

Results of a Qualitative Assessment of Northern Minnesota Loggers' and Foresters' Perspectives and Experiences with Dwarf Mistletoe in Black Spruce Stands

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Executive Summary

Eastern spruce dwarf mistletoe (*Arceuthobium pusillum*) (ESDM) is a native dwarf mistletoe in Minnesota. It is a parasitic plant that damages black spruce (*Picea mariana*) through branch distortions known as witches' brooms, and leads to increased mortality and reduction in regeneration success. Treatments for ESDM involve removal of infested trees, which is typically done utilizing a clearcut. While ESDM has been managed for decades in black spruce stands in Minnesota, little is known about the effectiveness of the management approaches.

This research is part of an interdisciplinary study to increase detection and management options for ESDM. This piece of the research was a qualitative assessment of loggers' and timber sale foresters' knowledge and perceptions of effectiveness of current ESDM management practices in black spruce. Five research questions were examined: 1) Can foresters and loggers identify ESDM? 2) Do foresters and loggers understand the need to eradicate ESDM where timber production is the objective? 3) Are the eradication treatments implemented as designed? 4) Are there impediments to implementing management treatments? and 5) Are the treatments effective? Data were gathered through in-depth interviews and focus groups with loggers, as well as focus groups with timber sale foresters, in the study area.

Research Question 1: Can Foresters and Loggers Identify Dwarf Mistletoe?

Loggers indicated a desire and need for training around ESDM. However, some loggers felt that they do not actually need to know how to identify dwarf mistletoe because they simply follow the sale contract specifications and clearcut which doesn't require them to identify black spruce trees infected with dwarf mistletoe. However, it was discussed that family forest owners are not often aware of dwarf mistletoe. Therefore, loggers may be in a position to educate them about dwarf mistletoe impacts and treatment options. Additionally, if loggers can identify dwarf mistletoe on adjacent sites when harvesting, that could aid in communication among different landowners and slowing the cyclical infection. Foresters, however, felt that they have sufficient knowledge with regards to identifying dwarf mistletoe and may not need additional training for that purpose. However, it is important that both foresters and loggers have sufficient dwarf mistletoe identification and management knowledge.

Research Question 2: Do Foresters and Loggers Understand the Need to Eradicate Dwarf Mistletoe where Timber Production is the Objective?

Some participants understood the need to treat dwarf mistletoe because of concerns about forest health (mortality, species conversion) as well as timber industry impacts (lower quality wood, fewer cords per acre, dependence on markets which purchase spruce and therefore make it possible to harvest black spruce commercially). However, other participants were not concerned about dwarf mistletoe because of its native status, its longevity in northern Minnesota, and its perceived slow growth and spread. Additionally, other forest pests and diseases were seen as greater concern than dwarf mistletoe including the larch beetle and spruce budworm. Several participants even noted that some disciplines within their organization see positive benefits of dwarf mistletoe in forests, such as creating structural diversity for understory plants and wildlife habitat. This diversity of opinions likely impacts treatment decisions by management agencies and may lead to inconsistent treatment approaches that could vary by agency or individuals, as well as confusion for loggers on best practices.

Research Question 3: Are Eradication Treatments Implemented as Designed?

Many foresters and loggers employ the 5-foot-rule as a standard prescription in black spruce on state lands and many other ownerships. However, loggers indicated there is some latitude in carrying out the prescription with differences both by landowner group and by forester *within* an agency. Loggers indicated they just do what they are asked to do or follow the sale contract. Loggers believe that they are properly implementing the treatments they are contracted to implement without many issues. They indicated that foresters can instruct them to go back to a harvest site and knock down stems if they did not properly implement treatments. However, this appears to be an infrequent request on the part of timber sale administrators. Most foresters and loggers agree that conventional logging equipment with a feller-buncher and grapple skidder is preferred or more efficient to implement the prescription in cutting small stems. However, both conventional and cut-to-length configurations can implement treatments as designed.

Research Question 4: Are there Impediments to Implementing Management Treatments?

Several important impediments to implementing dwarf mistletoe treatments emerged. For loggers, the cost burden associated with implementing treatments was of top concern. Dwarf mistletoe treatment prescriptions, such as the 5-foot-rule, create additional costs for loggers with having to expend time, fuel and labor to remove many non-merchantable stems, while receiving no financial incentives for implementing the treatments. Foresters also experienced economic barriers associated with implementing treatment prescriptions. Even when they desired to undertake additional steps beyond the logger's harvest, there were typically no funds available for post-harvest treatments.

Another top barrier to effective treatment implementation identified by participants was the lack of treatment coordination on adjacent stands which may have a different ownership. Both loggers and foresters felt if they were harvesting a sale and the adjacent stand contained dwarf mistletoe, then it would likely reinfest the regeneration on the current stand. Participants also shared there is little to no communication and coordination about this issue regarding adjacent stands, often due to a lack of administrative structure to allow coordination across organizational boundaries.

Market availability also emerged as a significant barrier to effective dwarf mistletoe treatment. Specifically, weak spruce markets mean loggers have a difficult time finding markets for their harvested black spruce and are not making much money on black spruce sales, which may be a barrier to their cutting every non-merchantable stems as required by the 5-foot cutting rule. Also the lack of a biomass market in the state means there is no market for the unmerchantable stems that have to be cut in the prescriptions. Loggers discussed warming winters and the difficulties they pose for harvesting black spruce, but that agencies are putting more winter wood up for sale. Additionally, agencies frequently offer black spruce sales for auction during warmer months when loggers cannot access them easily to assess stand conditions, access and volume estimates.

Research Question 5: Are the Treatments Effective?

Foresters and loggers are not clear on what an attainable measure of treatment effectiveness is or an overall goal of dwarf mistletoe treatments. To participants, total eradication of dwarf mistletoe does not

seem possible. If total eradication is not possible, foresters and loggers were not sure what they should aim to achieve to be “successful” or “effective.” However, foresters do believe that treatments are more effective currently than in the past due to using clearcutting as a management technique for black spruce, rather than doing partial cuts or leaving reserve trees.

Additionally, both loggers and foresters report a lack of certainty or confidence that treatments (and post-harvest treatments) are working. Many factors contribute to this lack of certainty around treatment effectiveness, including long rotation time of black spruce and the amount of time it takes for dwarf mistletoe to become visible. Foresters also shared that regeneration checks do not focus on evaluating dwarf mistletoe treatment effectiveness. Participants were hesitant to spend additional funds on dwarf mistletoe treatments (including those post-harvest) if they do not know whether they are going to be effective. Additionally, loggers typically do not possess equipment that they believe would be more effective, such as shearing blades and roller choppers that are often used in post-harvest treatments.

Improving Dwarf Mistletoe Treatment Implementation

A variety of suggestions emerged for improving treatment effectiveness or at least confidence in treatment effectiveness. First, better electronic searchable records of treatments are needed that would allow for tracking of treatments and outcomes over time. Long-term monitoring specifically for effectiveness of treatments, not just regeneration checks, was also suggested. Research that could document the effectiveness of treatments would also be imperative, as would communication of these findings to loggers and foresters. Loggers also desired more flexibility in dwarf mistletoe treatments that are tailored to actual stand conditions, rather than one-size-fits-all policies. Additionally, financial incentives and support for loggers to better implement treatments and maintain profitability were discussed. Lastly, but critically, improved treatment coordination across ownership and stand boundaries was suggested as essential in order to ensure treatments are not in vain and harvested stands will not be immediately re-infected.

1 Introduction

Dwarf mistletoes are parasitic plants that depend on host trees to live, taking nutrients and water from their host. Eastern spruce dwarf mistletoe (*Arceuthobium pusillum*) (ESDM) is a native dwarf mistletoe in Minnesota. It predominantly damages black spruce (*Picea mariana*) throughout the state and causes witches' brooms (distorted branches), increased mortality and reduction in regeneration where it spreads rapidly (Baker and Knowles, 2004).

Typical treatments for ESDM involve clearcut management systems to remove all infested materials. Another common treatment in Minnesota, especially on state-administered lands, is the "5-foot rule" which involves removing all standing live black spruce taller than 5-feet when ESDM is present (Minnesota DNR, 2019). While this rule has been used for several decades in Minnesota's black spruce stands, there have not been studies to assess the effectiveness of this rule – or other management techniques – in controlling ESDM.

This research is part of a broader, interdisciplinary study aimed at increasing management and detection options for ESDM. Detection and management of ESDM depends on the foresters who are tasked with managing black spruce forestlands and the logging operators (loggers) who implement the ESDM treatments through their harvesting activities. This part of the study seeks to assess foresters' and loggers' perceptions of and experiences with current ESDM management practices in Minnesota's black spruce.

This study is driven by five research questions: (1) Are foresters and loggers able to identify dwarf mistletoe? (2) Do foresters and loggers understand the need to eradicate dwarf mistletoe where timber production is the objective? (3) Are the eradication treatments implemented as designed? (4) Are there impediments to implementing the treatments? and (5) Are the treatments effective? Examining these research questions will provide an overview of ESDM detection and management efforts in Minnesota currently, as well as inform future management decisions.

2 Methodology

2.1 Study Area

Most of the black spruce in Minnesota is found in the northern part of the state. Our study area focused on three northern Minnesota counties: Itasca, Koochiching, and St. Louis (Figure 1). Those three counties produced 95% of the black spruce timber volume harvested by county land departments during 2016 (Minnesota Department of Natural Resources, Division of Forestry, 2017).

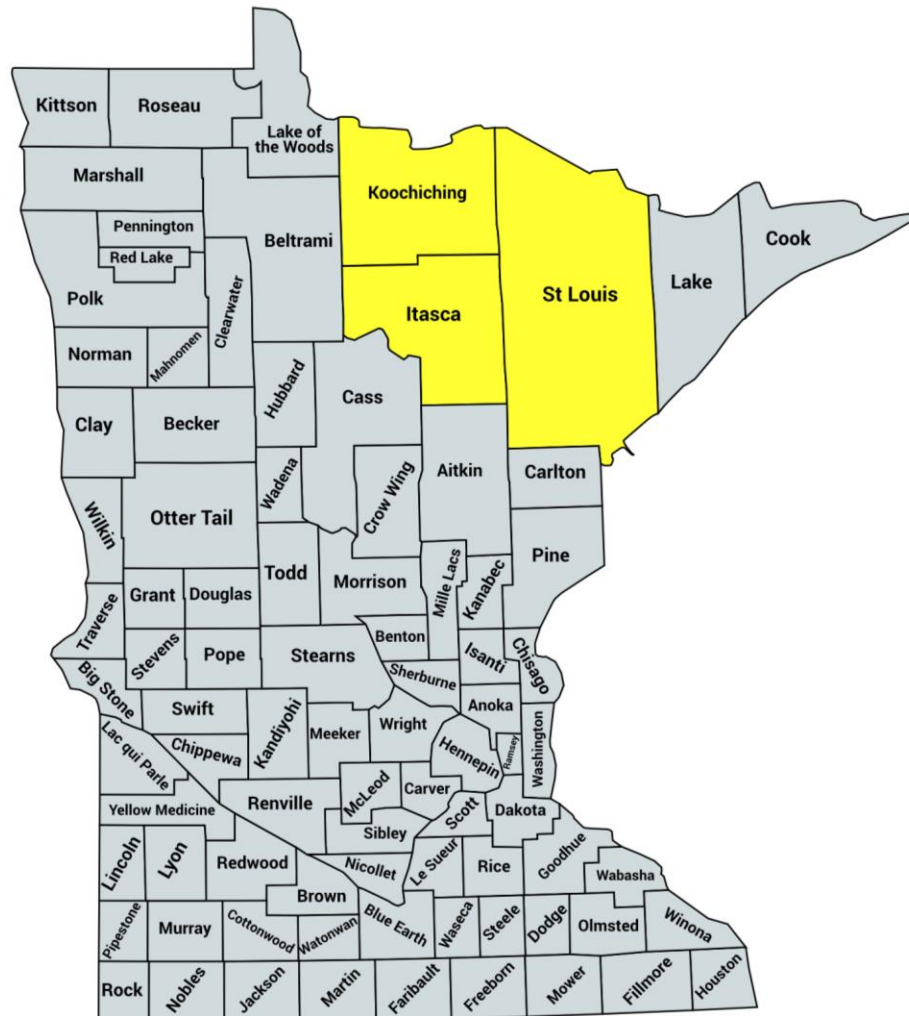


Figure 1. Study Area: Location of Itasca, Koochiching, and St. Louis Counties in Minnesota

2.2 Qualitative Approach

To answer the five research questions, we applied a qualitative research approach. Data were gathered through in-depth interviews and focus groups with loggers who operate in the study area, as well as focus groups with foresters who set up and administer timber sales, including prescribing ESDM management techniques, in the study area. The University of Minnesota's

Institutional Review Board reviewed the protocol for the project and determined it was exempt from further review.

2.3 Logger Interviews

A list of logging business owners (from here known as loggers) who bought black spruce timber sales in the study area (Itasca, Koochiching, or St. Louis County) between July 1, 2015 – June 30, 2018 was compiled – along with the number of black spruce timber sales purchased and approximate volume of black spruce harvested for each business. The list of loggers was compiled from county land department and state DNR offices who shared their public timber sale purchase records and from forest products companies who shared information about loggers who had made black spruce deliveries to their mills. Business information for each logger was found on the public Minnesota Logger Education Program's member database (Minnesota Logger Education Program – Logger Member Search, 2020). In total, the names, contact information, and black spruce harvesting information for 83 loggers were gathered. Due to the nature of the questioning around black spruce sales, we prioritized contacting logger who had cut more than one black spruce sale in the study area (n=54). Sampling ensured that loggers from varying geographies were contacted as well.

Interview instruments were developed for loggers in the study area. Instruments were designed based on a literature review and feedback from project personnel. First, a contact script was created for recruiting potential participants by phone which described the study purpose, participation process, and how the data would be used (Appendix A). A consent form was developed for participants to sign and give permission for the interview to be audio recorded and for responses to be anonymously quoted (Appendix B). An iPad survey requesting business and sociodemographic information was developed for participants to complete after an interview (Appendix C) in order to create an aggregate participant profile. Lastly, a semi-structured interview guide was developed to guide discussion around dwarf mistletoe, treatment implementation, and perceived effectiveness (Appendix D). The interview guide included questions about their logging business and experiences with black spruce sales; their experiences with ESDM including identification, frequency of infection, and perceived impacts of ESDM; and their experiences with ESDM treatments including treatment prescriptions, differences by landowner, barriers implementing treatments, and perceived effectiveness of treatments.

Loggers were contacted by phone using the contact script. Interviews were scheduled with interested and willing participants. In total, 43 loggers owners were contacted, with ten agreeing to be interviewed. Four individuals declined the interview. Participants were contacted until there were two unreturned phone messages or a verbal refusal to participate.

Interviews were conducted between October and December of 2018 at a location chosen by the interviewee – typically the participants' residence, workshop, or in-woods harvest site. Prior to the interview, each participant signed the consent form and the researcher answered any questions the interviewee had. The researcher asked the participant if they were comfortable having the interview recorded, reminded them of the voluntary nature of the study and assured

them that every reasonable effort would be made to maintain confidentiality. After working through the questions in the interview guide and ensuing discussion, participants were asked to complete the background information on the iPad. All interviews were audio recorded and transcribed verbatim. Interviews lasted between 20 minutes to one hour, with an average of 32 minutes.

2.4 Logger Focus Groups

Following the interviews with loggers, data collection instruments were developed for focus groups with loggers to continue to probe and triangulate findings from the interviews. Instruments were designed based on preliminary findings from the logger interviews, as well as feedback from project personnel. The focus group facilitator's script included questions about the impacts of dwarf mistletoe on their harvesting productivity, dwarf mistletoe treatments used, and perceived effectiveness of treatments (Appendix E). A consent form (Appendix F), a background information survey conducted on an iPad (Appendix G), and a contact script (Appendix H) were also developed.

The same list of loggers in the study area who had purchased at least one black spruce timber sale within the past 3 years was used to recruit focus group participants. Additional support in focus group recruitment was provided by the Minnesota Logger Education Program (MLEP) who also provided continuing education credits for focus group participation as an incentive. Participants were initially contacted by phone using the contact script. Three focus groups were scheduled to be concurrent with the MLEP annual logger conferences to increase participation. Additional loggers who had relevant experience with black spruce timber sales within or adjacent to our study counties were recruited in person at the MLEP conferences. In total, 34 loggers agreed to participate in the 3 focus groups.

Focus groups were conducted in April 2019 in Bemidji and Duluth, Minnesota during the MLEP annual logger conferences. Prior to participation, each participant signed a consent form and completed the background information survey on the iPad. The researcher reminded all participants of the voluntary nature of the study. The second and third focus groups were audio-recorded and transcribed verbatim. During the first focus group, the audio recorder malfunctioned. However, two researchers each took copious notes which were later combined. Focus groups lasted on average one hour and 20 minutes.

2.5 Forester Focus Groups

Separate from the qualitative data, an online survey about dwarf mistletoe in black spruce was administered to timber sale administrators in the study area to collect baseline information on their perspectives and experiences with dwarf mistletoe (Snyder et al. 2021). Following the focus groups with loggers and the aforementioned survey of foresters, instruments were developed for focus groups with foresters to probe for deeper meaning to our research questions. Instruments developed included a facilitator script (Appendix I), a consent form (Appendix J), and a background iPad survey (Appendix K).

Names, titles, and contact information of foresters who set up and administer timber sales in the study area were compiled from public organizational staff directories and personal contacts. The list included county, state, and federal level foresters, as well as those working for private timber industry and tribal organizations. In total, 194 foresters were represented in the sampling frame. Maximum variation purposive sampling was used to ensure focus groups included participants with varying experiences and characteristics (Patton 2014) – such as agency type, geographic location, and years of experience. Participants were contacted by phone and email using the contact scripts (Appendix L). Sixty nine foresters were contacted and seventeen agreed to participate in the three focus groups. Fifteen declined to participate or were too busy to participate at that time. Participants were contacted until there was a verbal refusal or two unreturned phone and/or email messages.

Focus groups were conducted in October 2019. The focus groups took place in three central locations throughout the study area in the towns of Grand Rapids, Tower, and International Falls, Minnesota. Prior to participation, each participant signed a consent form and completed the background information survey on the iPad. The researcher reminded all participants of the voluntary nature of the study. The focus group guide included questions about administering sales containing ESDM; ESDM treatments prescribed and perceived effectiveness of them; experiences and perspectives around pre- and post-treatments for ESDM; and coordination of management regarding sales with ESDM. All focus groups were audio-recorded and transcribed verbatim. Focus groups lasted on average one hour and 45 minutes, including a short break after the first hour.

2.6 Data Management and Analysis

Qualitative data were analyzed using open coding consistent with adapted grounded theory procedures (Charmaz, 2006; Corbin & Strauss, 2008). Each interview and focus group transcription was proofread. Each line of every interview and focus group transcription was fully analyzed and coded by the same person across the three data collection efforts – logger interviews, logger focus groups, and forester focus groups. During that coding process, the open-ended responses were categorized into different groups, each containing similar thoughts or ideas.

By combining the three data collection efforts, we could triangulate a coding schema and findings during the open coding process. Additional focused coding was used to identify responses directly related to the research questions. QSR International's NVivo 11 software was used to perform data analysis including the managing, coding, and organizing of the data from the ten interviews and six focus groups (QSR NVivo 2016).

The goal of qualitative analysis is not to statistically represent beliefs of all loggers and foresters in Minnesota. Instead, the goal of the coding was to develop insights and identify patterns and concepts related to the perspectives and experiences of loggers and foresters, grounded in the data, to assess current management and inform future management. While the study findings represent the beliefs and opinions of the study participants only, wide ranging and diverse

perspectives were captured. Participants have differing backgrounds and experiences related to dwarf mistletoe and black spruce management that provide important insights.

After coding, data were grouped into larger concepts and categories in order to find common themes and relationships, as well as diverging themes. Coding cross-checks by fellow researchers ensured validity through intercoder reliability. The purpose of cross-checking was to ensure interpretations are valid and no meaning was missed in the data.

3 Results

3.1 Participant Profile

Logger participants in interviews and focus groups were all white males (Table 1). The majority of participants had completed high school or their GED, at a minimum. The average number of years participants had been logging was 36 (interviews) and 27 (focus groups) (Table 2). Most loggers had 10 or fewer winter in-woods staff employees at their current logging business. Nearly 90% of interviewees harvested 15,000 or more total cords annually (i.e., black spruce and other species), compared to only 42% of focus group participants. Loggers reported cutting sales from a variety of landowners at the time of the study and using a variety of types of equipment.

Table 1. Logger Socio-demographic Characteristics

		Interviews (n=10)		Focus Groups (n=34)	
Age		Mean: 47 Range: 36 to 63		Mean: 46 Range: 22 to 69	
Gender	Male	10	100%	34	100%
Race	White	10	100%	34	100%
Level of Formal Education (n=9)	Did not finish high school	0	0%	1	3%
	Finished high school/GED	3	33%	17	50%
	Some college, no degree	2	22%	6	18%
	Associates or vocational degree	2	22%	5	15%
	College bachelor's degree	2	22%	3	9%
	Some graduate school	0	0%	1	3%
	Completed graduate degree (MS or PhD)	0	0%	1	3%

Source: Logger Interview and Logger Focus Group Background Information Surveys (Appendices C & G)

Table 2. Logger Business Characteristics

		Interviews (n=9)		Focus Groups (n=34)	
Years Logging		Mean: 36 years Range: 20-58 years		Mean: 27 years Range: 5-50 years	
Years with Current Business		Mean: 30 years Range: 8-45 years		Mean: 24 years Range: 5-49 years	
Winter In-woods Employees	≤5	3	33%	17	50%
	6-10	2	22%	9	26%
	11-20	2	22%	2	6%
	21-30	2	22%	2	6%
	30+	0	0%	2	6%
Annual Harvest (cords)	≤5,000	0	0%	8	24%
	5,001 – 10,000	1	11%	3	9%
	10,001 – 15,000	0	0%	8	24%
	15,001 – 25,000	4	44%	5	15%
	25,001 – 50,000	4	44%	6	18%
	50,001 – 100,000	0	0%	2	6%
	100,000+	0	0%	1	3%
Sales cut last year	Itasca County	3	33%	16	47%
	Koochiching County	5	55%	18	53%
	St. Louis County	4	44%	13	38%
	DNR	9	100%	29	85%
	Forest Service	4	44%	14	41%
	Private Industry	9	100%	22	65%
	Other County	1	11%	15	44%
	Family Forest Owner(s)			11	32%
	Other			5	15%
Equipment Type	Cut-to-length/Harvester	4	44%	12	35%
	Feller Buncher	9	100%	28	82%
	Forwarder	4	44%	9	26%
	Skidder	9	100%	27	79%
	Loader	8	89%	20	59%
	Chipper	3	33%	3	9%
	Grinder	0	0%	0	0%
	Bulldozer	9	100%	20	59%
	Slasher	7	78%	26	76%
	Delimber ¹			20	59%

Source: Logger Interview and Logger Focus Group Background Information Surveys (Appendices C & G)

¹The delimber equipment type wasn't listed as an option during the logger interviews.

Forester participants in focus groups were all white and 76% identified as male. All participants had at minimum a college bachelor's degree (Table 3). About two-thirds of participants worked for a state agency (65%) (Table 4). The second most common employer was county agencies (29%). Over half of participants reported their role covers a portion of St. Louis County (53%)

and Koochiching County (65%). The average number of years participants had been working as a forester was 9.6 years, and 8.2 years working in black spruce specifically.

Table 3. Forester Socio-demographic Characteristics

		n	Percent
Age		Mean: 36 Range: 25-48	
Gender	Male	13	76%
	Female	4	24%
Race	White	17	100%
Level of Formal Education	Did not finish high school	0	0%
	Finished high school/GED	0	0%
	Some college, no degree	0	0%
	Associates or vocational degree	1	6%
	College bachelor's degree	15	88%
	Some graduate school	0	0%
	Completed graduate degree (MS or PhD)	1	6%

Source: Forester Focus Group Background Information Surveys (Appendix K)

Table 4. Forester Role Characteristics

		n	Percent
Agency/Organization	State	11	65%
	County	5	29%
	Federal	0	0%
	Private Industry	1	6%
Counties job covers	Aitkin	1	6%
	Beltrami	1	6%
	Carlton	1	6%
	Cass	1	6%
	Itasca	4	24%
	Koochiching	11	65%
	Lake	1	6%
	Lake of the Woods	1	6%
	St. Louis	9	53%
Years working as forester		Mean: 9.6 years Range: 2-22 years	
Years working for current employer		Mean: 7.8 years Range: 2-20 years	
Years working with black spruce		Mean: 8.2 years Range: 2-20 years	

Source: Forester Focus Group Background Information Surveys (Appendix K)

3.2 Key Findings

Thematic analysis across the three qualitative datasets revealed a variety of key findings related to our five research questions: (1) are foresters and loggers able to identify dwarf mistletoe, (2)

do foresters and loggers understand the need to eradicate dwarf mistletoe where timber production is the objective, (3) are the eradication treatments implemented as designed, (4) are there impediments to implementing the treatments, and (5) are the treatments effective? Results for each research question are presented in a qualitative theme table (Appendix M) and then further elaborated on below under each research question. Quotes from participants are used to help describe key findings.

I. Dwarf Mistletoe Identification

Table 5. Dwarf Mistletoe Identification Theme Table

Research Question	Emergent Themes	Logger Interviews	Logger Focus Groups	Forester Focus Groups
Are loggers and foresters able to identify ESDM?	Loggers desire and need improved training	x	x	x
	Foresters have sufficient identification knowledge	x	x	x

Source: Logger Interviews, Logger Focus Groups, and Forester Focus Group Qualitative Data

Two divergent themes emerged related to foresters' and loggers' ability to identify dwarf mistletoe.

Loggers desire and need improved training

Loggers described the lack of any dwarf mistletoe focused training available to them. One logger shared, "There really hasn't been a ton of awareness brought about for it. I don't know who's supposed to be teaching us about it?" Another similarly stated:

That hasn't been talked about. I'm thinking MLEP should take this up a little bit. If there's that much concern within the state, then they should probably have a class on this that is possibly pushed at everybody.

Loggers shared that they mostly learn how to identify dwarf mistletoe from the different forestry professionals they interact with. For example, when asked about trusted sources of information about dwarf mistletoe, one logger said, "Probably the two main agencies that we deal with...and that's just because of the professional forester base that's there setting up the sales."

Additionally, a need for improved training was demonstrated through the varied descriptions loggers shared about how they believe dwarf mistletoe grows and spreads. Some loggers described dwarf mistletoe as a fungus, a disease, a bug, or a parasite that can spread by birds, "exploding seeds", wind, and rain. As one logger elaborated, "It climbs and gets washed down during rain, which is why [foresters] want the tall stuff killed."

Similarly, loggers shared that there are many differing characteristics for identifying dwarf mistletoe but no “standard” that is reliable. Loggers described identifying characteristics to include “witches brooms,” containing “double tops,” “sick” or “skeletal” looking crowns, “deformed” trees, “strange looking limbs”, “goofy tops”, and “dead areas” within a stand. Others said the “damn stuff is too small” to identify or “I don’t even know what I would be looking for...it might not even exist, I’ve never seen it.” Foresters agreed that increased training on identifying symptoms of dwarf mistletoe would be helpful for loggers, as shared by this participant: “...they’re not always all the same. Some [trees] flag really hard and some are real subtle. And it’s the subtle ones you’re not gonna notice. I think that would help.” However, some loggers felt that they do not actually need to know how to identify dwarf mistletoe, as described by this logger: “Whether it’s infected or not, we cut it the same way. We cut all black spruce so we don’t actually need to know how to identify it.”

Foresters have sufficient identification knowledge

On the other hand, foresters felt that they had sufficient knowledge with regards to identifying dwarf mistletoe and did not need additional training for that purpose. Foresters – and loggers – shared that foresters are already very knowledgeable. One forester said simply, “Everybody went to college for it in the industry and is pretty knowledgeable.” When a logger was asked if foresters are effective at identifying dwarf mistletoe, they responded, “Foresters are effective at everything...There’s several good foresters in the area that are pretty knowledgeable.” However, some foresters felt more education can always help:

I think if you went and asked most foresters, field foresters to go out and identify it on something that doesn’t have a, you know, mature stand with witches broom, it’s probably a small amount of people that are going to be able to do that.

Foresters described that those who they depend on for dwarf mistletoe related information are commonly at the state level, as shared by this forester: “Those [state] insect and disease specialists, I mean they’re doing it for everybody too. [County agency] don’t have insect and disease specialists. Nobody in county does, so everybody depends on those folks.”

II. Dwarf Mistletoe Eradication Need

Table 6. Dwarf Mistletoe Eradication Need Theme Table

Research Question	Emergent Themes	Logger Interviews	Logger Focus Groups	Forester Focus Groups
Do loggers and foresters understand the need to eradicate ESDM where timber production is the objective?	Forest health concerns	x	x	x
	Timber industry concerns	x	x	x
	Dwarf mistletoe is not a concern	x	x	x

Source: Logger Interviews, Logger Focus Groups, and Forester Focus Group Qualitative Data

Three themes emerged related to foresters and loggers understanding the need to eradicate dwarf mistletoe where timber production is the objective.

Forest health concerns

Loggers and foresters described a variety of reasons why a dwarf mistletoe infection leads to concerns for overall forest health. As one forester shared, “Just the presence of it decreases your forest health.” One logger shared his concern for dwarf mistletoe impacts: “I am concerned a little because our spruce swamps are valuable but we don’t really look into it that far because the spruce is still growing.” Another logger when asked if he was concerned about dwarf mistletoe impacts said, “Well sure. I mean if you care at all about the environment...I’d like to think we care. Yeah I’m concerned.”

Loggers also expressed concerns that dwarf mistletoe killing black spruce stands is leading to tamarack conversion, which is less profitable in their eyes. One logger said, “Site conversion is a big problem too. Black spruce turning into tamarack, which is not merchantable. There is so much unsold [tamarack] and we should be more worried about it.” Another said, “There is definitely a concern for tamarack taking over spruce – and also being infected by dwarf mistletoe.”

Both loggers and foresters shared examples of dwarf mistletoe killing stands and increasing stand mortality over time. One logger shared, “It kills the forest. In spots of the black spruce it’ll be gone, there will be big holes in them, just gone.” Similarly, a forester said, “I think it kills trees pretty fast and it actually spreads faster than you think.” Another logger shared an experience of losing merchantable volume during his 3-year sale length:

The first year I went in there and the edge of the mistletoe I couldn’t get through there very good. I was trying to make landings and freeze it down. I couldn’t make a landing because there was too much timber standing. I went in there the second year of the sale and tried again and the weather just didn’t cooperate. Last year I went in there, I could go anywhere I wanted to, it changed that much. It was shocking how much it changed!

One forester described that while dwarf mistletoe is a native problem, they still experience a variety of impacts from it, including “Pocket mortality, structural diversity, increased standing deadwood, and then eventually increased down deadwood.”

Loggers and foresters described dwarf mistletoe being most present in state lands – so the forest health concerns for state lands were higher than other land management areas. As one logger shared, “The state of Minnesota has got the bulk of the black spruce lands, so the bulk of the mistletoe problem would be the state.” Another logger agreed: “Up here, the DNR has most of the land, so of course they have probably 90% of the mistletoe.” One frustration for loggers, however, was that it seems foresters care more about the impacts to forest health caused by dwarf mistletoe than its impacts to logging businesses.

Timber industry concerns

Both loggers and foresters overwhelmingly agreed that dwarf mistletoe also leads to impacts to the timber industry – and in particular, negatively impacts the loggers. One logger shared how dwarf mistletoe impacts his business, “Usually they’re not the greatest sites...the volume per acre is low and size of trees is usually smaller.” Loggers and foresters also discussed the ways dwarf mistletoe impacts the mills that purchase black spruce. One logger said, “There might be some decent trees there, but a lot of it’s dead laying on the ground or standing dead that’s unmerchantable...the mills don’t want the dead trees...there’s not really a market for dead spruce.” One forester shared their perspective on this: “Higher cost for the logger ultimately is impacting both the landowner and the end market of the wood.” Another logger described the impacts to the timber industry with heavy dwarf mistletoe infection:

One thing we face is volume for the mills. If these stands are deteriorated by the time we get to them, we don’t have an overabundance of wood on the market to begin with. You have to fight, claw, to get what you got. And then if you get there and half the wood is there, it’s a problem.

Foresters described the ways poor quality black spruce in timber sales with dwarf mistletoe intersect with mills and the industry:

You see lower bid prices on stands that are lower quality. Along with the lower bid prices, it likely impacts the ultimate gate price at the mills...with the reduced efficiency that additional cost is either going to come from the stumpage or the gate price at the mill and so which one its impacting more, I don’t know.

Foresters also felt that they can experience some negative impacts in their role due to dwarf mistletoe: “All of this kind of affects...all three sides. Loggers, agencies, and logging businesses.” One forester shared their thoughts on how dwarf mistletoe impacts foresters and the timber industry, including decreased spruce due to dwarf mistletoe infection:

If it’s not meeting its potential, or their expectations, you’re gonna have to substitute with other species. They’re gonna be making different products and that might be moving out of areas where the resource is more promising. So if we’re not doing our job, keeping the resource on the landscape like it could be, you know it’s a problem for the industry.

Dwarf Mistletoe is not a concern

Despite the discussions of impacts to forest health and the timber industry, there were still loggers and foresters who felt in general, dwarf mistletoe is not very concerning. First, some loggers and foresters discussed how it is native and has been here as long as they can remember, so it is a normal pest. One logger said he was “Not too concerned...just because it’s been here my whole life and I don’t know if it’s getting any worse.” Similarly, a forester

shared, “Dwarf mistletoe is a native problem. It’s always been here and it’s hard to assess: is it getting worse, is it actually a problem, or is it just normal?”

Loggers and foresters also shared that it is something they have always dealt with and are comfortable dealing with, so it really is not a problem, as described by this forester: “Mistletoe isn’t going that fast. It will be here in 100 years. It will be here over there in 200 years. Is it that big of a deal?” One logger felt the situation will solve itself over time: “Mother Nature. Mother Nature does more than we do...no matter what you cut...she’ll heal itself. No matter what the ground is.”

Some loggers and foresters felt that it cannot be eradicated, as demonstrated from its existence for a century, so it might not be worth trying to eradicate it. One logger simply said, “It’s been that way forever. So don’t bother. It’s too bad.” One logger was asked if he was concerned about dwarf mistletoe and responded:

No, not really, but what do you do? There’s nothing you can do about it. If I can do something to help and prevent it, okay, fine and dandy. But if they’re not going to do something about it, if the agencies or the government aren’t going to buy anything to kill it off, then that’s the way it is. What do you do?

Other loggers and foresters highlighted the fact that there are many other forest pests and diseases they are dealing with that are of much higher concern than dwarf mistletoe, including the larch beetle, emerald ash borer, and spruce budworm. One logger said: “I’ve never heard them make a big stink about mistletoe versus like bark beetles or something in the pine, they talk about that stuff all the time. Mistletoe doesn’t get talked about a whole lot.” Similarly, a forester shared, “The spread of dwarf mistletoe isn’t fast enough to warrant any effort to keep track of when there’s other things more pressing to do.” Another forester said that while dwarf mistletoe can cause mortality, “It’s not going to annihilate a forest like larch beetle.”

Loggers and foresters also highlighted that dwarf mistletoe can vary by geography across Minnesota. So while there are some areas that dwarf mistletoe is a problem, it does not impact them as much on a local scale. One logger shared how it is less of a problem in his local area:

Up until 5-10 years ago, around here, nobody really took it seriously because of spruce volume. Farther north, it’s been there for quite a while. But down here...they probably didn’t really know what to do with it so now they’re just like ‘well let’s cut the tree’ and hopefully if you cut that it won’t spread.

Other loggers suggested the impact of dwarf mistletoe in black spruce has to do with the ground conditions of the stand. One logger said, “More stagnant black spruce stands are worse...but smaller stands in bad ground are worst.” Lastly, there were discussions among

foresters of the positive impacts dwarf mistletoe can have, such as creating structural diversity within a stand. One forester said that dwarf mistletoe could be considered:

...as a good thing. Increased cranberries for the red squirrels. And blueberries. And you might even see a white pine come into one of those death pockets, just because you don't have flooding out, so you can maybe get some diversity.

As other foresters suggested, there are other natural resource managers, besides foresters, that "are looking for other things from the forest than typically we are," including structural diversity and wildlife habitat.

III. Implementation of Treatments

Table 7. Implementation of Treatments Theme Table

Research Question	Emergent Themes	Logger Interviews	Logger Focus Groups	Forester Focus Groups
Are the eradication treatments implemented as designed?	Internal administration of treatments	x		x
	Outward communication of treatment	x	x	x
	Diverse treatment prescriptions	x	x	x
	Equipment decisions	x	x	x
	Incomplete implementation consequences	x	x	x

Source: Logger Interviews, Logger Focus Groups, and Forester Focus Group Qualitative Data

Five themes emerged related to the implementation of dwarf mistletoe eradication treatments.

Internal administration of treatments

First, foresters discussed how administering sales with dwarf mistletoe may differ from sales without its presence. Foresters had differing perspectives on this idea. Some felt sales with dwarf mistletoe took less time to set up and administer than those without because you know exactly what the prescription or treatment will be, as shared by one forester:

It gets to be a standard prescription. Clearcut all stems over 5 feet. You don't have to go mark any reserves. You don't have to think about anything. It takes some of the aspects that you would do on a normal timber sale out of the question. Makes it very simple.

Others felt it took more time due to it taking "more time to navigate through those woods than it does when everything's pretty much still standing." Additional reasons some foresters felt stands with dwarf mistletoe take more time to set up and administer include deciding where to locate timber sale boundaries when the dwarf mistletoe is patchy and deciding what to add on to a sale if the stand is not ideal. For example, one forester said:

You're picking your line through and then you find a mistletoe pocket, so then you're thinking oh do I include it? Should I go on this side, should I go on that side?...There's a lot of debating in my mind that goes on, as far as what would be the smartest thing to manage it. If we're out here cutting it, it would be better just to have them fell a little bit extra, accept a lower bid price, and just that's what it has to be. So I think it takes longer.

Other foresters agreed with that sentiment, saying:

It does take some more time 'cause we try to chase it. So we'll go as far as we can, grab as much as we can, and then we have to do on plan additions and send them to our divisions to ask them if it's alright.

Alternatively, many foresters felt there was no difference in setting up and administering sales with dwarf mistletoe compared to those without. Some county foresters, for example, described how they do not need special approval from other divisions to extend timber sale boundaries, so it is not a hassle and there is "very little difference" in setting up and administering stands with or without dwarf mistletoe.

Outward communication of treatments

Loggers and foresters then discussed how those treatments are communicated between foresters and loggers. In general, foresters did not feel like the presence of dwarf mistletoe on a sale has changed much around communicating their expectations with loggers during presale meetings and timber sale administration. One forester said, "There's times where if we know it's present, we'll talk to the operators, skidder man, felling man, and make sure that they understand." They described working with the same loggers frequently enough that it was an easy discussion, as one forester described:

If you are able to buy black spruce, they are dealing with me, so if they have dealt with me before, they know what I am going to require. You know the first presale meeting I'm going to talk about it. And the second presale meeting they are going to know what I mean...I might just refresh their memory.

Another forester said, "Loggers that are dealing with spruce a lot...after they bought one sale, they know that's a standard practice." Similarly one forester shared:

It's usually brought up before you have a chance to bring it up. A lot of presales that I've done...they're gonna ask 'does the five foot rule apply? Does this apply?'...I've never really had to push to bring it up because it comes up automatically.

Foresters said they do occasionally need to remind loggers of utilization policies on stands with dead trees due to dwarf mistletoe. One forester described, "...You are going out there and checking on them and that's maybe when you're telling them to go back and get

something if they missed it.” Another forester said, “In general, you’re doing sale administration and you remind them of utilization and ‘run over that stuff’ and ‘you said you were going to get that balsam over there.’”

Loggers discussed how the communication goes both ways, and that they will raise concerns with foresters about dwarf mistletoe on sales. One logger said, “Normally the foresters are pretty good about telling you about that stuff, if it’s healthy or if it’s got mistletoe.” Another said, “They usually do a pretty good job of describing the condition.” Other loggers felt frustration when communicating with foresters about dwarf mistletoe treatments. One logger said, “I like to complain as much as I can to the foresters...It doesn’t really affect them too much...They don’t compensate you for it.” Another logger said, “they don’t care [that it is difficult], they get paid no matter what.”

Diverse treatment prescriptions

Loggers and foresters shared the diverse treatment prescriptions for managing dwarf mistletoe that they have encountered or used. Many talked about the five foot cutting rule (“5-foot-rule”) as the standard prescription, especially on state land. One logger described - this as, “Usually the guidelines are all the same. You’ve got to meet that five-foot-rule and that’s the big one as far as I know.” Another shared the purpose of this rule is, “Harvesting everything of five foot height or greater in hoping to alleviate the continuation or the chance of it showing up on the site after we leave.” One state forester agreed: “It’s a canned statement that goes on every permit with black spruce.”

Other loggers shared it goes beyond just the state guidelines:

I think that’s pretty common for the state and for counties. I’ve cut a lot of federal spruce. We just take everything five foot. That’s kind of a common rule for spruce is take everything five foot high. They want it down for the mistletoe.

Many foresters agreed that the five-foot-rule was the standard: “It was kind of assumed that there’s mistletoe in the stand so you just always used the five-foot-cut-rule. That’s just kind of the state standard...in my opinion it’s not necessarily up for debate.” Another forester said, “No matter what, we use it...I always just use it just as good insurance.” When asked if they take any steps beyond executing the five-foot-rule, one logger said, “I wouldn’t say so. I don’t know what else we can do.”

However, a variety of other treatments were described, including cutting merchantable timber only versus cutting or running down every single stem. One logger shared an experience where “they just told us to go in and cut the merchantable trees out...and then the DNR went in and then they sheared¹ it all off...because they wanted it all cleaned up.” Another logger described a federal contract they had where they could “go around on merchantable patches and...leave them if they’re under a certain size at breast height.”

¹ Shearing: process of felling a tree by a large blade attached to a tractor, often used in site-preparation

On the other hand, other loggers described their treatment instructions as “just kill it.” More specifically, they could “cut it off, run it over, knock it down” – anything to kill all stems. One individual said, “As long as it’s flat...as long as you kill it”, the foresters do not care how it gets done. Another logger said “Most spruce sales nowadays say no matter what, all the unmerchantable stuff has to be broken off or cut off.” Another logger said, “In the contract they say everything greater than two inches needs to be cut.” Other loggers felt running over smaller stems was an easier approach to fulfill the treatment: “Just run it over...driving it down seems to be the easiest way for us to get rid of it.”

Some loggers described leaving reserve trees as part of the treatment instructions. One logger described how this might not be effective in the long run: “When we leave trees as we’re asked to do, they reinfect the stand.” Another logger shared their feelings about leaving trees when dwarf mistletoe is present:

That idea of leaving patches of black spruce...that is a wildlife nutty project. It’s ignorant and it needs to stop. Maybe there is a reason for it for [tree] types that don’t get a disease. But black spruce when [dwarf mistletoe] is already there, why in the world leave it?...You’re here to manage healthy forests and leaving pockets of black spruce is not a good idea.

One forester described a situation where leave trees are part of the management prescription, even if they believe it is not effective to do so:

[Agency] designated a bunch of acres as lowland conifer old growth and these are adjacent or next to the spruce stands or occupying decent spruce ground. But if they are harboring mistletoe, you have an infection right next to it...I guess the management guidelines haven’t come out yet exactly 100% of the way we are supposed to treat these adjacent lands. But for now, it’s totally hands off. So there is implied to leave a buffer...That’s just something our people in [location] and our higher ups...they got to push through in the field to get some freedom for insect and disease.

Loggers described different instructions they have encountered with regards to sale boundaries as well, including cutting outside the sale boundary if you see any dwarf mistletoe to cutting to a species’ change or ‘natural’ boundary. One logger described his experience:

The forester don’t see everything either but that’s why they stipulate in there that if you see a tree with mistletoe, go ahead and cut it. Even if it’s just a little over our boundary, they want you to get rid of it.

Another logger shared a similar situation: “They have told us to go outside the boundaries and run that stuff over if you can. If it’s not merchantable, run it over.”

Other loggers and foresters talked more generally about dwarf mistletoe treatments and their purpose. Some foresters felt that the goal of treatments was just to mitigate future risk of dwarf mistletoe, but not actually eradicate it: “We’re just mitigating the risk, that’s what we’re doing. You can never get it all...we’re just mitigating risk. Trying to reduce.” Another forester said their perspective on the goal of treatment was so “it will be able to be harvested...at least get it up to a nourishable age.” Similarly, another forester said, “That’s what we’re after is just trying to get the stand as healthy as possible and give it as much chance as we can afford.”

Many loggers described implementing dwarf mistletoe treatments was as simple as following the instructions on the sale contract. As one logger described, “We usually follow the orders that they give and that’s the end of it...they just give us their instructions on what to do and we do it.” Similarly, another logger shared, “All we can really do is follow what they say to do. I mean, I don’t know what else there is to do.” Finally, another simply said, “We just show up and cut what we’re told to cut. We don’t need information.”

Equipment decisions

Loggers and foresters also discussed the merits of different logging equipment configurations in their ability to implement dwarf mistletoe treatments. Some advantages to using a conventional logging configuration with a feller-buncher and skidder included the skidding aids in running everything over, as this forester shared: “[Conventional] have a little more opportunity to run over the place and sever quicker.” Another added, “A hot saw and a buncher can just kind of shear stuff off as you go.” One logger described why this was preferable over cut-to-length configurations with a harvester and forwarder: “Cut-to-length is a whole different ball game, it’s much harder for them to smash everything...I think it’s a lot harder for cut-to-length operations to meet the guidelines.” Another logger agreed, “It’s a little more burdensome with a cut-to-length system...they don’t have wide tires on them so it’s a little bit more difficult.” One forester said:

When you get a cut-to-length, it can be difficult to get those guys to do it because it’s a lot of time and effort on their part. So you push on them as much as you can without causing a problem.

Another forester added, “When [cut-to-length] grabs a tree, they want to process a tree. They don’t want to grab a tree and cut it and leave it lay. So it’s a little more time consuming on their end.”

However, an advantage to using a cut-to-length configuration included its ability to be ‘lighter’ on the site and begin harvesting earlier in winter than conventional operations, as described by this forester: “Cut-to-length has the ability to stay up a little bit better ‘cause they’ll land on the slash mound in front of you...cut-to-lengths you can get into a site earlier, you can harvest there earlier.”

Many foresters felt though that both systems in general work fine to implement treatments. Foresters also shied away from the idea of requiring a specific equipment type to implement dwarf mistletoe treatments:

We have moved away from prescribing types of equipment. We're just prescribing what we would like to see out there and letting the logger determine their best way to do that. So if they want to use a certain use of equipment, then as long as the outcome is the same as what we're prescribing.

Incomplete implementation consequences

Loggers and foresters also discussed what happens when treatments are not implemented as designed or instructed – and what the consequences can be. Loggers and foresters described the different penalties loggers can encounter if they do not fully implement the treatment. Loggers described foresters directing them to go back out to a site and knock down more stems if they did not feel it was sufficient: “There’s been times where everything didn’t get run over and they tell you to go back and get it satisfactory.” A forester said similarly, “You have to keep up on ‘em and sometimes you have to tell them to go back, do it again.” Another forester said, “I’ve never had a problem where it didn’t enforce, but communicating with them...” about the need to implement the policy was common.

Others described monetary penalties if treatments are not fully implemented: “I think the DNR could charge you for not doing it...some of the counties too, you got performance bonds. If you don’t do the job correctly, they’ll keep your performance bond or something.” Foresters agreed that monetary penalties *can* be used if treatments are not implemented, but said that rarely occurs, as described by this forester: “I know we’ve had permits that were purchased and where liquidated damages have been threatened...that’s a rare example but it can happen. It’s been threatened, so I am sure it has happened.”

Foresters also described the extra work required of them when treatments are incomplete. One forester shared:

We would be planning, like I said, on coming back and shearing to get that lower stuff anyways. So you push on them to get as much done because it lowers your shearing costs. But I don’t know that I’ve ever seen anybody withhold liquidated damage on them, because they are going to come back anyways. So it really doesn’t matter – you’re just trying to reduce your shearing costs for sites that are heavily impacted.

However, loggers and foresters shared that usually everyone follows the treatments and it is not a common issue to deal with. As one logger described, “Hopefully a forester shows up once a week or something...so they can see the progression and you don’t have to go back in the beginning and start all over if it isn’t satisfactory.” Another logger said:

We usually follow the orders that they give and that's the end of it...They just give us their instructions on what to do and we do it and at the end of the sale if they're not satisfied, they'll tell you to do more and typically they're satisfied.

Foresters agreed, as shared by this individual:

If [sites] are not all that heavily impacted in the first place, then it's probably a small pocket that they got to worry about and they are pretty apt to do one small area. You don't get much pushback on isolated pockets.

IV. Treatment Barriers

Table 8. Treatment Barriers Theme Table

Research Question	Emergent Themes	Logger Interviews	Logger Focus Groups	Forester Focus Groups
Are there impediments to implementing the treatments?	Cost burden on loggers	x	x	x
	Fluctuating spruce markets	x		x
	Bidding considerations with dwarf mistletoe	x	x	x
	Potential improvements to dwarf mistletoe sales	x	x	x
	Lack of coordination on adjacent stands			x
	Differing flexibilities among landowners	x	x	x

Source: Logger Interviews, Logger Focus Groups, and Forester Focus Group Qualitative Data

Six themes emerged related to the barriers or obstacles of implementing dwarf mistletoe treatments.

Cost burden on loggers

Of all the barriers associated with implementing dwarf mistletoe treatments, the cost burden on loggers was one of the biggest. Loggers and foresters first acknowledged that operating in black spruce stands, with or without dwarf mistletoe, is difficult. Loggers and foresters also shared that spruce lowland or bog areas are especially difficult due to the soft ground conditions. One logger described his experience with this:

The [swamps] where there's all these little one and two inch – we call them volunteers – underneath, that affects my production bad...There are also little spears that can go up into your engine compartments and whatever else...That stuff is way more of a challenge than mistletoe. The other thing is soft swamps, when they don't freeze, big challenge...Access, understory, how frozen, all that stuff is way more [challenging].

Similarly, one logger said:

When the ground is so wet like that...usually that stuff is growing in the worst spot you can get to...so then you look at the guy and say 'which way do you want it? Do you want big ruts or do you want this stuff smashed flat?' You know, which is worse?

Noting the difficulty of operating in areas where dwarf mistletoe has killed the black spruce with the loss of roots from living trees for flotation, another logger said:

[Dwarf mistletoe] kills the forest. In spots of black spruce, it'll be gone, there will be big holes in them, just gone. And that's tough to operate in. They're soft and there's not root base to it. It's tough to skid there.

Foresters agreed: "When it breaks up too much, then you have a hard time. Your root mass goes away. Difficult operability."

Much of the black spruce land is only operable in the winter because of the soft ground conditions. Loggers and foresters also discussed the increased difficulty of loggers needing to harvest a large percentage of their sales in the winter when the ground is frozen. One logger said simply, "They give us so much wood to do in the wintertime, you can't even do it all anymore." A forester agreed: "There's a lot of work for loggers to cut spruce stands just with having to freeze down winter roads and freeze down the site and, so having less volume than they expected could just make a loss for them." One forester said, "You can only ask them to do so much when they are trying to cut 70% of their volume in a three month period." While foresters are assigning sales as 'winter only' to avoid rutting or other environmental concerns, it is increasingly difficult for loggers to accomplish so much in a short time frame. As one logger shared:

The winters are getting warmer and warmer. The last winter had an exceptionally good winter, but winters is a lot of it. The environmentalist people, this and that, and there are rules on some of our spruce ground...it's tough. We can't get to it because it's too wet.

As described in the diverse treatment prescriptions, a key component to most dwarf mistletoe treatments is cutting or running down small, unmerchantable stems. This is one of the larger frustrations for loggers as it is extremely time consuming to ensure those stems are felled or broken off, but they do not make any money doing it as described by this logger, "It's time consuming because we're cutting non-merchantable trees so we're doing extra work for the same amount of wood...we're doing more motions for the same work." Another logger said, "If trees are merchantable, it's not a problem. But clearing land takes time which equals money. If all the wood is junk, shearing is better." The more time it takes to cut non-merchantable stems means more non-productive time and increased fuel

consumption, wear and tear on machinery and additional operator time spent which equates to reduced profit margins. One logger shared his frustration with this:

If we're cutting a bunch of non-merchantable species, my buncher runs ten hours a day. For three of those hours it's dealing with non-merchantable species or stems that we're just putting in the ground. Then I'm losing all that production to what could be actually usable product on a different site. There's definitely a cost there. It's several hundred dollars an hour for a piece of equipment and the operator, that adds up in a hurry.

The lower the stocking within a timber sale, the more it costs loggers to cut it. One logger described an example: "When you have a sale that says five to six to seven hundred stems that must be felled, there's absolutely no money in it of any kind that you're going to receive. You're just going to spend a lot." Foresters acknowledged that dwarf mistletoe can make things "more costly for them...slower for the loggers which again is cost." They recognize that it is a burden for loggers, especially if the stocking is low or the wood quality is degrading. However one forester shared they are not sure what to do about that:

I can't blame 'em for complaining. We don't really have a mechanism to compensate them for when we don't necessarily accurately represent the sale as it is. You know, we just say 'well, you should've went out there and looked, sucks for you.' You know, what are you going to do? I don't know how else to do it.

Loggers also identified detrimental impacts to their equipment as a common occurrence when cutting small black spruce stems. One logger shared about these impacts:

Sometimes we rent a little newer equipment and you kind of hate to go beating your machine through that stuff where – about five, six foot high – you got spears going everywhere, scratch the paint, rips the hoses right off in the radiator area.

Another shared running through small stems can also be very dusty: "When you are running it down, there's a lot more dust. It gets in the air filters and plugs them up, burning more fuel." Another simply said, "It's hard on stuff. Hard on tires. Everything...just wear and tear. You're making extra moves for no money at all," about cutting unmerchantable stems.

Several loggers felt that additional payments to ensure dwarf mistletoe treatments are implemented effectively should be considered, given the burden on loggers who are doing the work at no profit. One logger offered to do more if they were compensated for the work: "I would do more if I was paid for it. For example, if I was paid \$X an hour to cut non-merchantable. Or the appraisal value needs to be adjusted accordingly."

Fluctuating spruce markets

Fluctuating black spruce markets were another barrier cited by loggers and foresters in their efforts to implement dwarf mistletoe treatments. In recent times, the black spruce market in Minnesota has been challenging as one mill closed and another reduced its purchases.

One logger described their experience with recent markets:

Our main contractor was Blandin and they really cut us back to nothing. It forced us to go to Boise more...to get rid of the wood we had purchased ahead of time. We had to sell it somewhere...I mean we're experiencing some pretty rough times.

Foresters acknowledged that spruce markets are not as strong right now: "The spruce market is a little soft right now...paper is soft." If loggers do not have markets to sell their harvested product to, there is less of an incentive to purchase some species and to ensure every stem on a sale that they purchase is cut as prescribed. Additionally, there is no longer a strong chipping or biomass market in Minnesota. When that market existed, it was possible for loggers to make some profit off the small, unmerchantable stems they were required to cut in stands containing dwarf mistletoe. Now there is no market for them, as this logger shared:

There's a lot of spruce that got harvested in the last ten years with LEA [Laurentian Energy Authority] in Virginia and Hibbing – the biomass plants that were out there. Where it was low volume or smaller run of spruce but operators bought those sites and it all went in a chipper. The site was extremely clean and then they were utilizing every single stem because it didn't go for pulpwood. That was a great thing but those markets are really by the wayside at this point, they're not really there anymore.

Another forester agreed: "There just needs to be more markets available. Biomass or something would be nice – then people would be willing to own this stuff." Another added, "When markets are weak for spruce, then we can't do as much management in spruce...just because they won't bid on it."

Foresters also felt in their experience that the markets can have an impact on how effectively loggers implement the dwarf mistletoe treatments. When black spruce markets are bad, money may be tighter, and loggers might be more likely to take a shortcut in the woods, as shared by this forester: "When money is tight...you're less likely to do anything and you're really grumpy about it."

On the other hand, when black spruce markets are good, loggers are making more of a profit on these sales and are more likely to implement the treatment exactly, as shared by this forester:

Yeah markets will play a lot in that - and that's cyclical and markets are great. You're getting paid a fair wage to do your job. Loggers are making money. They're updating equipment. They're in a better mood. They're willing to do that extra thing because they know it's the right thing to do.

Bidding considerations with dwarf mistletoe

Loggers discussed what they consider when bidding on timber sales that contain dwarf mistletoe and how that can be a barrier to implementation of dwarf mistletoe treatments. Loggers consider a wide variety of factors when bidding and every logger has their own perspective on what is important. Loggers shared their thoughts around several factors impacted by dwarf mistletoe: wood density, wood quality, infection level, and access to sites, whether for viewing before auctions or accessing once purchased.

One logger shared how volume per acre of merchantable timber can be affected by dwarf mistletoe: "It depends on how many small stems there are...the sales that have affected areas of mistletoe are probably going to reflect on the volume per acre because it's probably going to be smaller wood." Similarly, another logger shared that there are no incentives to loggers to implement dwarf mistletoe treatments so "that's why you have to be careful what you bid on. If you're out there for a week just cutting their stems off, that's no good." Another logger described factoring in dwarf mistletoe to their bidding: "Typically your sites with dwarf mistletoe will have poor wood quality, so the prices usually reflect that."

Loggers shared experiences where they had sales that underperformed in volume (i.e., less volume harvested than was appraised) because of dwarf mistletoe impacts that led to a lower profit. One logger said, "Most sales are under-running because of both dwarf mistletoe and lower volumes due to bad cruising by foresters." Experiences like these have led loggers to feel that there are sales they will not buy if the dwarf mistletoe infection is very high. One logger described their method for determining whether to bid:

I can usually tell on the map whether it's our type of timber or not...if I can tell just on the literature that they have written up on it that it's going to be small and is infected with mistletoe, then usually I'm not interested because it's not the size we're looking for. It's typically too small.

Another logger described in more detail about what an allowable level of dwarf mistletoe in a stand is and how that impacts merchantable volume per acre:

Every stand is different, you know. It's something you've got to look at. You can tell when you walk up and look at something if you want it or not...a lot of it for me is cords per acre. If it's damaged to the point where you're doing less than ten cord per acre, it's not hardly worth my time to go into it...And it depends on the stage of it. A lot of times it's got mistletoe in it, but the trees not dead yet. So, if the agency has gotten to it fast enough, a lot of times it doesn't affect it at

all. But if they've let it go so far, then most of it's dead and you got all the blow down laying on the ground, all the dead trees are there and stuff, and then your cords per acre aren't there. That's what really determines whether it's worth it to go in and cut or not.

One logger summarized their thoughts simply with:

It's less about the percent of infection but more about the degree of mortality and estimate of cords...Regardless of how cheap you make it and where it is, even if it's right on the highway. Nobody will touch 10 cords on the acre.

Foresters agreed with this sentiment. One forester said, "10 cords in the acre and less, can't sell it." Similar to the infection level described previously, there is a point where loggers will turn away from sales with dwarf mistletoe due to wood quality. Another logger said, "Usually if its infected bad and has been for a long time, it's stunted and sometimes it's not very good wood. So I try not to buy that kind of wood." One logger felt the burden should be shifted to the forester if a stand is heavily infected and has low wood density:

The person that's going to have to take the hit is the agency. I mean, it's their stumpage. They're going to have to deal with the problem. It's not the logger's issue to deal with. That's the way I look at it. We'll just cut a different site if that's the case. We'll stay away from it and it's not trying to be mean, it's just reality. Why buy a site like that?

Loggers also described occasions where poor access to look at a proposed timber sale prior to an auction limited their ability to even look at a stand. One logger said:

When the state put up black spruce, it's always put up in either the fall or spring. And sometimes we're not able to get out there because it might be a few miles out into the swamp. There is really no good way to get out there because it's either thawed out or too wet. I know other loggers have talked about this too – that boy, it would be nice if they could sell their spruce almost in the middle of winter so a guy could take a snowmobile out to it. That's kind of the problem we have.

Foresters discussed how excellent road access into a site could be a reason to buy a stand with dwarf mistletoe. One forester said, "It's kind of a matrix of a lot of stuff. They'd tolerate more of it if it was easier to access, closer to where the mills work, if they're more hungry."

There were several loggers who shared that dwarf mistletoe presence does not affect their bidding in any meaningful way. One logger said simply, "[Dwarf mistletoe] is not really a big deal to me, I don't think. It hasn't affected us enough to change the way we bid on a sale."

Lack of coordination on adjacent stands

Another top barrier to effective treatment implementation identified by loggers and foresters was the lack of coordination on adjacent stands. For example, if a logger is harvesting a state sale with dwarf mistletoe that directly borders a stand – also infected – but is owned by another land management agency or landowner that is not harvesting their infected stand, the harvested stand is likely to be reinfected as it regenerates. When asked about the consequences for not coordinating in these instances, one forester said, “Just the potential for continued mistletoe into the stand.” Foresters shared that there is no policy existing that requires them to communicate with other entities or notify them regarding the sale of bordering stands: “You don’t have a policy where you have to notify adjacent landowners with mistletoe. So it’s up to the individual forester to do it.” Additionally, even if foresters do notify each other, it does not mean there will be action because of it. One forester shared:

You can’t necessarily make somebody cut their stand if they don’t want to. So I think a lot of times...there would always be that cooperation and understanding, but there’s times where you don’t have that ability to control that aspect of the harvest.

Foresters also shared that it can be time consuming to coordinate and communicate, so if they are very busy, they are less likely to take that time to reach out. One forester shared their perspective on this issue:

I think of all the people at this table, all of our agencies...have goals for managing across boundaries, coordinating because of the implications for better functioning ecological systems and habitat. So sort of all those ecological benefits that go along with actually managing regardless of property lines...we’re not doing. And that’s something that everybody agrees they want to do, regardless of disease issues, but it’s tough to do.

Some described there being no incentive to “go above and beyond” and coordinate. One forester shared, “I think you become a little complacent too. You know, you just say ‘well, yeah I got all these great ideas, but it ain’t gonna go anywhere so why should I worry about it,’” when discussing other agencies not caring if they have dwarf mistletoe in bordering stands. Some foresters felt they should be more aggressive with treatments. One forester described their experience with other foresters who were not aggressive about dwarf mistletoe:

There’s other foresters who just don’t try. They go off, they follow their ... line and flag it out. I’ve taken over a stand from somebody who gets rave reviews because he sets up a lot of timber, but then I go along his flag. I’m like, ‘this flag is on a tree with mistletoe, I mean really? Did you look up?’ I’m looking at the regen right next to it and again they followed the ... lines and that regens got mistletoe it’s like, ‘did you try?’ And that can be frustrating too, when you’re a

forester who is trying to think out there versus just 'eh I'm going to show up, do my sale,' because we get judged by metrics. You get judged by how many acres you set up, not by the quality of acres you set up. And that's another thing that kind of deters, I think, away from putting in more effort out in the woods.

Differing sale schedules, land management objectives, and sale planning requirements were cited as one of the main obstacles to coordinating. One forester described a situation with another agency and said, "I told 'em about it and they were very receptive, wanna do what they can. But a lot of times there's timing issues. It just takes different agencies longer to respond." Another forester shared, "...Depends what time of the year too. If you're at the end of the year and we've had our four auctions and we're already over our allowable cut...then it's harder to justify."

Certain landowners were also identified by foresters as being more difficult to coordinate or communicate with including the USDA Forest Service and family forest owners. As one forester shared, "Don't even call the feds. I don't know if that's going to even be worth your time because they are so stringent of what they have...it will take time and effort." Another forester continued:

...It's got to do with where their NEPA approved acres are...they're not willing to go outside or don't have a process to bring in new acres that aren't already pre-approved... you can try tagging along into their sales, but there is no getting them to tag onto you.

Private landowners were also cited as being difficult to communicate or coordinate with. One forester shared their perspective:

The thing is the time. How much time you're going to spend to try to track down the right person to talk to about it. If it's a private landowner or a different agency, like everyone said, there's other stuff going on. So do you just go put in the boundary line and walk away from it or is it a big enough concern that you're wanting to track down the right person and make it work?

Another forester added on about working with private landowners:

...Just not being interested in harvesting at all. Some people are interested and sometimes the loggers will cut theirs at the time and that works out great. And other times they just don't want to have anything to do with it.

One forester even suggested leaving it up to the logger to coordinate the different landowners if they are cutting a sale that borders other stands: "...Maybe it's easier left up to a logger to just let him...go talk to a private landowner or something to see if they're willing to do it."

Differing flexibilities among landowners

Loggers and foresters also described the varying degrees of flexibility of land management agencies being a barrier to effective treatment implementation. Loggers especially expressed frustration that there are too many different rules and different voices when it comes to what they should do on black spruce stands with dwarf mistletoe. Some foresters described that their respective agency does not have a standard policy regarding dwarf mistletoe treatments. One forester said:

I know on our lands, we don't have a policy that says you have to do [five-foot-rule] or there's not a standard generally...sever all stems, but sometimes we don't worry about it. It might depend on the presence or absence of a lot of small stems or not, whether or not it's put into the prescription or just general health of the stand.

Meanwhile, other foresters described their agency as having strict rules on dwarf mistletoe. One forester said, "The enforcement of what we're asking for people to do definitely changes in the heart of where the black spruce mistletoe is. [My agency], we're definitely more apt to require certain things and get to the edges [of an infected stand]." Another forester shared ways their organization has become more strict about dwarf mistletoe:

We have gone kind of the opposite route of prioritizing and just saying that 'this is the next one you're going to cut, period, because it's already showing mortality' or something. So we might shorten that time frame to benefit the ultimate outcome there.

Additionally, loggers described experiences of varying flexibility of the rules within one agency depending on which forester administered the sale: "It definitely varies by forester across all landowners. There are too many different voices telling you the rules. It depends on forester *only*, not agency." Some loggers attributed the differences among foresters to age and experience. One logger said, "Young foresters are more afraid to be flexible or make changes. It depends on experience. Old foresters don't care as much." Similarly, another logger elaborated:

New foresters are learning different things in school. For example, wildlife, invasive species, climate change. But they don't have the field experience. We need an apprenticeship period and mentoring. They need to learn from senior foresters. They need to learn how to manage "gray areas". It's not black and white decisions.

Loggers and foresters shared experiences of county agencies and private forest industry being more flexible on the rules. One logger shared, "[Industrial private land] is more aggressive. They want to chase you back out there and make you run it down." Foresters agreed that private forest industry has a lot of flexibility:

On industry lands, it's very simple for 'oh I went in to set up this stand and then I noticed that one. Oh and this one and this one and this one.' And there is like zero red tape to go through and a very simple process for us.

One logger felt that counties were also very nimble and able to react quicker to dwarf mistletoe issues: "The counties seem a little bit faster at reacting to things than the state or federal. Because it would be easier for them to adjust the stand that's damaged - they can go out and set it up faster." Foresters shared similar sentiments: "Counties are pretty nimble, typically." Similarly another logger shared:

With the DNR - you ask any forester what it takes to set up a timber sale...you got to jump through so many hoops. That's where the counties have total advantages because they can respond much faster. Look at a blowdown. Counties respond like instantly and they're the first ones out in the market.

Along with being nimble and reactive, another logger shared how county agencies can be more flexible on existing sales: "County is not very strict on it...like if you have some stand out there, they don't say anything. They're way more lax." On the contrary, many loggers and foresters shared feelings of state lands having too much red tape to be adaptive to situations or flexible on rules. One forester said, "You guys have your stand list and planning protocols so that can slow things down." Another forester added:

We have some policy issues...lowland conifer old growth or other policy or land statutes that affect where we can go and what we can harvest. If we are bumping [up against] one of those policy designations, we just don't have the ability to do it.

One forester shared their perspective of the 'red tape' encountered when dealing with state lands:

Any additional stands that we want to add have to go through interdisciplinary coordination, so meaning our other divisions have to review them and put in comments. Much of the time it can be an obstacle. It depends on how big the stands are, how many acres. But there are certain times when it's become a problem or just an obstacle to add it. Where they don't want to. So then either you have to let it go or you have to try to keep fighting it...they don't wanna be over-harvesting, or their perception of over-harvesting.

Loggers also described working with private landowners who had dwarf mistletoe in their forest stands and the different preferences those landowners can have. Many loggers suggested private landowners mostly just want to maximize profit when having trees harvested on their land, as one logger described: "I've logged spruce and they never mentioned anything about [mistletoe]...they just want to see how many dollars they can

get...nobody's ever mentioned mistletoe...it's all about the money." One logger shared their experience working with private landowners about dwarf mistletoe:

Typically when you are cutting private land, you try and tell them what is the right way to do it, but on private land, people think if you don't need to cut the tree then why knock it down if they're not getting anything out of it?...They see you come in and level something. Well, it's not because we had to, it's because we needed to try and stop the spread of something...We try to explain it to them but let's say they've got some black spruce that is 20 feet tall and it might be infected with mistletoe, well they're going to be like 'well if I'm not going to get any value out of those trees, don't cut them'. Well if you leave them it's going to affect new growth. I think the private [landowner] could be educated a little bit more on these treatments instead of just assuming we're flattening everything just because we can.

Another logger shared a similar experience of needing to fulfill landowners' wishes at the end of the day: "It's up to us...but I guess it's up to them too. You probably should run it all down if it's helping, but a lot of landowners don't want it run down."

Potential improvements to dwarf mistletoe sales

When timber sales are not selling because of the dwarf mistletoe infection, loggers and foresters identified ways to improve the sales that would make loggers more likely to purchase them. Loggers and foresters shared that the most likely method to get loggers to buy a sale would be to either add additional wood to it for the same price, or lower the price altogether as one logger described, "If the average diameter or cords per acre are under a certain stat, the forester should pay extra for the management or treatment of that site." Foresters also proposed those ideas: "Add timber to it would probably be the best thing to do" and "lower the prices." Another logger shared their opinion:

If there was a stand that was infected that had a great deal of small stuff, that it took a lot of extra time to go around and smash down, it would be good if they sold that timber for less money or would somehow compensate us for trying to help them with it.

One forester shared that even though it takes extra effort, if a stand with dwarf mistletoe is not selling, adding on wood would be a good solution:

...Adding on a stand. More so than walking away from it...there's a lot of extra steps that go into that too, as far as if it's not a stand that was initially on the planned list, then you have to go through and get coordination with other divisions. And so it does take longer that way too. But I would say more so adding, than not managing it.

Another strategy loggers identified that they would like to see is only requiring loggers to harvest the merchantable stems on sales that are heavily infected, rather than forcing them to cut all the small unmerchantable stems. One logger shared:

I think the state should make their own task force and buy their own equipment. We'll just cut the harvestable and they can go back and take care of the mistletoe if they want to...I don't know why it costs us every time they come up with a plan.

Foresters identified other methods they have used to get sales to sell with dwarf mistletoe, including extending the sale length to give loggers more time than usual. One forester said, "A lot of times larger sales with tough access...we'll make it a longer sale. Give them more time to get in there." On the flip side, mortality due to dwarf mistletoe can increase over time and extending a sale length could lead to further mortality, as described by this forester:

I think the only time you change the length of the sale is if you're starting to get excessive blow down in those mortality pockets. That's when you need your harvest to move a little bit faster so you don't lose more of the stand.

Another method foresters reported using to sell dwarf mistletoe sales was trying to target sales to specific loggers that may already be working in that area, as described by this forester:

I like to peddle sales, if you can get the price low enough I like to call up certain people who have certain equipment or who work in a certain area most of the time and just kind of keep it on their radar and seeing if I can peddle it somehow.

Foresters also described offering sales over the counter:

And you always have it for like over the counter, so if they have a good year and all of a sudden they run it out of that stuff and they can still get in to stuff, 'it's better than us not working'...And so then you can give it to 'em...'Cause once they start coming in and you're like 'I gotta keep my logging crew working. I don't want to pay unemployment.'

V. Effectiveness of Treatments

Table 9. Effectiveness of Treatments Theme Table

Research Question	Emergent Themes	Logger Interviews	Logger Focus Groups	Forester Focus Groups
Are the treatments effective?	Effectiveness generally unknown	x	x	x
	Lack of "effective" definition			x
	Recent improvements in effectiveness			x
	Needs for improving effectiveness	x	x	x
	Post treatment and its effectiveness	x	x	x
	Pre treatment and its effectiveness	x		x

Source: Logger Interviews, Logger Focus Groups, and Forester Focus Group Qualitative Data

Six themes emerged related to the perceived effectiveness of dwarf mistletoe treatments.

Lack of "effective" definition

First and foremost, loggers and foresters shared that there is not a common definition of what "effectiveness" even means. Foresters debated ideas of what could be considered an "effective" treatment. Many foresters felt that if the dwarf mistletoe treatment is implemented as designed or instructed, then that equals an effective treatment, as shared by this forester: "I consider it effective if the logger complies and it looks good for me at the end...All we can really do is make sure that what we ask the logger to do actually got implemented." Similarly, one forester shared, "I think you're equating implementation with effectiveness. Like I look and I say, 'Well they've got it all. They've knocked everything down. They sheared it all, whatever. So we are good to go.'"

Other foresters felt treatments are only effective if in the long-term there is success with eradication of dwarf mistletoe, as shared by this forester: "The best way to tell is...long term monitoring. It's going into these second growth stands now and seeing that there's regen as it is elsewhere." Yet other foresters said simply if you kill the trees containing dwarf mistletoe, you are effective in its control: "You're killing more stems and that kills mistletoe, so that's effective right?"

Other foresters focused more on the timber production side of things and felt if wood was being salvaged that would have otherwise died if left, that is an effective treatment. Or similarly, if the trees can make it to a harvestable level, even if containing dwarf mistletoe, that could be considered 'effective' as shared by this forester:

In my mind, I guess it doesn't necessarily matter if it's [dwarf mistletoe] there as long as the stand is healthy...when you start seeing a lot of deformity and mortality is when you start having a problem, or needing to treat immediately. But, if it's there...and it's asymptomatic or if it's just existing, I guess in my mind it's not too big of a deal because it's always going to be there, we're never going

to get rid of it. So, it's just a matter of is it affecting the growth, the health of the stand, and what kind of mortality are we willing to accept?...but I think the five foot cutting, just eliminating that, helps with the level of infection and the amount of mortality.

Most foresters agreed though, even without a definition of effectiveness, doing something about dwarf mistletoe is more effective than doing nothing, as shared by this forester:

Effectiveness, again it's hard to say. I think it's a matter of mitigating or minimizing your risk. And that's all you can do when that's what we're after is just trying to get the stand as healthy as possible and give it as much chance as we can afford. Whether it's effective or not, I'm sure it's more effective than doing nothing.

Effectiveness generally unknown

One major idea loggers and foresters discussed around effectiveness was the fact that effectiveness of treatments, regardless of its definition, is widely unknown. The first reason for this that loggers and foresters described was that black spruce has a decades-long rotation. Stands being harvested now likely will not be set up to sell again for at least 80 years, in which a new forester will be the one setting up the sale, as shared by this forester:

Usually by the time you're retired is when you're gonna find out whether something you did out there worked or had a chance, and even then you might not 'cause it's just what, 30 years down the line. It's not a long time in a lifespan of a black spruce stand.

Another forester shared their similar perspective:

If a forester's career is 40 years, you're looking at only half of rotations though...We're not seeing a lot of the mistletoe until 25-30 year, so the chance of that forester being back in that same one and seeing if the past treatment was effective is probably pretty small. Especially now with the turnover in foresters statewide. So there's a lot of that they don't have any to go on and see if a past treatment of theirs has been effective.

Foresters and loggers both felt like they have no idea if what they are doing is effective because of black spruce's relatively long rotation length. When loggers were asked about how they measure their effectiveness of dwarf mistletoe treatments, one said, "I don't know. I have no answer for that. Is it effective or isn't it effective? I do not know. I'll never know because it takes 100 years for that stand to reach maturity." Another logger added, "It's hard to know if it's working because spruce grows so slowly...we don't go back to the same stand for 45 years."

Other loggers suggested it is the forester's job to know if treatments are effective. One logger said, "I hate to keep throwing this in forester's lap, but that's theirs right? Isn't that their job to see how effective it was?" Similarly another logger said, "A problem is we don't know if our efforts are working. It's the forester's job to monitor. We won't know for 20 years if what we did worked." "We have to *assume* our efforts are being effective, but we don't know," shared another logger. Loggers expressed desire to know from foresters and others if their efforts are actually effective:

It'd really be nice to see some research that you're actually doing something that's positive...some results or something. I mean, we're implementing what they're telling us is the best thing to do. We're just blindly following, so we don't know if it is or if it isn't [effective].

Foresters also shared that they are just assuming their treatments are working, but don't always know or have data to show it is. One forester described their perspective: "[Foresters] are assuming what we are doing is working...that's a big assumption that we have no grounds for that...everything we are doing is based on the assumption that these things we're doing are working and we don't know that." Another forester said:

As far as a rigorous 'it works' or 'it doesn't work' or 'this treatment is effective', I just don't think the studies have been done. There is no data to back it up...you could rely on somebody's anecdotal evidence. But the forester that's been working for 30 years, he will tell you just as well as, you know, as [name redacted] could have, you know? If you ask our forest and disease people right now, they would say the same thing, 'Well, we think it works.'

Another forester had related sentiments:

I don't think there is any compelling evidence of it working. There is a lot of evidence for why it should work, but I don't think there has been real publicized information about 'this is definitely working, we've made an impact', because it is still everywhere. And I don't think it's been totally effectively studied in a convincing way. And if it has, it has not been communicated because a lot of folks are just unsure.

Similarly, foresters shared they generally do not know what was done to manage stands historically because there are not always data or records from decades back on dwarf mistletoe levels or treatments used, as one forester shared:

Going into a stand now at age 30 or something...If you were to do a regen check, how do you know it had mistletoe 30 years ago before the sale? We just don't. I mean all those records are in a file somewhere in somebody's office, but I'm not going to go digging through the [agency] attic files to look for that one sale from 35 years ago for a fully stocked stand.

Another forester added: "I think a lot of it is record keeping. I mean, even if we did make a considerable effort now, I'm not sure we have the data from the previous harvest to know was there mistletoe in the stand before that harvest."

Additionally, while foresters do typically go into stands between harvests for regeneration checks, they said they typically are not checking specifically for dwarf mistletoe. Instead, they are assessing whether the stand has sufficient levels of black spruce regeneration (number of stems per acre). Also, if they are looking for dwarf mistletoe but it is only 5-10 years post-harvest, the dwarf mistletoe might not be easily visible yet even if it is present, as described by this forester: "We do a regen checks at five years, so maybe people aren't sure if it's been effective or not, because it might be 15 years to see it." Another forester shared, "I don't know if we sample at a fine enough scale to find things in a 15 year old spruce stand." Similarly felt, this forester said:

With those younger trees it might be harder to really see it and identify it...versus once you get a death pocket and you see all these witches brooms or what not, or 20 trees growing out of one, you're like 'okay, it's got mistletoe', ding ding. But when it's so subtle, on something like regen...

Additionally, what regenerates post-harvest could depend on many variables, so it is difficult to say what role the dwarf mistletoe treatment might have played. One forester shared their view:

There are a lot of other variables that could affect your regen coming back, you know? What time of year it was cut, how frozen the ground was, there's lots of other variables that can affect what the next rotation is looking like.

Overall, many foresters felt there just is not evidence showing that treatments do work. They described how long they have been dealing with dwarf mistletoe and treating it, yet still have it throughout their managed forests. Some foresters felt they did not want to spend any additional money on treating dwarf mistletoe unless they know things are effective, as described by this forester:

We're not going to try to spend the money to do it if we don't think it's effective. I don't think we're going to eradicate it from a site...maybe we're just living with the fact that there is mistletoe on the site, so why spend the extra money?

Another key idea related to the lack of coordination on adjacent stands is that cyclical infections which move from one stand to another and back to a treated stand limit the effectiveness of treatments. Loggers and foresters repeatedly described this concern when discussing effectiveness of treatments. One logger said:

Sites that I have looked at in the past where we've treated it, it seems to work, but it just spreads to the next stand. We can only cut so much in areas so I don't know if it's going to just keep making circles or if we're ever going to get rid of it.

Another logger shared that they don't know how effective their dwarf mistletoe treatments are because of the ownership differences across the landscape:

If one agency cuts theirs, the stand right next to it might be infected and doesn't get harvested for several years. And the regen comes on the site that was harvested...does that infected stand that's besides it carry over and affect the stand regrowth?

Foresters agreed that the lack of coordination and cyclical infections were a major problem, as shared by this individual:

Without coordination, you're not going to do anything no matter how hard you try to eradicate on your property. Public, private industry - it doesn't matter. But if the adjacent landowner isn't ready to do the same thing, you just did nothing.

Foresters described a need to treat dwarf mistletoe at the landscape level, rather than the stand level, if they hope to make progress in management. When asked about needs foresters have in order to improve effectiveness of treating dwarf mistletoe, one forester said:

Larger cuts I think. A specific treatment change is just to go big. I mean, even if it's not up to rotation, it's only 60 years old, and it's better just to go big and actually treat an area versus a stand. Treat the landscape [instead] of the stand.

Recent improvements in effectiveness

Foresters did point out that even though effectiveness is not well defined or studied, they believe they are more effective now than they have been historically. Some foresters partially attributed this to the fact that past generations did not clearcut, whereas that is a frequent method in black spruce harvesting and dwarf mistletoe management now. One forester shared their experience seeing this change:

I've gotten more strict on my mistletoe management because I'm going back into stands that are relatively young – 50, 60 years old – and they're really productive stands, but it's the worst mistletoe I've ever seen. And you look back at old historic photos and you can see that they're partial cut. So there was a lot of spruce left on the site after they were cut...And when you start coring trees they're all different ages. But everything that's coming up now...is just dying. So that's why I'm all about the five foot cutting rule.

Along the same lines, foresters felt that their current treatments allow for better future rotations. Another forester shared how they have changed the treatments they require over time:

I've gotten a little more aggressive on that I think. Stretching my lines farther, just going back into stands or going into older stands and seeing productive stands that are not productive anymore because...the mistletoe is so bad. So I've gotten more aggressive I think on it. More strict on my sales supervision I think too.

Pre-treatment and its effectiveness

Loggers and foresters were asked about pre-treatments or management actions they take to eradicate dwarf mistletoe prior to a harvest. Most foresters felt pre-treatments were ineffective because you do not know what the stand will look like after a harvest and what the logger might leave behind. Similarly, foresters shared that it would not be economically effective to enter a stand for pre-treatment: "You aren't going to go into a stand unless you are cutting the whole thing." One forester said:

I don't see how pre-treatment would be effective unless you're able to time it with the logging in the same season. But I still don't see how it could be effective, because you don't know what's going to be left by the logger until it's left.

"Nobody does it," said one forester simply. One forester shared that a pre-treatment would only make sense if you know a sale is not going to sell and be harvested: "You might not need to spend that money. So I don't think very many people would do a pre-treatment – unless they thought the sale wasn't going to sell."

Loggers suggested looking into aerial spray options for dwarf mistletoe for a pre-treatment, but that they "don't think it would be cost effective." However, similar to foresters, some loggers only suggested a pre-treatment if the wood is not worth harvesting. In which case, a prescribed burn was suggested as an option, as shared by this logger: "Once it's in the stands, maybe the wood is so far gone that it's not worth harvesting. Then I could see maybe burning it, doing some kind of spray, just to try to keep it down."

Post-treatment and its effectiveness

Loggers and foresters were asked about any treatments after harvest, or post-treatments. Piling slash and burning it, or a full prescribed burn post-harvest, was suggested among loggers and foresters. One logger said, "It depends on what the state decides you're going to do about it...if they want the crap from it piled up so they can burn it and get rid of it or whatever needs to be done." Another logger suggested, "Try to do like a prescribed burn or something. Burn it off, instead of running it down." Foresters, however, were not sure on the practicality of burning:

...Can't even light a burn pile without filling out too much paperwork. I can't imagine writing a burn plan for a spruce stand. I can't imagine you get a clean burn either, so I don't know how effective that would be.

Another forester shared concerns about using fire in black spruce when there is peat: "It'd be nice, but no we don't just because usually 'cause of peat...we're worried about that fire sinking into the peat and not being able to put it out." Others wondered if there were "dwarf mistletoe specific herbicides, fungicides, insecticides" that could be used.

The majority of post-treatment discussion however was centered around the physical removal of remaining stems post-harvest with various types of equipment such as shearing blades and roller choppers. Loggers desired access to equipment such as shear blades for their own use: "I want more shearing than cutting, for efficiency sake." Loggers were willing to do that work for foresters if they were paid, as one logger shared: "You should pay loggers to bring in a shearcut when its winter and they are actively on-site already." Some loggers said that post-harvest equipment is only effective when the ground is frozen:

The roller chopper works well. It smashes brush and slashes it. It runs over the non-merchantable and chops it all up. It's less effective on swamps though and better on frozen ground. It flattens it all and works well on DM (dwarf mistletoe).

Foresters felt physical removal of stems by shearing or other post-treatment was most effective "on sites where you lost so much merchantable volume that you could go in there and hopefully try to reclaim those acres. There are just some pockets of mistletoe that are just so bad."

Foresters shared that they want to do more post-treatment, but it rarely happens for a variety of reasons including cost and unknown effectiveness. One forester said:

If we can't get it done by the person cutting the wood...we're not gonna pay someone. We just don't have the resources, it's not in our management to shear black spruce, so generally we try to get stuff done with the person harvesting.

Another forester said, "If you're gonna put a KG [shearing] blade in for 200 bucks an acre and gain a cord or two at rotation, it ain't good." One forester said:

I think when you talk about up against stagnant...if it is unmerchantable, it's not always realistic to put it in the timber sale or have the logger do it. So then you do have to, if you're going to pursue it, follow up with post harvest treatment which costs money and there's not always necessarily money available or that's not always a high priority.

Another forester shared their perspective that using post-treatments comes down to whether or not they believe its effective:

It goes back to that effectiveness...we're not going to try to spend the money to do it if we don't think it's effective. I don't think we're going to eradicate it from a site...maybe we're just living with the fact that there is mistletoe on the site so why spend the extra money?

Similarly, a forester added: "[Post-treatments] are effective at cutting the trees down, but I don't know if that stops the mistletoe or not...we are assuming that our treatment is effective." One forester summed up these sentiments:

[Post-treatments can] work really good and cannot work very good at all. And it's a lot of effort because you're working on a swamp. I think it depends on the money available, for that kind of work. And the site potential probably, too. What are your losses, what's the potential that could be gained from doing the treatment? I think that's all stuff that you have to weigh out because they could go for ever and ever and ever if you wanted to shear off a bunch of mistletoe.

Loggers felt that post-treatments were necessary in order to eliminate all trees and prep the stand for aerial seeding, which is common in black spruce stands. One logger said:

Whether the swamp is infected or not, they treat it as if it could be. Then they like to aerial seed it so they don't want scattered trees sticking up for the plane or helicopter, or however they're going to seed it.

Needs for improving effectiveness

Loggers and foresters identified many ideas, suggestions, and needs in order to improve effectiveness of dwarf mistletoe treatment and management. Loggers stressed a need for flexibility in sales in order to be profitable: "Can agencies have more flexibility or allowable acres for cuts? We should be able to get agencies to allow cutting beyond the boundary to help clean up dwarf mistletoe." Similarly, in order to be more profitable, loggers shared a desire for improved sales from agencies: "They should provide economic incentives for sales with dwarf mistletoe. Cheaper stumpage, more flexibility in not cutting if it's a certain size and could shear instead. That would help create better margins." For some loggers, an improved sale meant more tailoring of sales to actual conditions, rather than a standard treatment regardless of the amount of dwarf mistletoe:

Well, instead of taking a two hundred acre black spruce swamp and having us level the whole thing and they've only found one tree, foresters should be cruising the whole thing. If they only found one or two trees up in the Northwest corner, well then maybe within a certain area that [treatment] needs to be implemented. But with the rest of the area, we don't have to destroy

everything that isn't merchantable. Instead of one size fits all, maybe a little bit more tailored.

They also described the need for agencies to be more reactive and timely when stands are declining due to dwarf mistletoe. One logger shared their frustration with this:

If their cut plan is only to cut 50 acres out of that whole stand or something, when will be the next time they come in and manage it? How bad is the mistletoe going to get from now to when they go in again? So it's a tough one to manage that way. I mean realistically, yeah, they should have come and said 'yeah, do you want to buy the rest of it?' We'll cut the whole thing. That would have been a good way to slow the mistletoe down, but you have a whole bunch of other agencies screaming at them because they cut too much or something.

Loggers and foresters also stressed a need for agencies to be more proactive when there are opportunities for coordination across stand boundaries. One logger shared their perspective that loggers were doing their part and they need agencies to improve coordination:

I think the loggers are doing what they're asked to do...I think a big issue on that is...you got fragmented land. So you might have a state and county butts up to it, and there might be private or somebody else. So this big spruce stand might be infected. One agency might cut theirs, but the other might not cut theirs...they took care of their patch and you got it all clearcut and the loggers flatten it out. But if the adjoining landowner isn't on board with the fact that the mistletoe is there, it's just going to blow over and the regens all going to have it. So, have you really accomplished what you're after? I think that's a big thing, is the agencies really need to be working together to get a good end result.

Another forester shared a similar example, although focused on a different forest pest, that illustrates the need for improved coordination across stand boundaries:

I mean stepping away from dwarf mistletoe, I've seen numerous times where you got a state or fed line that runs right through the middle of a swamp. We cut ours and we tell them, 'Hey. We're cutting ours and there is a little bit of larch beetle in there.' And they are like, 'Yeah, nothing we can do.' And then you go back and do your regen checks at year 5 and their whole stand is dead because our slash just threw a bunch of beetles into theirs and they can't do anything about it. I mean you lose productive acres across the state to that sort of thing.

Loggers also shared that non-logging equipment could aid in better dwarf mistletoe management. Loggers described equipment types, such as shearing blades and roller

choppers, that are more effective in killing small unmerchantable stems than their own traditional logging equipment. One logger said:

Most operators don't have the equipment to do it. We don't have a KG blade, or we don't have one of them rollers. So you can go over there and run it over, but is that effective?...You've got to kill the tree that is infected and just running it over or bending it doesn't do it, so it has to be sheared.

Along those lines, some foresters suggested that a single treatment will not be enough to eradicate dwarf mistletoe:

You can't just rely on that single treatment of felling the stems over five feet because there's still mistletoe in that stuff that's below five. So you probably need to have some type of follow up treatment if you want to eradicate it. Not one single treatment is going to work, like stuff that might reduce it or slow it down and that might be any multiple of those. But probably not one single treatment is going to work.

Other foresters focused on the need for flexibility and creativity within regulations – or even new regulations, especially at the federal level. One forester shared an example of what could change to improve treatment effectiveness:

I think we would all agree maybe having some funding for lobbying for federal law change...to give them more freedom to improve things for insect and disease issues. For example, if a state or a county or private appraisers sees that on the other side of the line that they can do some sort of good neighbor sale and take care of the appraisal, and the administration for the feds, and just get it done... something that would work outside of...the NEPA process so that you're not just confined to that.

One forester shared that we should be thinking outside the box for solutions: "Maybe there's other things that we can do to stay open minded...I'm trying to keep an open mind and keep thinking outside the box really." For example, several foresters noted how spruce top (also known as spruce tip) markets are better than the markets for spruce trees currently. One forester shared their perspective on this:

Even on a better spruce site, the proposition of owning and growing black spruce to rotation is not a good financial investment...one thing that really helps us to own black spruce land is the harvest of these spruce tips. 'Cause we can bring in money early in the rotation.

Another forester shared how their organization is combining spruce top harvesting with pre-commercial thinning (PCT) in dwarf mistletoe management:

We've gone to this decorative tree harvest and we do it in by and large in our regenerated stands. And we've integrated some PCT into that... so he'll [go] through and every acre he'll leave those trees at eight by eight and then he'll take all the tamarack out, all the birch, if there's any aspen, or brush and he'll get rid of all that. And he'll do his spruce tip harvest at that time and then he'll leave the smaller spruce present...he's going through and he's treating most all acres and if there were any mistletoe or any residual stems that got through the harvest treatment...he would take it out anyway.

Foresters also focused on the need for increased black spruce and dwarf mistletoe research to know concretely about effectiveness of treatments. One forester asked for:

...better education on if there is evidence that these things are working or not or what are the actual risks? None of us here can actually speak to like real evidence of if it's working or not or what the actual loss to productivity is. A lot of it is just anecdotal.

They wanted better information on the timing and frequency to do regeneration checks to ensure effectiveness, as one forester described, "...Sooner, more often, and education would all kind of go together. What are we looking for? How often do we need to look at it?" They also expressed the need for increased funding in order to be effective in treatments, as shared by this forester: "More funding for continually tracking sites and regen checks sooner, I think that's imperative."

4 Discussion

Are foresters and loggers able to identify dwarf mistletoe?

Dwarf mistletoe knowledge and need for training differ among loggers and foresters. Foresters feel they have adequate knowledge regarding the identification of dwarf mistletoe. Whereas many loggers are not confident they can identify dwarf mistletoe in the absence of multiple large brooms or a mortality center. Some loggers questioned whether they actually need to be able to identify dwarf mistletoe if their role is just to follow the sale contract and many black spruce sales are cut the same way regardless of dwarf mistletoe presence. However, loggers do not only harvest timber sales on county, state, and federal properties who manage for dwarf mistletoe. They also harvest on family forest owner (FFO) tracts where the logger can provide the FFO with information about dwarf mistletoe and its management (i.e., what it is and how to recognize it, how it spreads, treatment recommendations, potential impacts from not eliminating it within the stand, treatment effectiveness). Because FFOs commonly do not understand the implications of managing for black spruce on their ownerships, foresters and loggers feel that those lands are not being properly managed to prevent the spread of dwarf mistletoe. Therefore, trainings for identification skills are important so loggers can apply that knowledge on FFO tracts. Additionally, if loggers can identify dwarf mistletoe on adjacent sites when harvesting, that could aid in communication among different landowners and slowing the cyclical infection. Therefore, it is important that both foresters and loggers have sufficient dwarf mistletoe identification and management knowledge.

Do foresters and loggers understand the need to eradicate dwarf mistletoe where timber production is the objective?

While foresters and loggers cited concerns around dwarf mistletoe, not all were related to impacts on timber production. There were also a diversity of views related to their level of concern about dwarf mistletoe. Some participants understood the need to treat dwarf mistletoe because of concerns about forest health (mortality, species conversion) as well as timber industry impacts (lower quality wood, fewer cords per acre, dependence on markets which purchase spruce and therefore make it possible to harvest black spruce commercially). However, other participants were not concerned about dwarf mistletoe because of its native status, its longevity in northern Minnesota, and its perceived slow growth and spread. Additionally, other forest pests and diseases were seen as being a greater concern than dwarf mistletoe including the larch beetle and spruce budworm. Several participants even noted positive benefits of dwarf mistletoe in forests, such as creating structural diversity for understory plants and wildlife habitat.

This diversity of opinions indicates a need for a better understanding of dwarf mistletoe biology and impacts. Varying degrees of familiarity with dwarf mistletoe likely impacts treatment decisions by management agencies. Different levels of concern – including a lack of – could lead to inconsistent treatment options across the landscape. This diversity of opinions also likely impacts the amount of additional monitoring, pre- or post-harvest treatments, and reporting activities that currently take place or are recommended for future action. Those foresters who are less concerned are probably less likely to elevate future dwarf mistletoe management actions when compared to their other job duties and forest health concerns. Overall, this may lead to inconsistent treatment approaches that could vary by agency or individuals, as well as confusion for loggers on best practices.

Additionally, the lack of clarity around the goals of dwarf mistletoe treatments (including mitigating ESDM risk, getting trees to harvestable age, or fully eradicating ESDM) can perpetuate the inconsistencies throughout treatment approaches, including the 5-foot rule. While the 5-foot-rule is the standard on state lands and is used by some county land departments, loggers and foresters do not necessarily understand the purpose and especially the effectiveness of the rule. Educating loggers helps build a shared understanding about ESDM among forest professionals. That shared understanding is especially important for businesses which operate on FFO tracts.

Are the eradication treatments implemented as designed?

Foresters and loggers alike seem to be aware of the 5-foot-rule and employ it as a standard prescription in black spruce on state lands and many other ownerships. However, loggers indicate there are varying instructions used on black spruce, apart from the 5-foot-rule, for managing dwarf mistletoe. Foresters concurred that the 5-foot-rule is not necessarily used on all land ownerships. Additionally, loggers indicated there is some latitude in carrying out the prescription with differences both by landowner group and by forester *within* an agency. Minnesota's forests are often a mosaic of ownerships, each with potentially different ownership objectives and rules governing their management. Across that landscape, a logger may interact with many different ownership groups and individuals within some agencies.

Loggers, most simply, said they just do what they are asked to do or follow the timber sale contract. While those contracts are created by foresters on agency and industrial ownerships, the logger likely creates that document on many FFO tracts. Loggers seem to be properly implementing the treatments they are contracted to implement without many issues. They indicated that foresters can instruct them to go back to a harvest site and knock down stems if they did not properly implement treatments. However, this was extremely rare and infrequent and non-compliance does not seem to be an issue on agency and industrial ownerships.

Most foresters and loggers agree that conventional logging equipment with a feller-buncher and skidder are preferred or more efficient to implement the prescription. However, both conventional and cut-to-length configurations can implement treatments as designed, so foresters did not believe one equipment type should be required in black spruce stands. Loggers are not told which type of equipment they need to use, but there seems to be some self-selection among conventional loggers to purchase black spruce sales because of the efficiencies in implementing the timber sale requirements over cut-to-length equipment in cutting small stems.

Are there impediments to implementing the treatments?

Several important impediments to implementing dwarf mistletoe treatments emerged – both from the point of view of the loggers and the foresters. For loggers, the cost burden associated with implementing treatments was of top concern. Working in black spruce systems themselves, even without dwarf mistletoe, can be costly and difficult due to soft soils that only allow winter access and harvesting and extremely dense young stems. Those stems and dust created can cause additional wear and tear on machinery. Dwarf mistletoe treatment prescriptions, such as the 5-foot-rule, also were reported to require additional costs with having to expend time, fuel and labor to remove so many non-

merchantable stems. In addition, loggers have indicated that they can fail to meet the appraised sales volume on stands with dwarf mistletoe. When a logging business bids on a timber sale, they may have certain minimum volume targets (e.g., total cords removed, cords/acre removed) which factor into their assessment. Loggers receive no financial incentives for implementing dwarf mistletoe treatments and are encouraged to consider dwarf mistletoe impacts to logging when they bid on sales. Suggestions were made by loggers about the need for different payment structures, either additional compensation for the removal of non-merchantable stems, reduced appraisal values or timber sales with larger volumes within that stand or a nearby stand so they are not absorbing the costs associated with ESDM treatments without compensation.

Foresters also experienced economic barriers associated with implementing treatment prescriptions. Even when they desired to undertake additional steps beyond the timber harvest, there were typically no funds available for post-harvest treatments. But overwhelmingly, the cost burden of ESDM treatment falls to loggers without necessary mechanisms to adequately compensate or incentivize them.

Markets are critical to eradicating dwarf mistletoe. Without their availability, commercial harvesting will not occur. Thus, market availability emerged as a significant barrier to effective ESDM treatment. Specifically, weak spruce markets mean loggers are having an increasingly difficult time finding markets for their harvested black spruce and are not making much money on black spruce sales, which may be a barrier to their cutting every non-merchantable stem. Also a lack of a biomass market in the state means there is no market for the unmerchantable stems that have to be cut in ESDM prescriptions, which could also be a deterrent to loggers removing non-merchantable stems. All of these factors can negatively impact logger interest in bidding on black spruce sales with ESDM. Should mills, which purchase black spruce, increase their merchantability standards, it will make it even less likely that a logger will want to purchase a sale with lower quality wood due to dwarf mistletoe or spend the additional time and money applying the 5-foot-rule. Thus, if markets decline, it could become more difficult to manage DM in black spruce in the future. Foresters shared that the most likely method to get loggers to buy a sale with significant ESDM infection would be to either add additional merchantable wood to the timber sale for the same price, or lower the price. Another suggestion by foresters was to offer a longer sale contract so loggers have more time to harvest. However, as several participants shared, more time to harvest a stand can lead to increased mortality over time.

Another top barrier to effective treatment implementation identified by participants was the lack of coordination on adjacent stands. Both loggers and foresters felt if they were harvesting a sale and the adjacent stand contained dwarf mistletoe, then it would likely reinfect the regeneration on the current stand. Participants also shared there is little to no communication and coordination about this issue regarding adjacent stands. Some described there being no incentive to “go above and beyond” and coordinate, as well as a lack of administrative structure to allow coordination across organizational boundaries. They cited differing sales structure and timing, allowable cut issues, and NEPA issues on federal land as specific factors limiting cross boundary collaboration and in being flexible enough to quickly respond to opportunities for cross-boundary management or expanding the size of a timber sale to include an infection site on their own lands adjacent to a current timber sale they are setting up or managing.

Participants also talked about how dwarf mistletoe management prescriptions and flexibility varies among agencies and landowners. The perception is that counties are more nimble and able to respond more quickly and have fewer administrative hurdles to address dwarf mistletoe, particularly if it is found in adjacent stands that need treatment. Aside from variability between agencies, some participants also reported a lack of consistency among foresters within the same agency as to how to address ESDM. Agencies may need to revisit their standard approaches to dealing with dwarf mistletoe to reduce the amount of confusion that differing prescriptions or enforcement have on loggers operating on their lands. On FFO lands, forest owners often want to maximize their financial return when setting up a harvest. Loggers shared this can lead them to not use the 5-foot-rule or other dwarf mistletoe management treatments on some timber sales, as they are following the preferences of the landowner. But, as loggers reported that they are not well educated on ESDM and its management, they likely are not able to provide enough relevant information to FFOs to allow those landowners to make a more informed decision.

Black Spruce is usually harvested during the winter when cold temperatures and compressed snow allow soil to freeze. Warm winters or winters with deep snow reduce soil freezing and increase difficulty in harvesting. If it is not cold enough to freeze the soil, loggers are unable to get into stands to harvest them. Or, warming winters may lead to a shorter timeframe to harvest black spruce stands, reducing the amount of area which can be treated. While agencies have provided extensions on their timber sales to allow harvest operations to occur in future years, the additional time can increase mortality within the stand and further decrease merchantability. Loggers discussed warming winters and the difficulties it poses for black spruce, but that agencies are putting more and more winter wood up for sale. This could draw loggers away from black spruce sales and towards species that can be harvested in winter more dependably and where their profit margin may be higher. Additionally, agencies frequently offer black spruce sales for auction during warmer months when loggers cannot access them easily to assess stand conditions and volume estimates.

Are the treatments effective?

Overall, foresters and loggers are unsure if treatments are effective because there is no clear definition on what effectiveness means, nor is there any rigorous post treatment monitoring, with sufficient records or tracking of dwarf mistletoe management over time.

Foresters and loggers are not clear on what an attainable measure of treatment effectiveness is or an overall goal of dwarf mistletoe treatments. To participants, total eradication of dwarf mistletoe does not seem possible. If total eradication is not possible, foresters and loggers were not sure what they should aim to achieve to be “successful” or “effective”. For example, does implementing the treatment as prescribed equal success or does getting black spruce to survive to a harvestable age, regardless of dwarf mistletoe level, equal success? Foresters and loggers need clarity on what is achievable, and what needs to be achieved, with respect to dwarf mistletoe treatments. However, foresters perceive that treatments are more effective currently than in the past due to using clearcutting as a management technique for black spruce, rather than doing partial cuts or leaving reserve trees.

Additionally, it is clear there is a lack of certainty or confidence that treatments (and post-harvest treatments) are working among both loggers and foresters. Many factors contribute to this lack of certainty around treatment effectiveness including long rotation time of black spruce and the time it

takes for dwarf mistletoe to become obvious or clearly visible. Foresters also shared that regeneration checks do not focus on evaluating dwarf mistletoe treatment effectiveness. If there is established research that can demonstrate how standard dwarf mistletoe treatments (such as the 5-foot-rule) are effective, then this needs to be communicated to loggers and foresters so they can be confident in their prescriptions and methods. If there is not established research, then clearly the need exists for it. Additionally, recent studies have shown dwarf mistletoe presence in trees less than five feet tall, suggesting that the 5-foot-rule might not be eliminating the parasite in stands, even when implemented correctly (Skay et al. 2021).

While the lack of funding for foresters to do post-harvest treatments was commonly shared, this barrier was compounded by the fact that foresters do not have knowledge or confidence in how effective post-treatments are in the first place. Participants indicated they were hesitant to spend additional funds on dwarf mistletoe treatments (including those post-harvest) if they do not know whether they are going to be effective. Additionally, loggers also do not possess equipment that they believe would be more effective, such as the shearing blades and roller choppers that are often used in post-harvest treatments.

A variety of suggestions emerged for improving treatment effectiveness or at least enhancing confidence in treatment effectiveness. First, better electronic searchable records of treatments that would allow for tracking of treatments and outcomes over time was suggested. Long-term monitoring specifically for effectiveness of treatments, not just regeneration checks, was also suggested. As mentioned previously, research that could document the effectiveness of treatments would also be imperative. Loggers also desired more flexibility in dwarf mistletoe treatments that are tailored to actual stand conditions, rather than one-size-fits-all policies. Additionally, financial incentives and support for loggers to better implement treatments and maintain profitability are needed. Lastly, but critically, improved treatment coordination across ownership and stand boundaries is essential in order to ensure treatments are not in vain and harvested stands will not be re-infected immediately.

5 Conclusions

This study illuminates several important gaps and needs in Minnesota's dwarf mistletoe management efforts, including 1) increased education and training, 2) better defined expectations for management outcomes, 3) improved research, monitoring, and record keeping, 4) improved coordination and communication within and among landowners, and 5) increased funding.

First, education is needed so loggers in particular are able to identify dwarf mistletoe in earlier stages when witches brooms are not yet present, how ESDM is spread and spread rate, why management treatments like the 5-foot-rule were created, and what is known about treatment effectiveness. While foresters might identify ESDM early on county, state, federal, or industry land, it is frequently up to loggers to identify it when operating on FFO tracts. Additionally, that will allow loggers to spot it earlier and communicate it to foresters if they see it in neighboring stands to their harvest site, when otherwise a forester might not check on that stand until years later.

At a broad level, there is a need to define what 'success' is when managing dwarf mistletoe as there are unanswered questions when it comes to discussing effectiveness. Is success: a) eradicating dwarf mistletoe from the stand, b) a logger cutting down every stem or c) just minimizing dwarf mistletoe impacts while getting black spruce to a harvestable age? What does being effective look like post-harvest, as well as ten years post-harvest during regeneration checks? Additionally, how will success or effectiveness be either encouraged or enforced? Are the treatments used for management based on evidence of success?

To answer all these questions, there is a clear need for improved research and monitoring regarding dwarf mistletoe. First, additional monitoring in the form of more frequent visits to sites post-harvest to assess effectiveness of the dwarf mistletoe treatments, rather than just checking on regeneration success would be extremely useful. Additionally, aerial survey approaches, such as drones, planes, or satellites, could be used to assess dwarf mistletoe presence and spread over larger areas or sites with difficult access. Finally, research studies are needed to monitor sites over time after treatment. These studies can evaluate the effectiveness of different eradication treatments and equipment types so that foresters and loggers can be confident that what they are doing is working.

There is also a need for an improved system for tracking, monitoring, and record keeping across a black spruce stand's lifespan. These records would include site conditions and infection presence or levels before a harvest. It should include the type of dwarf mistletoe eradication treatment that was used, equipment used as well as any post-treatment applied. Finally, it should include what is found during regular regeneration checks as well as post-treatment monitoring to assess dwarf mistletoe levels. Knowing that a single forester likely will not conduct a management treatment more than once in a spruce stand during their career, the data need to be clear and maintained for whoever is managing the stand in the future. It should be easily accessible and clear, even if there is forester turnover within an office or agency. The goal with this tracking and record keeping system is to inform the current forester about what was done in the past when a black spruce stand is ready to be appraised and be offered for sale,. Additionally, it will allow for better analysis across landownerships on the types of treatments that have been more effective or how dwarf mistletoe has spread.

One forester mentioned the presence of historical stand records in the attic of their agency. It may be worthwhile to go through those records to compile and analyze relevant information about past

practices, add that information to current stand histories and assess whether there is new knowledge which could be used to modify current management practices or used within education programs.

An agency may improve dwarf mistletoe treatment effectiveness with improved communication and coordination *within* their departments on establishing forest management goals and strategies for black spruce. Participants shared that retaining leave trees or any black spruce stems on a site is a forest health concern, in terms of eliminating a pathogen to ensure healthy pathogen-free stands and future timber production. However, some agency wildlife managers see removal of all stems as a forest health concern in terms of biodiversity and lack of habitat variability. While both groups are concerned for forest health, their goals to achieve it are clearly at odds.

Landscape-scale approaches to dwarf mistletoe treatment could be improved if coordination *among* different landowners and forest managers on adjacent stands could be achieved. While flexibility and administrative procedures can differ among agencies, land managers could explore opportunities to be proactive with stands that border land outside their jurisdiction. Better communications with other land managers who work in black spruce stands about possibilities for concurrent and coordinated management could help prevent cyclical (re)infection of black spruce stands. Forester participants felt this was possible – to have regular conversations and be more proactive – but it just takes the effort to do so and focus on a “landscape level” view.

Increased funding for dwarf mistletoe management was another clear need suggested by our study participants. Loggers feel that the requirement to cut and flatten every nonmerchantable stem has a negative impact on their bottom line. One potential solution offered by participants was extra payments for loggers to ensure they are flattening a stand after they harvest what they can sell. Another potential solution was to pay loggers to shear immediately after harvest while the site is still accessible – or contract others besides the logger to shear or rollerchop a site after harvest. Foresters want to do post-treatments but felt funding was a huge impediment to their accomplishing that.

Lastly, it may be possible to apply lessons learned here to Lodgepole Pine Dwarf Mistletoe (LPDM). While our eastern spruce dwarf mistletoe (ESDM) is native to Minnesota, LPDM is a new invasive dwarf mistletoe which could reach Minnesota and have more detrimental impacts to Minnesota’s jack pine (*Pinus banksiana*) such as rapid tree mortality and reduced timber yields. Lessons we learn from foresters and loggers managing ESDM currently can help in the creation of a proactive management plan in preparation for LPDM.

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Appendices

Appendix A – Logger Interview Contact Script

Logger Experiences and Perspectives of Dwarf Mistletoe Script for Initial Contact

“Hello, my name is Sarah Fellows. I am a researcher at the University of Minnesota conducting research on logger perspectives and experiences with dwarf mistletoe in black spruce. You were selected as a possible participant for an interview because you are a Minnesota logger who has purchased at least one timber sale containing black spruce within the last three years in one of the following counties: Itasca, St. Louis, or Koochiching. I have been interviewing loggers to gather their insights about dwarf mistletoe and experiences implementing treatments designed to eradicate dwarf mistletoe. I was hoping you would be able to assist me by participating in the study and sharing your perspectives with me. The interview takes about one and a half hours. Would you be willing to participate?”

If yes: “Thank you. I am available on ____ (days of week, times, have alternates ready) is there a time that would work best for you? [Set date, time, location (get directions)]. I would like to send you a confirmation email with date, time and location information. The email will include all of my contact information, in case you have any questions or concerns. Do you have an email address I can send the confirmation to?”

- a **If yes,** take it down or confirm we have the correct email address for them. “Thank you. I look forward to meeting with you on ____ (agreed upon date)___.”
- b **If no,** “Is ____ (phone # you contact them with)___ the best way for me to get a hold of you? In case you need to get a hold of me with questions or concerns, my phone number is _____. I look forward to meeting with you on ____ (agreed upon date)___.”

If no: “Ok, thank you for your time. Good bye.”

If they seem unsure: “Just to be clear, participation is completely voluntary and if you decide to participate you can withdraw at any time. Your identity will remain confidential and we won’t include any information that would make it possible to identify you in any reports. We’re only talking to a limited number of key representatives, so capturing your perspective is important. Can I ask, what are your concerns about participating?” [Try to address their concerns]

If they want to know why they are being asked to participate: “We’re interviewing a variety of loggers to try to get diverse perspectives, a range of experiences, and a range of operation types and sizes. Since we are only able to conduct a limited number of interviews, capturing your perspective is important.”

If they want to know how the information will be used: “We are trying to better understand loggers’ perspectives with dwarf mistletoe, challenges they face, and experiences associated with implementing dwarf mistletoe treatments. We’ll be putting together a final report that describes how loggers view these issues to share with educators, resource professionals, and the Minnesota Logger Education Program. Your information will be kept confidential and there will not be any identifying information in any reports.”

If they want to know what the study is for: “The purpose of this study is to better understand loggers’ experiences with dwarf mistletoe in northern Minnesota forests. This will lead to an improved understanding of the opportunities and concerns associated with dwarf mistletoe treatment so recommendations can be provided for dealing with the identified concerns. Funding for this project was provided by the terrestrial invasive species center at the University of Minnesota”

If they want to know who is supervising the research: “Charlie Blinn is the supervisor for this study. He is a professor in the Department of Forest Resources at the University of Minnesota. If you would like to contact him directly I can give you his phone number [612-624-3788] or email address [cblinn@umn.edu].”

Appendix B – Logger Interview Consent Form

Logger Experiences and Perspectives of Dwarf Mistletoe Consent Form

You are invited to participate in a study of logger perspectives of and experiences with dwarf mistletoe in Minnesota. You were selected as a possible participant for an interview because you are a Minnesota logger who has purchased at least one timber sale containing black spruce within the last three years in one of the following counties: Itasca, St. Louis, or Koochiching. We ask that you read this form and ask any questions you may have before agreeing to be in the study. This part of the study is being conducted by: Charlie Blinn, Professor at the Department of Forest Resources, University of Minnesota.

Background Information

The purpose of this study is to better understand loggers' experiences with dwarf mistletoe in northern Minnesota forests.

Procedures:

If you agree to be in this study, we would ask you to participate in an interview lasting approximately 90 minutes. The interview will be audio-recorded and later transcribed.

Risks and Benefits of being in the Study

Risks associated with this study are minimal; responses are confidential and participants' names will not be linked to any information in any reports. Indirect benefits of participation may include increased awareness of dwarf mistletoe and treatment options. Study results will be made available to the public and all participants will have access to them.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify you or any other individual. Research records will be stored securely and only researchers will have access to the records. Your responses to the interview questions will be audio-recorded, transcribed and kept for three years in a locked office. Afterward, these recordings will be destroyed. A participant database with your name and address will be stored in a password protected computer. Only those directly involved with the project will have access to the audio recording or the interview notes.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher conducting this study is: Charlie Blinn. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at address: 115 Green Hall 1530 Cleveland Ave. North, St. Paul, MN 55108-6112, phone: 612-624-3788, email: cblinn@umn.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

“I agree _____ I disagree _____ to have my responses audio-recorded”

“I agree _____ I disagree _____ that I may quoted anonymously in any reports”

Signature: _____ Date: _____

Signature of Investigator: _____ Date: _____

Appendix C – Logger Interview Background Information Survey

5/27/2021

Qualtrics Survey Software



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Default Question Block

Researcher Only

Participant ID:

What city/town is your logging business located in?

How many years have you been logging?

How many years have you been with your current logging business?

Approximately, how many people employed by your current logging business during the winter are **in-woods** staff (including yourself, if applicable)?

of in-woods winter employees

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What is the average number of years any winter **in-woods** staff have worked for your current logging business?

Average years experience

Approximately, how many cords do you harvest annually?

Cords

What equipment types does your current logging operation use? (Select all the apply)

- | | | |
|--|----------------------------------|------------------------------------|
| ☐ Cut-to-length/Harvester | ☐ Skidder | ☐ Grinder |
| ☐ Feller buncher | ☐ Loader | ☐ Bulldozer |
| ☐ Forwarder | ☐ Chipper | ☐ Slasher |

What entities have you purchased wood from in the past year? (Select all that apply)

- | | |
|---|--|
| ☐ Itasca County Land Department | ☐ US Forest Service |
| ☐ Koochiching County Land Department | ☐ Other County/Counties |
| ☐ St. Louis County Land Department | ☐ Private landowner(s) |
| ☐ DNR | ☐ Other |

What is your gender?

- ☐ Male
- ☐ Female

Appendix D – Logger Interview Guide

First I'd like to start with a few questions about you and your logging business in general.

- 1 Tell me a little bit about your logging operation.**
 - 1.a What equipment does your operation/business regularly use?
 - 1.b What is your preferred species? Why?
 - 1.c What is your role in the business?**
- 2 Why did you choose to be a logger?**
- 3 Approximately how many black spruce sales do you buy a year?**
 - 3.a Approximately what percent of your annual volume is black spruce?
 - 3.b Has that changed over time? If so, why?
 - 3.c Approximately what percent of those are public vs private?
- 4 Do you or someone else in your business walk a stand before bidding on it?**
 - 4.a Are you/your business more likely to walk a black spruce stand before bidding on it? Please explain.

Next, I would like to learn more about your experiences with Dwarf Mistletoe.

- 5 What have you heard or what do you know about dwarf mistletoe?**
- 6 Tell me about your experiences with dwarf mistletoe.**
 - 6.a Approximately what percentage of your black spruce sales in the past 3 years have had dwarf mistletoe present?
 - 6.b On what land ownerships have you seen dwarf mistletoe present in the past 3 years?
- 7 What is your approach to identifying dwarf mistletoe?**
 - 7.a Who or where did you learn about identifying dwarf mistletoe?
- 8 How effective do you think foresters are at identifying dwarf mistletoe?**
 - 8.a How often does a sale prospectus match up to what you are seeing in the woods with regards to dwarf mistletoe?**
 - 8.b When dwarf mistletoe is present, how often does a forester discuss it with you during a pre-sale meeting?**
 - 8.c Does it vary by landowner or agency?
 - 8.d Does it vary by forester within an agency?
- 9 Within the past 3 years, approximately what percent of black spruce timber sales have included a treatment to eradicate dwarf mistletoe?**

Now, I would like to learn more about your experiences with Dwarf Mistletoe treatments. First, we'll talk about public lands.

- 10 Have you ever implemented a dwarf mistletoe treatment on public land? (If no, skip to #14)**
 - 10.a What treatment(s) did you use?**
 - 10.b What was that experience like?
 - 10.c Do you take any further steps to eradicate dwarf mistletoe or prevent spread beyond what is contractually obligated?

- 11 Does the treatment on public land vary by landowner or agency?
 - 11.a How are those different?
 - 11.b Does it vary by forester within an agency?
 - 11.c What do you do if you find dwarf mistletoe that was not mentioned in the sale prospectus?
- 12 Are there incentives to implement a dwarf mistletoe treatment on public lands?
- 13 Are there penalties to *not* implement a dwarf mistletoe treatment on public lands?

Now we'll move to private land.

- 14 Have you ever implemented a dwarf mistletoe treatment on private land? (If no, skip to #15)
 - 14.a What treatment(s) did you use?
 - 14.b What was that experience like?
 - 14.c How was it different than what you do on public lands?

These next few questions refer to across all ownerships, not just public or private sales.

- 15 What factors *most* affect your ability to implement a dwarf mistletoe treatment?
- 16 How do you measure effectiveness of a dwarf mistletoe treatment?
- 17 How effective do you think the treatments have been that you have implemented?
 - 17.a How effective do you think the treatments you have implemented have been at eradicating or preventing the spread of dwarf mistletoe?
 - 17.b What support do you need (if any) to improve your ability to implement dwarf mistletoe treatments?
- 18 Are there other treatment options you've heard of but haven't tried?
- 19 What is your preferred treatment option and why?

Next, I would like to learn more about your perspectives on impacts of dwarf mistletoe.

- 20 Are you concerned about dwarf mistletoe and its impacts?
 - 20.a What impacts are you concerned about?
 - 20.b Does knowing about dwarf mistletoe influence the sales you buy?
 - b.i [If yes] If you walked a sale ahead of time and found dwarf mistletoe that wasn't listed in the sale prospectus, does that change your interest in buying a sale?
- 21 What do you do differently when bidding on a sale known to have dwarf mistletoe compared to one without?
 - 21.a Does dwarf mistletoe presence impact your bidding? Please explain.
- 22 What do you do differently when harvesting a sale with dwarf mistletoe compared to one without?
 - 22.a Does dwarf mistletoe affect the time spent on a sale? Please explain.
 - 22.b Does dwarf mistletoe affect your production rate or level on a sale? Please explain.
 - 22.c Does dwarf mistletoe affect your end volume on a sale? Please explain.

Finally, I have a few wrap-up questions for you.

- 23 Do you talk to others about dwarf mistletoe?
 - 23.a If yes, who do you talk to?
- 24 **Who do you consider the most trusted source of information about dwarf mistletoe and/or treatments?**
- 25 How do you share information to your crew about dwarf mistletoe and/or treatments?
- 26 Is there anything else you would like to add about dwarf mistletoe, black spruce, or logging in general?

Appendix E - Logger Focus Group Facilitator Script

Logger Focus Group Script – 1:00 – 3:00 PM

1 Welcome and agenda (1:05 - 5 min): Sarah

Hello everyone and welcome. My name is Sarah Fellows. I am a researcher at the University of Minnesota. We are hosting this focus group to explore your perspectives and experiences with dwarf mistletoe in black spruce sales. Thank you for joining us today. This focus group is part of a larger research project led by the University of Minnesota aimed at improving dwarf mistletoe detection and management. I am joined today by my colleague Charlie Blinn, a professor at the University of Minnesota in the Department of Forest Resources, who many of you know already.

Agenda

I have today's agenda here. Let's take a minute to look it over together. *(Walk through day's agenda)*

Roles

Your role today is to share your thoughts and opinions and to listen to the thoughts and opinions of others. **There are no right or wrong answers.** We invite ideas that may differ from what others have said. The success of this process depends on your willingness to think creatively, voice your ideas, listen to others' ideas, and maintain an open mind.

I have posted some "ground rules" on the wall beside us. They will just serve as a good reminder to be respectful, let one person talk at a time, and to share differing perspectives. "Equal air time" means I do want to hear from everyone, but not everyone needs to respond to every question.

I will play the role as facilitator - Charlie will be assisting me throughout and taking notes. As a facilitator, my job is to direct the flow of conversation and make sure that everyone has the opportunity to participate. I am also responsible for keeping us on task and on time, so I may need to interrupt discussions to make sure we stay on target. I know everyone's time is valuable. We hope to work together to make the most these two hours and will end on time.

We will be taking some notes throughout the discussion, jotting down responses on the flipchart, and making sure you have what you need to participate. In order to not miss any of the discussion while facilitating, we will also be audio recording the conversation. As mentioned in the consent form you signed before we began, all reasonable efforts will be made to maintain confidentiality and your name will not be associated with any of the data collected.

Sherman Anti-Trust Act: Charlie

We recognize that you as loggers have to abide by, and benefit by, anti-trust laws as part of participating in a free enterprise system. In today's focus group, we will be asking for your perspectives on a variety of topics. However, we do not anticipate discussing prices or markets in any way that would violate the

anti-trust act. We do want you to feel comfortable at all times in this discussion, so if you ever feel like the discussion is posing antitrust dangers, feel free to raise your hand and we will make sure to redirect the conversation. But again, we do not anticipate there being any issues.

Before we begin, I want to ask you to please check your cell phones and make sure they are silenced or turned off. Also, if you should need to use the restroom, they are _____. Feel free at any time to help yourself to the refreshments at any time.

2 Introductions and ice-breaker (go-around) (1:10 - 5 min)

While many of you may already be acquainted with one another, I would like to start by letting you all introduce yourselves.

Q1. Let's go around the room and, one at a time please tell us your name and something that inspires you about your work (in one sentence).

3 Dwarf mistletoe treatment open discussion (1:15 – 35 min)

Thank you. I next want to start a discussion about dwarf mistletoe treatments. To begin the discussion, we first want to know:

Q2. What “treatments” to manage dwarf mistletoe have you been asked to use/implement?

[Probe for details on differences in wording and what is expected.]

Q3. Do those treatments differ by landowner/agency? Do those treatments differ by forester within a landowner/agency? Do those treatments differ by across the areas in which you work?

We'd like you to think of the treatments you've implemented and those experiences.

Q4. What is working well about implementing dwarf mistletoe treatments? For example, what is easy about implementing them?

Q5. What is not working well about implementing dwarf mistletoe treatments? For example, when you are actively implementing the treatment, what is difficult? What is constraining your ability to do that efficiently or effectively?

Q6. Do you share those constraints with landowners/agencies (or specific foresters)? If so, how? If not, why not?

4 Open discussion and idea listing (1:50 – 20 min)

Next, we'd like to discuss more about dwarf mistletoe and the way it impacts your businesses and the industry. For these next questions, we will be documenting your responses on the flip chart.

Q7. What impacts of dwarf mistletoe are you seeing in the forest and/or concerned about?

[Forest health impacts]

Q8. What impacts of dwarf mistletoe are you seeing with regards to your production or business? [Production level, volume, equipment, impacts]

Q9. Is there a point in which dwarf mistletoe impacts your interest in buying a sale? If so, what is that point? (Open discussion only)

5 Break (2:10 – 10 min) (Participants use stickers to prioritize items listed in Question 7 and 8 during break. Three votes total. Reconvene with brief discussion of results.)

It is now time to take a short break. To help keep the day on time we ask that everyone is back and ready to start in 10 mins at (say specific time). As a reminder restrooms are _____ and please help yourself to refreshments. However, before I let you go, we do have one task for you during the break. You each have 3 colored sticky dots. Please use three stickers to identify your top priorities listed on the flip charts. You can put all your stickers on one or you can distribute them across the lists. It's up to you.
[Break]

6 Reconvene and debrief prioritization activity (2:20 – 5 min)

Welcome back. Thank you all for being on time. Let's take a quick moment to reflect on where everyone placed their dots...

Q10. Any thoughts you would like to share about the results?

7 Effectiveness open discussion (2:25 – 20 min)

The remainder of the time we will be focused on improving dwarf mistletoe management.

Q11. What do you think of current efforts to manage dwarf mistletoe? For example, how effective do you think dwarf management efforts have been, both your own and more broadly across the state? Are we doing enough? Too little?

Q12. What could be done to improve the treatment of dwarf mistletoe?

8 Open discussion & closing (2:45 – 10 min)

We have just a few more minutes now before we wrap up. We are interested to know from you...

Q13. What additional information do you and/or your crews need with regards to dwarf mistletoe?

Q14. What else should we know about your experiences with dwarf mistletoe in black spruce?

Thank you all so much for your participation today. Your input has been extremely valuable. Our next steps in the project is to survey foresters and eventually host focus groups with foresters around the same topic to understand their perspectives and experiences. We will be available after the session to answer any specific questions about the project or if you have anything else you would like to share with us.

Appendix F – Logger Focus Group Consent Form

FOCUS GROUP CONSENT FORM

Thank you for participating in this project! We are seeking loggers' insights and experiences with dwarf mistletoe in black spruce stands. You were selected as a possible participant because you are a Minnesota logger who has purchased at least one timber sale containing black spruce within the last three years in one of the following counties: Itasca, St. Louis, or Koochiching. Study findings will be used to improve management, education, and communication associated with dwarf mistletoe management. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The focus group lasts approximately two hours. You will be asked questions about your perspectives with dwarf mistletoe, challenges you face, and experiences associated with implementing dwarf mistletoe treatments in black spruce stands. Your participation is voluntary and you may withdraw from the project at any time. Your decision will not affect your current or future relations with the University of Minnesota.

Risks associated with this study are minimal, responses are confidential and names will not be linked to any information in any publications. Benefits of participation include increased awareness of timber sale and guideline issues. Study results will be made available to the public and all participants will have access to them.

If you agree to participate in this project, all reasonable efforts will be made to maintain confidentiality. Since the focus group session takes place in a group setting and others are privy to your responses, the research team cannot guarantee absolute confidentiality. However, your name will not be associated with the data collected. Only those directly involved with the project will have access to the focus group notes.

Contacts and Questions:

The researcher conducting this study is: Charlie Blinn. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at address: 115 Green Hall 1530 Cleveland Ave. North, St. Paul, MN 55108-6112, phone: 612-624-3788, email: cblinn@umn.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

"I agree_____ I disagree_____ to have my responses audio-recorded"

"I agree_____ I disagree_____ that I may be quoted anonymously in papers"

"I agree_____ I disagree _____that my photo may be taken during the group discussion"

Signature:_____Date: _____

Signature of Investigator: _____Date: _____

Appendix G – Logger Focus Group Background Information Survey

5/27/2021

Qualtrics Survey Software



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Dwarf Mistletoe

Dwarf Mistletoe Perspectives

How would you rate your level of knowledge about dwarf mistletoe in Minnesota?

Not at all knowledgeable

☐

Slightly knowledgeable

☐

Somewhat knowledgeable

☐

Very knowledgeable

☐

How confident are you in your ability to correctly identify dwarf mistletoe in the field?

Not at all confident

☐

Slightly confident

☐

Somewhat confident

☐

Very confident

☐

Out of this list of dwarf mistletoe indicators, which do you primarily use/think is the most important to identify mistletoe? Please choose one.

- | | |
|---|---|
| ☐ Presence of witches brooms in branches (dense mass of shoots from a single point) | ☐ Grouping of dead black spruce trees |
| ☐ Presence of multiple tops in individual trees | ☐ Presence of dead witches brooms on the ground |
| ☐ Dead black spruce tree tops | |

https://umn.ca1.qualtrics.com/Q/EditSection/Blocks/Ajax/GetSurveyPrintPreview?ContextSurveyID=SV_5g/VkbNi8Z8D7p3&ContextLibraryID=UR_ah... 1/5

When you purchase a timber sale that contains dwarf mistletoe, do any of the landowners/agencies that you work with perform any pre-harvest on-site treatments to control or eradicate dwarf mistletoe before you enter the site?

Yes

☐

No

☐

I don't know

☐

When you purchase a timber sale that contains dwarf mistletoe, do any of the landowners/agencies that you work with perform any post-harvest on-site treatments to control or eradicate dwarf mistletoe after the timber sale is closed?

Yes

☐

No

☐

I don't know

☐

Logging Business

About Your Business

What city/town is your logging business located in?

How many years have you been logging?

How many years have you been with your current logging business?

Approximately, how many **in-woods employees** are employed by your current logging business during the winter (including yourself, if applicable)?

of in-woods winter employees

Approximately, how many cords do you harvest annually?

Cords

What equipment types does your current logging operation use? (Select all that apply)

- | | | |
|--|----------------------------------|------------------------------------|
| ☐ Cut-to-length/Harvester | ☐ Loader | ☐ Bulldozer |
| ☐ Feller buncher | ☐ Chipper | ☐ Slasher |
| ☐ Forwarder | ☐ Grinder | ☐ Delimber |
| ☐ Skidder | | |

What entities have you purchased wood from or been contracted with to harvest timber on their stumpage purchases during the past year? (Select all that apply)

- | | |
|---|---|
| ☐ Itasca County Land Department | ☐ Other County/Counties |
| ☐ Koochiching County Land Department | ☐ Private industry |
| ☐ St. Louis County Land Department | ☐ Family forest owner(s) |
| ☐ DNR | ☐ Other |
| ☐ US Forest Service | <input type="text"/> |

Sociodemo

About You

What is your gender?

- ☐ Male
☐ Female
-

In what year were you born?

What is the highest level of formal education you have completed?

- | | |
|--|---|
| ☐ Did not finish high school | ☐ College bachelor's degree |
| ☐ Completed high school/GED | ☐ Some graduate work |
| ☐ Some college but no degree | ☐ Completed graduate degree (Masters or PhD) |
| ☐ Associate degree or vocational degree | |
-

How would you describe your race? (Please check all that apply)

- | | |
|---|--|
| ☐ White | ☐ Chinese |
| ☐ Black or African American | ☐ Japanese |
| ☐ American Indian or Alaska Native | ☐ Korean |
| ☐ Asian Indian | ☐ Vietnamese |
| ☐ Native Hawaiian | ☐ Filipino |
| ☐ Pacific Islander | ☐ Other Race (Please specify) |
-
-

Appendix H – Logger Focus Group Contact Script

Logger Experiences and Perspectives of Dwarf Mistletoe Contact Script for Focus Groups

“Hello, my name is Sarah Fellows. I am a researcher at the University of Minnesota conducting research on logger perspectives and experiences with dwarf mistletoe in black spruce. You were selected as a possible participant because you are a Minnesota logger who has purchased at least one timber sale containing black spruce within the last three years in one of the following counties: Itasca, St. Louis, or Koochiching.

I am calling to invite you to participate in a focus group to share your insights about dwarf mistletoe and experiences implementing treatments designed to eradicate dwarf mistletoe. The focus group is part of a research study being conducted by the Department of Forest Resources, University of Minnesota and is being funded by the terrestrial invasive species center at the U of M. The purpose of these focus groups is to learn more about challenges loggers face associated with implementing dwarf mistletoe treatments.

The focus groups will take place at the Minnesota Logger Education Program (MLEP) 2019 conferences on **April 16th (Bemidji)** and **April 23rd (Duluth)** during the concurrent breakout sessions. All focus group participants will still earn the **full 8 credit hours** for conference attendance. Would you be willing to participate?”

If yes: “Thank you. Which conference date will you be attending? Would you like to attend the AM (9:30-11:30) or PM (1:00-3:00) session?”

I would like to send you a confirmation email with date, time and location information. The email will include all of my contact information, in case you have any questions or concerns. Do you have an email address I can send the confirmation to?

- a **If yes**, take it down or confirm we have the correct email address for them. “Thank you. I look forward to meeting with you on ____ (agreed upon date)___.”
- b **If no**, “Ok, I will leave you a reminder card at the MLEP check-in table. I can also give you my phone number now in case you have any questions or concerns.”

If no: “Ok, thank you for your time. Good bye.”

If they seem unsure: “Just to be clear, participation is completely voluntary and if you decide to participate you can withdraw at any time. Your identity will remain confidential and we won’t include any information that would make it possible to identify you in any reports. We’re only talking to a limited number of key representatives, so capturing your perspective is important. Can I ask, what are your concerns about participating?” [Try to address their concerns]

If they want to know why they are being asked to participate: “We’re asking a variety of loggers to participate in order to get diverse perspectives, a range of experiences, and a range of operation types and sizes. Since we are only able to conduct a limited number of focus groups, capturing your perspective is important.”

If they want to know how the information will be used: “We are trying to better understand loggers’ perspectives with dwarf mistletoe, challenges they face, and experiences associated with implementing dwarf mistletoe treatments. We’ll be putting together a final report that describes how loggers view these issues to share with educators, resource professionals, and the Minnesota Logger Education Program. Your information will be kept confidential and there will not be any identifying information in any reports.”

If they want to know what the study is for: “The purpose of this study is to better understand loggers’ experiences with dwarf mistletoe in northern Minnesota forests. This will lead to an improved understanding of the opportunities and concerns associated with dwarf mistletoe treatment so recommendations can be provided for dealing with the identified concerns. Funding for this project was provided by the terrestrial invasive species center at the University of Minnesota”

If they want to know who is supervising the research: “Charlie Blinn is the supervisor for this study. He is a professor in the Department of Forest Resources at the University of Minnesota. If you would like to contact him directly I can give you his phone number [612-624-3788] or email address [cblinn@umn.edu].”

Appendix I – Forester Focus Group Facilitator Script

Forester Focus Group Script Wed Oct 16th – 2:00 – 4:00 PM

1 Welcome and agenda (2:00 - 5 min): Sarah

Hello everyone and welcome. My name is Sarah Fellows. I am a researcher at the University of Minnesota. We are hosting this focus group to explore your perspectives and experiences with dwarf mistletoe in black spruce sales. Thank you for joining us today. This focus group is part of a larger research project funded by the Minnesota Invasive Terrestrial Plants and Pests Center and led by the University of Minnesota aimed at improving dwarf mistletoe detection and management. I am joined today by my colleague Charlie Blinn, a professor at the University of Minnesota in the Department of Forest Resources, who many of you know already.

Agenda

I have today's agenda here. Let's take a minute to look it over together. (*Walk through day's agenda*)

Roles

Your role today is to share your thoughts and opinions and to listen to the thoughts and opinions of others. **There are no right or wrong answers.** We invite ideas that may differ from what others have said. The success of this process depends on your willingness to think creatively, voice your ideas, listen to others' ideas, and maintain an open mind.

I have posted some "ground rules" on the wall beside us. They will just serve as a good reminder to be respectful, let one person talk at a time, and to share differing perspectives. "Equal air time" means I do want to hear from everyone, but not everyone needs to respond to every question.

I will play the role as facilitator – so my job is to direct the flow of conversation and make sure that everyone has the opportunity to participate. I am also responsible for keeping us on task and on time, so I may need to interrupt discussions to make sure we stay on target. I know everyone's time is valuable. We hope to work together to make the most these two hours and will end on time.

Charlie will be assisting me throughout, taking notes, and making sure you have what you need to participate. In order to not miss any of the discussion while facilitating, we will also be audio recording the conversation. As mentioned in the consent form you signed before we began, all reasonable efforts will be made to maintain confidentiality and your name will not be associated with any of the data collected.

Before we begin, I want to ask you to please check your cell phones and make sure they are silenced or turned off. Also, if you should need to use the restroom, they are _____. Feel free to help yourself to the refreshments at any time.

2 Introductions and ice-breaker (go-around) (2:05 - 5 min)

While many of you may already be acquainted with one another, I would like to start by letting you all introduce yourselves.

Q1. Let's go around the room and, one at a time, please tell us your name, where you work, and how long you've been working with black spruce.

3 Dwarf mistletoe treatments & effectiveness open discussion (2:10 – 60 min)

Thank you. Before we begin the next line of questions, I want to share a little bit about another part of this project. Earlier this year, we sent out an online survey to foresters in our study area of all different agencies & organizations. Most, if not all of you, were invited to participate in that survey. We had over 100 responses. Throughout today, we will be sharing some preliminary data from the survey and hearing your reflections about it or asking you to shed more light on the responses.

First, I next want to start a discussion about dwarf mistletoe treatments. To begin, I'll share with you the survey results displaying the treatments you require to manage dwarf mistletoe on your respective lands. *[Show survey results for treatments used – slide 1]*

Q2. Do these results surprise you?

Q3. How do you decide which treatment to use/require?

Q4: How would you describe your interactions with loggers around these treatments? *[Are there treatments more difficult to implement? Do you have to remind them to use them? What do you do if loggers haven't done the required treatment? Do you have to assess penalties?]*

In our survey of foresters, 33% said they rarely or never discuss dwarf mistletoe & its treatment during a pre-sale meeting for timber sales that do contain DM.

Q5. Why do you think it isn't always discussed in pre-sale meetings?

Q6. Have you changed the treatments you require over time? If yes, why?

The next survey results I'd like to show you display how effective you believe the treatments you use or require are (on a scale from 'not effective at all' to 'very effective', also including an 'unsure' option). For whatever treatment options a respondent said they use, they were then asked to rate its effectiveness. *[Show survey results for treatments effectiveness – slide 2]*

Q7. Do these results surprise you?

Q8. What is working well about the dwarf mistletoe treatments you require?

Q9. What is not working well about the dwarf mistletoe treatments you require? *[What is difficult? What is constraining an operators' ability to do that efficiently or effectively? Time vs money?]*

Q10. Why do you think so many foresters said they were unsure of effectiveness? *[What is needed to improve knowledge on level of effectiveness?]*

We also asked foresters in the survey about harvesting equipment configurations and what is most effective for implementing dwarf mistletoe treatments. Most agree that conventional is most effective.

[Show survey results for effectiveness of equip configurations – slide 3]

Q11. Why is conventional more effective than cut-to-length?

Next, we'd like to discuss more about treatment effectiveness.

Q12. How do you determine if a treatment is effective?

Q13. How is effectiveness measured?

In the survey of foresters, there were many comments about regeneration checks to monitor effectiveness.

Q14. Are regen checks adequate/sufficient monitoring tools for evaluating dwarf mistletoe treatment effectiveness?

Q15. Who defines or creates the criteria for measuring effectiveness?

In the survey of foresters, we also asked about the use of dwarf mistletoe pre-treatments (prior to a logger/operator entering a site for harvest) and post-treatments (after a logger leaves a harvesting site).

In general, neither are widely used. *[Show survey results for pre-treatment & post-treatment use – slide 4]*

Q16. What influences your ability or decision to use (or not use) pre- or post- treatments?

Q17. How effective do you think the pre- and post- treatments you use have been? *[Chemical use, burning, shearing, etc.]*

We have one more question before we take a short break. The next part of our discussion will be about impacts of dwarf mistletoe. I will record responses to this first question on the flip chart. First, let's focus on forest impacts.

Q18. What impacts of dwarf mistletoe are you seeing in the forest? What impacts of dwarf mistletoe are you seeing with regards to logging businesses and/or their production? *[forest health, logging businesses, markets]*

4 Break (3:10 – 10 min)

It is now time to take a short break. To help keep the day on time we ask that everyone is back and ready to start in 10 mins at (say specific time). As a reminder restrooms are ____ and please help yourself to refreshments. However, before I let you go, we do have one task for you during the break. You each have 3 colored sticky dots. Please use three stickers to identify your top priorities listed on the flip charts. You can put all your stickers on one or you can distribute them across the lists. It's up to you. Dot colors don't matter.

[Break]

5 Idea listing and open discussion (3:20 – 20 min)

Welcome back. Thank you all for being on time. Let's take a quick moment to reflect on where everyone placed their dots...

Q19. Any thoughts you would like to share about the results?

We held focus groups with loggers at the MLEP conference earlier this year and asked them the same question. They also then prioritized the impacts they thought were most important. Here are their results. *[Show logger flip chart results – slide 5]*

Q20. What reflections do you have after seeing how loggers' identified and prioritized impacts of dwarf mistletoe?

Now we'd like you to think overall about sales you set up or deal with that contain dwarf mistletoe. First, foresters who took our survey earlier this year said that sales containing dwarf mistletoe take slightly longer to setup/design/administer. *[Show survey results – slide 6]*

Q21. Why do sales containing dwarf mistletoe take longer to setup?

Q22. Is there a level of dwarf mistletoe presence that impacts whether or not you put a stand up for sale?

Q23. Do you change the sale length for stands containing dwarf mistletoe? [Does it depend on the level of DM? What is that level?]

Q24. What do you do if a sale doesn't sell due to the level of dwarf mistletoe?

6 Open discussion (3:40 – 10 min)

Next we'd like to move into a discussion about management coordination. In our interviews and focus groups with loggers, one key theme that emerged was the desire for increased coordination around bordering stands. In the survey of foresters, we asked how often foresters coordinate the management of dwarf mistletoe infected stands with bordering stands – both under their own landownership and those under different land ownership. *[Show survey results for management coordination – slide 7]*

Q25. What are the obstacles preventing coordination of management with adjoining black spruce stands within your landownership? [Think about DNR forestry land vs wildlife land]

Q26. What are the obstacles preventing coordination of management with adjoining black spruce stands under different landownership?

Q27. What are the consequences of not coordinating?

7 Closing discussion (3:50 – 10 min)

We have just a few more minutes now before we wrap up. The last questions we asked on our survey to foresters asked for recommendations to improve dwarf mistletoe management. Here are some of the higher level answers. *[Show survey results of DM management recommendations – slide 8]*. We want to

gauge how some of these recommendations stack up. You each have 6 colored sticky dots – 3 green and 3 red. Please use 3 green stickers to identify your top recommendations. And 3 red stickers to identify your bottom three recommendations.

Q28. What are your reflections on these recommendations and where priorities might be?

Q29. Is there anything else we should know about your experiences with dwarf mistletoe in black spruce?

Thank you all so much for your participation today. Your input has been extremely valuable. We will be available after the session to answer any specific questions about the project or if you have anything else you would like to share with us.

Appendix J – Forester Focus Group Consent Form

FOCUS GROUP CONSENT FORM

Thank you for participating in this project! We are seeking foresters' insights and experiences with dwarf mistletoe in black spruce stands. You were selected as a possible participant because you are a forester working in or near one of the following counties: Itasca, St. Louis, or Koochiching. Study findings will be used to improve management, education, and communication associated with dwarf mistletoe management. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The focus group lasts approximately two hours. You will be asked questions about your experiences managing dwarf mistletoe, challenges you face, and perceived effectiveness of your management efforts. Your participation is voluntary and you may withdraw from the project at any time. Your decision will not affect your current or future relations with the University of Minnesota.

Risks associated with this study are minimal, responses are confidential and names will not be linked to any information in any publications. Study results will be made available to the public and all participants will have access to them.

If you agree to participate in this project, all reasonable efforts will be made to maintain confidentiality. Since the focus group session takes place in a group setting and others are privy to your responses, the research team cannot guarantee absolute confidentiality. However, your name will not be associated with the data collected. Only those directly involved with the project will have access to the focus group notes.

Contacts and Questions:

The researcher conducting this study is: Charlie Blinn. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at address: 115 Green Hall
1530 Cleveland Ave. North, St. Paul, MN 55108-6112, phone: 612-624-3788, email: cblinn@umn.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

"I agree_____ I disagree_____ to have my responses audio-recorded"

"I agree_____ I disagree_____ that I may be quoted anonymously in papers/publications"

"I agree_____ I disagree _____that my photo may be taken during the group discussion"

Signature:_____Date: _____

Signature of Investigator: _____Date: _____

Appendix K – Forester Focus Group Background Information Survey

5/27/2021

Qualtrics Survey Software



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Forester Focus Group Background Info

Work Experience

What is your job title?

What type of agency or industry do you work for?

☐ Federal

☐ State

☐ County

☐ Tribal

☐ Private Industry

☐ Other (please specify)

What county(ies) does your current job responsibilities cover? Check all that apply.

☐ Beltrami

☐ Cass

☐ Itasca

☐ Koochiching

☐ Lake

☐ Lake of the Woods

☐ St. Louis

☐ Other (please specify)

How many years have you been working...

0	5	10	15	20	25	30	35	40	45	50
0	5	10	15	20	25	30	35	40	45	50

...as a forester/in
the forestry field?

...for your current
employer?

...with black
spruce?

About You

What is your gender?

- ☐ Male
- ☐ Female

In what year were you born?

What is the highest level of formal education you have completed?

- | | |
|--|---|
| ☐ Did not finish high school | ☐ College bachelor's degree |
| ☐ Completed high school/GED | ☐ Some graduate work |
| ☐ Some college but no degree | ☐ Completed graduate degree (Masters or PhD) |
| ☐ Associate degree or vocational degree | |

How would you describe your race? Check all that apply.

5/27/2021

Qualtrics Survey Software

- | | |
|---|--|
| ☐ White | ☐ Chinese |
| ☐ Black or African American | ☐ Japanese |
| ☐ American Indian or Alaska Native | ☐ Korean |
| ☐ Asian Indian | ☐ Vietnamese |
| ☐ Native Hawaiian | ☐ Filipino |
| ☐ Pacific Islander | ☐ Other Race (Please specify) |
| | <input type="text"/> |

Powered by Qualtrics

Appendix L – Forester Focus Group Contact Script

Hello,

I am writing to invite you to participate in a focus group in [International Falls, Grand Rapids, Tower], MN to share your experiences and insights with dwarf mistletoe in black spruce stands. We hope to speak to foresters at different agencies and industries with varying experiences and opinions about these issues. We are only hosting 3 focus groups throughout northern Minnesota, so capturing your perspective is important!

- A We will be hosting the meeting on **Thursday, October 17th from 9:00am to 11:00am at the Koochiching County Courthouse (715 4th St.) in International Falls.** Light refreshments will be served.
- B We will be hosting the meeting on **Wednesday, October 16th from 8:30am to 10:30am at the UMN Research and Outreach Center (1861 E. Hwy 169) in Grand Rapids.** Light refreshments will be served.
- C We will be hosting the meeting on **Wednesday, October 16th from 2:00pm to 4:00pm at the DNR Office (650 Hwy 169) in Tower.** Light refreshments will be served.

Please **reply** to this e-mail if you are able to join us.

Additional information on the project and meeting is described at the end of this email.

If you are interested in learning more about the project but are unable to attend the meeting, or if you have specific questions, please contact me as well.

Sincerely,

Sarah Fellows and Charlie Blinn

**** Additional Project Information ****

The purpose of this study is to better understand loggers' and foresters' experiences with dwarf mistletoe in northern Minnesota forests. This will lead to an improved understanding of the opportunities and concerns associated with dwarf mistletoe treatments and management so recommendations can be provided for improving future management. Funding for this project was provided by the terrestrial invasive species center at the University of Minnesota.

If you are able to attend, further details and reminders will go out prior to the meeting.

Again, please reply to this email if you are able to attend the meeting on [October 16th/17th]. I look forward to the opportunity to meet you! Thank you for your time.

Appendix M – Qualitative Theme Table

Research Questions	Emergent Themes	Logger Interviews	Logger Focus Groups	Forester Focus Groups
Are loggers and foresters able to identify ESDM?	Loggers desire and need improved training	x	x	x
	Foresters have sufficient identification knowledge	x	x	x
Do loggers and foresters understand the need to eradicate ESDM where timber production is the objective?	Forest health concerns	x	x	x
	Timber industry concerns	x	x	x
	Dwarf mistletoe is not a concern	x	x	x
Are the eradication treatments implemented as designed?	Internal administration of treatments	x		x
	Outward communication of treatment	x	x	x
	Diverse treatment prescriptions	x	x	x
	Equipment decisions	x	x	x
	Incomplete implementation consequences	x	x	x
Are there impediments to implementing the treatments?	Cost burden on loggers	x	x	x
	Fluctuating spruce markets	x		x
	Bidding considerations with dwarf mistletoe	x	x	x
	Potential improvements to dwarf mistletoe sales	x	x	x
	Lack of coordination on adjacent stands			x
	Differing flexibilities among landowners	x	x	x
Are the treatments effective?	Effectiveness generally unknown	x	x	x
	Lack of "effective" definition			x
	Recent improvements in effectiveness			x
	Needs for improving effectiveness	x	x	x
	Post treatment and its effectiveness	x	x	x
	Pre treatment and its effectiveness	x		x