. For other sections, results from the 2024 survey expanded on robust data from previous surveys to provide further context or describe trends.

The use of clearcut regeneration harvests relative to other regeneration harvest types has held stable at 73% following a continued decline from 1991 to 2017. Other regeneration harvest types have likewise continued to be implemented at rates similar to those reported in 2017. The clearcut regeneration harvest as the most consistent regeneration harvest reflects both species and markets; aspen, red pine, and black spruce represent three critical species that are conventionally and generally managed using a clearcut regeneration harvest. There are opportunities for other types of regeneration harvests to be used or in the case of red pine or black spruce the use of extended rotations. Additionally, as the aspen-spruce mixed wood systems continue to mature, we may see more two-aged regeneration systems being used as the aspen are harvested and regenerated while the white spruce is retained.

Harvest intensity continues to decline. Tending practices—including commercial thinning and other intermediate treatments—are occurring on fewer acres than in previous years which can negatively impact growth and future economic returns and increase potential impacts from forest health threats. Beyond forest health considerations, projections of warmer, wetter winter conditions in Minnesota (Minnesota Department of Natural Resources, 2026) also have implications for implementing Minnesota's voluntary site-level guidelines. Organizations expressed concerns about decreased durations of frozen ground conditions and associated increases in rutting or compaction on sites with fine-textured or poorly drained soils.

Forest management organizations are adapting to these changes and working with existing conditions using a range of tools in their toolboxes. This includes the continued use of even-aged systems, especially a clearcut regeneration harvest, to maintain species that provide important ecological and economic value. Additionally, many organizations are using artificial regeneration to increase species diversity and are considering the species and genetics used in plantings (e.g., assisted migration). Many organizations expect that during the next survey their silvicultural practices will have changed, representing another opportunity to connect forest management decisions to broader society goals and objectives and how that influences forest structure and composition within Minnesota's forests.

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7. TABLES

Table 1: Summary of 2024, 2017, 2008, and 1996 silvicultural survey responses for acreage and volume harvested. Data from 2017, 2008, and 1996 surveys are from Windmuller-Campione et al. (2019), D'Amato et al. (2009), and Puettmann and Ek (1999), respectively.

Variable	2024				2017			
	n	**reported**	**Min**	**Max**	**n**	**reported**	**Min**	**Max**
Timberland ownership (ac)	23	10,508,706	0	5,800,000	22	10,367,761	3,061	5,800,000
Total volume harvested (cords)	23	1,436,143	0	661,710	22	1,559,921	0	671,625
Fuelwood (cords)	22	6,476	0	1,914	20	17,620	0	3,120
Average clearcut size (ac)	20	19.3	0	87	22	17	0	120
Average partial cut (ac)	20	18.9	0	106.7	22	30	0	91
Total area in silvicultural systems (ac)	23	70,703	0	26,277	22	90,516	0	47,300
Cords harvested/acre timberland	23	0.137	-	-	21	0.15	-	-
Cords harvested/acre timber sale	23	21.3	-	-	22	20.8	-	-

Table 1, continued: Summary of 2024, 2017, 2008, and 1996 silvicultural survey responses for acreage and volume harvested. Data from 2017, 2008, and 1996 surveys are from Windmuller-Campione et al. (2019), D'Amato et al. (2009), and Puettmann and Ek (1999), respectively.

Variable	2008				1996			
	n	**reported**	**Min**	**Max**	**n**	**reported**	**Min**	**Max**
Timberland ownership (ac)	26	9,865,694	4,258	4,500,000	25	7,720,204	5,400	2,600,000
Total volume harvested (cords)	26	1,973,290	1,873	783,249	25	1,965,164	1,474	533,000
Fuelwood (cords)	26	10,080	50	3,400	25	63,468	50	20,000
Average clearcut size (ac)	26	29	10	135	25	24	6	50
Average partial cut (ac)	22	25	12	49	21	27	3	200
Total area in silvicultural systems (ac)	26	125,234	241	41,000	25	99,297	126	41,546
Cords harvested/acre timberland		0.2	-	-		0.25	-	-
Cords harvested/acre timber sale		15.8	-	-		19.8	-	-

Table 2: Reported silviculture survey results and statewide estimates for Minnesota in 2024, 2017, 2008, 1996, and 1991.

Variable	Survey results					Statewide estimate				
	2024	2017	2008	1996	1991	2024	2017	2008	1996	1991
Ownership, harvesting, and regeneration										
Timberland ownership (ac)	10,508,706	10,367,761	9,865,694	7,720,204	7,848,031	15,816,878	15,815,400	14,988,700	14,723,200	14,723,200
Total volume harvested (cords)	1,436,143	1,559,921	1,973,290	1,965,164	1,858,849	2,656,682	2,514,286	2,924,500	3,810,000	3,530,333
Harvesting operations (ac)	70,703	90,516	88,965	99,297	90,128	125,016	145,894	134,209	192,514	171,155
Regeneration (ac)	60,111	74,180	102,380	85,786	84,991	95,252	119,564	130,257	166,380	161,400
Acres by silvicultural system and thinning (% of total acres in parentheses)										
Clearcut	51,273 (73)	65,607 (72)	97,908 (78)	85,294 (86)	82,017 (91)	94,849 (73)	105,746 (72)	128,167 (78)	163,956 (86)	152,328 (91)
Strip clearcut	5 (0)	25 (0)	0 (0)	234 (0)	901 (1)	9 (0)	40 (0)	0 (0)	454 (0)	1,711 (1)
Seed tree	1,431 (2)	2,455 (3)	1,974 (2)	1,356 (1)	0 (0)	2,647 (2)	3,957 (3)	3,002 (2)	2,629 (1)	0 (0)
Shelterwood	2,976 (4)	1,887 (2)	2,830 (2)	789 (1)	0 (0)	5,505 (4)	3,041 (2)	4,303 (2)	1,530 (1)	0 (0)
Selection (group and single-tree)	3,392 (5)	5,276 (6)	4,712 (4)	1,022 (1)	1,802 (2)	6,275 (5)	8,504 (6)	7,164 (4)	1,981 (1)	3,422 (2)
Thinning (commercial)	11,625 (16)	15,266 (17)	17,809 (14)	10,602 (11)	5,408 (6)	21,505 (16)	24,606 (17)	27,044 (14)	20,555 (11)	10,270 (6)

Table 3: Reported harvesting activities by ownership within Minnesota in 2024. Data represent 66% of all timberland in Minnesota.

Variable	**Ownership group**						
	Survey Total	State	County	Federal	Forest Industry	Tribal	Non-profit
Ownership, harvesting, and regeneration							
Timberland ownership (ac)	10,508,706	5,800,000	2,391,268	2,060,717	157,721	91,000	8,000
Total volume harvested (cords)	1,436,143	631,067	656,142	114,274	33,440	1,219	0
Harvesting operations (ac)	70,703	29,680	30,549	8,063	2,026	385	0
Regeneration (ac)	60,111	21,623	27,706	7,620	2,358	804	0
Acres by silvicultural system and thinning (% of total acres in parentheses)							
Clearcut	51,273 (73)	20,891 (70)	23,936 (78)	4,844 (60)	1,267 (63)	335 (87)	0 (0)
Strip Clearcut	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (1)	0 (0)
Seed Tree	1,431 (2)	960 (3)	445 (2)	0 (0)	0 (0)	26 (7)	0 (0)
Shelterwood	2,976 (4)	646 (2)	1,190 (4)	627 (8)	513 (25)	0 (0)	0 (0)
Single Tree Selection	1,192 (2)	384 (1)	46 (0)	762 (9)	0 (0)	0 (0)	0 (0)
Group Selection	2,200 (3)	1,015 (4)	934 (3)	169 (2)	82 (4)	0 (0)	0 (0)
Thinning (commercial)	11,625 (16)	5,784 (20)	3,998 (13)	1,661 (21)	164 (8)	19 (5)	0 (0)

Table 4: Reported acres of silvicultural practices by ownership in Minnesota in 2024. Data represent 66% of all timberland in Minnesota. N refers to the number of respondents implementing a given practice out of 23 total responses.

Variable		Ownership group						
	n	Survey Total	State	County	Federal	Forest Industry	Tribal	Non-profit
Regeneration								
Artificial, including underplanting	19	13,866	3,127	5,825	4,063	800	51	0
Cutting	1	5	5	0	0	0	0	0
Direct seeding	5	3,082	1,919	594	569	0	0	0
Natural regeneration, from seed	12	4,935	2,793	1,006	0	671	465	0
Natural regeneration, vegetative	19	36,533	12,874	20,204	2,303	887	265	0
Two+ years of successive planting	4	1,690	905	77	685	0	23	0
Average percent conifer	16	23	20	13	44	30	28	0
Average percent hardwood	16	77	80	87	56	70	72	0
TOTAL		60,111	21,623	27,706	7,620	2,358	804	0
Site preparation								
Chemical - aerial	1	55	55	0	0	0	0	0
Chemical - ground	10	1,954	909	1,045	0	0	0	0
Mechanical	14	6,837	1,614	3,138	1,734	231	120	0
Prescribed burning	3	196	93	0	14	0	89	0
TOTAL		9,042	2,671	4,183	1,748	231	209	0
Timber stand improvement								
Chemical release - aerial	2	197	111	86	0	0	0	0
Chemical release - ground	8	942	672	270	0	0	0	0
Mechanical/Manual release	15	10,965	2,375	2,805	4,887	698	100	100
Precommercial thinning	6	933	285	15	239	376	18	0
Residual stem felling	1	60	0	60	0	0	0	0
TOTAL		13,097	3,443	3,236	5,126	1,074	118	100
Salvage harvesting								
Salvage harvesting	7	1,285	713	210	361	0	1	0
Protection from herbivory								
Budcapping	16	14,694	5,101	6,516	2,174	900	3	0
Cages around individual trees	7	2,085	8	2,021	6	9	41	0
Fences (exclosures)	0	0	0	0	0	0	0	0
Sprays or repellants	1	1	0	1	0	0	0	0
TOTAL		16,780	5,109	8,538	2,180	909	44	0

Table 5: Summary of biofuels harvests reported within Minnesota in 2024, 2017, and 2008. Table extends to next page.

Variable	Ownership group and survey year											
	Survey Total			State			County			Federal		
	2024	2017	2008	2024	2017	2008	2024	2017	2008	2024	2017	2008
Number of respondents	23	20	15	1	1	1	14	10	7	3	1	2
Number of respondents that harvested biofuels	6	11	-	1	1		2	4		0	1	
Total acres of biofuels harvest	1,628	7,592	7,642	637	2,400	5,467	824	3,071	1,675	0	736	0
Average percent of biofuels removed on second entry	0	3	21	0	-	25	0	10	36	0	0	-
Average percent of biofuels harvested where roundwood was sold as biofuel	10	26	20	0	-	25	0	23	36	0	0	-
Average percent of biofuels on second entry involved backhauling slash	0	0	-	0	-	-	0	0	-	0	-	-
Location of slash before collection (average percent):												
Windrows	0	0	0	0	-	0	0	0	0	0	0	-
Piles at landing	9	23	75	0	-	50	5	33	60	0	50	-
Scattered	12	25	3	0	-	0	10	50	0	0	50	0
Other locations	4	37	-	0	-	-	0	0	-	0	0	-
Average percent of biofuel harvests for which:												
Sub-merchantable materials were harvested	10	36	72	0	-	75	8	47	65	0	60	-
Hard snags were harvested	5	6	17	0	-	15	0	5	2	0	0	-

Table 5, continued: Summary of biofuels harvests reported within Minnesota in 2024, 2017, and 2008.

Variable	Ownership group and survey year											
	Survey Total			Forest Industry			Tribal			Non-profit		
	2024	2017	2008	2024	2017	2008	2024	2017	2008	2024	2017	2008
Number of respondents	23	20	15	2	3	1	2	3	4	1	2	-
Number of respondents that harvested biofuels	6	11	-	1	3		2	1		0	1	-
Total acres of biofuels harvest	1,628	7,592	7,642	100	1,307	300	67	20	200	0	58	-
Average percent of biofuels removed on second entry	0	3	21	0	0	-	0	0	0	-	0	-
Average percent of biofuels harvested where roundwood was sold as biofuel	10	26	20	50	63	10	50	0	10	-	500	-
Average percent of biofuels on second entry involved backhauling slash	0	0	-	0	0	-	0	0	-	-	0	-
Location of slash before collection (average percent):												
Windrows	0	0	0	0	0	0	0	0	0	-	0	-
Piles at landing	9	23	75	0	0	100	60	0	90	-	10000	-
Scattered	12	25	3	50	50	0	0	0	10	-	0	-
Other locations	4	37	-	0	100	-	40	100	-	-	0	-
Average percent of biofuel harvests for which:												
Sub-merchantable materials were harvested	10	36	72	0	45	75	49	40	-	-	9500	-
Hard snags were harvested	5	6	17	50	0	50	1	60	0	-	0	-

Table 6: Number of responses to the question, "Which species are you currently having the most difficulty regenerating?"

Tree species	n
Eastern white pine	10
Jack pine	6
Northern white cedar	5
Northern red oak	5
Red pine	3
Yellow birch	3
White oak	3
Paper birch	2
Black spruce	1
Silver maple	1

Table 7: Respondents (n = 23) who indicated an issue was their biggest forest health threat in Minnesota in 2024.

Forest Health Threat	n (%)
Emerald ash borer	10 (44)
Spruce budworm	5 (22)
Oak wilt	5 (22)
Bark beetles	2 (9)
Windthrow	2 (9)
Flooding and saturated soils	1 (4)
Eastern larch beetle	1 (4)
White pine blister rust	1 (4)
Hypoxylon	1 (4)
Two-lined chestnut borer	1 (4)

8. FIGURES

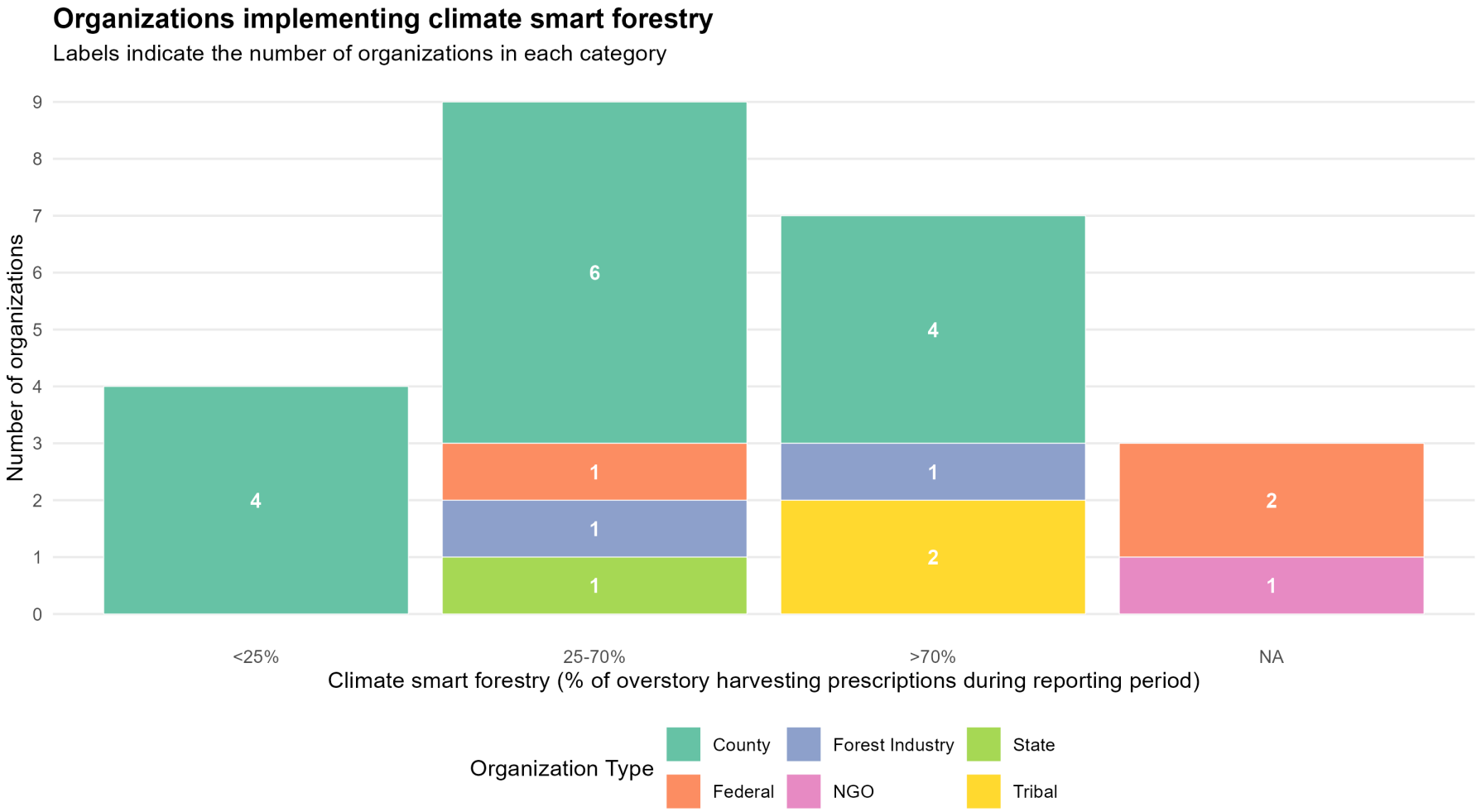


Figure 1: Respondents' extent of climate smart forestry practices as a percent of overstory harvesting prescriptions during the reporting period. Climate smart forestry was defined as the implementation of specific silvicultural practices intended to enhance the forest's resistance to climate-driven change in composition, structure, or extent, resilience to climate-driven weather and disturbance patterns, or to reduce the forest's susceptibility to canopy loss due to wildfire, extreme wind, ice storms, drought, flooding (or other weather-related phenomena), insects and disease, and other threats.

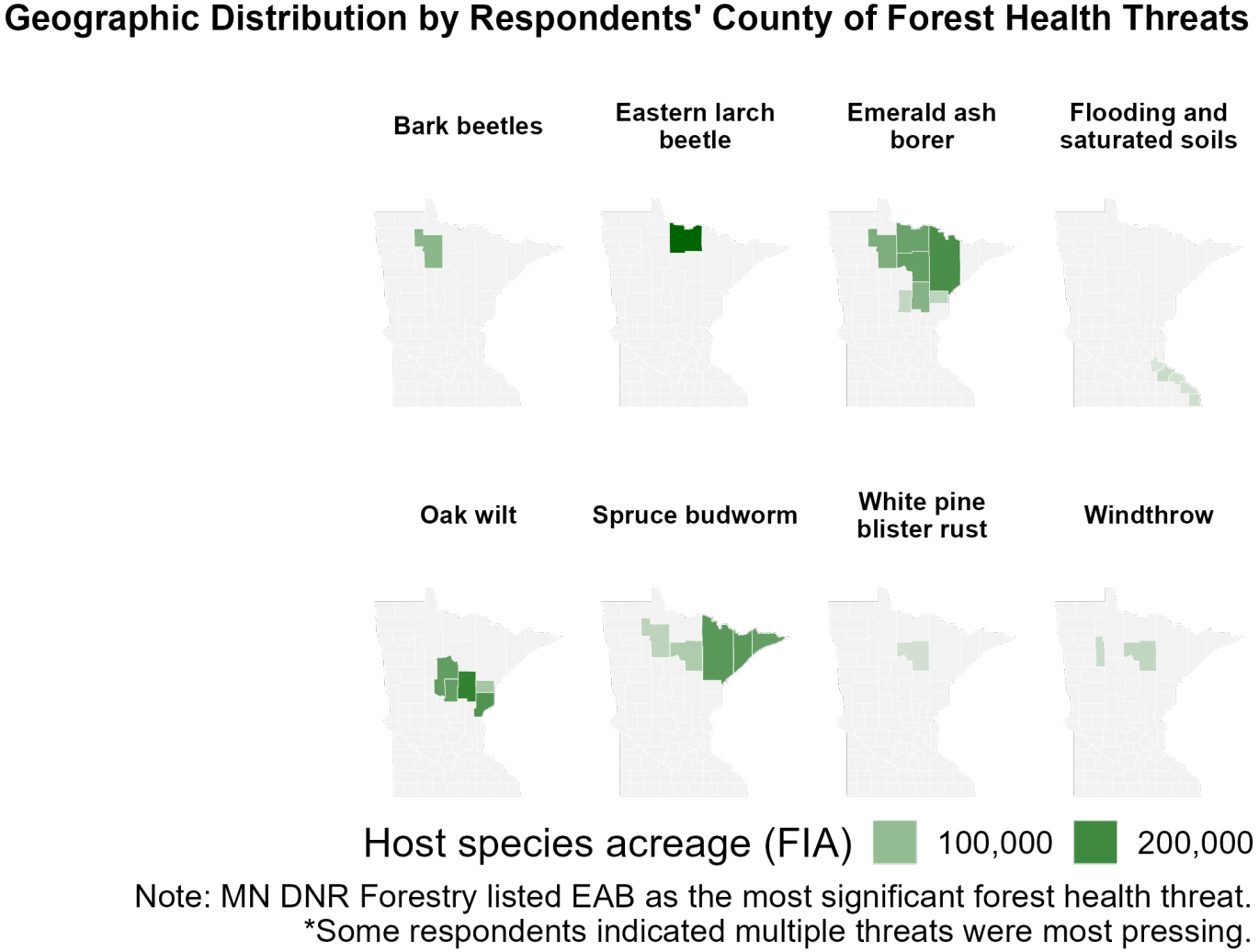


Figure 2: Map of the most pressing forest health threats by respondent county/s. Darker shades indicate increased area of host species in acres based on FIA data. Windthrow acres in Clearwater and Itasca counties were calculated using post hoc FIA data of affected areas.

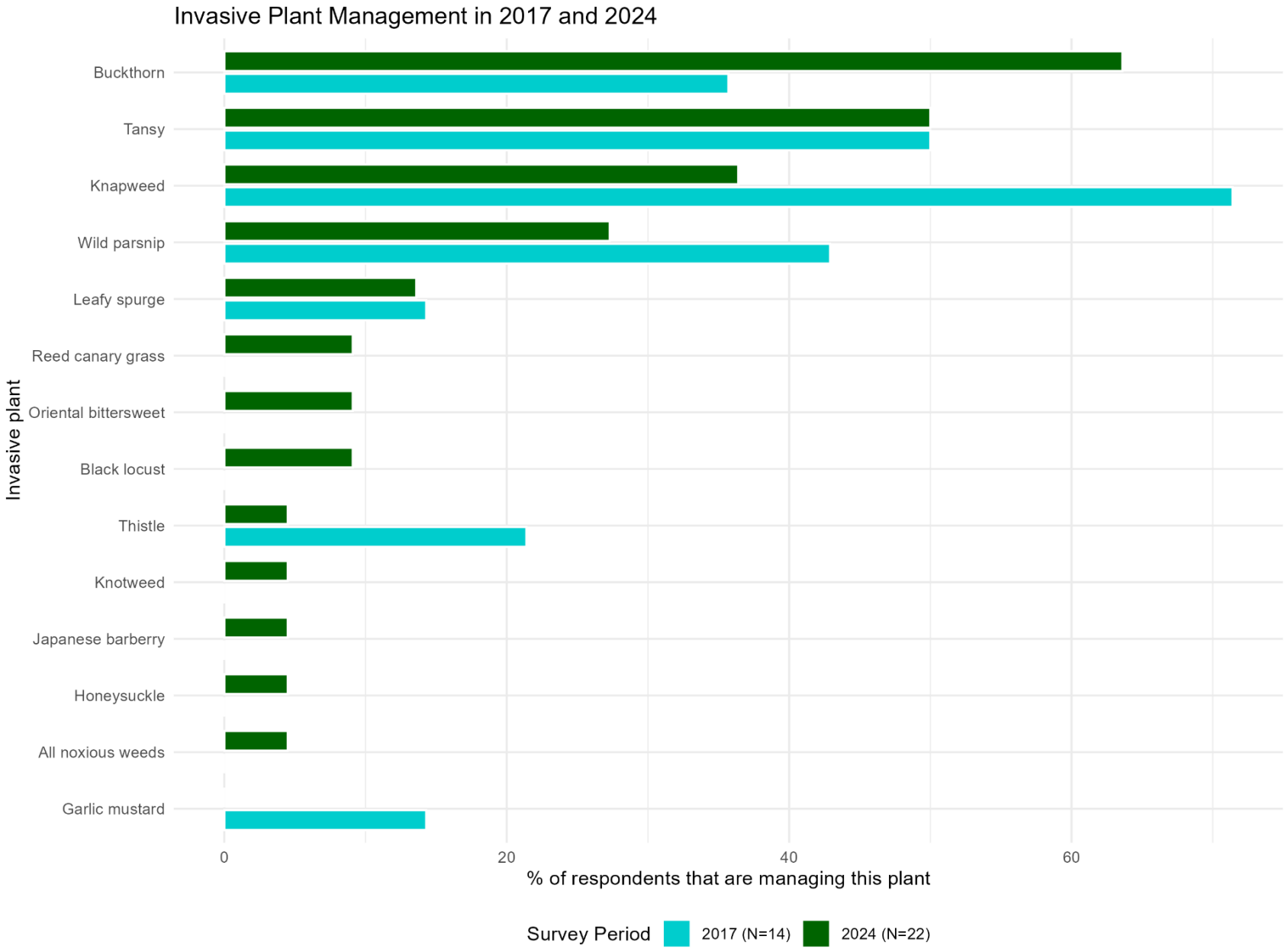


Figure 3: Percent of respondents that are managing specific invasive plants in 2017 and 2024. Credit for 2017 survey data to Matt Russell.

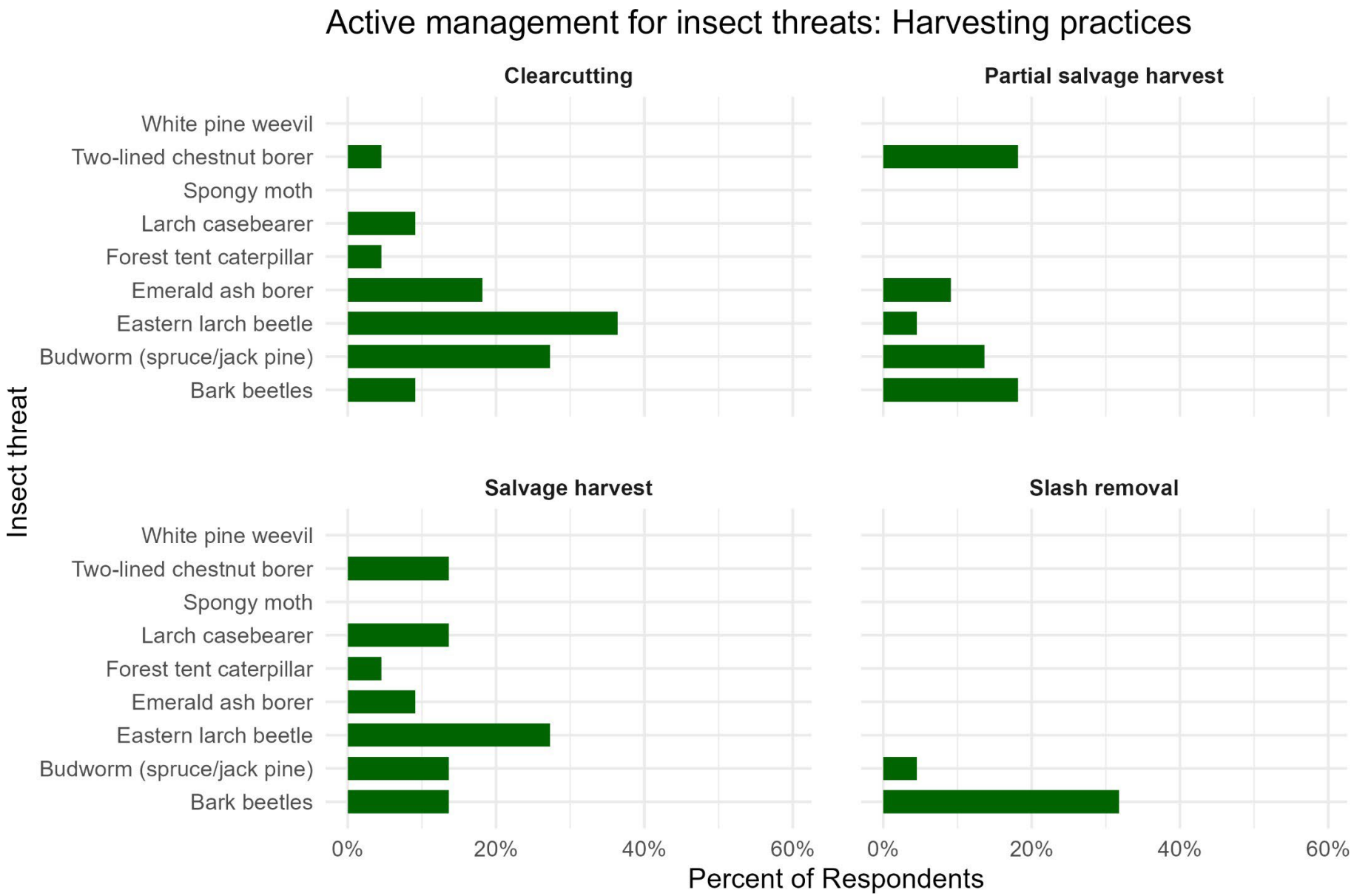


Figure 4: Percent of respondents that commonly used harvesting silvicultural practices to manage insect forest health threats.

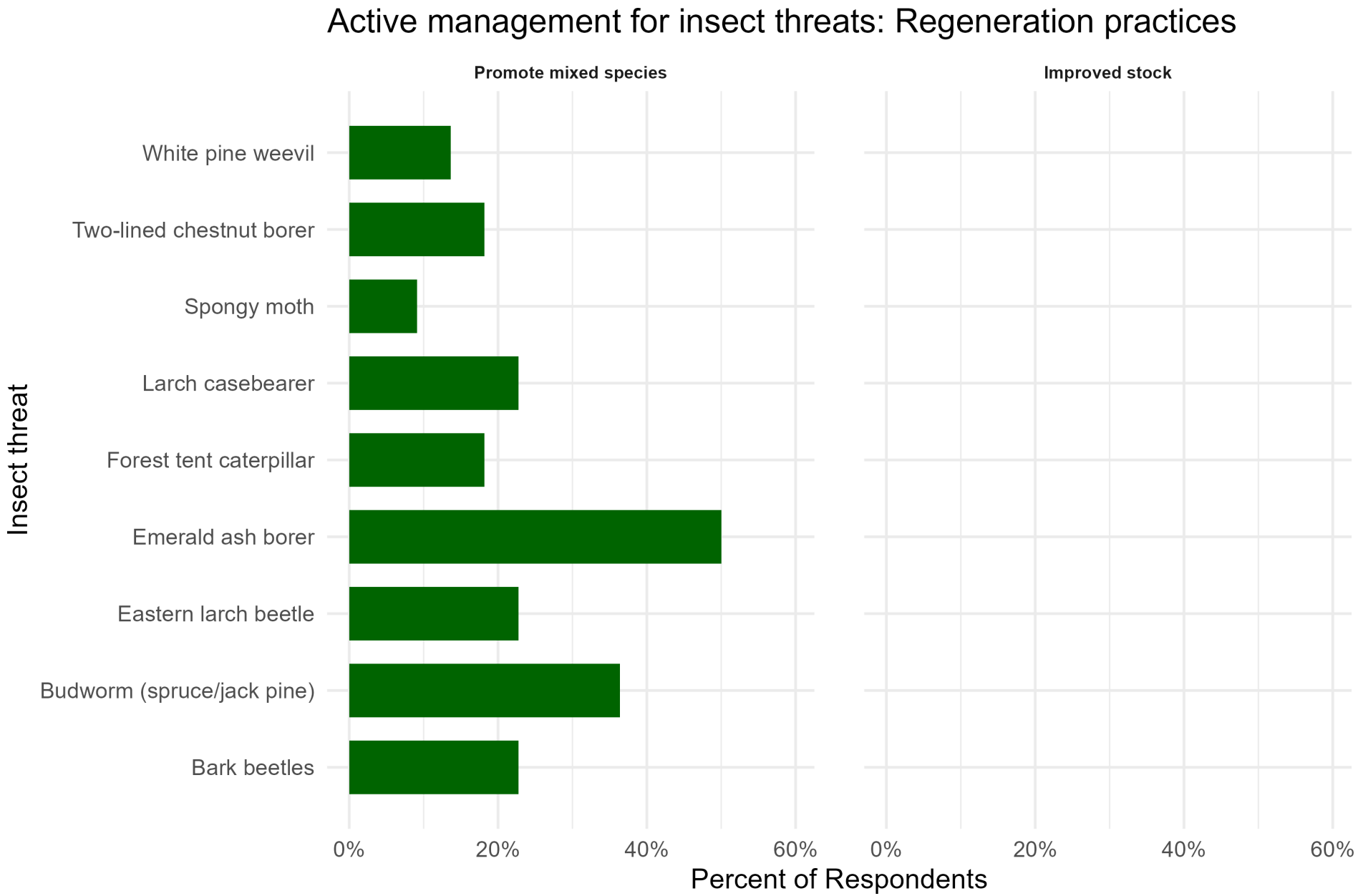


Figure 5: Percent of respondents that commonly used regeneration silvicultural practices to manage insect forest health threats.

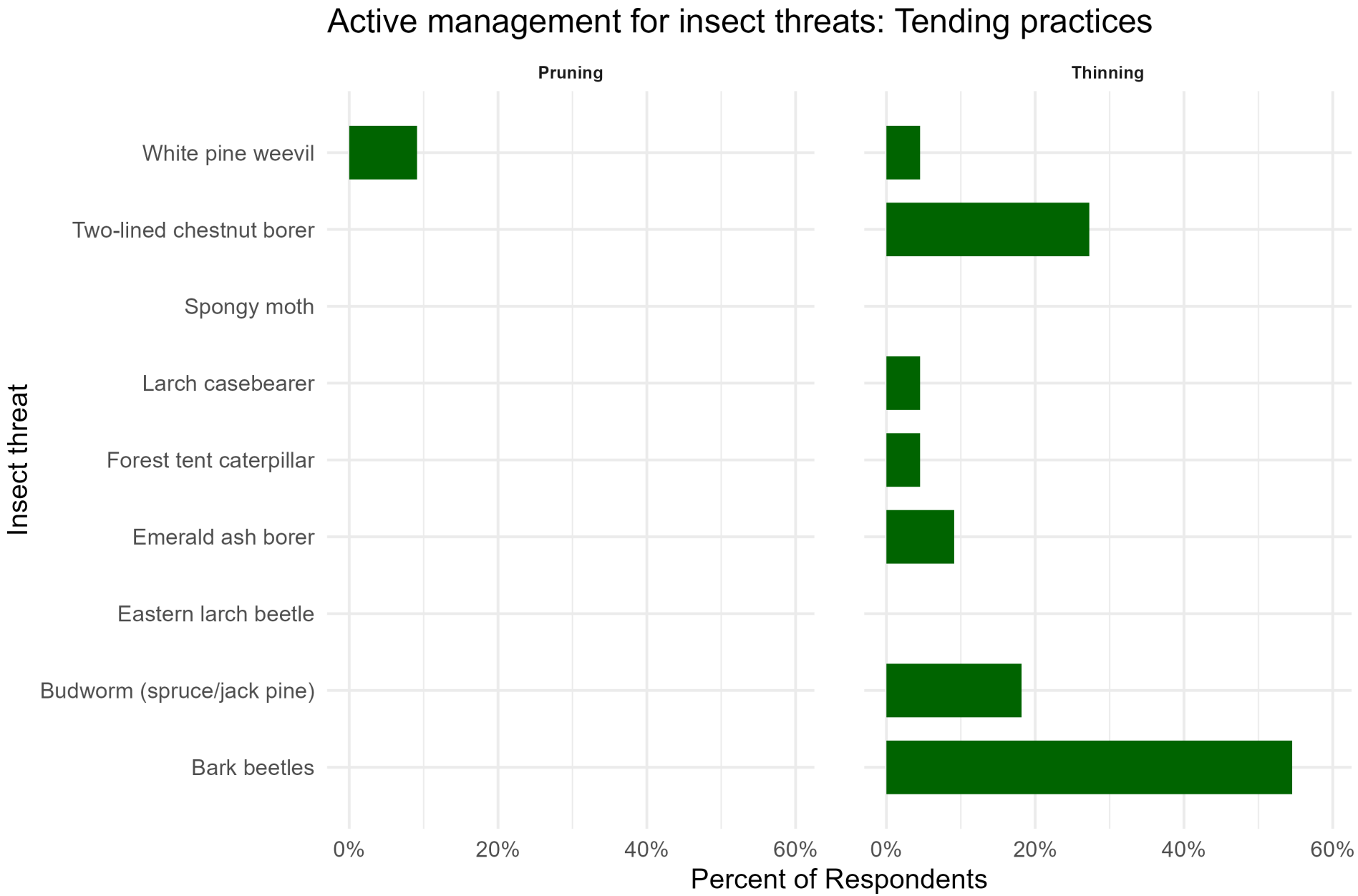


Figure 6: Percent of respondents that commonly used tending silvicultural practices to manage insect forest health threats.

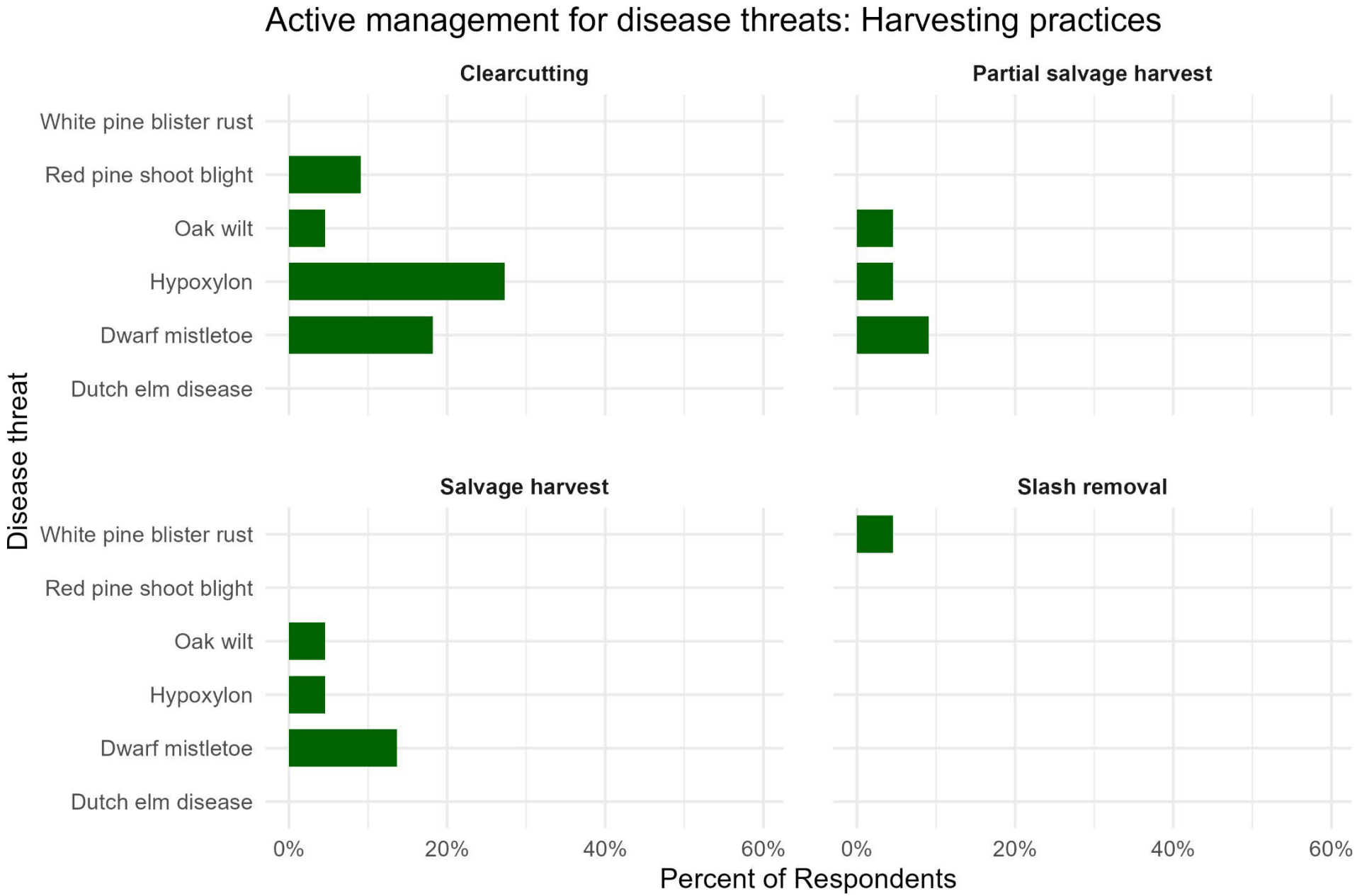


Figure 7: Percent of respondents that commonly used harvesting silvicultural practices to manage disease forest health threats.

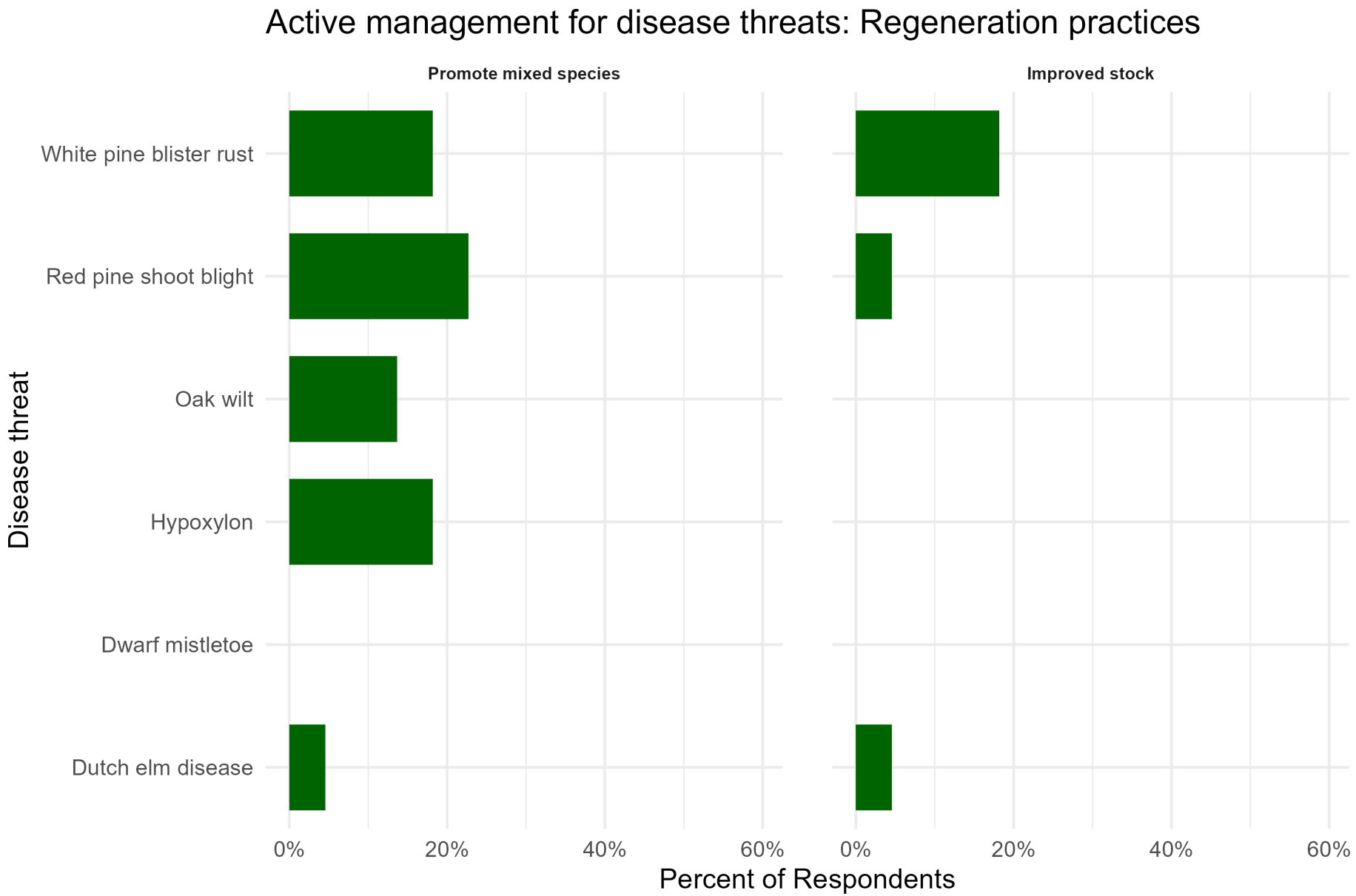


Figure 8: Percent of respondents that commonly used regeneration silvicultural practices to manage disease forest health threats.

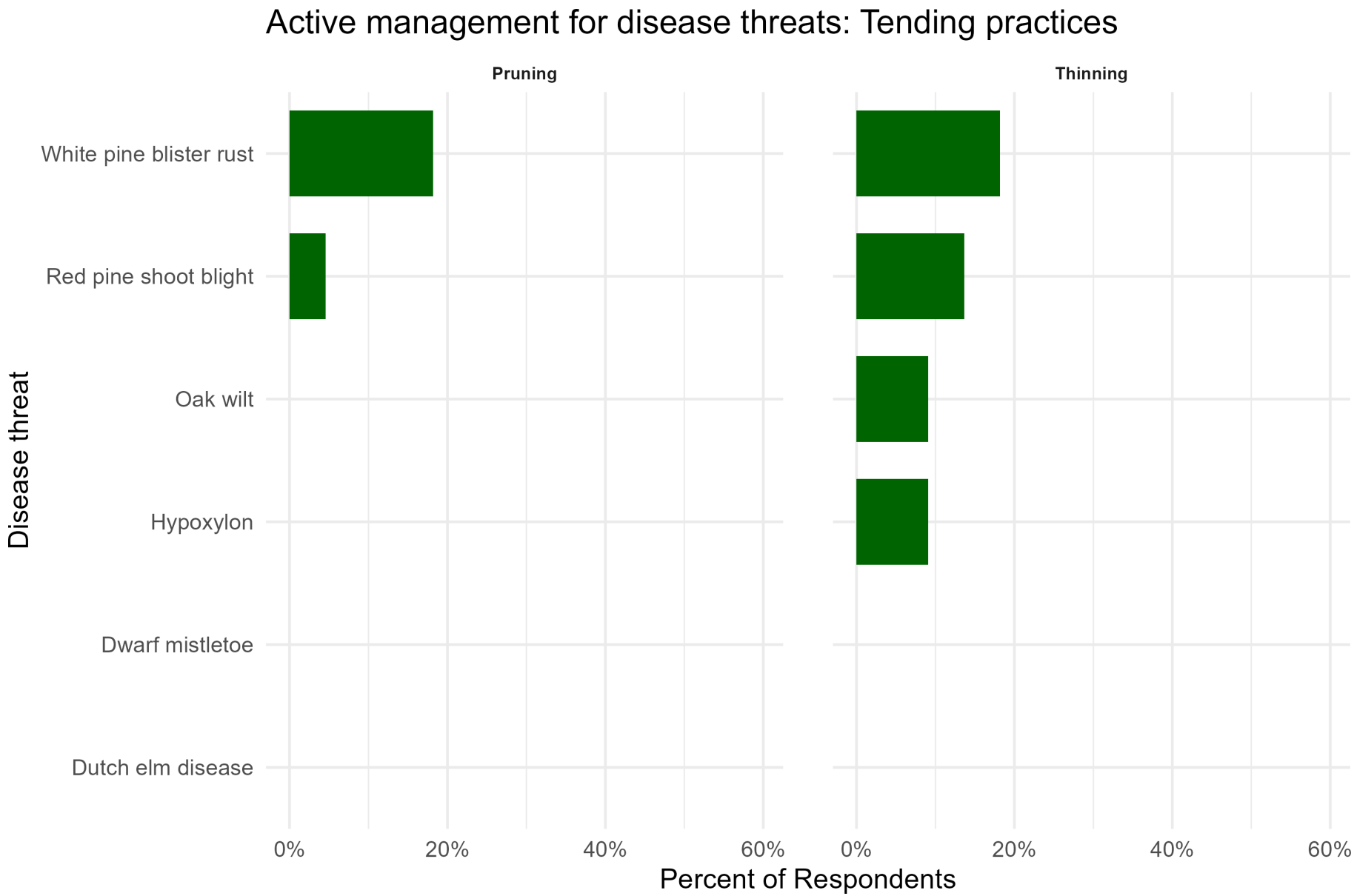


Figure 9: Percent of respondents that commonly used tending silvicultural practices to manage disease forest health threats.

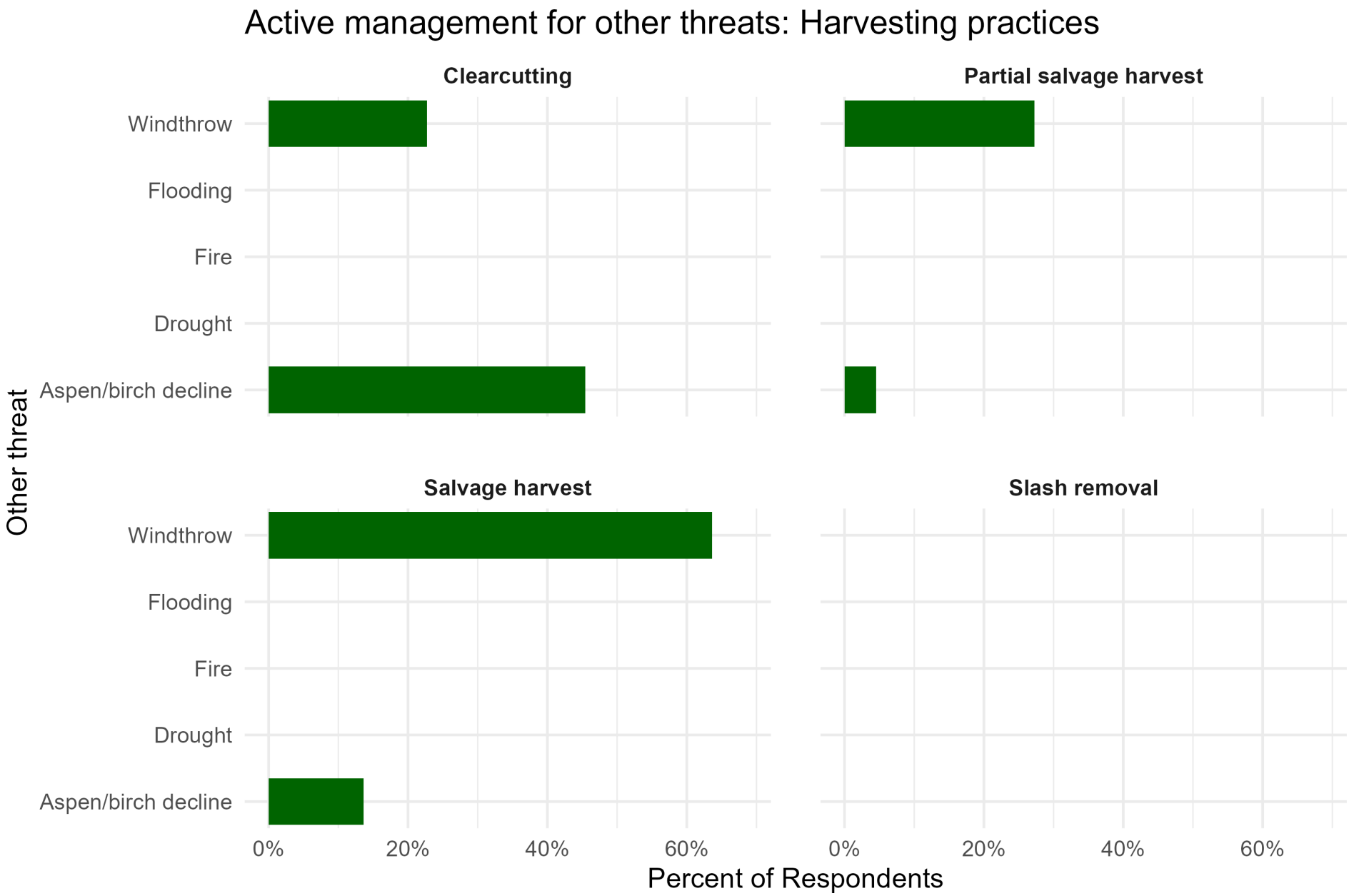


Figure 10: Percent of respondents that commonly used harvesting silvicultural practices to manage other forest health threats.

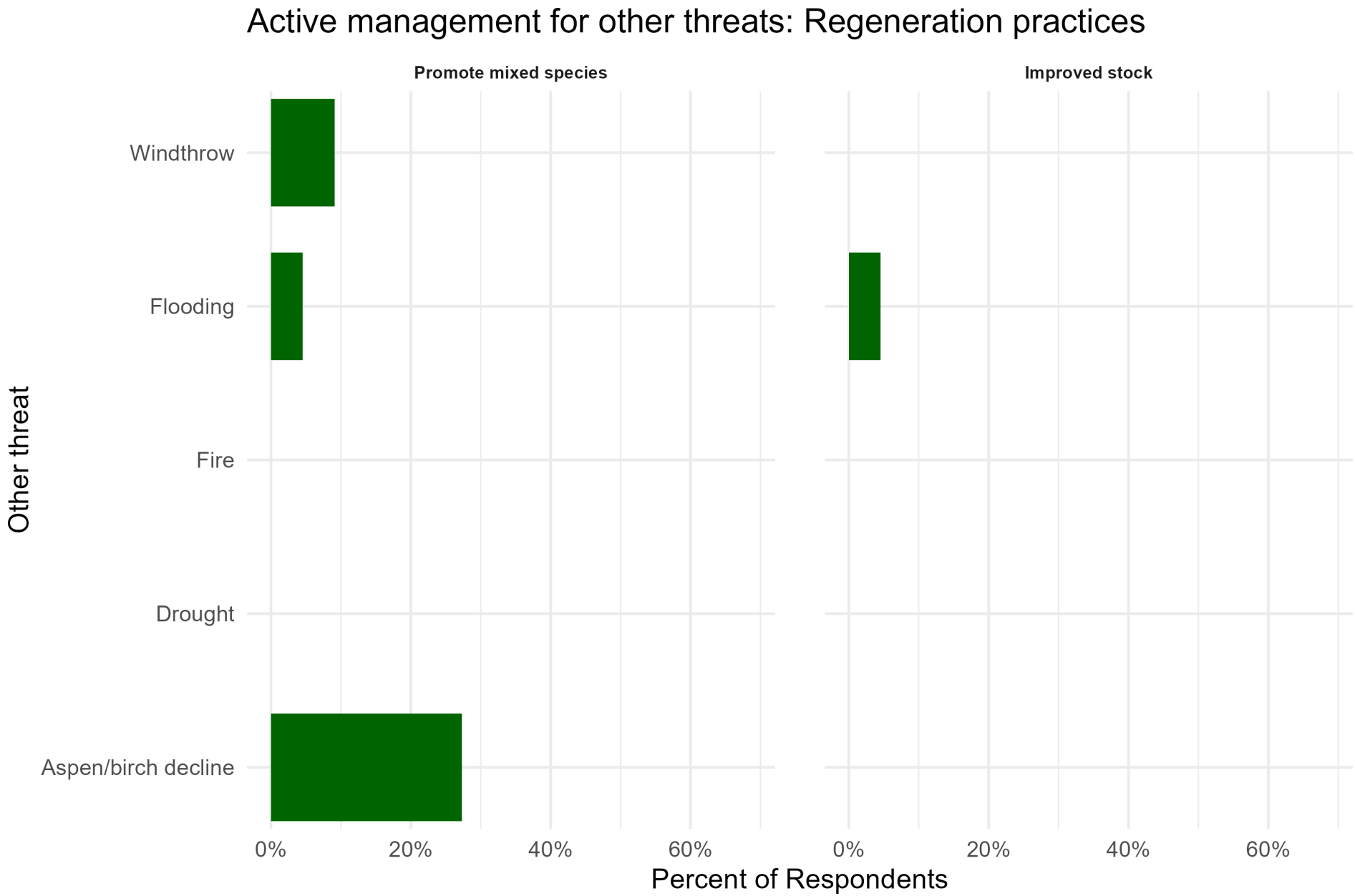


Figure 11: Percent of respondents that commonly used regeneration silvicultural practices to manage other forest health threats.

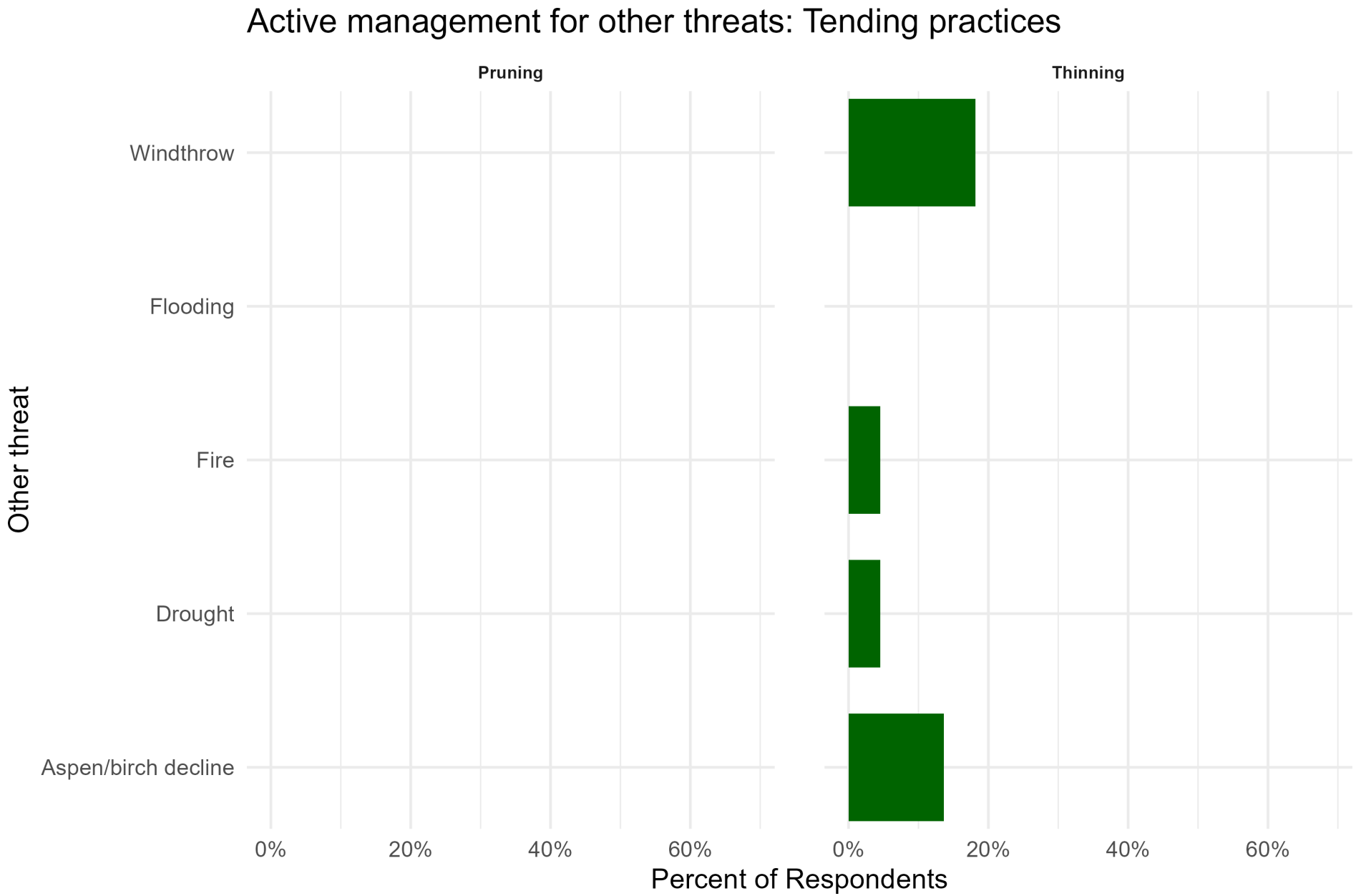


Figure 12: Percent of respondents that commonly used tending silvicultural practices to manage other forest health threats.

9. APPENDICES

APPENDIX A: Questionnaire: Silvicultural Practices in Minnesota

Questionnaire: Silvicultural Practices in Minnesota



Contact:
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The purpose of this questionnaire is to learn more about the silvicultural and forest health practices applied across Minnesota in 2024 or your most recently completed fiscal year.

The questions should take a couple of hours to complete. Your organization's participation is entirely voluntary and there is no penalty for choosing not to complete the questionnaire. Your answers will never be associated with you personally and only aggregate results, with no personal identifiers, will be reported. (The name you provide will only be used to halt reminders once you have returned your questionnaire.)

You may complete and submit the questionnaire in either of the following ways:

1) Qualtrics survey: **https://z.umn.edu/SilvSurvey**
2) Fill in the digital (PDF) questionnaire, then **save the file with a new name** and upload the file to **https://z.umn.edu/SilvSurveyBox**
   Note: It can be helpful to print the PDF version of the survey to be able to share across individuals and departments

If you wish to comment on any question or expand on your response, feel free to use the space allotted at the end of this survey.

See the enclosed sheet for definitions of the terms used throughout the questionnaire. **Terms marked with an asterisk* appear in the glossary (https://z.umn.edu/SilvGlossary).**

Respondent's Name: _____

Organization: _____

If possible, please complete the survey for the period January 1 to December 31, 2024. If your database structure makes this a challenge, you may report on a different 12-month period (e.g. your most recently completed fiscal year).

The 12-month period that you are reporting on runs from:

_____(month, year) through the end of _____(month, year).

PART 1: ANNUAL FOREST MANAGEMENT OPERATIONS

Throughout the questionnaire, answers should be based on timberland only (all forested land available for management). **If you don't have exact figures available, provide your best estimates throughout the questionnaire.**

1.1 Which of the following best describes the ownership of the land base you are reporting on? (Check one option.)

- ◯ Federal
- ◯ State
- ◯ County
- ◯ Private (including corporate or TIMO/REIT)
- ◯ Private (forest industry) ◯
- Tribal
- ◯ Other (please specify): _____

1.2 What was your organization's total timberland acreage during the reporting period?

_____ acres

1.3 How many acres were harvested during the reporting period?

_____ acres

1.4 What was the total volume harvested? Please report cords plus additional MBF or tons, where appropriate. (MBF = thousand board feet):

1.4.1 Total (excluding firewood):

_____ cords of pulpwood

_____ MBF of sawtimber tons

_____ biofuels/biomass

1.4.2 Firewood

_____ cords

_____ tons

PART 2: SILVICULTURAL ACTIVITIES

Please base your response to the following questions on tracts that were offered for sale during the reporting year, regardless of whether the tract sold or not. Acreage should include the entire sale area, including reserve patches. If none, please write in 0.

2.1 How many different sales were offered?

_____ sales

2.2 What was the total acreage of all sales offered?

_____ acres

2.3 How many sales were offered, but not sold?

_____ sales

2.4 Some timber sales involve multiple blocks, sometimes with different harvest treatments. For the following questions, estimate the **average size and number of harvest blocks offered during the reporting year** for each silvicultural system. If none, please write in 0.

2.4.1 Clearcut* (including coppice) with or without residuals:

_____ acres in _____ harvest blocks

2.4.2 Strip clearcut*:

_____ acres in _____ harvest blocks

2.4.3 Shelterwood*:

_____ acres in _____ harvest blocks

2.4.4 Seed tree*:

_____ acres in _____ harvest blocks

2.4.5 Group selection*:

_____ acres in _____ harvest blocks

2.4.6 Single tree selection*:

_____acres in _____harvest blocks

2.4.7 Thinning (commercial only)*:

_____acres in _____harvest blocks

2.5 From those acres **commercially** thinned (your response to 2.4.7 above), indicate the percentage of acres that used the following thinning methods (NOTE: Totals should add to 100%). If none, please write in 0.

2.5.1 Thinned from above _____%

2.5.2 Thinned from below _____%

2.5.3 Row thinning _____%

2.5.4 Free thinning _____%

2.6. From those acres **commercially** thinned (your response to 2.4.7 above), indicate the percentage of acres that were logger select*: _____%

2.7 Estimate the total acreage receiving each of the following **timberstand improvement** or release methods. If none, please write in 0:

2.7.1 Chemical release – aerial: _____acres

2.7.2 Chemical release – ground: _____acres

2.7.3 Mechanical release: _____acres

2.7.4 Noncommercial thinning: _____acres

2.7.5 Harvest of residual trees: _____acres

2.8 Estimate the acreage receiving a salvage harvest*. If none, please write in 0.

Salvage harvest: _____acres

2.9 If there are other silvicultural treatments not listed above, specify them here and estimate the number of acres on which each occurred. NOTE: Omit biofuels* harvests here, which will be addressed in the next section. If left blank, we will assume no other treatments were applied.

Other treatment 1: _____ on _____acres

Other treatment 2: _____ on _____acres

Other treatment 3: _____ on _____acres

2.10 Approximately what percent of your overstory harvesting prescriptions could be classified as climate smart forestry? "Climate smart forestry" means the implementation of specific silvicultural practices intended to enhance the forest's resistance to climate driven change in composition, structure, or extent, resilience to climate driven weather and disturbance patterns, or to reduce the forest's susceptibility to canopy loss due to wildfire, extreme wind, ice storms, drought, flooding (or other weather-related phenomena), insects and disease, and other threats. (See Appendix B for additional details.)

- ◯ <25%
- ◯ 25-70%
- ◯ >70%

2.11 Please upload a blank version of your organization's silviculture prescription form to https://z.umn.edu/SilvSurveyBox

PART 3: BIOFUELS* HARVESTS

3.1 How many acres received any harvest for biofuels* during the reportingperiod? Biofuel harvest: _____acres

3.2 For what percentage of biofuels harvest sites were biofuels removed through a second entry into the stand after the primary harvest was complete?

Second entry: _____% of biofuels harvest sites

3.3 For what percentage of biofuel harvest sites was roundwood sold as biofuel?

Roundwood sold as biofuel: _____% of biofuels harvest sites

3.4 For biofuel harvests involving a second entry, what percentage of biofuel harvest sites involved first backhauling of slash?

Backhauling slash: _____% of biofuels harvest sites

3.5 For biofuel harvests, where was the biofuel material located prior to collection?

3.5.1 Windrows: _____% of biofuels harvest sites

3.5.2 Piles at a landing: _____% of biofuels harvest sites

3.5.3 Scattered: _____% of biofuels harvest sites

3.5.4 Any other location: _____% of biofuels harvest sites

3.6 For what percent of biofuel harvest sites were submerchantable materials or snags harvested?

3.6.1 Sub-merchantable materials harvested: _____% of biofuels harvest site

3.6.2 Hard snags harvested: _____% of biofuels harvest sites

PART 4: REGENERATION METHODS

4.1 Estimate the areas regenerated during the reporting year. If none, please write in 0:

4.1.1 Total regeneration including each of the following methods:

_____ acres including _____ % conifer and _____ % hardwood species

4.1.2 Planting/artificial regeneration including underplanting:

_____ acres including _____ % conifer and _____ % hardwood species

4.1.3 Seeding:

_____ acres including _____ % conifer and _____ % hardwood species

4.1.4 Cuttings (e.g., hybrid poplar):

_____ acres including _____ % conifer and _____ % hardwood species

4.1.5 Two or more years of successive planting:

_____ acres including _____ % conifer and _____ % hardwood species

4.1.6 Natural regeneration from sprouts or suckers:

_____ acres including _____ % conifer and _____ % hardwood species

4.1.7 Natural regeneration from seed:

_____ acres including _____ % conifer and _____ % hardwood species

4.2 Other regeneration methods used (please specify). If left blank, we will assume no other regeneration methods were used.

Other method 1: _____ on _____ acres

Other method 2: _____ on _____ acres

Other method 3: _____ on _____ acres

4.3 Estimate the area receiving protection from ungulate herbivory using each of the following methods. If none, please write in 0:

4.3.1 Total acreage protected from ungulate herbivory using any method:

_____acres

4.3.2 Bud capping:

_____acres

4.3.3 Cages around individual trees:

_____acres

4.3.4 Fences around larger areas (e.g., exclosures):

_____acres

4.3.5 Sprays or repellents:

_____acres

4.3.6 Other herbivory protection methods used (please specify). If left blank, we will assume no other methods were used.

Other method 1:_____on_____acres for:

Other method 2:_____on_____acres for:

Other method 3: _____on_____acres for:

PART 5: SITE PREPARATION METHODS

5.1 Estimate the acreage receiving each of the following types of site preparation during the reporting year. If none, please write in 0:

5.1.1 Chemical-aerial:

_____acres

5.1.2 Chemical-ground:

_____acres

5.1.3 Prescribed burning:

_____acres

5.1.4 Mechanical (scarification, root raking, etc.):

_____acres

5.2 Other site preparation methods used (please specify). If left blank, we will assume no other methods were used.

Other method 1:_____on_____acres

Other method 2:_____on_____acres

Other method 3: _____on_____acres

PART 6: FOREST HEALTH

6.1 Next, we are interested in how you are addressing specific forest health threats. For each row of the following tables, please indicate **EITHER** that you are not managing that threat (and why) **OR**, if you are managing it, **indicate up to two** treatments/practices that you use most commonly to treat that threat on your land base.

6.1.1. Insect threats:

Are you managing this threat?	**No**. Why not?		**or**	**Yes.** Which practices do you use most commonly? (***select up to two*** *most common*)							
	Threat is not known on our land	Present, but not treating it		Pre-emptive thinning for vigor	Clear-cutting (pro-actively)	Salvage harvest to liquidate after mortality	Partial salvage harvest (sanitation of infested material)	Promotion of mixed species	Slash removal	Improved growing stock	Pruning
Bark beetles	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Budworm (spruce/ jack pine)	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Eastern larch beetle	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Emerald ash borer	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Forest tent caterpillar	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Spongy moth	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Larch casebearer	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Two-lined chestnut borer	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
White pine weevil	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Other:	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Other:	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐

6.1.2 Disease threats:

Are you managing this threat?	**No**. Why not?		**or**	**Yes.** Which practices do you use most commonly? (***select up to two*** *most common*)							
	Threat is not known on our land	Present, but not treating it		Pre-emptive thinning for vigor	Clear-cutting (pro-actively)	Salvage harvest to liquidate after mortality	Partial salvage harvest (sanitation of infested material)	Promotion of mixed species	Slash removal	Improved growing stock	Pruning
White pine blister rust	○	○		☐	☐	☐	☐	☐	☐	☐	☐
Red pine shoot blight(Diplodia/Sirococcus)	○	○		☐	☐	☐	☐	☐	☐	☐	☐
Dwarf mistletoe	○	○		☐	☐	☐	☐	☐	☐	☐	☐
Hypoxylon	○	○		☐	☐	☐	☐	☐	☐	☐	☐
Oak wilt	○	○		☐	☐	☐	☐	☐	☐	☐	☐
Other:	○	○		☐	☐	☐	☐	☐	☐	☐	☐
Other:	○	○		☐	☐	☐	☐	☐	☐	☐	☐

6.1.3 Other forest health concerns:

Are you managing this threat?	**No**. Why not?		**or**	**Yes.** Which practices do you use most commonly? (*select **up to two** most common*)							
	Threat is not known on our land	Present, but not treating it		Pre-emptive thinning for vigor	Clear-cutting (pro-actively)	Salvage harvest to liquidate after mortality	Partial salvage harvest (sanitation of infested material)	Promotion of mixed species	Slash removal	Improved growing stock	Pruning
Windthrow/blowdown	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Aspen and birch decline	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Other:	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Other:	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐
Other:	◯	◯		☐	☐	☐	☐	☐	☐	☐	☐

6.1.4 If you are managing for forest health threats listed in the above tables, but are **using methods that are not listed**, indicate the threat and the methods used below. Be sure to check or write in **only up to two methods** per threat.

Forest health threat:_____ treatment method: _____

Forest health threat:_____ treatment method: _____

Forest health threat: _____ treatment method: _____

6.2 Which of the forest health issues listed in the tables in section 6 is your biggest threat?

_____

6.3 Are you actively managing invasive plants?

◯ Yes ◯ No

If YES, which invasive plants are you managing and by which techniques? List up to four plants.

Plant: _____ Technique: _____

Plant: _____ Technique: _____

Plant: _____ Technique: _____

Plant: _____ Technique: _____

PART 7: TRENDS IN SILVICULTURAL PRACTICES

7.1 How have your silvicultural practices changed over the past five years? What factors caused these changes?

7.2 Over the past five years, which site-level guideline(s) have been the most difficult for your staff to implement? Why?

7.3 Which species are you currently having the most difficulty regenerating?

7.4 To what extent are you incorporating climate smart forestry? Are there specific forest types on which you are incorporating these practices more than others?

7.5 How do you expect your silvicultural practices to change in the next five years?

7.6 Looking ahead to the next five years, what is your biggest silviculture and/or forest health concern?

PART 8: OTHER COMMENTS

8.1 Is there anything else you would like us to know about your silvicultural practices, plans or concerns about the future, or other issues? Please write your comments here.

Thank you! If completing the questionnaire digitally, **be sure to save the file with a new name** before closing so that your data are properly recorded. Then upload to https://z.umn.edu/ SilvSurveyBox. If you are having any problems with an upload or the Qualtrics survey please reach out to Lane Moser at sfec@umn.edu

Please submit your silviculture prescription form in the same way.

If you have any questions about this survey, please contact Marcella Windmuller-Campione at (612) 624-3699 or sfec@umn.edu

THIS CONCLUDES THE QUESTIONNAIRE

Survey of Silvicultural Practices

13. Definitions

Below are definitions of terms used throughout the survey.

Biofuels: Any woody biomass used as a feedstock for bioenergy or the development of biofuels.

Clear-cutting (reproduction} method: A method of regenerating a forest stand in which new seedlings become established in fully exposed micro-environments after removal of most or all of the existing trees. The objective is to create an even-aged stand.
Regeneration can originate naturally or artificially. Direct

seeding: Application of seed direcUy to the site.

Even-aged stand: A stand of trees having a narrow range of ages, e.g. not exceeding 20% of the rotation.

Group selection: A method of regenerating uneven-aged stands in which trees are removed, and new age classes are established, in small groups. The maximum width of groups is approximately twice the height of the mature trees, with small openings providing micro-environments suitable for more intolerant regeneration. In the Group Selection System, the management unit or stand in which regeneration, growth, and yield are regulated consists of a landscape containing an aggregation of groups.

Patch clear-cut: Utilizing the clear-cut method of regeneration in an area typically equal to or less than 3 acres.

Pre-commercial thinning: A thinning that does not yield trees of commercial value, usually designed to improve crop spacing. Pruning: The

cutting of lower limbs from standing trees.

Release (Release cutting, Release operation): A treatment designed to free young trees-usually not past the sapling stage (1.0-4.9" in the Lake States) from undesirable competing vegetation. Treatments includedeaning, liberation, and weeding.

Residual: A tree that remains on the landscape after a harvest takes place for reasons other than providing a source of regeneration (e.g., wildlife, aesthetics}.

Reproduction method: A cutting method by which a new age class is created. Major methods are clear-cutting, seed-tree, shelterwood, selection, and coppice.

Salvage cutting: Theremoval of trees (dead or otherwise} to inhibit actual or anticipated spread of insects or disease. Selection (reproduction) method: A method of regenerating a forest stand, as well as c4·eating or maintaining an uneven-aged structure, by the periodic removal of trees. Trees are removed either individually or in small groups.

Seed-tree (reproduction) method: An even-aged regeneration method in which a new age class develops from seeds that germinate in fully-exposed micro-environments after removal of all the previous stand except a small number of trees left to provide seed.
Seed trees are removed after regeneration is established.

APPENDIX B: Email communications to survey contacts

Initial 'heads-up' email

Good afternoon,

I'm writing to ask for your help with an important long-term study of Minnesota forest practices.

Dating all the way back to 1991, the Minnesota Silviculture Survey quantifies the silvicultural practices of state, federal, county, forest industry, and Tribal forest lands in Minnesota. We appreciate the efforts that have gone into creating this long-term data set which is extremely valuable for our management within Minnesota.

I will be sending the latest iteration of the Minnesota Silviculture Survey in about 2 weeks on June 2nd to this email address, to fill out on behalf of your organization. Our work is funded through the Minnesota Forest Resources Council (MFRC).

If you are not the best point of contact to answer questions on your organization's forest management practices in Minnesota, please let me know as soon as possible.

The email will be generated from Qualtrics with the subject line "Minnesota Silviculture Survey " and provide instructions on filling out the survey. Your participation in this survey will help provide the most complete picture possible of forest management practices throughout the state.

Again, we appreciate the coordination and the data wrangling that goes into completing this survey. Thank you!

Survey distribution email via Qualtrics

Good morning,

We are inviting you to fill out the 2024 Minnesota Silviculture Survey on behalf of your organization. The purpose of this questionnaire is to learn more about the silvicultural and forest health practices applied across Minnesota in 2024 or your most recently completed fiscal year.

The questions should take a couple of hours to complete and will likely require coordination among multiple individuals and/or departments. Your organization's participation is entirely voluntary and there is no penalty for choosing not to complete the questionnaire. Your answers will never be associated with you personally and only aggregate results, with no personal identifiers, will be

reported. (The name you provide will only be used to halt reminders once you have returned your questionnaire.)

We are asking that you please fill out this survey by Friday, 1 August.

While the survey is administered through Qualtrics, a PDF version of the survey is also available at **https://z.umn.edu/SilvSurveyPDF**. This PDF version can be printed and/or partially completed and shared digitally across individuals and departments. As an alternative to Qualtrics, this PDF version of the survey can also be filled out and uploaded with a unique file name to **https://z.umn.edu/SilvSurveyBox.** If at all possible, however, we ask that you please submit your survey through Qualtrics.

Again, please fill out this survey by **Friday, 1 August**. Reach out to Lane Moser at moser196@umn.edu with any questions, or if you are having trouble accessing or entering data via Qualtrics or the form-fillable PDF. We appreciate you taking the time to fill this survey out and provide information on silvicultural practices in Minnesota.

Follow this link to the Survey:
${l://SurveyLink?d=Take the survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}