Promoting the Adoption of Snow Fences through Landowner Engagement

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16. Abstract (Limit: 250 words)

Snow and ice problems on Minnesota roadways represent a cost of close to $100 million annually to MnDOT in addition to the associated public safety and environmental costs. MnDOT and the University of Minnesota have collaborated to estimate the costs and benefits of snow control measures as well as the constraints that landowners face to adopt snow fences to control snow and ice problems. Benefits outweigh costs, often by a wide margin, but landowners are constrained by the lack of knowledge and the real and perceived inconvenience of installing, maintaining, and farming around a snow fence. Landowners think that the payments provided by MnDOT to install and maintain a snow fence are an important incentive but want more information about the issues involved with installing and maintaining a snow fence from a trusted source, a peer, or a testimonial. The project goal is to promote greater adoption of measures to address blowing and drifting snow problems through greater landowner and public engagement. To move toward that goal, we 1) carried out and prepared a minimum of 30 case studies of landowners who have implemented snow control measures; 2) entered the case studies into a computer and smartphone-based program that can be accessed by MnDOT and landowners; 3) revised and improved a MnDOT snow fence inventory to assist MnDOT in identifying and reporting on snow fences; and 4) developed curriculum and training materials for MnDOT personnel to prepare them for promoting snow control measures.

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Promoting the Adoption of Snow Fences through Landowner Engagement

FINAL REPORT

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EXECUTIVE SUMMARY

In previous research, MnDOT and the University of Minnesota (UMN) collaborated to estimate the costs and benefits of snow control measures and develop a tool to help estimate those costs and benefits for individual fences to more effectively implement snow fence placement (Wyatt, et.al., 2012). That project also included focus groups with landowners and others at different sites across the state. That research was followed up with a project that evaluated MnDOT training and procedures for implementing snow fences drawing on the perspectives of MnDOT employees using a Knowledge, Attitudes and Practices (KAP) framework (Current, et.al., 2017). The KAP framework was used again for a follow-up project that evaluated the constraints and opportunities that landowners perceive when adopting snow fences, drawing on focus groups and surveys of adopters and non-adopters of snow fences (Current, et.al., 2019). This project concentrated on tools and training that respond to what was learned in previous projects and that improve the efficiency and effectiveness of efforts to promote snow fences.

Landowner constraints that were identified included a lack of knowledge and the real and perceived inconvenience of installing, maintaining, and farming around a snow fence. It was found that landowners think that the payments provided by MnDOT to install and maintain a snow fence are an important incentive but want more information about issues with installing and maintaining a snow fence from a trusted source, a peer, or a testimonial (Current, et. al., 2019). The goal for this project, *Promoting Adoption of Snow Fences through Landowner Engagement*, was to promote greater adoption of measures to address blowing and drifting snow problems through greater landowner and public engagement. To move toward that goal, we 1) carried out and prepared a minimum of 30 case studies of landowners who have implemented snow control measures; 2) entered the case studies into a computer and smartphone-based program that can be accessed by MnDOT and landowners; 3) revised and improved a MnDOT snow fence inventory to assist MnDOT in identifying and reporting on snow fences; and 4) developed curriculum and training materials for MnDOT personnel to prepare them for promoting snow control measures.

Interviews for the case studies were conducted in the fall and winter of 2020 and included 30 unique cases from across Minnesota. Participants were those who responded to a letter inviting them to participate in this voluntary study. The case studies were written up following an interview with each participant. The interview protocol was included in appendix A. Responses to each question were recorded and summarized allowing the answers to be compared.

The results of these case studies were shared during three live webinars with MnDOT employees. The presentations were included in Appendix D. Notable responses from the case studies focused on how participants began using a snow fence, what their motivations were, any additional costs they incurred, and their suggestions for improvement. These results are discussed in-depth in Chapter 2 and summarized below.

For this set of early adopters, 21 reported their initial contact for the snow fence program was a MnDOT employee, while seven others reported a different source. This indicates the success that MnDOT staff have had, and the important role they play in recruiting participants for the snow control program. It

also illustrates a recurring theme. Generally, the farmers and community members we have met with or talked to are not aware of the program. This presents two options that MnDOT can use either individually or combined in outreach efforts. MnDOT could continue to promote snow fences through MnDOT personnel and/or look for ways to introduce the program to landowners and communities. A blended approach might be most effective.

In discussing motivations for using a snow fence, "public safety and transportation" was the strongest motivator for a majority of respondents, with "financial" being the primary motivation for a strong minority, conservation was the primary motivation for only a handful of respondents. For secondary motivations (a significant motivation, but not as strong as the primary) a plurality reported "financial," while public safety/transportation and conservation were close minorities. Conservation was not a strong motivation for most respondents.

For costs incurred by landowners in using a snow fence, the majority saw some increase, whether in labor costs, equipment needs, or reduced yields. With this, most respondents felt they were compensated fairly and that their costs were adequately covered.

Participants also discussed more general observations of the program and potential improvements. These are discussed in Chapter 2, but included suggestions on increasing compensation, providing more information about snow fence function to landowners, and providing more consistent interactions with MnDOT staff to landowners.

The interviews and information shared by early adopters was used to develop the training sessions and training curriculum, drawing on materials and lessons from past training. As the COVID pandemic continued into 2021, it became apparent that online educational sessions and not face-to-face district meetings would be necessary. While the online format placed some limitations on the materials, it also increased accessibility. We determined that one lunch and learn session (held on June 8, 2021), which targeted MnDOT staff, would be best before the grant ended at the end of June followed by a MnDOT snow fence training in September 2021 to kick off the fall season of contacting landowners regarding leaving standing corn rows and implementing other types of snow fences that MnDOT would contract. The agenda and participant responses to the online questions were included in Appendix D.

With the case studies complete, summaries of key aspects of each case were written up in two formats: one viewable online via the FarmMaps webtool (farmmaps.umn.edu) (Appendix C), and one as a fact sheet in a PDF format, also available as a download from FarmMaps that can be used by interested farmers and for outreach purposes by MnDOT or others. The FarmMaps app was developed by CINRAM, the SW Regional Sustainable Development Partnership, and the Sustainable Farming Association (SFA) of Minnesota to document sustainable farming practices and make farmer-generated information available to other farmers/landowners as well as for outreach efforts by extension agents, SWCD personnel, and MnDOT staff.

MnDOT personnel involved in promoting snow fences had requested a way to present past experiences to potential adoptees so they could better understand issues in implementing a snow fence and what they look like on the ground. These case studies discuss the experiences and observations of participants and reveal information about how early adopters of snow fences have dealt with the challenges of using

snow fences, their recommendations to potential adopters, and their suggestions for program improvements. It also allows someone considering a snow fence to contact and discuss constraints and implementation issues with someone who has gone through the process.

As we developed the protocol for the case studies, we relied heavily on our previous projects (Wyatt, et.al. 2012) (Current, et.al., 2017, 2019) to identify the constraints to adoption that had been expressed by landowners who had not adopted snow fences. Understanding what constrains adoption (i.e., maintenance) and what might encourage adoption (i.e., payments) from a landowner's perspective allowed us to bring out these issues in the case studies so other landowners could see how the constraints were addressed by adopters of snow fences. We used the same approach in our trainings for MnDOT personnel and for developing the curriculum for the trainings, which, again, drew on our past training efforts while incorporating the knowledge gained through our interviews, surveys, and case studies.

Two trainings were carried out during the project (Appendix D). Originally, we had planned to hold trainings at several locations around the state to provide access to MnDOT personnel in the districts. Due to COVID restrictions, we were not able to do that so opted for online training sessions. Although in-person training has its advantages, online training provided better access to a greater number of MnDOT employees and allowed us to record the trainings that can be used by others who were not able to attend the online trainings.

The first training was in a "Lunch and Learn" format on June 8, 2021. This was a brief interactive overview of our research given to MnDOT employees over the lunch hour. The training was an interactive session that allowed us to inform the attendees of the results of our research but also to gather information and ideas from the participants to improve the snow fence program. We received excellent input from the attendees, which can be used for future programming (See Appendix D).

Our second trainings were two sessions carried out on September 16 and 23, 2021, and drew approximately 100 participants between the two sessions. The content was the same for each session, and the second session was recorded and made available to MnDOT personnel. The trainings were used to kick-off promotional efforts for promoting standing corn rows and other options in preparation for the 2021 snow season and to guarantee that farmers would be able to start planning for the 2022-23 snow season.

In our previous joint effort (Current, et.al., 2019), we initiated work on a simple snow fence inventory tool/app. For this project, we worked closely with MnDOT personnel from the shared services program and the MNDOT Transportation Asset Management System (TAMS) to improve the app to make it more functional and user friendly for the needs of the MnDOT Blowing Snow Control Shared Services Program. The inventory/app will allow MnDOT to establish an inventory of MnDOT-sponsored snow fences, locate them on a map by truck station and district, and to query the database to generate information needed for maintenance and reporting on the snow fence program. As work on the project was starting, the decision was made by MnDOT to incorporate the inventory into the TAMS database and tool. For that reason, we included personnel responsible for the TAMS work in our meetings and discussions to facilitate the integration of the inventory tool into TAMS. This also addresses one of the

major concerns and tasks, which was to ensure maintenance of the database/tool beyond the end of the project. TAMS will now take on that responsibility.

We did make one change to the project tasks. We initially had programmed funding to cover a presentation at a conference. Again, due to COVID restrictions, we eliminated that task and replaced it with funding to support the consolidation of reports, materials, and resources on the Center for Integrated Natural Resources and Agricultural Management (CINRAM-UMN) site (cinram.umn.edu) where the information would be accessible to MnDOT personnel as well as to others who have expressed interest in implementing similar programs in other states. There is a wealth of valuable information that can be useful to MnDOT and others, and this will provide a repository for that information that's readily accessible to those who may be interested.

The benefits from this study are contingent on adoption of recommendations and outreach to landowners. Implementation of the findings and recommendations of the study and effective landowner outreach activities are of critical importance. We will provide recommendations based on the results of our training session and the new and previous research efforts to improve outreach and engagement with landowners in the promotion of snow control measures.

We do see opportunities to expand outreach to landowners through key partners in the farming communities as well as to local communities with concerns about blowing and drifting snow problems. We will also be developing a research proposal to explore the use of native willows for living snow fences, which can significantly reduce MnDOT costs of implementing snow control measures.

Due to past research and the active engagement of MnDOT colleagues, we have a good understanding of the structure of the MnDOT snow control program. This combined with the involvement of MnDOT personnel throughout the project has helped us identify where interventions are feasible to increase the effectiveness of the program. The actual implementation of the recommendations will depend on MnDOT's decision whether to adopt them.

We understand that there may be recommendations contained in this report that MnDOT may not be able to implement due to limitations related to existing resource or policy constraints. However, we encourage MnDOT to consider providing the resources and potentially the policy support needed to implement the recommendations.

1   INTRODUCTION

Landowner engagement is an essential tool in understanding the adoption and uptake of conservation practices such as snow fences. Building on previous research conducted by the University of Minnesota (UMN) in partnership with the Minnesota Department of Transportation (MnDOT), this project further explores the use of snow fences by landowners, and in doing so develops a series of educational and outreach tools for furthering the adoption of snow fences.

This project began in the fall of 2020 and included the following activities:

1. Carry out and prepare a minimum of 30 case studies of landowners who have implemented snow control measures
2. Enter the case studies into a computer and smartphone-based program that can be accessed by MnDOT and landowners
3. Update and improve a MnDOT snow fence database and reporting tool to facilitate MnDOT's documenting and monitoring of snow fences in Minnesota
4. Develop curriculum and training materials for MnDOT personnel based on previous MnDOT/UMN research projects and carry out training for selected personnel from all MnDOT districts.

The case studies were gathered between the fall of 2020 and spring of 2021. A large cohort of landowners was interviewed using a standardized protocol. Interviewees were a geographically diverse cohort and included individuals using structural, standing corn rows, and living snow fences. Questions for these interviews focused on each landowner's experience with using the snow fence, their observations on its effectiveness, their thoughts on the program at large, and their motivations for engaging in the process. The case study methodology for this project provided deeper insights to each individual and set the groundwork for further research or deeper explorations of specific issues identified in the cases.

The results of these interviews provided interesting insights into how early adopters have been able to use snow fences as part of the MNDOT program. Notable results from this cohort of interviews showed that many participants were motivated by a sense of civic duty, or a desire to see improved travel and safety on their roadways, while financial and conservation motivations played a smaller role. It was also notable that most snow fence adopters reported minimal costs associated with the snow fence and that the compensation provided was generally adequate.

The results of these interviews were compiled into case studies, and the information was made available via the FarmMaps web application. Each online case was geotagged to a road and satellite map and contained information provided in the interviews. Drone imagery of most snow fences was also made available by MnDOT, both still imagery and video. In addition to being viewable on FarmMaps, the cases

were provided in a downloadable and printable PDF format in the web application. The user can also find directions to each snow fence practice using FarmMaps.

In addition to the early adopter case studies, this project developed a database tool for MnDOT to document and monitor current snow fence practices. SFMaps is a web-based tool that contains a large inventory of existing snow fence practices. SFMaps was developed in our previous MnDOT project (Current, et. al., 2019) and further developed in this project in close consultation with the MnDOT snow fence team. The plan is to incorporate the app into the MnDOT TAMS data base.

Following the completion of the case studies and the FarmMaps tool, trainings were developed to share the results with MnDOT staff. Due to the ongoing pandemic, trainings were held remotely via the Zoom application. A lunch and learn session was held June 8, 2021, that presented our results to a broad set of MnDOT employees. In September, two training sessions were held targeted at district maintenance staff. The presentations for this training were designed as a standing corn row kickoff event but provided a broad set of information designed to help employees in their outreach and promotion of snow fences.

This project successfully provided information from 30 independent interviews of early adopters of snow fences. The information from these interviews was used to develop case studies, which are hosted on the FarmMaps web tool, facilitate several trainings, and develop curriculum to promote the adoption of snow fences. For management and inventory purposes, a separate online tool was developed to assist in this effort.

2 INITIAL MEMORANDUM ON EXPECTED RESEARCH BENEFITS AND POTENTIAL IMPLEMENTATION STEPS

2.1 EXECUTIVE SUMMARY

This memorandum outlines the methodology and results of an initial assessment of the potential benefits of promoting the adoption of snow fences through landowner engagement with respect to snow control measures. Previous research indicates that Minnesota taxpayers will profit from the implementation of snow control measures in snow problem areas in the following ways: reduced cost of snow drift removal and blow ice treatment, decreased travel costs related to blowing and drifting snow, moderated costs and damages attributed to snow-related car accidents, increased greenhouse gas (GHG) emission avoidance, and improved efficiency of landowner engagement and outreach by MnDOT. Preliminary analyses suggest that expanded landowner adoption of snow control measures would likely boost and distribute the abovementioned benefits across the state of Minnesota.

2.2 BENEFIT ASSESSMENT METHODOLOGY

In 2012, as a part of MnDOT TRIG Project #99008, University of Minnesota researchers developed a Snow Control Cost-Benefit Web Tool to estimate the return on investment of implementing blowing and drifting snow control measures on private lands (Wyatt et al., 2012). The tool also approximates snow removal, travel, and safety costs, as well as carbon-related benefits linked to snow control measure establishment. In the final benefit assessment (Task #7b), the tool was employed, where applicable, to quantify benefits in each of the selected regions and corridors. The tool is utilized when adequate MnDOT district input information is provided.

2.3 BENEFITS

2.3.1 Reduction in costs to remove snow drifts and treat blow ice

Snow control measures offer quantifiable cost savings by decreasing expenses associated with snow removal equipment and sand and salt application. The equations developed by Wyatt et al. use input data including the number of snow and ice events, the average number of operational hours and costs for each type of equipment during snow and ice events, cost of sand and salt application mixture, application rate, and number of lane miles travelled during snow and ice events (Wyatt et al., 2012). The tool is used when evaluating whether or not to implement a snow fence and results of the analysis can be aggregated over time to establish an estimate of cost savings.

2.3.2 Reduction in travel costs due to increased travel time related to blowing and drifting snow

Increased travel time is a common result of poor winter driving conditions. As previous research confirms, these delays incur economic costs. The Snow Control Cost-Benefit Web Tool calculates the costs of increased wintertime travel using variables including the average number of blowing and drifting snow events in each area, the amount of time required for MnDOT to clear the roadway, and

the speed reduction associated with each blowing and drifting snow event (Wyatt et al., 2012). The tool is used when evaluating whether or not to implement a snow fence and results of the analysis can be aggregated over time to establish an estimate of cost savings.

2.3.3 Reduction in costs and damages due to accidents attributable to blowing and drifting snow

Winter weather events create hazardous road conditions that lead to increased numbers of car accidents and associated damage. Using winter crash data from 1984-2009, MnDOT's Office of Traffic, Safety, and Technology estimated that snow control measures reduce snow and ice related accidents by 40% on super elevated curves and by 8% on non-super elevated curves (MnDOT, 2011). The Snow Control Cost-Benefit Web Tool calculates the number of avoided snow and ice related accidents, which, when multiplied by the U.S. Department of Transportation's accident values, will produce approximations of cost reductions. The tool is used when evaluating whether or not to implement a snow fence and results of the analysis can be aggregated over time to establish an estimate of cost savings.

2.3.4 Environmental benefits due to reduced use of chemicals to treat snow and ice and GHG emission avoidance

Snow control measures decrease the amount of snow and ice build-up, thus reducing the amount of salt, sand, and additional chemicals required to clear roadways. This reduction in or elimination of chlorides, abrasives, and other de-icers preserves ecosystem health that may have otherwise been compromised due to contamination from runoff (Fay and Shi, 2012). Quantification of this environmental benefit is possible but is not a focus of the present study. Unrelated to chemical runoff, snow control measures also deliver GHG-related advantages. GHG emission is avoided with the use of snow control measures, both living and structural, by reducing operational times of GHG-emitting equipment used for snow removal and ice treatment activities. Furthermore, because snow fences take land out of production, there are marginal reductions in nitrous oxide emissions, as less nitrogen-based fertilizers are applied. On average, a 100ft snow fence is estimated to reduce CO_2 emissions by 10.4lbs/ft (Wyatt et al., 2012). The tool is used when evaluating whether or not to implement a snow fence and results of the analysis can be aggregated over time to establish an estimate of cost savings.

2.3.5 Improve MnDOT's efficiency at landowner engagement and outreach

The present study uses a case study approach to document the experiences of landowners who have implemented different types of snow fences and make their experiences available to other landowners considering implementing snow fences and provide opportunities for conversations between adopters and non-adopters. Research has shown that peer-to-peer networking can often be an effective way to promote change. The findings from this analysis should assist MnDOT employees in determining the most effective ways to introduce and promote novel concepts and worthwhile technologies to landowners taking advantage of opportunities for peer-to-peer exchange and learning. The case studies were designed to address concerns of non-adopters that were explored in our previous research project (Current, et.al., 2019)

2.4   IMPLEMENTATION

Implementation of the present study's benefits is largely contingent upon MnDOT utilizing the tools and materials developed and making any suggested changes to promotional activities and changes in landowner interest in and adoption of snow control measures. Thus, the tools and recommendations are of critical importance. We will provide recommendations based on the results of the landowner case studies, outreach efforts and MnDOT personal input to assist MnDOT in their outreach efforts to farmers to implement snow control measures. Due to past research and the active engagement of MnDOT colleagues, we have a good understanding of the structure of the MnDOT snow control program. This combined with involvement of MnDOT personnel in the project will help us identify where interventions are feasible to increase the effectiveness of the program. The actual implementation of the recommendations will depend on MnDOT's decision to adopt the recommendations or not.

2.5   REFERENCES

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3   CASE STUDIES

3.1   SUMMARY

Thirty case studies were conducted of landowners who have implemented snow control measures. These measures included temporary standing corn rows, living snow fences, and structural fences. The landowners interviewed represented a geographically diverse sample of those participating in the snow control program.

The case study involved an interview with each landowner that explored their experiences with the program, their observations on the function of the snow control practice they use, information on additional costs incurred as a result of implementing the practice.

3.2   METHODOLOGY

In this project, a case study methodology was chosen. This methodology was appropriate because it allowed a deeper examination of a small number of cases. The limited population of landowners participating in MNDOT's snow fence program precludes a more representative sampling methodology. The case studies that were conducted provided more details than would be obtained in a survey, and provide both a sample of larger trends, and a guide for future inquiry. The case study approach also provided richer detail on each experience that was incorporated into the Farmmaps tool.

Potential interview participants were identified from a list of landowners with snow fences enrolled in the MNDOT snow control program. Individuals were identified based on prior interactions with MNDOT staff, their MNDOT service district, and their snow fence type. An effort was made to create a geographically diverse study group, and to capture a broad set of snow fence practices.

Outreach to these participants followed a modified Dillman method[1]. Needing 30 participants, we assumed a higher-than-average response rate from our sample of early adopters. Introduction letters (see appendix) were sent to 45 landowners, and approximately 20 responses were received indicating interest in participating in the case studies. Additional participants were recruited with follow up calls to those that received introductory letters. Two of the cases included were University of Minnesota Outreach and Education centers.

Once participants were identified, an interview time was identified. Due to the Covid-19 pandemic, interviews were conducted remotely, either via the Zoom online video calling application, or via telephone. Answers to the interview protocol were recorded in notes by the interviewer, and audio was digitally recorded.

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[1] Dillman, Don A. 1978. Mail and Telephone Surveys: The Total Design Method, 1978. John Wiley: New York.

There were several focuses of the interview protocol. These questions sought to explore the motivations of early adopters, how they began using a snow fence, as well as their experiences with the snow fence program, and additional costs they had incurred.
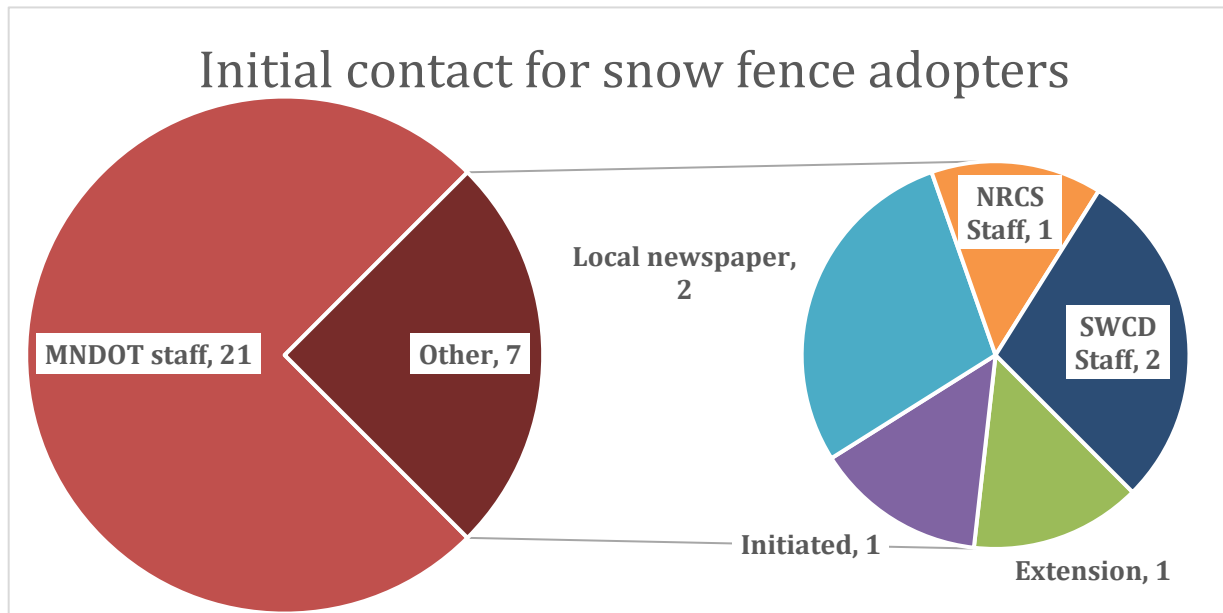

Figure 1 - Source of initial contact for early adopters

For early adopters of a conservation practice, it is important to explore how that practice came to be adopted. For this set of landowners, their participation in the program was driven by agency staff, responses can be seen in figure 1. The overwhelming majority of participants noted that MNDOT staff were responsible for their use of a snow fence. Of the remaining responses to this question, four were non-MNDOT agency staff, two reported reading about the program in the local newspaper, and one individual installed their snow fence independently.

Another key element of the interview was the motivation of early adopters. Knowing these motivations allows the program to be adjusted to encourage adoption and can be used to create further research questions. The responses to the questions on motivation are listed in figure 2. Primary motivations were those identified as the strongest motivation, while secondary motivations were factors that impacted adoption, but were not as strong as the primary. Motivators were identified as "not a strong motivator" if they were not identified as a significant reason behind adoption. The most common primary motivator was public safety / transportation. Responses that fell in this category were those that specifically identified improved traffic conditions, reduced crashes, a sense of civic duty, or a related response. Financial was the second most common primary motivator, and the most common secondary motivator. Responses in this category were those that identified financial compensation as a motivating factor. The least common primary and secondary motivator was conservation. Responses in this category were

Motivations of snow fence adopters
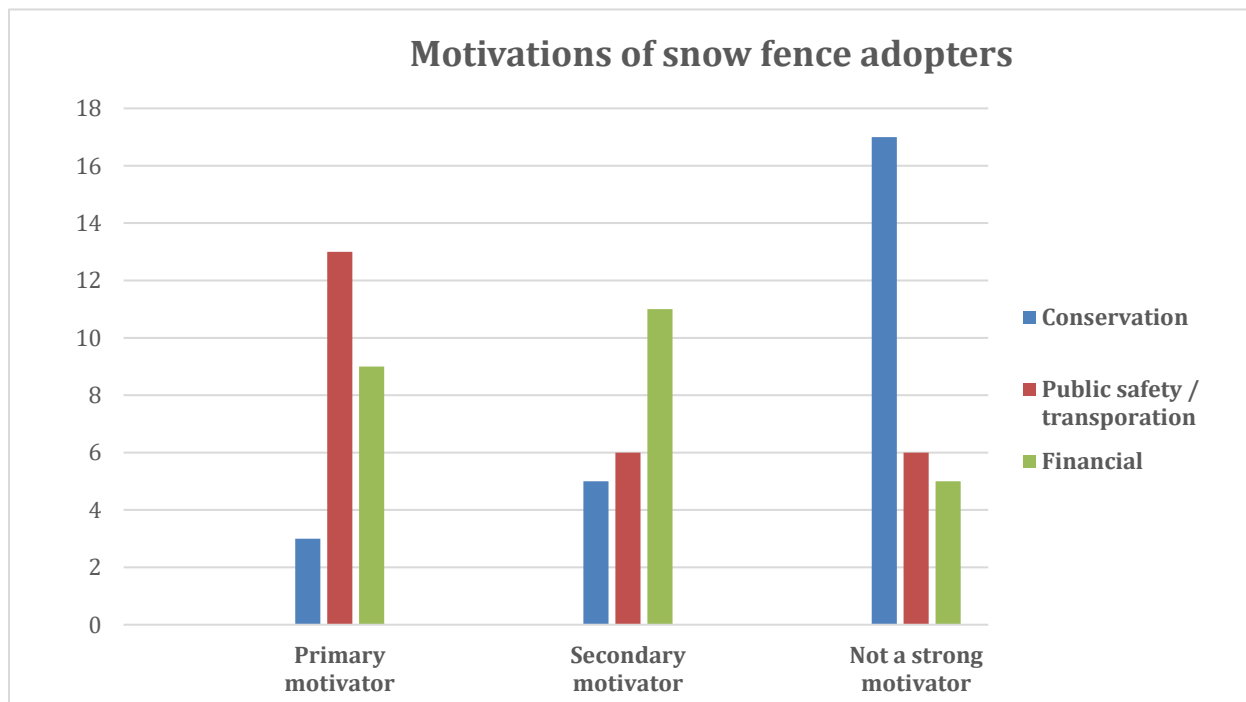
Figure 2 - Different motivations of early adopters

those that specifically identified an element of conservation such as wildlife habitat, pollinators, aesthetics, or a related response. Of the three response categories, conservation was the least likely to be a strong motivating factor.

One of the main objectives of the case studies was to capture any additional costs incurred by early adopters. Questions in the interview protocol prompted interviewees to assess the impact of their snow fence on various elements of their farming operation. Costs that were identified by participants included a drop in crop yield, an increase in labor, and an increase in equipment use.

The responses to the impact on yield can be seen in figure 3 where a majority of landowners did not observe an impact. Approximately a third of participants noticed a drop in yield. This question was specifically referring to the area outside of the acreage they were receiving compensation for.
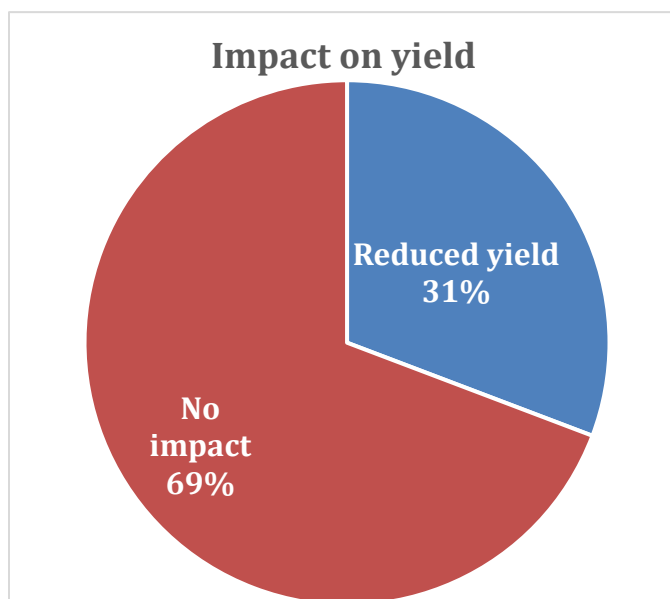
Figure 3 - Observed impact on yield of snow fences

Impact on equipment

Impact on labor

Figure 5 - Observed impact on equipment

Figure 4 - Observed impact on labor

For example, a drop in yield in the rows adjacent to a standing corn row fence, rather than a drop in yield in the fence area itself.

The impact on labor can be seen in figure 4. Approximately a third of respondents identified no impact on their labor, a third reported a slight increase in labor (1-5 hours per year), while a third reported a significant increase (5+ hours per year) with a maximum identified as 15-20 hours per year. Increased labor came in different forms depend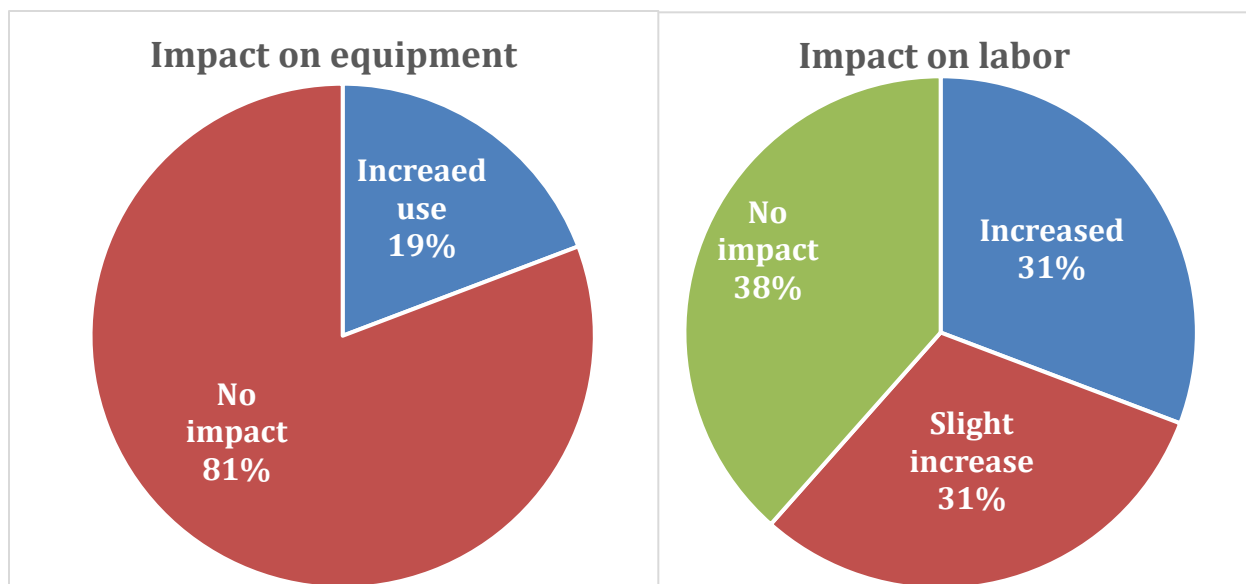ing on the fence type. For living snow fence owners, this was often in the form of mowing, pest management, or plant replacement. For those with standing corn rows increased labor was often in the form of spring combine operations or the time required to adjust farming operations around strips of corn left standing. For all snow fence types, it was common for additional labor to come from farming around the fence.

For impact on equipment (figure 5), the majority of cases reported no impact. Those that identified an increase in use, it was attributable to spring harvesting of standing corn rows, or to additional work that needed to be done in farming around the snow fence.

Additional impacts that were reported, but that are more difficult to attribute a cost to are soil moisture and an impact on the start of season. As can be seen in figure 6, nearly half of the interviewees reported an increase in soil moisture, typically in the snow drop area. A similar number of responses indicated no increase, while several indicated a reduction in soil moisture. This increase in soil moisture is related to impacts on start of season – how soon a farmer is able to begin field operations in the spring. While nearly half of cases showed an increase in soil moisture, only 85% indicated there was no delay to their start of season (figure 7). For these responses, a slight delay indicates that the farmer was
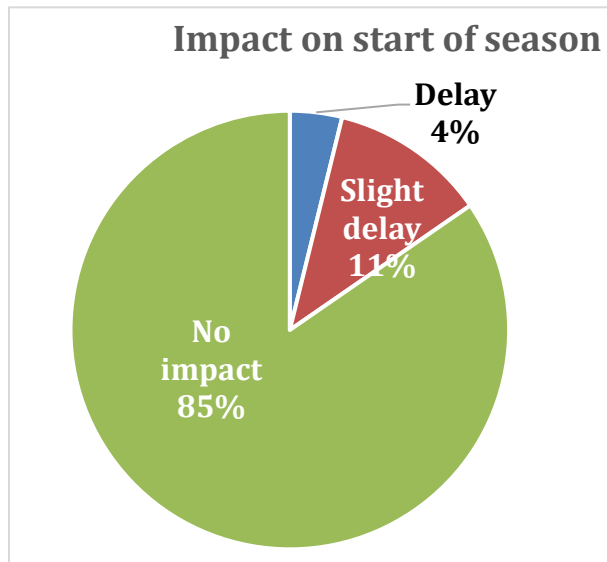
Figure 6 - Observed impact on start of season
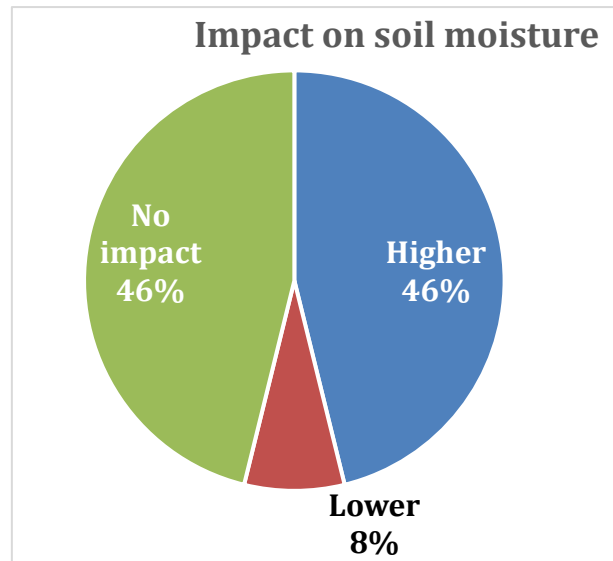
Figure 7 - Observed impact on soil moisture

unable to begin field operations on that field at their typical time, but that their overall farming operations were unaffected. A significant delay indicates that their overall farming operations were delayed by this particular field.

The issue of compensation was explored in the interviews. Questions were asked to explore if the landowner had been compensated, and if they felt that compensation had been fair and adequate. The
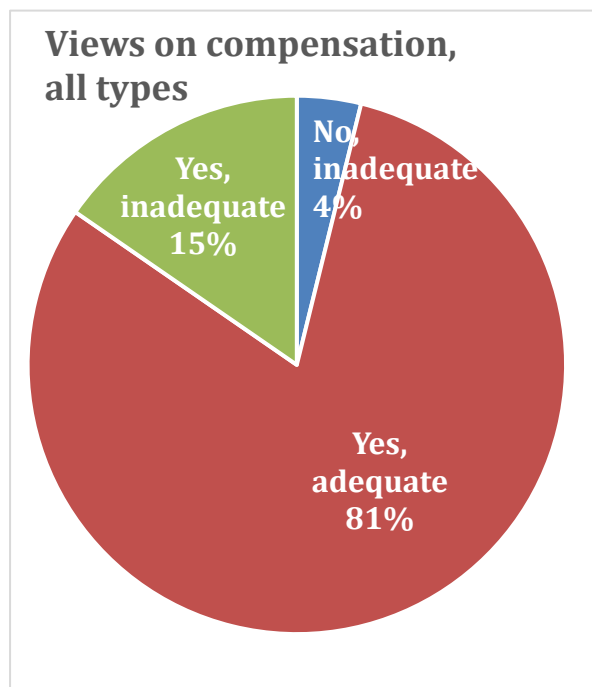
Figure 8 - Thoughts on compensation from early adopters

majority of participants had been compensated, and felt it was adequate, with 15% of participants feeling the compensation was inadequate. These results can be seen in figure 8. The compensation received by interviewees ranged from annual payments in contract ranging from 1-15 years, to individuals who had received a lump sum payment for a permanent easement. Most respondents stated that they wished the compensation was higher but agreed that it was adequate as an alternate land use. The 15% that responded the compensation was inadequate believed that that their payments did not cover their costs sufficient to be an alternate land use. Only one individual reported that they had not been compensated (excluding one of the UMN Outreach Centers, which was an experimental fence). This individual had purchased a property that contained a snow fence, and felt the compensation was inadequate simply
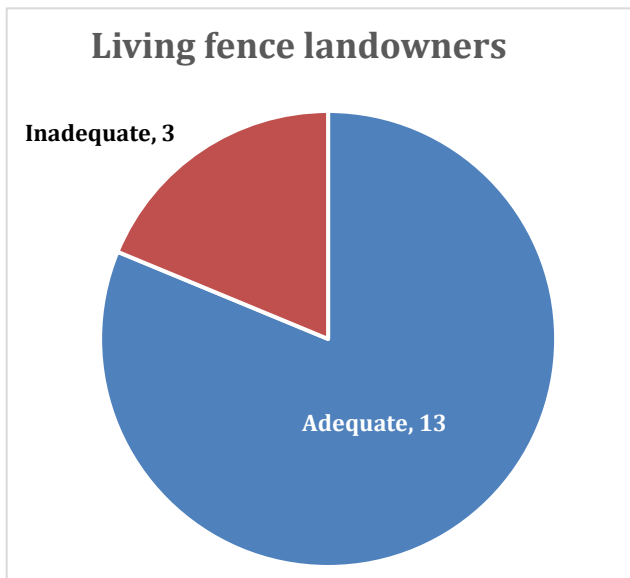
Figure 10 - Thoughts on compensation for living snow fences
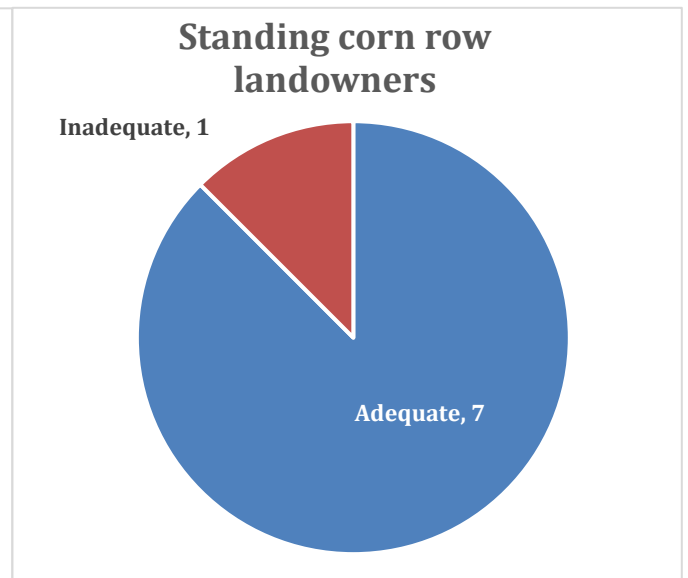
Figure 9 - Thoughts on compensation for standing corn fences

because they had not reported that they had received the property at a fair price, and so the payment could be viewed as a reduction in the price of the property.

When examined by snow fence practice, the overall trend remains the same for living snow fences and temporary standing corn rows, as seen in figures nine and ten. This trend was not examined for structure snow fences as there were only a few structure snow fence landowners.

A final series of questions prompted interviewees to identify issues they had with their snow fences, or with the program in general, or to identify any improvements they would like to see. The suggestions that were brought up by interviewees can be seen in figures 11 – fixes to perceived issues, and 12 – suggested improvements.

Easements shouldn't be taxed as productive farmland

Opportunity to sell or rent the snow cache area to MNDOT

More certainty for annual contracts

Program Fixes

Annual payments vs lump sum

More consistent MNDOT staff

Increased compensation

Compensation tied to commodity prices

Figure 11 - Suggested fixes to perceived issues

The program fixes included several suggestions for issues that are elaborated on below:

1. Opportunity to sell or rent the snow cache area to MNDOT – Several landowners who used living snow fence suggested that they would appreciate the opportunity to include the area the snow drops into as part of their rental or easement agreement. There were several reasons given for those, but it can be generalized as an inconvenience in farming this area. This was the result in some cases of higher moisture content, or the impracticality of farming around this area.
2. Easements should not be taxed as productive farmland – Depending on the county, the area that living snow fences occupy continues to be taxed as productive farmland. This is particularly frustrating for individuals who sold the area as a permanent easement and find themselves still paying the same rate of taxes.
3. More consistent MNDOT staff – One recurring comment was that some landowners found themselves working with different MNDOT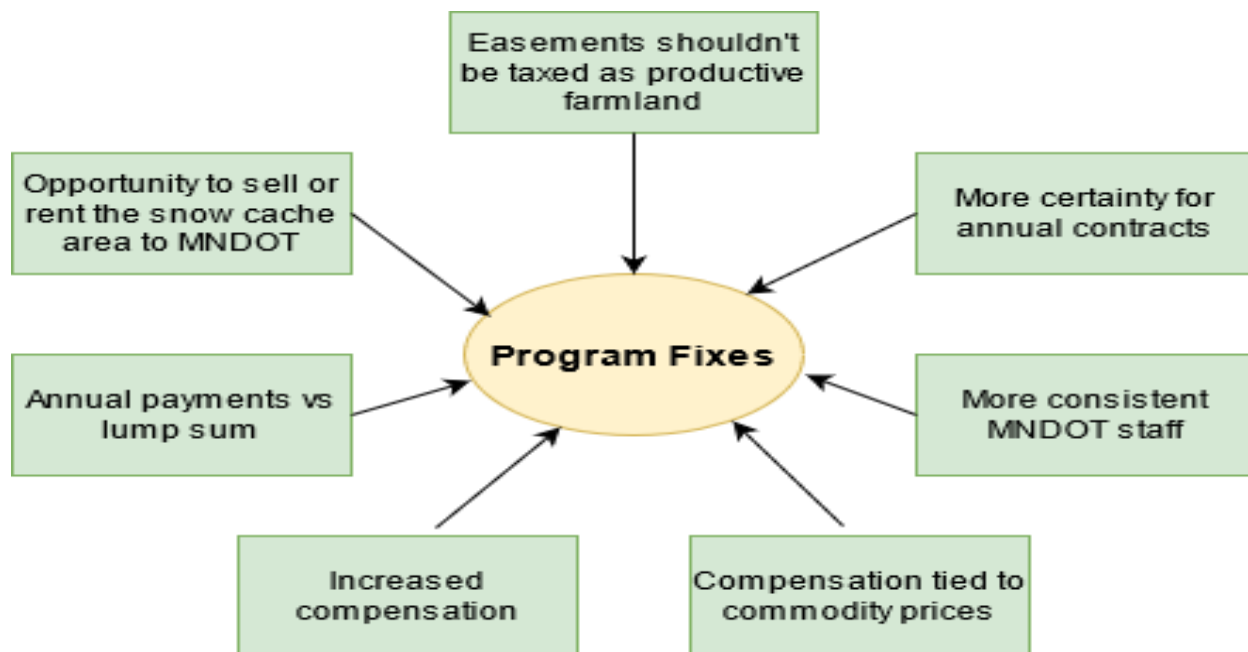 staff each season. This lack of continuity occasionally presents frustrations and prevents a stronger professional relationship from developing.
4. More certainty for annual contracts – Several individuals using standing corn rows expressed their interest in agreeing on their contracts, and delineating snow fence boundaries earlier in the fall.

The program enhancements included suggestions from landowners on ways to improve the program, but not necessarily resolving problems they had encountered. Some of these are elaborated on below:

1.) More information about the species being used, why they were chosen, what the options are – In some cases the landowner expressed interest in knowing more about the trees and shrubs used in their living snow fence. Especially for those interested in the wildlife or aesthetic value of living snow fences, more information would be interesting and useful.

2.) Information about how effective the fence is – Many landowners commented that they would like to know information about the effectiveness of the fence beyond what they could observe. Information on cost savings, snow captured, or reduced salt applied would all be of interest to a number of participants.
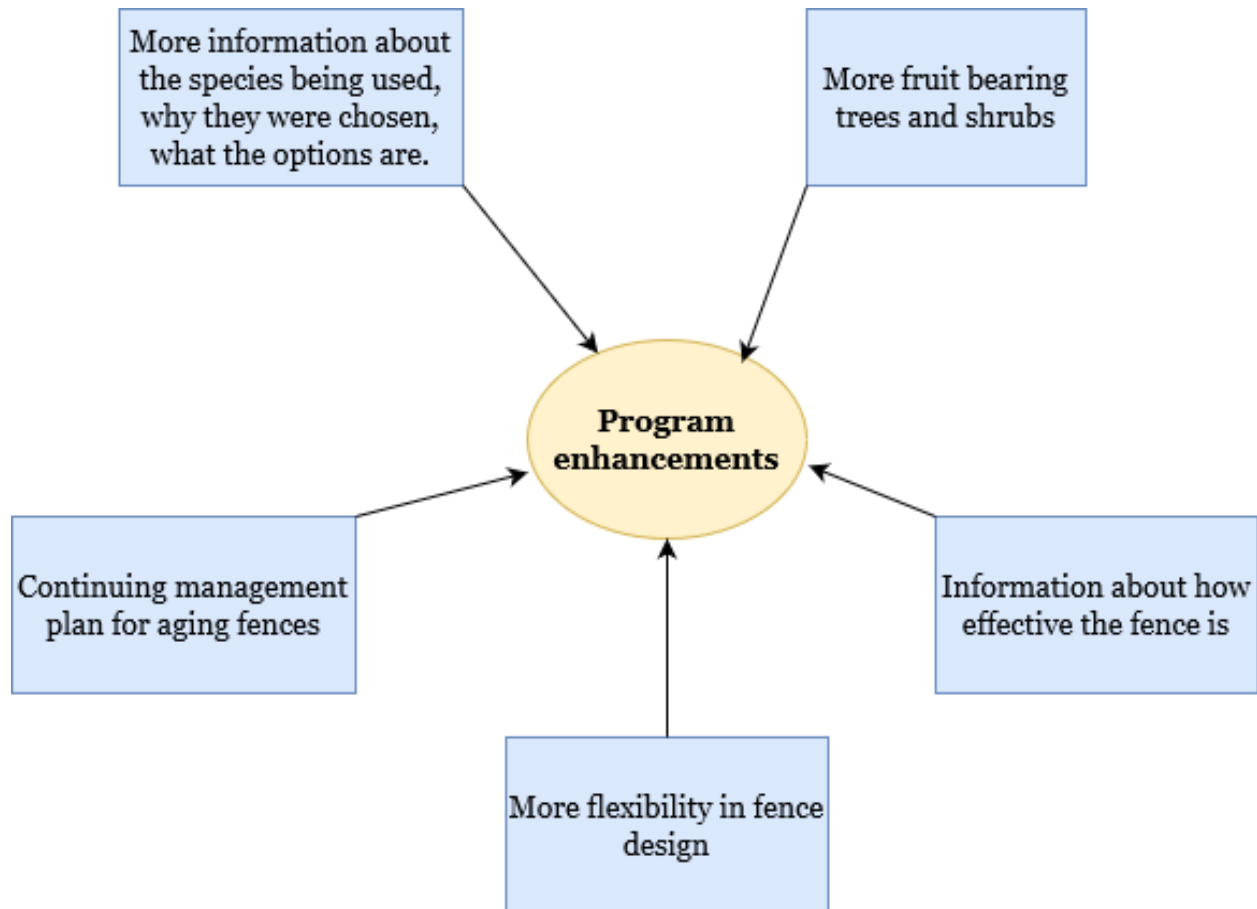
Figure 12 - Suggested program enhancements

Following the completion of these interviews, information was uploaded to the FarmMaps web application where it is accessible to the general public, although it is targeted towards farmers, landowners, conservation professionals, and agency staff. The website, along with the case studies, can be found at the following link: farmmaps.umn.edu.

3.4   DISCUSSION

There are several strengths of the case study methodology that are highlighted in this project. While fewer participants are involved, the more in-depth interview process allowed for a deeper exploration of some of the experiences of snow fence early adopters. This study involved a relatively small sample size (n=30)

and was not randomly selected. The participants in this group are a unique population as they represent a self-selected sample of early adopters. As such, these results are not statistically significant, but provide important insights on this group of participants, and can serve as a guide for future research. Notable results were obtained on the topics of motivations, additional costs, and impacts on farming operations.

When it comes to motivations, based on the results of the case studies, it can be said that the primary motivator for this group was an appeal to public safety or civic duty. The idea of doing the right thing served as a greater motivator than monetary compensation, although the compensation remained important. It is likely that this appeal was especially strong with the group of early adopters, and future program participants may be less motivated by public safety.

It is important to note the relatively minor role that conservation played as a motivating factor. For the participants that did describe conservation as a factor, they had installed living snow fences. There continues to be interest in improving pollinator and wildlife habitat, as well as the aesthetic value that trees and shrubs can add, but it is less important than public safety and financial compensation in most cases. There were notable exceptions who stated that they would participate in the program without any compensation, however these are in the minority, and are likely to be even less common outside of this sample of early adopters.

When exploring costs, the majority of participants encountered minimal or no increase in their operating expenses. This is important to note when considering rates of compensation. Issues such as increased labor expenses, decreased yield, and excessive soil moisture were encountered, but not to an extent that presented issues to most interviewees. Tying this in with the responses about compensation indicate that most landowners are satisfied that the compensation they are provided covers their additional expenses as well as the alternative land use. Farming is a profession that requires adaptability, and the participants in this study showed that in most cases they were easily able to adapt to any added difficulties that the snow fence created, in a way that did not incur significant costs. Some of these costs, such as labor and increased soil moisture, could be further reduced with modifications to fence designs.

In the discussion about program issues or enhancements, it was clear from the responses that the experience has been positive for the majority of interviewees. The most common response was that nothing needed to be changed, and the everything worked great. Due to the purpose of this study, everything working great was not an adequate response, so interviewees were heavily prompted to identify any issues or enhancements. These responses are laid out in the appendix, and in general highlight some of the issues identified by participants. Many of these responses highlight the importance of financial compensation to the participants. Compensation that is adequate and consistent is a theme in several responses. Other responses highlight the importance of creating a sense of participation in the landowners. Information on the effectiveness of the fence, or on the species selected in a living snow fence, and consistency in MNDOT staffing, all of these indicate participants' desire to be involved in the process as a partner. It is likely that this is a stronger factor for early adopters and less so for the general population but creating a greater sense of involvement and participation is unlikely to inhibit adoption of snow fences.

4 FARMMAPS WEB-BASED APPLICATION AND NETWORKING TOOL

4.1 INTRODUCTION

The focus of activity three as outlined in the work plan was the adaptation of the existing FarmMaps database to be used for snow fences under the Minnesota Department of Transportation's (MNDOT) blowing and drifting snow control program. The existing platform was designed for soil health case studies and consisted of a public facing user interface where farms using conservation farming techniques can be found, and information about those practices was visible. This application was modified to

Figure 13 - FarmMaps home screen

include the snow fence case studies created under this project and is now accessible to the public.

FarmMaps was designed to allow farmer to farmer networking and facilitate the sharing of conservation practices amongst farmers and landowners in Minnesota. The application is accessible to the public, and education staff from the University, agencies, and other partners can add cases that feature conservation practices used by farmers and landowners. Having a large diversity of cases and unique practices allows for the diffusion of new ideas and techniques more rapidly. This application, originally designed to feature soil health case studies, has subsequently grown to include silvopasture practices, and through this project now includes snow fences.

FarmMaps Web Application: https://farmmaps.umn.edu/

FarmMaps Administrator Interface: https://farmmaps.umn.edu/admin/ (password protected)

4.2 ACTIVITIES

4.2.1 Revise our existing Farmmaps case study database and tool to incorporate the data identified in Task 1.a

The existing Fammaps case study template that was used for soil health case studies was used as a starting point for development of an interview protocol that also addressed the constraints that were expressed by farmers who participated in the former "Expanding landowner adoption of snow control measures to improve public safety and achieve cost savings through a better understanding of landowner knowledge, attitudes, and practices" research project. The protocol was then used to interview the 30 landowners who had been selected for the case studies in Task 2. The interview protocol was then used to add case descriptions in the FarmMaps tool and also the two page case study write up which is included as a pdf document in FarmMaps.

4.2.2 Enter the data from interviews and other sources into the FarmMaps database snow fence section

30 landowners were interviewed for our snow fence case studies. Following the interviews, the interview data was entered into the FarmMaps database and tool using the user interface developed for the project.

4.2.3 Create a user interface for data entry and access by landowners and MnDOT personnel to the case study information

Another objective of this project was to develop a user interface so that the MnDOT Blowing Snow Control shared services team and potentially other MnDOT employees will be able to continue add case studies to the database as needed. A user interface was created and tested by the project research assistant and PI and adjustments were incorporated as needed. We expect that MnDOT will be doing the data entry in the future.

4.2.4 Test database and FarmMaps tool, finalize the database and tool, and publish the tool online

The database and tool have been tested and the database is now online and accessible by the general public.

4.3 APPLICATION

The FarmMaps application consists of two different user interfaces (UIs). The public facing UI is pictured in figure 14. This UI allows the user to navigate by location or to search by practice. This home screen includes case studies on soil health, silvopasture, and now snow fences. This map can be sorted by either of the three practice categories.

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Selecting one of the icons brings up a detail page listing information about each practice. An example of this can be seen in figure two where information about one participant, as well as a picture and a downloadable PDF are available. Detailed information about the fence is provided based on the interviews conducted with each landowner. Other information is provided such as challenges the landowner faced, any impacts they have observed related to the snow fence, and any advice they have for anyone exploring a similar practice.

This user interface requests a location from anyone accessing it but can be used without location information. As the user navigates the map, the list of farms and practices on the right updates accordingly.
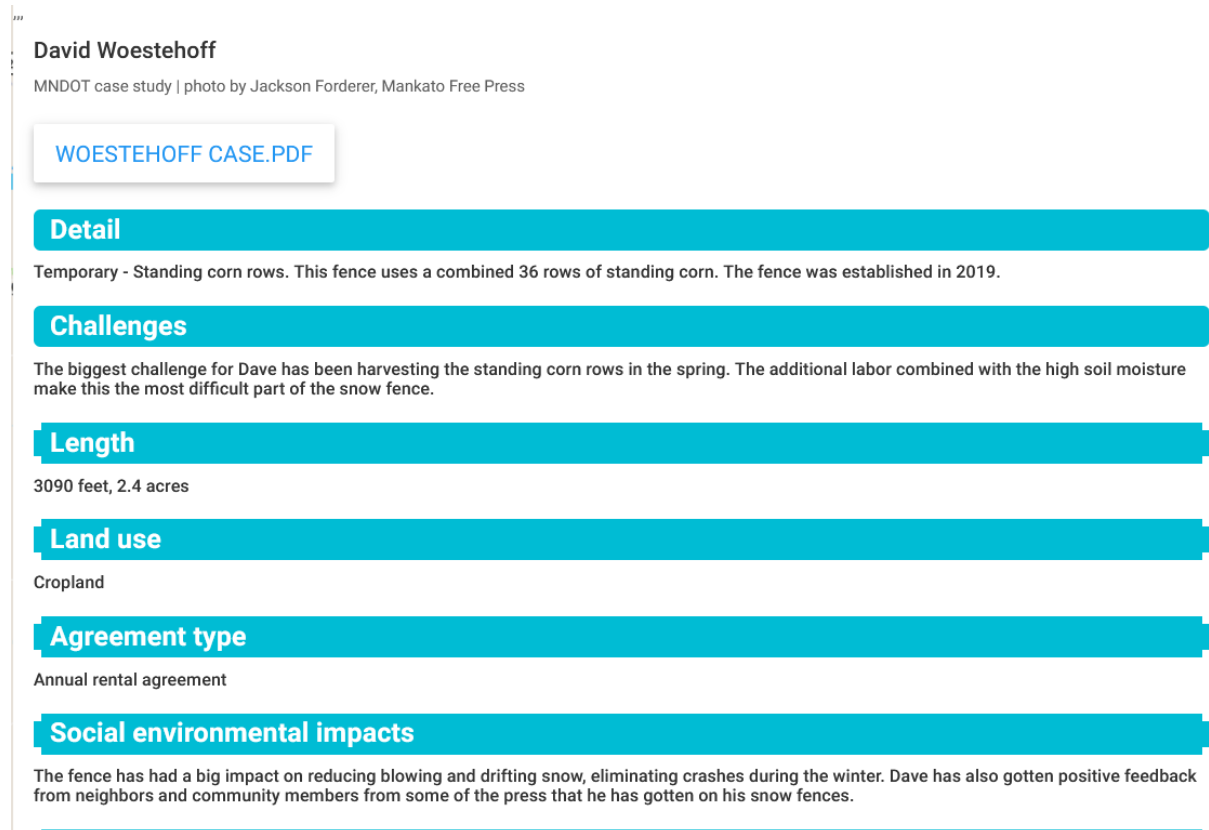
David Woestehoff

MNDOT case study | photo by Jackson Forderer, Mankato Free Press

WOESTEHOFF CASE.PDF

Detail

Temporary - Standing corn rows. This fence uses a combined 36 rows of standing corn. The fence was established in 2019.

Challenges

The biggest challenge for Dave has been harvesting the standing corn rows in the spring. The additional labor combined with the high soil moisture make this the most difficult part of the snow fence.

Length

3090 feet, 2.4 acres

Land use

Cropland

Agreement type

Annual rental agreement

Social environmental impacts

The fence has had a big impact on reducing blowing and drifting snow, eliminating crashes during the winter. Dave has also gotten positive feedback from neighbors and community members from some of the press that he has gotten on his snow fences.

Figure 14 - FarmMaps details page

Along with the UI for the public, a separate interface was developed for administering the application and adding cases. This administrator UI is accessible at a different URL and is password protected. Logins can be provided to university or agency staff that need to add or edit cases on the publicly accessible FarmMaps website. The information on the administrator UI is also downloadable so responses can easily be accessed for continuing research.

The administrator UI consists of three separate tabs allowing for the creation of a farm/landowner profile, the details of that profile, and file uploads for that profile. This allows details to be added to each text field for the profile, and items such as pictures, videos, and PDFs to be made accessible to the public. This administrative interface can be viewed in figure 15.

The information in the FarmMaps application can be easily presented through the web interface or can be downloaded in a variety of formats. Searching by keyword in the administrative interface will create

tables that can be downloaded. In addition to the 30 snow fence cases that have been uploaded, there are a wide variety of soil health farming practices, and five silvopasture case studies that are viewable.

The information that is included in each detail section varies depending on the type of practice, soil health, silvopasture, or snow fence. The fields used to describe snow fences are described below:

- Detail – A description of each fence is provided outlining its type, composition, and the year it was established.
- Length – The fence size is given in both linear feet, and in total acres.
- Challenges – The challenges each landowner faced in their adoption of the snow fence. These include issues from any part of the snow fence process.
- Land use – The main land uses is described such as cropland, pasture, CRP, etc.
- Agreement type – The type of agreement or contract is described such as permanent easement, annual rental, etc.
- Social and environmental impacts – These impacts describe things such as improved travel conditions, reduced crashes, or more pheasants. It is a broad category that allows the interviewee to describe some of the benefits they have observed.
- Impact on farm operations – This category describes impacts specific to the enterprise. This includes things such as higher soil moisture content, changes in labor use, etc.
- Reason for implementation – One thing the interviews sought to capture was the motivation behind using a snow fence. This section provides some of the reasons why landowners began using snow fences.
- Advice for new adopter – This provides advice from the landowner to someone looking to use a similar conservation practice.
- New practice process – This field provides the specific steps that were taken by the landowner in implementing their snow fence.

These fields continue to be updated and improved as necessary. In general, these fields provide considerable detail on the snow fence case studies and provide information that can be used to promote further adoption of snow fences.

4.4 SUMMARY

FarmMaps has successfully been adapted to include the thirty snow fence case studies, and these studies have been uploaded to the web application. The

Figure 15 - Administrator interface for FarmMaps

publicly accessible features of this site allow anyone with the URL to search and browse the full set of case studies in the FarmMaps application. Drone imagery from MNDOT has been added as available. As more information and more case studies are collected, FarmMaps will continue to be updated and improved.
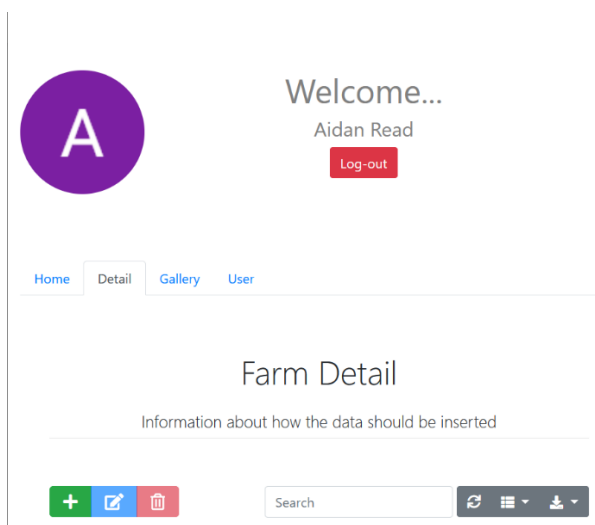
5 MNDOT SNOW FENCE DATABASE AND REPORTING TOOL

5.1 WORK WITH MNDOT BLOWING SNOW CONTROL SHARED SERVICES TEAM TO REVISE AND IMPROVE THE EXISTING DATABASE AND TOOL.

As an add-on to our previous MnDOT research project, we initiated the development of a snow fence database and reporting tool. Task 4 was designed to continue that work improving the original tool and database to better meet the needs of the MnDOT shared services team. As a consequence of the MnDOT effort to move their operations online using the TAMS system, the database and reporting tool, SFMap was also designed to be compatible with the TAMS system so that the work on the database and tool can easily be migrated to TAMS once TAMS Is operational, likely later in 2021. The process that was followed to revise and improve the database and tool was the following:

1.   Review of tool developed in previous project by the MnDOT blowing snow control shared services team. This was a continuous process with periodic meetings further described below.

2.   Definition of the fields/attributes of snow fences to be included in the database and tool (See Appendix 1 for the list of fields/attributes). This was based on the snow fence information that was required by the shared services team. The shard services team was responsible for identifying the fields which were revised as the team tested the tool and requested changes. The intent was to provide information that would be important for inclusion in the database that would help the shared services team manage and monitor snow fences and prepare reports on the snow fence program.

3.   Adding existing data from MnDOT shapefiles to the database and tool. 527 existing snow fences which were in MnDOT shape files were transferred to the tool. Entries were not complete, but the fences were transferred over and the shared services teams will be able to update the entries as they are able through the data entry interface of the tool.

4.   Development of a data entry interface for database and tool users. As part of the database tool, a user interface was developed for data entry and for correcting and completing the existing snow fence data. The tool will be used to enter existing snow fences but also allow the shared services team to add additional snow fences as they are implemented. This will provide and up-to-date register of snow fences in the state from which the shared services team can monitor, maintain and report on snow fences.

5.   Providing additional functionality by adding features to better locate fences within MnDOT administrative units. Truck stations and district boundaries were added to the map in the tool to be able to better identify administrative units responsible for the maintenance of snow fences.

The database and tool has been created and tested by the shared services team. Screenshots of the tool are included in Appendix 2 of this report. Users must have a password to access the database and tool. Passwords can be requested from the shared services team. The current address of the database and tool is sfmap.umn.edu.

5.2 SET BI-ANNUAL AND QUARTERLY DATES TO RECEIVE COMMENTS AND UPDATE THE TOOL

Although we had originally contemplated bi-annual and/or quarterly dates to update the tool, in practice and to better coordinate the development of the tool, meetings and tool updates were planned as new functionality was added to the tool and comments received from the shared services team. Towards the end of the database and tool development preparation, biweekly meetings were held which included the shared services team as well as representatives from the TAMS team and MnDOT personnel with access to the existing shapefiles that were needed to add data to the database. The TAMS team members were included to ensure that tool would be compatible with the TAMS system.

5.3 WORK WITH MNDOT TO DEVELOP A PLAN FOR CONTINUED MAINTENANCE OF THE TOOL

As the database and tool has been developed, we have discussed the long-term maintenance of the database and tool. If the database and tool are transferred to TAMS, the activities related to servers and the website maintenance would be taken on by TAMS. The activities related to data entry and editing would be the responsibility of the shared services team.

6   CURRICULUM AND TRAINING MATERIALS

6.1   OVERVIEW

As part of the past MnDOT/UMN research projects, we have developed curricula for training of MnDOT staff responsible for promoting snow control measures. Based on the results of our most recent research project we consolidated and adjusted our existing training materials to create an updated version and provided training sessions which were open to MnDOT personnel from all districts. a) we consolidated our existing curricula from past efforts; b) We updated the curricula based on our most recent findings and MnDOT policy changes; and c) We held training sessions online and invited personnel from all MnDOT districts to attend.

6.2   INTRODUCTIONS AND METHODS

Due to COVID – 19, our team modified MnDOT trainings to an online format. Our team drafted 6 one-to-2-hour online sessions from previous grant funded projects and recent research findings. A list of previous research items and projects can be found in Appendix D.

6.3   RESULTS

As the COVID pandemic continued into 2021, it became apparent that we were looking at online educational sessions and not face to face district meetings. We determined that one lunch and learn session (June 8, 2021) which targeted MnDOT staff would be best before the grant ended the end of June. The agenda and participant responses to the online questions are given below (#2).

Many topics were discussed to be part of the MnDOT district trainings which would review the MnDOT snow fence program. Many of these topics are reviewed below under planning for district meetings (#1).

The team also hosted a MnDOT snow fence training in September 2021 to kick off the fall season of contacting landowners about leaving standing corn rows and other possible snow fences which MnDOT would contract.

6.3.1   Planning for district meetings

Topics that have been taught at previous MnDOT trainings and presentations of new tools and materials to improve landowner snow fence program adoption are listed in Appendix D. We recorded the Fall meetings and they will be posted on the CINRAM website (Task 9) which MnDOT staff could access and view at any time. That site will also include training materials from our past projects with MnDOT.

6.3.2 Lunch and Learn – Microsoft Teams Meetings – June 8, 2021

Our first training was in a Lunch and Learn format on June 8th. This was a brief interactive overview of our research given to MNDOT employees over the lunch hour. The resulting responses from this session can be found in Appendix D.

6.3.3 Standing Corn Row Training for Snow Plow Drivers

Two Zoom training sessions were held in September, 2021 to give snowplow drivers essential information, handout materials, checklist and results of the current UM study of participating early adopter farmers/landowners – "why they are participants in the MnDOT snow fence program?"

       September 16 at 7:00 AM with 55 participants
       September 23 at 7:30 AM with 45 participants

The September 23, 2021 "Snowplow Drivers – Standing Corn Row Training" was recorded.
The agenda of these sessions, as well as the follow up email can be found in Appendix D.

The FarmMaps program was shown during these trainings, which is the computer story board that tells the story of these early adopters of snow fences in Minnesota.
https://farmmaps.umn.edu/

6.4 CONCLUSIONS AND RECOMMENDATIONS

This project during COVID was very challenging in delivering MnDOT snow fence trainings. However, our team is encouraged to possibly reach more MnDOT staff in snow fence education through online systems in the future. We are planning to host online trainings this fall (August) and assembling recordings and presentations for an online snow fence training course which could be accessed by MnDOT staff anytime. The lunch and learn online session was successful and participants shared many comments that can be used to direct future MnDOT efforts.

Many comments were suggestions for future projects. Several of the comments from the lunch and learn session suggested that a standardized forms agency wide; develop a guidebook similar to existing r/w guidebooks, use MnDOT's REALMS database system. Another suggestion was that a data metrics be developed to record benefits of the snow fences including B/C ratios to demonstrate to snow fence adopters the impact of their snow fences.

The MnDOT snow fence program is a successful tool in contracting landowners to establish snow fences on their property. This program is improving each year with research funding and inputs from MnDOT staff and landowners.

7 CONCLUSION AND RECOMMENDATIONS: RESEARCH BENEFITS AND IMPLEMENTATION STEPS

7.1 SUMMARY

Task 1 outlined the methodology and results of promoting adoption of snow fences through landowner engagement, case studies of landowner adoption, and tools for presenting case studies and an inventory of snow fences in Minnesota. Previous research indicates that Minnesota taxpayers will profit from the implementation of snow control measures in snow problem areas in the following ways: reduced cost of snow drift removal and blow ice treatment, decreased travel costs related to blowing and drifting snow, moderated costs and damages attributed to snow-related car accidents, increased greenhouse gas (GHG) emission avoidance, and improved efficiency of landowner engagement and outreach by MnDOT. Preliminary analyses suggest that expanded landowner adoption of snow control measures would likely boost and distribute the above-mentioned benefits across the state of Minnesota.

This project created several tools that can be used by MnDOT's snow control outreach program to improve promotion, adoption and documentation of snow fences. As has been demonstrated in previous research in District 8, training MnDOT staff and increased promotion of snow control measures by staff, primarily maintenance staff, resulted in increased adoption of snow control measures. Providing these same personnel with tools for promotion identified through previous research can make landowner outreach efforts more effective.

Through this project and engagement with MnDOT staff in trainings, we were able to identify additional areas where snow fence promotion can be improved. These suggestions are included in the Task 5 report and the final report.

7.2 BENEFIT ASSESSMENT METHODOLOGY

In 2012 as a part of MnDOT TRIG Project #99008, UMN researchers developed a Snow Control Cost-Benefit Web Tool to estimate the return on investment of implementing blowing and drifting snow control measures on private lands (Wyatt et al., 2012). The tool also approximates snow removal, travel, and safety costs as well as carbon-related benefits linked to snow control measure establishment. Dan Gullickson working with district staff carried out the analysis using the tool. In general, the use of the tool in the problem areas identified by this project has demonstrated about a 1:1 benefit-cost ratio. This indicates that the benefits from snow control measures would compensate for the cost of their installation. What is important to note is that the public benefits as described in section 8.3 below were often the determining factor in arriving at that benefit-cost ratio. There are associated public benefits that are real but not necessarily reflected in the calculations. Pollinator habitat, biodiversity and other environmental benefits are not necessarily measured but are benefits of the snow control measure installations.

7.3 BENEFITS

7.3.1 Reduction in costs to remove snow drifts and treat blow ice

Snow control measures offer quantifiable cost savings by decreasing expenses associated with snow removal equipment and sand and salt application. The equations developed by Wyatt et al. (2012) use input data including the number of snow and ice events, the average number of operational hours and costs for each type of equipment during snow and ice events, cost of sand and salt application mixture, application rate, and number of lane miles travelled during snow and ice events (Wyatt et al., 2012). The Snow Control Benefit Cost Web Tool was used to estimate cost reductions associated with snow removal and blow ice treatment for problem sites in each selected corridor.

7.3.2 Reduction in travel costs due to increased travel time related to blowing and drifting snow

Increased travel time is a common result of poor winter driving conditions. As previous research confirms, these delays incur economic costs. The Snow Control Cost-Benefit Web Tool calculates the costs of increased wintertime travel using variables including the average number of blowing and drifting snow events in each area, the amount of time required for MnDOT to clear the roadway, and the speed reduction associated with each blowing and drifting snow event (Wyatt et al., 2012). The estimated travel cost reductions for each selected corridor were calculated for those sites analyzed by MnDOT.

One thing that the calculator may underestimate is the cost of a potential slowdown or stoppage of traffic on a road segment where that has not occurred in the past. With increasing severity of storms, there is also an increased risk of road closures in areas where that has not happened in the past, strengthening the case for and savings from snow control measures.

7.3.3 Reduction in costs and damages due to accidents attributable to blowing and drifting snow

Winter weather events create hazardous road conditions that lead to increased numbers of car accidents and associated damage. Using winter crash data from 1984-2009, MnDOT's Office of Traffic, Safety, and Technology estimates that snow control measures reduce snow and ice related accidents by 40% on super elevated curves and by 8% on non-super elevated curves (MnDOT, 2011). The Snow Control Cost-Benefit Web Tool calculates the number of avoided snow and ice related accidents, which, when multiplied by the U.S. Department of Transportation's accident values, will produce approximations of cost reductions.

7.3.4 Environmental benefits due to reduced use of chemicals to treat snow and ice and GHG emission avoidance

Snow control measures decrease the amount of snow and ice build-up, thus reducing the amount of salt, sand, and additional chemicals required to clear roadways. This reduction in or elimination of chlorides, abrasives, and other deicers preserves ecosystem health that may have otherwise been

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compromised due to contamination from runoff (Fay & Shi, 2012). Although reduction of salt use and the associated cost is estimated by the snow fence tool, quantification of environmental benefit is possible but not a focus of this study.

Unrelated to chemical runoff, snow control measures also deliver GHG-related advantages. GHG emissions are avoided with the use of snow control measures, both living and structural, by reducing operational times of GHG-emitting equipment used for snow removal and ice treatment activities. Furthermore, because snow fences take land out of production, there are slight reductions in nitrous oxide emissions, as less nitrogen-based fertilizers are applied. On average, a 100-ft snow fence is estimated to reduce CO_2 emissions by 10.4 lbs/ft (Wyatt et al., 2012).

7.3.5   Improve MnDOT's efficiency at landowner engagement and outreach

The current study is based on our previous research and recommendation from that research to improve outreach and engagement with farmers. In our previous research project, landowners identified constraints to their adoption of snow fences and this project addressed those constraints. A key outcome of this research was the development of 30 case studies of landowners who have successfully implemented different types of snow fences. This will allow MnDOT personnel and other landowners to access those case studies and learn how other landowners have overcome constraints to successfully implement snow fences. Landowner-to-landowner (peer-to-peer) interaction has been shown to be a good tool for promotion of conservation measures and, in this case, snow fences. The findings from this analysis should assist MnDOT employees in determining the most effective ways to introduce and promote novel concepts and worthwhile technologies to landowners. These benefits will not be measurable until new promotional activities are initiated.

7.4   IMPLEMENTATION

The benefits from this study are contingent on adoption of recommendations and outreach to landowners. Implementation of the findings and recommendations of the study and effective landowner outreach activities are of critical importance. We provide recommendations based on the results of our training session and the new and previous research efforts to improve outreach and engagement with landowners in the promotion of snow control measures.

Due to past research and the active engagement of MnDOT colleagues, we have a good understanding of the structure of the MnDOT snow control program. This combined with the involvement of MnDOT personnel throughout the project helped us identify where interventions could increase the effectiveness of the program. The actual implementation of the recommendations will depend on MnDOT's decision whether to adopt them.

We understand that there may be recommendations contained in this report that MnDOT may not be able to implement due to limitations related to existing resource or policy constraints. However, we encourage MnDOT to consider providing the resources and potentially the policy support needed to implement the recommendations.

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Wyatt, G., D. Zamora, D. Smith, S. Schroder, D. Paudel, J. Knight, … & S. Taff. (2012, February). *Economic and environmental costs and benefits of living snow fences: Safety, mobility, and Transportation authority benefits, farmer costs, and carbon impacts* (final report). St. Paul, MN: MnDOT.

APPENDIX A: INTERVIEW PROTOCOL

A.1 SNOW FENCE CASE STUDIES: DRAFT INTERVIEW PROTOCOL

A.1.1 Introduction and Background

In an effort to create a publicly accessible database on snow fence types and practices, we are speaking with landowners who have already installed snow fences. You were recommended as a great person to interview, and we believe that you will provide valuable insights to this study.

A.1.2 Introductory Protocol

In addition, to your voluntary participation in this discussion, we ask that you review our informed consent form *(see attached)*, which protects the people who participate in this study and complies with UMN human subjects research requirements.

This document states that: (1) your participation is voluntary, and you may withdraw at any time; and (2) we do not intend to cause any harm. Please read this form carefully and let us know if you have any questions. If you would like to proceed with this interview, sign the consent form. Once signed, you will be provided a copy of the form.

[If consent is granted and form signed] Thank you for your agreeing to participate in this interview.

We have planned this interview to last an hour. During this time, we have several questions that we would like to cover. If time begins to run short, it may be necessary to end questions prematurely in order to push ahead and complete the remaining topics and questions.

Do you have any questions? If your schedule permits today would you be interested and willing to extend the interview time if necessary?

A.1.3 Interview Questions

A.1.3.1   General Information/History
1.)   Can you give me an overview of your operation?
    a. How do you use your land?, If in agriculture:
        i.   What kinds of crops/livestock do you have?
        ii. How many acres total? How many tillable acres?
        iii. Do you own or rent your land?
        iv. Is your snow fence on rented land, or on a purchased easement?
2.)   Can you tell me about yourself and the history of your property?

A.1.3.2 Snow Fence Practices
3.)   Tell me about your snow fence:
    a. How did you originally get started with your snow fence work?
        i.   Who contacted you?

   ii. Do you remember what your original thoughts were about installing a snow fence?
   iii. What concerns did you have about installing a snow fence?
   iv. How did you choose your specific practice?
  b. What prompted you to install a snow fence, or keep it once installed?
   i. What push and pull factors did you experience?
   ii. Were there economic incentives for changing? Do you receive any monetary benefits from incentive programs or subsidies?
   iii. Did you anticipate lowered costs, or a change in yield or income?
  c. How is your fence designed:
   i. Where you involved in the design process?
   ii. What kind of fence have you implemented (living, standing corn rows, hay bales, structural snow fence, other)
   iii. If a living snow fence, what plants/trees do you use?
   iv. How many rows?
   v. How long is the fence?
   vi. Setback distance?
  d. Do you have a copy of the snow fence plan, and do you reference it?
  e. In order for you to make an informed decision what information did you need to see on the snow fence plan?

4.) How did you establish the fence?
  a. Site preparation
  b. Weed control
  c. Watering
  d.

5.) How do you manage problems?
  a. Herbivory
  b. Pests (weeds, insects, etc.)
  c. Weeds
  d. Ongoing maintenance

6.) Do you receive any sellable goods from your snow fence?

A.1.3.3 Impacts

7.) What impacts have you observed from your snow fence? How do you quantify these impacts?
  a. Blowing and drifting snow
  b. Dust
  c. Wildlife / pollinators
  d. Soil moisture
  e. Livestock/crop performance – information from yield monitors
  f. Transportation (stuck vehicles, crashes, etc.)

8.) How has the snow fence impacted your operation?
  a. Labor

  b. Pesticides (Herbicide, Insecticide, Fungicide)
  c. Nutrient management (chemical and manure)
  d. Machinery/equipment
  e. Fuel

9.) Have these practices impacted water management?
  a. Infiltration rates
  b. Wet spots
  c. Runoff
  d. Start of season / delay of planting

10.) Has there been an impact on erosion?
  a. Wind/water
  b. Cost of repairs

A.1.3.4 Motivations

11.) What motivated you to implement snow fence practices?

12.) How did you weigh the risk of being an early adopter of your practice?

13.) Were there environmental motives for using a snow fence?

14.) Were there transportation motives for using a snow fence? Speed of travel, transportation access, reduced crashes/ road departures, etc.

15.) If you received compensation, did it adequately cover your risk and costs?

16.) After installing a snow fence were your expectations met?
  a. Did benefits come immediately or over time?
  b. What motivated you to continue if your results were not as expected?

A.1.3.5 Lessons Learned

17.) What was the most difficult part for you?

18.) What was the most rewarding part of adopting new practices?

19.) Given the chance, would you adopt your snow fence practice again? What would you do differently?

20.) Are you considering additional snow fence practices?
    a. What potential barriers or incentives do you anticipate?

21.) How did others in your community react to your snow fence?
    a. What did your agronomist, retailer, or lender think of your practices?
    b. Has anyone asked for advice and do you educate others?
    c. Do you believe that your neighbors or others are considering adopting practices similar to yours?
    d. What do you think would prompt your neighbors to consider adopting snow fences?

22.) What advice would you have for someone who is considering adopting different agricultural practices?
    a. What form of information do you think would be most helpful to them? (Website, phone app, in-person meeting/workshop etc.)

23.) What information would be helpful for you to make an informed decision on snow fence installation and maintenance?

24.) What changes would you make to how would you are involved in the design, construction, and upkeep of practices?

A.1.3.6 Wrap Up

Is there anything you want to share with me that wasn't already covered?

Thank you for participating in our case studies. Our hope is that these studies will offer a valuable resource to others throughout Minnesota. After I summarize the conversation we had today, I will e-mail it to you to review before we release it to the public. If you think of any additional information you would like to add or have questions in the meantime, don't hesitate to contact me.

APPENDIX B: SFMAP DATABASE AND TOOL SCREENS
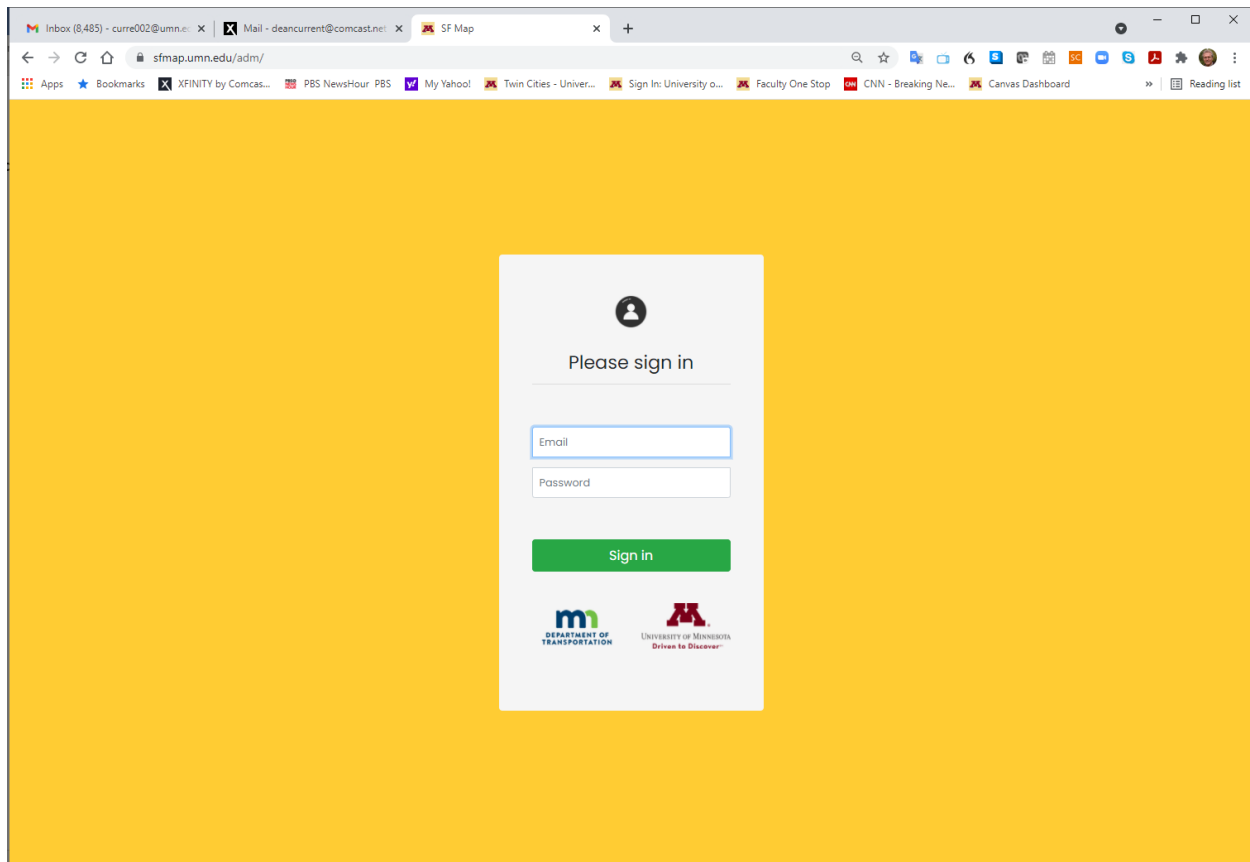
Figure 1. Start/Sign-in page for the SFMap database and reporting tool
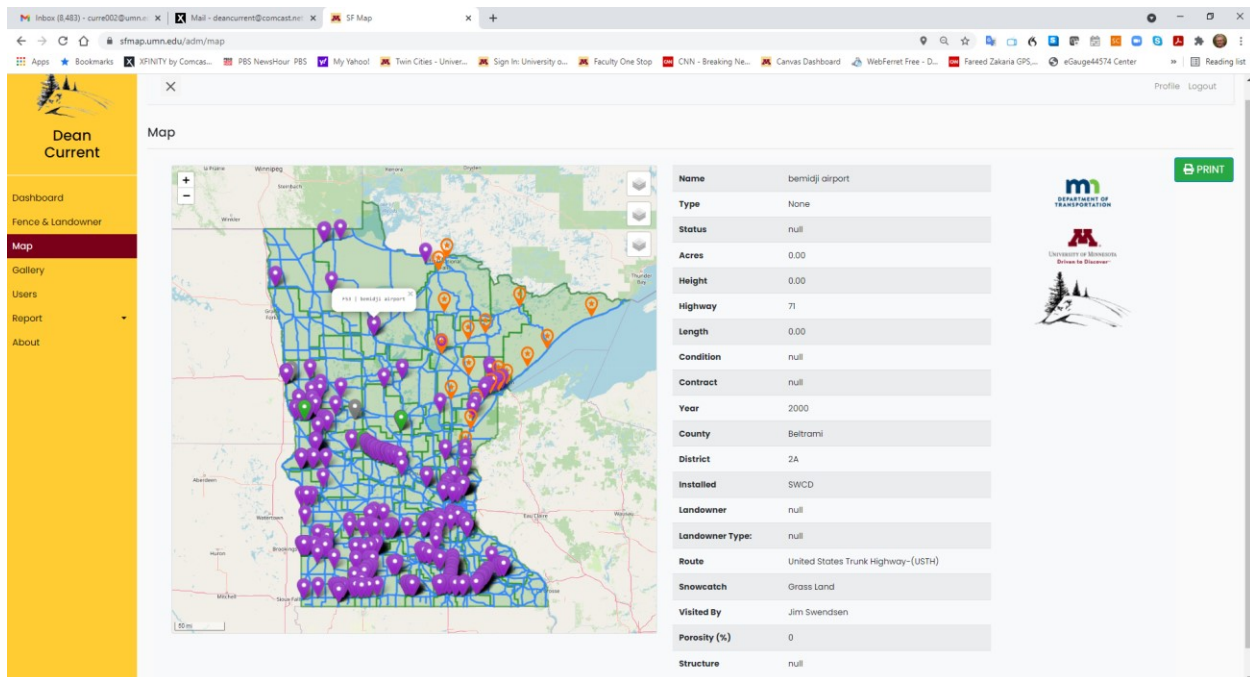
Figure 2. Map of snow fences (green and purple markers) showing the truck stations (orange markers/ turned on for MnDOT District 1. Individual truck stations can be toggled on and off by district.
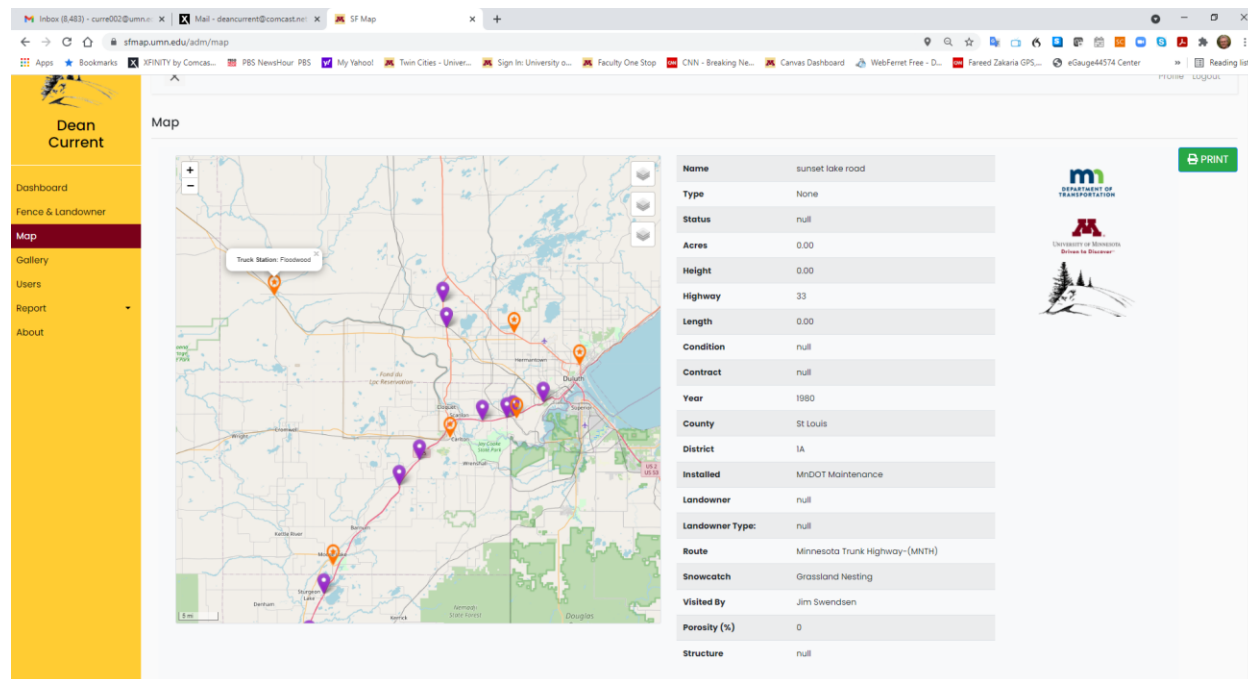
Figure 3. Zoomed in map of snow fences (purple markers) and truck stations (orange markers) near Duluth in MnDOT District 1.
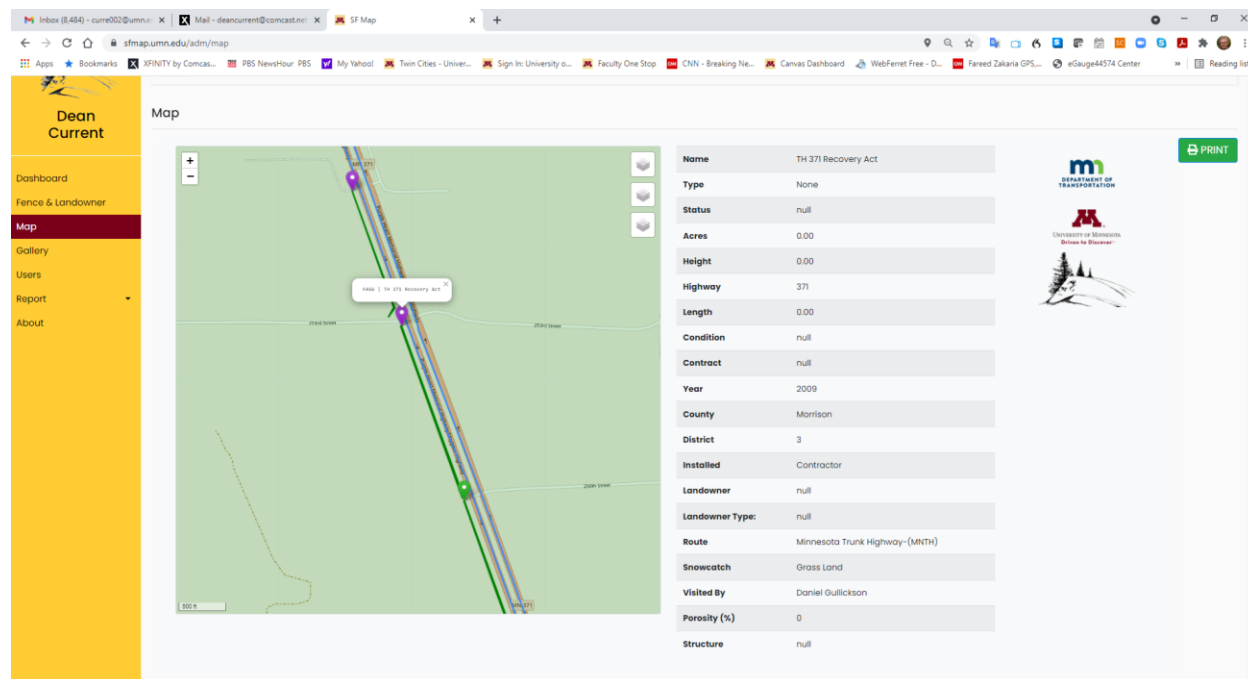
Figure 4. Detailed map view of 3 snow fences (purple markers uncategorized snow fences and green marker representing a living snow fence). Once all fences are categorized, the color of the marker will indicate the type of snow fence (living, standing corn row, structural, etc.).
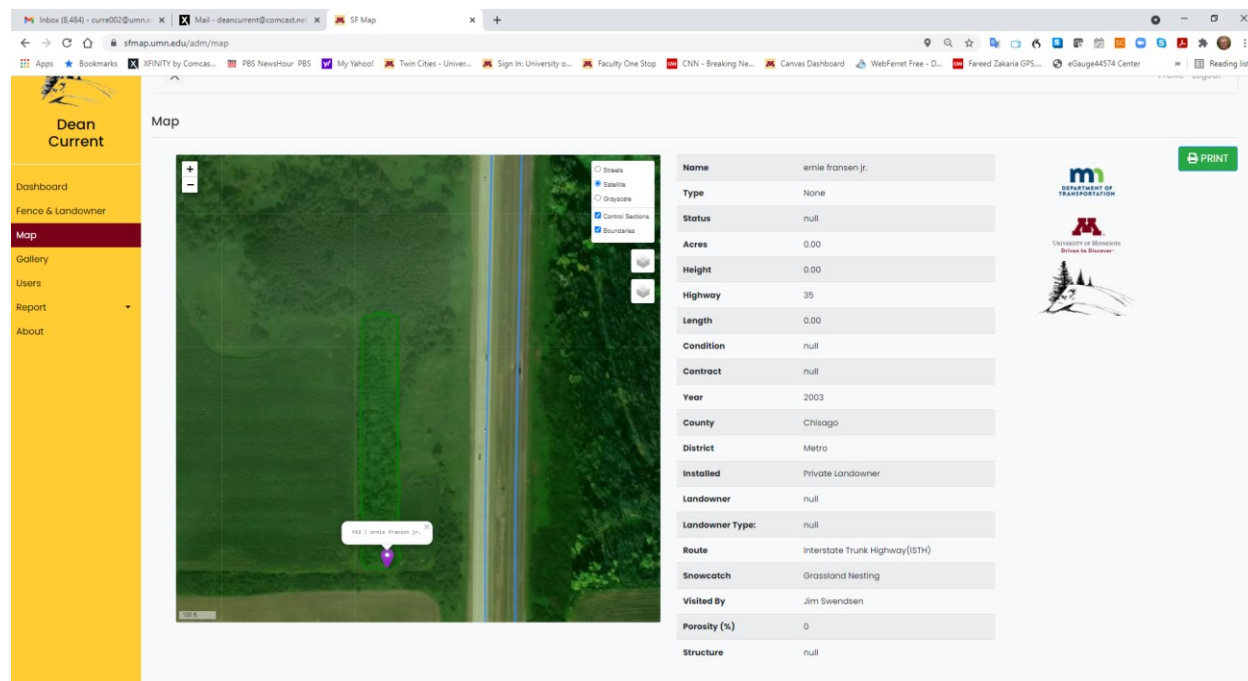
Figure 5. Detailed satellite view of a single snow fence in which you can see the planted vegetation enclosed by a green outline. Note: the attributes listed for each snow fence are selected from a list of total attributes (see also Figure 7).

Figure 6. Data entry and editing page. This page allows the user to select a fence by checking the box on the left to identify a snow fence for editing or to click on +Add to enter a new snow fence.

Upon selecting a fence by clicking on the box to the left or clicking on +Add to enter a new fence, the user will be taken to the screen demonstrated in Figure 7 to either edit an existing fence or add a new fence. In addition to being able to edit fence data in the edit page (Figure 7), the user can directly edit data directly on this page (Figure 6) for the data that appears on the page.

The search box in the upper right-hand corner of the Figure 6 screen allows the user to search for a fence using any of the attributes listed in Figure 7 allowing a user to easily locate a fence they would like to edit. Each fence also has a unique identifier (F579 for example) that appears on the Minnesota map if the user clicks on that marker. By using that identifier, the user can go directly to the fence they are interested in editing or reviewing.

Figure 7. Screenshot of the data entry and editing page.

The user opens this page to enter a new snow fence or to edit a snow fence that has already been entered in the database. This view is the editing view. If this were the page for entering a new fence, the user would find the location of the fence from the map, either enter coordinates for the fence or draw the fence and enter the corresponding data. Note that, for this existing fence, data is still missing. This page allows the shared services team to complete data entry for an existing fence and/or enter data for a new fence. This page includes all the attributes that the shared services team has identified that they would like to have in the database for each fence. When the fence is displayed on the map, the user selects the data they would like to be displayed which may be a subset of the full data set displayed here. The attributes here can be selected to appear in a report or not and the user can filter to display those fences meeting certain criteria defined by the attributes. For example, the user could request all

the living snow fences established in an identified year and occurring in a county or MnDOT district. That information can be extracted into an MS Word or Adobe Acrobat pdf document or Excel spreadsheet to be incorporated into reports.

Additional menu items for SFMap:

In addition to being able to enter and edit snow fence data, access the data and create reports, SFMap provide other menu options to the user:

- Gallery: Photos and videos can be associated with individual fences. For example, Mn DOT has recently flown drone footage of fences that are also included in the separate Fammaps case study database and program (Task 2). The drone footage can be included or linked to the individual snow fence.
- Report: The database and tool has the capacity to include templates for standard reports for reporting by the shared services team. Those reports will be developed as requests are received from the shared services team.

APPENDIX C: FARMMAPS
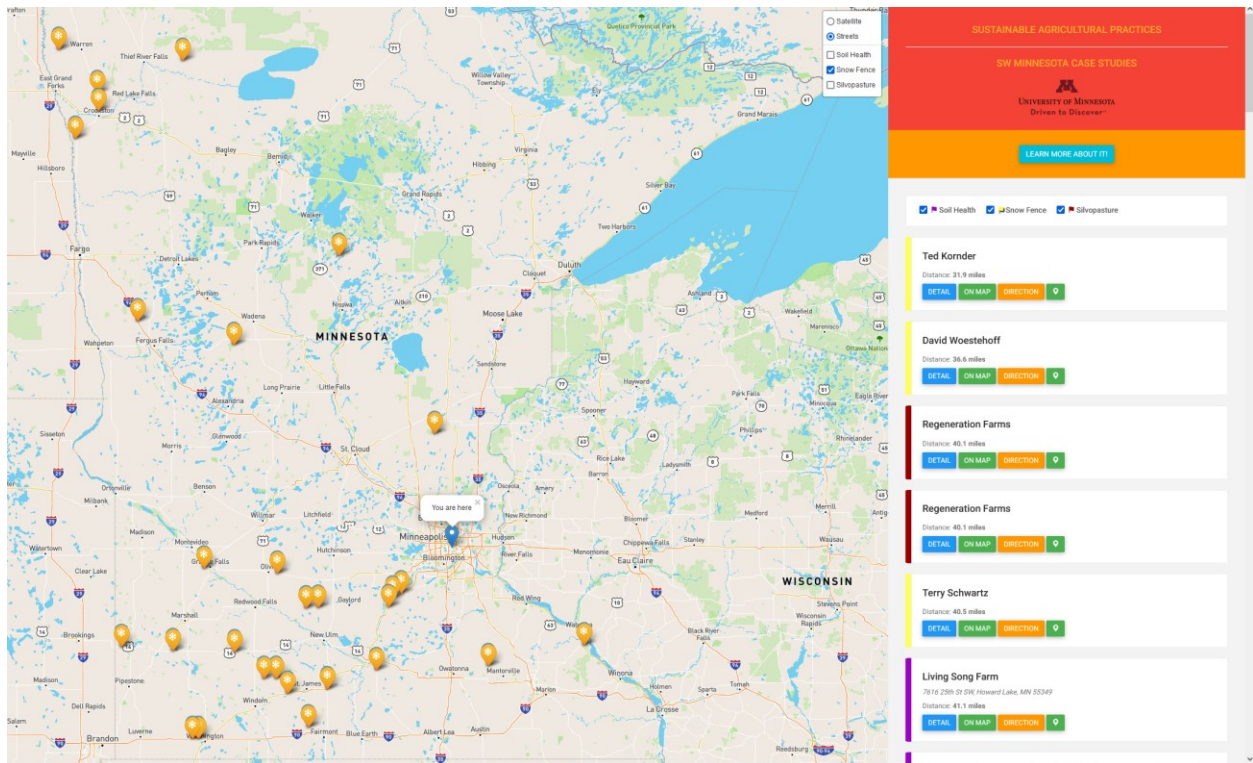
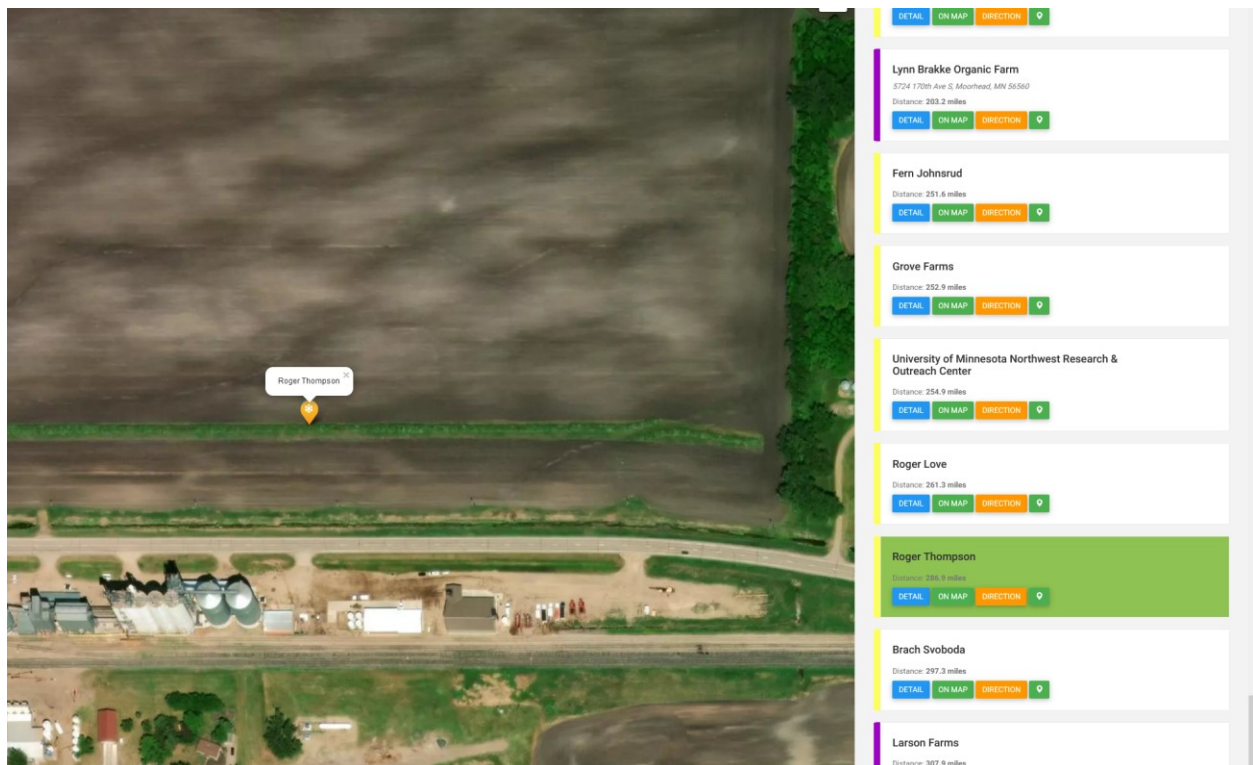**Figure 1 - The home screen of FarmMaps showing only snow fence cases.**

Figure 2 - The satellite view of a living snow fence.
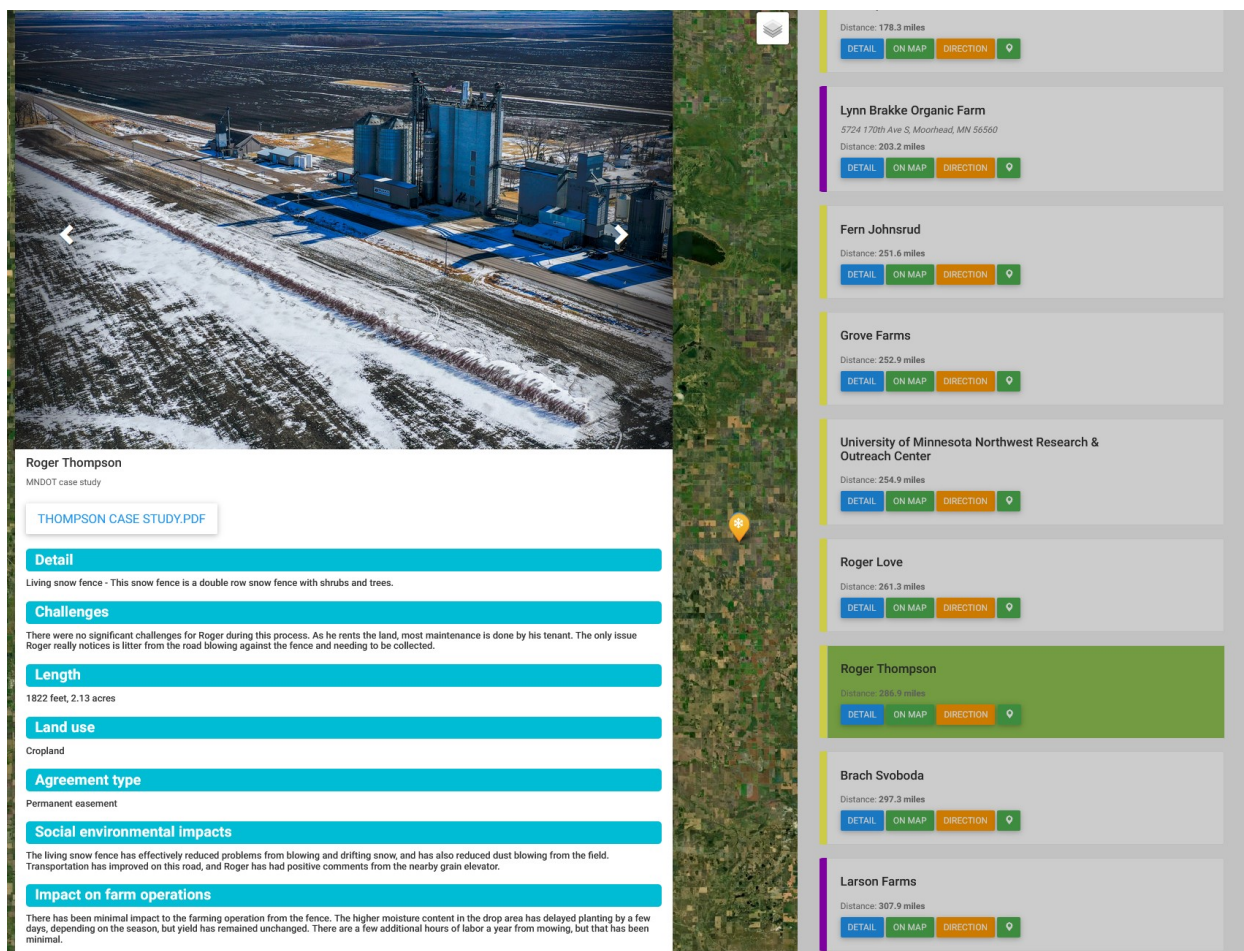

Figure 3 - The detail page of a snow fence case, showing the available information and imagery.

Roger Thompson

Alvarado, MN

(218) 960-2075

Fence type: Living snow fence - This snow fence is a double row snow fence with shrubs and trees.

Land use: Cropland

Agreement type: Permanent easement

Size: 1822 feet, 2.13 acres

New Practice Process

Roger was approached by local MNDOT staff looking to purchase an easement for a living snow fence. Roger recall being initially uninterested, mostly because of the potential impact it would have on his crops. After discussing the compensation, and having the program described by staff, Roger was on board. The fence itself was installed by contractors, and maintenance such as weed control was also contracted out.

Social and Environmental Impacts

The living snow fence has effectively reduced problems from blowing and drifting snow, and has also reduced dust blowing from the field. Transportation has improved on this road, and Roger has had positive comments from the nearby grain elevator.

Impact on Farm Operations

There has been minimal impact to the farming operation from the fence. The higher moisture content in the drop area has delayed planting by a few days, depending on the season, but yield has remained unchanged. There are a few additional hours of labor a year from mowing, but that has been minimal.

Challenges

There were no significant challenges for Roger during this process. As he rents the land, most maintenance is done by his tenant. The only issue Roger really notices is litter from the road blowing against the fence and needing to be collected.

1

Figure 5 - The downloadable and printable .PDF file accessible through FarmMaps.
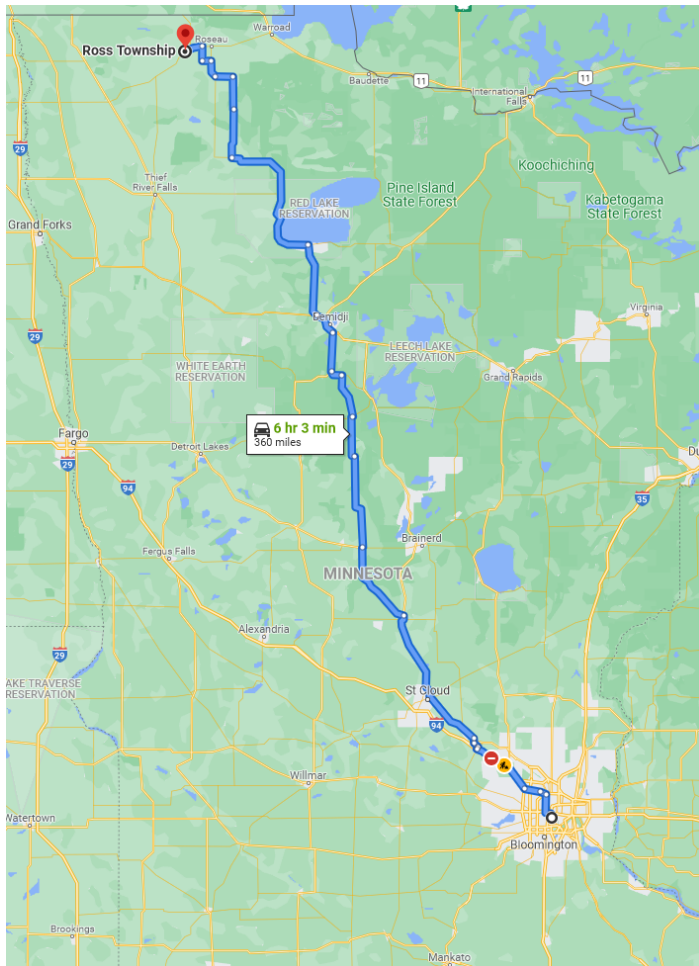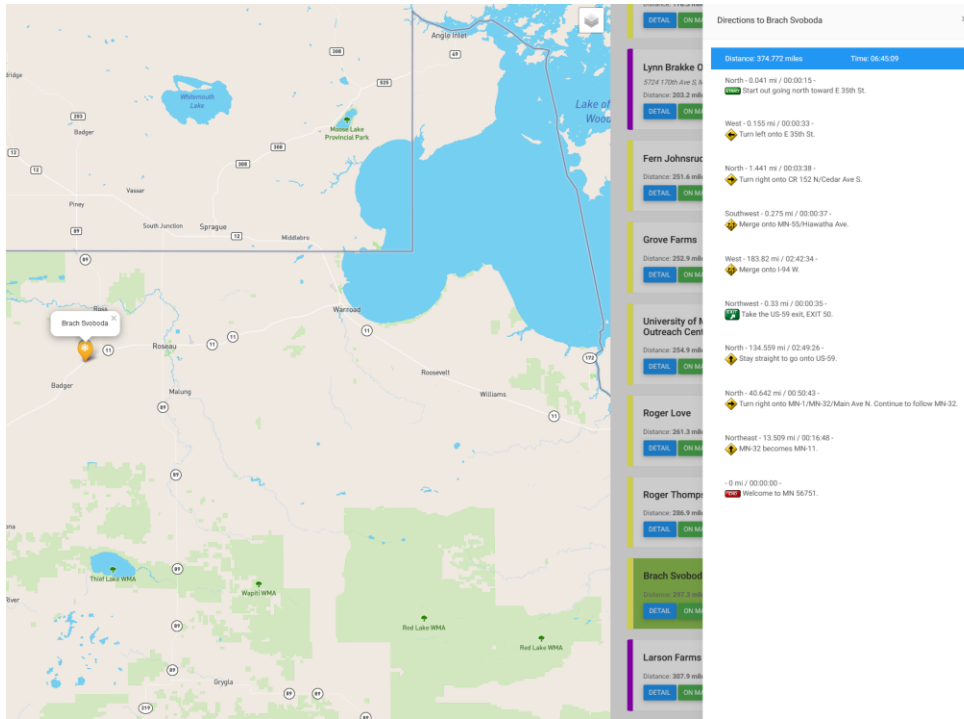
Figures 5 and 6 - Driving directions are available through FarmMaps.

The application is linked to Google Maps, which can be opened through a web or mobile application.

APPENDIX D: TRAINING & CURRICULUM MATERIALS

D.1 PRIOR RESEARCH AND GRANT FUNDED PROJECTS

History of Research and Landowner Constraints
   (4 Corridors Research, Current Research)
Results of Case Study Research – 2020 - 2021
Benefits of Snow Fences in MN
Management Costs of Snow Fences for landowner
Landowner Testimonials of Snow Fences/Lessons learned
SFMap
Farmmaps
MnDOT Employee Interviews (Megan Butler 7/11/17)
MnDOT Employee Testimonials - (Gene Munsterman, Gayle, Jason, Poncho, Mike Slater)
Sign Up Procedures – MnDOT SF Program
Promotional Handouts Used
MnDOT Snow Fence Program
Landowner Testimonials of Snow Fences/Lessons learned

D.2 LUNCH AND LEARN TRAINING

Lunch and Learn announcement to targeted MnDOT employees:
UMN Research on Early Snow Fence Adopters
Tuesday, June 8·11:30am – 12:30pm
Location: Microsoft Teams Meeting
46 guests had registered for this online session.

Description: Lunch and learn opportunity to hear the early snow fence adopter experience based on University of Minnesota research this past winter. Some of the farmer/landowners surveyed have over 25 years' experience working with and around snow fencing on their lands. Approximately, 30 farmer/landowners were interviewed across the state who implemented either; living snow fences, structural snow fences, or left standing corn rows to improve winter driving safety and mobility. University of Minnesota researchers are seeking ideas from you on how to enhance MnDOT's farmer/landowner engagement based on the early snow fence adopter experience for incorporation into the research projects final report. Please share this invitation with others in your area who might be interested in participating in this lunch and learn session. Sincerely, Dan Gullickson

D.2.1 AGENDA AND PROMOTION:

Improving Winter Driving Conditions:
Lessons from Early Snow Fence Adopters

Join the MnDOT and University of Minnesota research project team to learn what is motivating farmers and landowners to adopt blowing snow control fence solutions along Minnesota highways. You will hear the experiences of early snow fence adopters and how to increase snow fence adoption by others. You will also have a chance to provide feedback on our preliminary study results.

The event will take place on **Tuesday, June 8, from 11:30 am to 12:30 pm.**

The goal of MnDOT's blowing snow control program is to improve winter driving safety and mobility, while reducing snow and ice removal costs. Farmer and landowner participation is essential.

Based on the experiences of early snow fence adopters, University of Minnesota researchers are also seeking ideas from MnDOT on how to approach farmers and landowners about adopting snow fencing solutions to protect our highways from blowing snow. Meeting participants are encouraged to engage in the presentation, which will help shape the final research report.

Presenters include:
April Lucas, MnDOT Shared Services director
Dean Current, director of the Center for Integrated Natural Resources and Agricultural Management, University of Minnesota
Aidan Read, Graduate Research Assistant, University of Minnesota

Meeting topics include:
- History of Research and Landowner Motivations and Constraints
- Transportation Corridor Study Research from Districts 2, 3, 6 and 7
- Early Snow Fence Adopters Case Study Results
- Farmmaps Program (a farmer to farmer networking tool)
- Questions for MnDOT staff and discussion to improve snow fence adoption in MN.

D.2.2 RESPONSES TO THE LUNCH AND LEARN QUESTIONS:

Our team asked 5 questions during the lunch and learn online session, June 8, 2021.
MnDOT participants were very responsive in giving suggestions and comments to each question. The resulting slides are viewable here: https://drive.google.com/file/d/1Xq6ODTNGF--IObfynSYBp_fhpD494OBZ/view?usp=sharing

D.2.2 1. WHICH MNDOT DISTRICT ARE YOU FROM?

Those attending the lunch and learn from the following MnDOT Districts:

District 1 = 0

District 2 = 1

District 3 = 2

District 4 = 1

Metro   = 10

District 6 = 3

District 7 = 3

District 8 = 0

Total of 20 responding

D.2.2 2. WHAT IS YOUR ROLE AT MNDOT?

TPS 1 Maintenance Operations (2)

Communications Public Engagement (2)

Real Estate Representative (4)

Manage the Value Engineering Program

Blowing Snow Control Supervisor

Project Coordinator

Office Director

Shared Services Director

Snow Control Designer

Right of way Supervisor (2)

General Appraiser – RESS

Right of way Acquisition

Oversight

Utility Coordination

Director

Liaison Services

Research & Innovation Communications

Pm

D.2.2 3. HOW CAN STAFF VISITS AND MESSAGING BE MORE CONSISTENT OVER TIME?

Organized files for snow fence adopters.

Have snow fence inventory.

Use of Public Engagement staff.

Work with public engagement communications team to develop key messages, one pagers with information, key contact listings.

Keeping the landowners updated on who to contact on their snow fence.

Use same forms.

Work from a common "song sheet" helps keep messages consistent.

Fixed pricing based on commodity prices.

Send them a seasonal summary sheet to show them how it worked each season or provide those key facts about the benefits each year.

Have the same person, as often as possible, be the contact person.

Local small town papers love talking about snow fence and impacts.

Host some virtual "Town Halls" for landowners to learn more.

Standardized forms agency wide; develop a guidebook similar to existing r/w guidebooks, use MnDOT's REALMS database system.

Studies showing safe road travel on certain roads before and after snow fences.

D.2.2 4. WHAT INFORMATION CAN WE SHARE WITH PARTICIPANTS (FARMERS & LANDLORDS) TO COMMUNICATE THE EFFECTIVENESS OF THEIR SNOW FENCE?

Share with them before and after crash data.

Share data and stories from other landowners.

Share snow fence data in elementary schools. Add a slide into the STEM outreach.

Antidotal stories from neighbors and snowplow drivers.

Statewide 1 pager with real time B/C savings.

Remind them of how many stranded drivers they didn't have to rescue.

Share as many metrics with them as possible regarding salt usage, fuel consumption, etc.

A good mix of anecdotes, but also the details on the financials and effectiveness involving safety or best practices.

Testimonials from rural school bus drivers about how it helps get kids to school.

Reduction (%) in salt/chemicals applied to road, reductions (%) in traffic accidents, increase in snow fence participants along a corridor.

Performance metrics (est. lives saved and property damages avoided, maintenance avoided, etc.)

Public THANK YOU to those who are involved (Local papers, social media)

How much money did MnDOT save by utilizing the snow fence?

Talk to them early at the site.

Talk to them….early Corn row to permanent transition.

Early engagement.

Very early in planning ahead of scoping to allow coordination time.

Discuss and work with public engagement team to develop strategies and a plan. Try visits to the county fairs to connect with farmers and others who might like to learn or be part of an effort.

A variety of pollination plants/butterflies and bees.

Get their equipment widths for determining optional fence placement and accommodate turning radius.

Need to find out specifics of farm equipment. Cater the design to their operation.

Contact with project manager.

Have truck station employees engage landowners in problematic areas before the project is programed to plant the seed.

D.3 STANDING CORN ROW KICKOFF TRAININGS

7.4.1   Agenda

UMN and MnDOT Standing Corn Rows Kickoff

Introduction and MnDOT Goal for Snow Fences, *Jed Falgren, MnDOT*

Case Studies, *Aidan Read, UM Graduate Student, CINRAM*

Farmmaps*, Dean Current, Director for the Center for Integrated Natural Resources and Agricultural Management (CINRAM)*

Snow Control Program*, Dan Gullickson, MnDOT Snow Fence Coordinator*

Standing corn conditions due to summer drought – weak stalks, *Gary Wyatt, Extension Forester*

MnDOT Forms and Contract Agreements*, Dan Gullickson, MnDOT Snow Fence Coordinator*

7.4.2   Recording

Below is the link to the recording of the training session:

https://www.youtube.com/watch?v=GkTmQg0JnXY&authuser=0

7.4.3 UMN and MnDOT Standing Corn Signup Campaign Follow Up Materials and Links

As a follow up on the September 16th and September 23rd UMN and MnDOT Standing Corn Row Signup Campaign training sessions here are some additional support materials:

- YouTube link to UMN and MnDOT training presentation- if you missed it on September 16th and 23rd https://www.youtube.com/watch?v=GkTmQg0JnXY&authuser=0
- Meeting the Farmer/Landowner Checklist found in the attachment
- Determining Corn Standability How to Push-Pinch Test | Channel® Seed Brand
- UMN Early Snow Fence Adopter Research (*See What Early Snow Fence Adopters Experienced*) found in the Case Study attachment
- UMN Farm Maps with *Early Snow Fence Adopter Interactive Map* including Snow Fence Drone Video/Photos Farm Maps (umn.edu)
- MnDOT's Living Snow Fence Website Home Page http://www.dot.state.mn.us/environment/livingsnowfence/
- To get Snow Trap ID numbers visit MnDOT's Snow Trap Inventory Google Earth KMZ file http://ihub/livingsnowfence/index.html

Good luck with your standing corn row/stacked bale signups for this upcoming winter. Let us know if you find these resources helpful and how they can be improved upon.

Sincerely,

Dan Gullickson