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Evaluating the Costs and Benefits of Snow Fences in Illinois: Phase 2

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16. Abstract
Serving as a windbreak, properly sited and designed snow fences have been proven effective in mitigating the negative impacts of blowing snow. To achieve the best snow-control effects, the ideal locations for snow fences are usually outside the roadway right-of-way. Few efforts have been made to examine the economic efficiency of snow fences and explore ways to reward private landowners. The objective of this project was to develop methodologies for evaluation of the costs and benefits of snow fences in Illinois and identify ways to encourage private landowners' participation in the snow fence program while keeping it cost-effective. The researchers conducted a literature review as well as agency and landowner surveys. They also acquired crash data, snow fence and blowing snow segment inventory data, and blowing snow removal expenditure data as well as performed benefit-cost analyses of three types of snow fences following Federal Highway Administration guides. The survey results suggested that standing corn rows (SCRs) and structural snow fences (SSFs) were the least intrusive options for landowners and living snow fences (LSFs) with trees were the most intrusive. Some concerns related to LSFs could be reduced by allowing landowners to play a role in the design and plant-selection process. The crash data indicated that no fatal and severe crashes occurred at snow fence segments, while several fatal and severe crashes occurred at blowing snow segments during 2012–2016. The results of the benefit-cost analyses showed that the benefit-cost ratios for LSFs and SSFs are comparable. However, LSFs are favorable over SSFs because little maintenance is needed after the plants are mature. Although SCRs have the highest benefit-cost ratio, the need to renew the agency-landowner agreement annually and the alternating of crops planted may limit their snow-control effectiveness and large-scale implementation. A tool was developed using MS Excel to facilitate the benefit-cost analysis of snow fences.

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The research team is thankful for the assistance provided by the project's Technical Review Panel members and other IDOT staff. Members of the Technical Review Panel were the following:

- Mark Bloome—IDOT Central Bureau of Operations, TRP Chair
- Steve Niemann—IDOT District 3, TRP Co-chair
- Laura Shanley—IDOT Central Bureau of Operations
- Katherine Beckett Suter—IDOT Bureau of Safety Programs and Engineering
- Michael Brownlee—IDOT Central Bureau of Materials
- Wade Conn—United States Department of Agriculture
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- Rod Lashuay—IDOT
- Dean Mentjes—Federal Highway Administration
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- Tim Peters—IDOT Bureau of Local Roads and Streets
- Amber Ralph—IDOT
- Lyndsay Ramsey—Illinois Farm Bureau

EXECUTIVE SUMMARY

A snow fence is a natural or artificial structure that prevents snow from blowing onto the road. There are three main types of snow fences: a living snow fence (LSF), structural snow fence (SSF), and standing corn row (SCR). Serving as a windbreak to cause windblown snow to deposit in a desired location before reaching roadways, properly sited and designed snow fences reduce travel times, increase driver visibility, improve road conditions, prevent winter weather–related crashes, and save snow removal expenditure. To achieve the best snow-control effects, the ideal locations for snow fences are usually outside the roadway right-of-way. However, encouraging landowners to participate in a snow fence program has been difficult. Few efforts have been made to examine the economic efficiency of snow fences and explore ways to reward private landowners. The objective of this project was to develop methodologies for evaluation of the costs and benefits of snow fences in Illinois and identify ways to encourage private landowners' participation in the snow fence program while keeping it cost-effective.

To achieve the study objective, the researchers conducted a literature review on the costs, benefits, and economic efficiency of snow fences; an agency survey to collect information on current practices of snow fence program implementation; and an Illinois landowner survey to gather opinions on snow fences and appropriate ways to compensate landowners. The researchers also compiled snow- and ice-related crash data, an inventory of snow fence and blowing snow segments, and expenses related to blowing snow removal. The researchers analyzed the data to determine the crash modification factor (CMF) of Illinois snow fences and the cost per lane mile of blowing snow removal in each district. Subsequently, the benefit-cost analysis (BCA) of snow fences was illustrated through a case study following Federal Highway Administration guides. Snow fence cost information obtained from the literature was used in the BCA, and when possible, Illinois-specific values were used. A tool was developed using MS Excel to facilitate the BCA of three types of snow fences.

The literature review only found four previous studies on the economic efficiency of snow fences. The studies confirmed the benefits of snow fences, particularly snow removal savings and crash reduction. No studies have performed BCAs of LSFs, SSFs, and SCRs following the USDOT *Economic Analysis Primer* and the FHWA *Highway Safety Benefit-Cost Analysis Guide*.

The best practices identified by the agency survey included identifying appropriate sites based on the experience and feedback from road maintenance personnel, developing rapport with landowners, considering snow fence types (such as structural versus living), using established design procedures, and compensating landowners with creative funding sources. The landowner survey found that key concerns included compensation, implementation, and maintenance. SCRs and SSFs were less intrusive than LSFs, and shrubs were more preferred than trees. The challenges of removing corn after winter were noted, including timing the removal and mobilizing/cleaning a combine again. Concerns about SSFs included harvesting adjacent crops, damaging property during installation, and making commitments with the state.

The crash data showed that no fatalities or severe injuries occurred on snow fence segments over 2012–16 during blowing snow events. Using screened crash and segment inventory data, the snow

fence CMF was determined following the cross-sectional approach. The calculated snow fence CMF was 0.656 with a standard deviation of 0.7473. Because of the small sample size, the standard deviation of the calculated CMF is relatively high. However, the CMF value of 0.656 is comparable to the snow fence CMFs developed by Peet et al. (2017) and Larson et al. (2019). Using the blowing snow removal expenditure data for the 2017–18 winter and blowing snow segment lane-mile data obtained in 2016 during the Phase I study, the average blowing snow removal cost per lane mile per snow event was determined by district. The results showed that District 3 has the highest cost per lane mile for blowing snow removal.

Besides snow fence installation and maintenance costs, the BCA also considered farmland rental, operational inconvenience, and production reduction cost. The benefits considered in the analysis included cost savings for travel time, fuel consumption, and snow removal as well as emission and safety benefits. The BCA results showed that the benefit-cost ratios for LSFs and SSFs were comparable. However, LSFs were favorable over SSFs because little maintenance is needed after plants are mature and their potential environmental benefits. SCRs were the most economical among the three alternatives. SCRs have the highest benefit-cost ratio, but the need to renew the agency-landowner agreement annually and the alternating of crops planted in the farmland may limit their effectiveness and large-scale implementation.

Four visible worksheets were included in the BCA tool. The introduction worksheet gives a brief overview of the study project and each worksheet, along with the color scheme used to represent different cell functions. The site-specific geometry, traffic, safety, and weather information and snow fence characteristics from the snow fence design are entered by users in the user input worksheet. The analysis parameter worksheet contains data items for calculating the costs and benefits of snow fences, along with the unit rates used in monetizing each cost and benefit, such as land rental rate, labor rates, equipment rates, fuel rate, crop yield, etc. Those rate values can be updated in their corresponding hidden worksheets. The benefit-cost summary worksheet provides the BCA results, including the itemized costs and benefits, the overall benefit-cost ratio, IDOT B/C ratio, the annual cost and benefit over the analysis period, as well as the annual and cumulative present values of cost and benefit over the analysis period. The annual cost over the analysis period can be used to determine the snow fence payment structure.

Based on the findings, the existing snow fences implemented along Illinois freeway and rural highways are effective in reducing crash severity and the total number of crashes related to blowing snow. Snow fences can be valuable investments for managing blowing snow along Illinois roadways, considering both agency and non-agency benefits (safety as well as travel time and emission savings). The BCA tool developed in this project can support the evaluation of each potential snow fence project and decision-making in investments for managing blowing snow along Illinois roadways.

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CHAPTER 1: INTRODUCTION

In high-latitude and/or high-altitude regions, blowing and drifting snow is a major issue that transportation agencies and users face during winter seasons. The amount of snow that blows onto the road could be more than a hundred times the amount that falls directly on it (Du et al. 2017). Blowing snow and snowdrifts have long been known to have negative impacts on winter roadway safety, mobility, and maintenance. Those negative impacts include hazardous driving conditions, continuous plowing needs, excessive use of chemicals, infrastructure damage, increased user costs (travel delay and vehicle corrosion), etc. As a typical agricultural-producing state in the Midwest, Illinois also faces the challenges of blowing or drifting snow on roadways, particularly along open areas near farmlands.

A snow fence is a natural or artificial structure constructed along a road to prevent blowing or drifting snow. There are three types of snow fences: structural snow fences (SSFs), living snow fences (LSFs), and standing corn rows (SCRs). Depending on the location, type, and design, a snow fence can be permanent or temporary. Serving as a windbreak to cause windblown snow to deposit in a desired location before reaching roadways, properly sited and designed snow fences have been proven effective in mitigating the negative impacts of blowing and drifting snow, while providing low-cost snow storage (Kumar 2004; Tabler and Meena 2006).

By controlling blowing snow and preventing snow build-up, snow fences reduce travel times, increase driver visibility, improve road conditions, and prevent winter weather–related crashes. Previous research has shown that snow fences also save thousands of taxpayer dollars through less frequent snowplowing, deicing, and infrastructure damage (Wyatt et al. 2012). Snow fences along a section of I-80 in Wyoming reduced crashes during blowing snow conditions by 70% and reduced snow/ice control costs by more than 30% (Tabler and Furnish 1982). Research conducted at the University of Minnesota showed an average benefit-cost ratio of about 17:1 when utilizing living snow fences in lieu of snow removal (Current et al. 2017). Living snow fences also provide wildlife habitat, prevent erosion, sequester carbon, and intercept runoff (Wyatt et al. 2012). Given these benefits and evidence that snow fences decrease snow-control costs, many states in the northern United States have adopted snow fence programs. The Illinois Department of Transportation (IDOT) has installed snow fences along rural highways and freeways, most of which are in districts 3, 4, and 5.

PROBLEM STATEMENT

To achieve the best snow-control effects, the ideal locations for snow fences are usually outside the roadway right-of-way. Therefore, buy-in by private landowners must occur for snow fences to be effective snow-control devices. However, encouraging landowners to participate in a snow fence program has been difficult.

Landowners or farmers sometimes show an unwillingness to cooperate with transportation agencies because of receiving insufficient funds from agencies for the maintenance of snow fences and/or having a dubious attitude to government policies. Few efforts were made to examine the economic efficiency of snow fences and explore ways to reward private landowners. The literature review only

yielded one comprehensive past study sponsored by the Minnesota Department of Transportation on snow fence costs, benefits, and payment structure (Wyatt 2012). This study did not consider SSFs, and the analyses conducted did not follow FHWA benefit-cost analysis (BCA) guides. Research is needed to develop a payment/reimbursement structure to facilitate a win-win situation on both sides and generate participation in the program.

RESEARCH OBJECTIVE

The objective of this project was to develop methodologies for evaluation of the costs and benefits of snow fences in Illinois and identify ways to motivate and reward private landowners' participation in the snow fence program while keeping it cost-effective. The research project answered the following questions:

1. What are the current practices in Illinois and other Midwest states to motivate landowners' participation?
2. What are the best strategies to motivate and reward private landowners and keep the program cost-effective?
3. How do agencies evaluate the safety effectiveness of snow fences in Illinois?
4. How do agencies evaluate the costs and benefits of different types of snow fences in Illinois?

RESEARCH APPROACH

The research approaches in this study were broken into the following five tasks.

1. Literature review: Published literature such as research reports, peer-reviewed journal articles, and conference papers were collected and reviewed to gather information on evaluating the costs and benefits of snow fences.
2. Survey: An agency survey was conducted among state departments of transportation (DOTs) in the Midwest to collect information on their snow fence programs. In addition, a landowner survey was conducted in Illinois to gather information on ways to increase program participation from their perspectives.
3. Data acquisition: Snow fence and blowing snow segment data as well as snow- and ice-related crash data were acquired from IDOT. As cost data were not available for Illinois snow fences, information from reviewed literature and local Illinois rates (labor, equipment, land rental, etc.) were used in the subsequent snow fence benefit-cost analysis, when applicable.
4. Benefit-cost analysis: The BCA of snow fences was conducted through a case study following FHWA guides (Lawrence et al. 2018). First, the costs and benefits items of LSFs, SSFs, and SCFs were identified, then each cost and benefit were quantified in terms of monetary value. Following that, all costs and benefits were converted to present values

and summed up over the analysis period. Finally, the total costs, total benefits, and benefit-cost ratios were calculated to compare the three types of snow fences.

5. Development of a BCA tool: To facilitate the benefit-cost analysis of snow fences, a BCA tool was developed using MS Excel that considers all three types of snow fences and all cost and benefit items identified in the case study.

CHAPTER 2: LITERATURE REVIEW

Previous studies related to snow fence costs, benefits, and economic efficiency were reviewed in the study. This chapter summarizes the literature review findings in terms of general characteristics of snow fences, benefit-cost analysis approaches, as well as previous studies on snow fence financial analysis.

SNOW FENCES

A snow fence deters and disrupts wind velocity and energy by directing the wind around and through the fence, trapping the snow particles behind it and preventing the snow from reaching the adjacent road. Figure 1 illustrates a typical layout of a snow fence and how it works (Heavey et al. 2015). To achieve the maximum snow-control effects, ideally, snow fences are installed perpendicular to the prevailing wind direction, as shown in Figure 1.

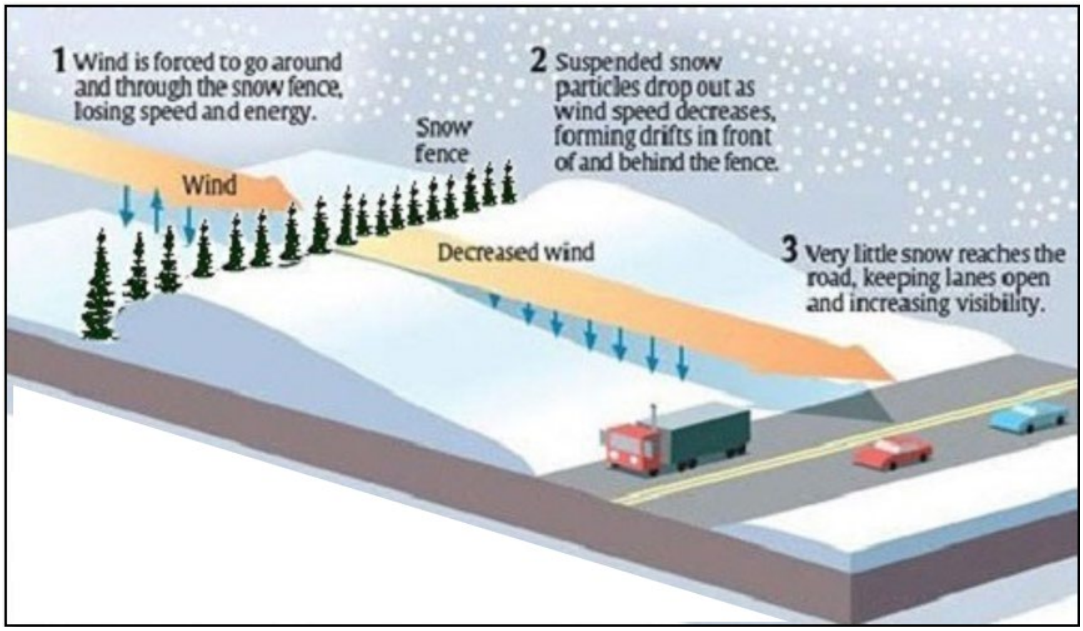


Figure 1. Image. Illustration of the mechanism of a living snow fence.
Source: Wisconsin DOT

There are three main types of snow fences: living snow fences (LSFs), structural snow fences (SSFs), and standing corn rows (SCRs). Table 1 presents an overview of the snow fences as well as their advantages and disadvantages (IOWADOT 2005; Tabler 2003).

Table 1. A brief overview of different types of snow fences

Snow Fence Type	Brief Description	Advantages	Disadvantages
Structural Snow Fence	❑ Made of wood, steel, or plastic and attached with vertical posts to stand firm on the ground. ❑ Height ranges from 6–15 ft.	❑ Occupies less space compared to other snow fences. ❑ Snow control starts immediately after installation.	❑ Requires regular maintenance in windy places. ❑ Comparatively costly construction.
Living Snow Fence	❑ Trees or shrubs planted strategically in rows. ❑ Height depends on the species. Varies from 10–30 ft.	❑ Provides room for wildlife habitat. ❑ Reduces soil erosion. ❑ Low-cost construction.	❑ Takes time (5–6 years) to be mature enough to become an effective snow-control measure.
Standing Corn Row	❑ Unharvested corn rows (6–8 rows) left standing by farmers throughout the winter. ❑ Height ranges from 6–8 ft.	❑ Reduces soil erosion. ❑ Low-cost construction. ❑ Immediate snow control.	❑ Temporary snow-control measure.

BENEFIT-COST ANALYSIS

A benefit-cost analysis (BCA) is the process of identifying and comparing the benefits and costs of a project or a course of action (USDOT 2003). A BCA reveals the most economically efficient option through monetizing different types of benefits by assigning currency value and then comparing them to the required investments to achieve those benefits (Lawrence et al. 2018). Therefore, the BCA approach could be an effective method in choosing the desired alternative or improvement among a pool of available or proposed options. Although BCA might seem similar to life cycle cost analysis, there is a difference between the two approaches. Life cycle cost analysis is an economic method applied to find a suitable candidate for implementation among possible alternatives when they produce identical benefits (USDOT 2003). However, in transportation economics, the alternatives under consideration mostly do not derive the same form of benefits. In that case, the BCA approach is the desired economic tool that should be employed. A BCA might consider the benefits and costs occurring over the life cycle of a project, depending on the type of project and degree of analysis (USDOT 2003).

The USDOT developed the *Economic Analysis Primer* (2003) to provide a foundation for understanding the role of economic analysis in highway decision-making. The primer describes the benefit-cost analysis process, identifies benefit and cost elements to include, and explains how to compare benefits to costs. In addition, FHWA developed the *Highway Safety Benefit-Cost Analysis Guide* (Lawrence et al. 2018) to assist transportation agencies in making investment decisions related to transportation safety projects. It specifies ways to quantify the costs of all potential factors that should be addressed in the project as well as direct and indirect safety-related benefits. Direct safety benefits were derived from the expected difference in crash frequency and severity. Indirect benefits include performance and environmental benefits such as a reduction in delay time, travel time, fuel consumption, and emissions because of fewer crashes and smooth-riding quality of the road surface. The guide illustrates the methods in various scenarios and quantifies monetary values of various items based on the road facility type and crash severity.

PREVIOUS STUDIES

Tabler and Furnish (1982) evaluated the costs and benefits of installing a structural snow fence along a 100 km road segment along I-80 in Wyoming, between Laramie and Walcott. This was the first study on snow fence costs and benefits that considered snow removal expenditures, crash frequency, and road closure criteria. The study estimated a 33% reduction in snow removal costs due to reduced snow drifting in the presence of a structural snow fence and a 70% reduction in crash rates under blowing snow conditions. They projected that the resulting reduced winter maintenance cost and property damage savings will amortize the installation cost of the snow fence within 10 successive years from construction. Daigneault and Betters (2000) also conducted a study on the economic efficiency of Wyoming snow fences. They compared three types of snow fences: a 14 ft high stationary Wyoming wooden board fence anchored with metal posts supported with rebar, a double-row 4 ft high removable slatted snow fence, and a three-row (two rows of conifer trees, one row of shrubs) living snow fence. The study used the snow removal information and crash reduction benefits provided by the agency. The analysis showed that the snow fences were highly effective in harnessing benefits when used for road protection. The main costs for the Wyoming wooden board and double-row slatted snow fences were installation and maintenance, respectively.

More recently, Wyatt et al. (2012) evaluated the economic and environmental costs and benefits of LSFs and SCRs in Minnesota. The snow fences were installed and maintained by the Minnesota Department of Transportation in collaboration with the Farm Service Agency, Natural Resources Conservation Service, and private landowners. Interviews with 45 landowners revealed that their main concerns were many indirect costs not considered in the contract with the agency and that the compensation provided was not enough. Accordingly, payments for farmers (land value changes, production reduction, inconvenience, incentives, etc.) were specified and quantified, along with the crash reduction, reduced travel time, snow removal cost saving, and carbon emissions avoided by snow fences. A new annual payment structure for farmers was developed as well. Snow fence costs and benefits were also examined by a research project sponsored by the New York Department of Transportation. This project mainly focused on designing, developing, and implementing a living snow fence program for New York State. One of the project's tasks was creating a benefit-cost model for LSFs. The benefit-cost model was created by itemizing the costs associated with LSF installation and maintenance as well as snow and ice control. The values of LSFs related to travel time savings and crash reduction were also quantified. Example scenarios run using the model showed that LSFs had positive net present values and benefit-cost ratios larger than one (Heavey et al. 2015).

SUMMARY

The literature review only found four previous studies on the economic efficiency of snow fences. The studies confirmed the benefits of snow fences, particularly blowing snow removal cost saving and crash reduction. The 2012 study conducted by Wyatt et al. is the only one that considered detailed snow fence costs and benefits, including production reduction, changing land value, and farming inconvenience costs, as well as societal and environmental benefits. It also highlighted the importance of paying over market value to increase landowners' participation in the snow fence program.

Tabler and Furnish and Wyatt et al. evaluated snow fence costs and benefits but did not conduct a BCA following the USDOT *Economic Analysis Primer* (2003). Daigneault and Betters as well as Heavey et al. conducted BCAs of snow fences, but the analyses did not follow FHWA's *Highway Safety Benefit-Cost Analysis Guide* (Lawrence et al. 2018) to quantify the safety benefit of snow fences, because the FHWA guide was issued after the studies were conducted. In addition, no previous studies have compared the cost/benefit of SSFs and LSFs. Aimed to fill the knowledge gap, this study conducted BCAs of SSFs, LSFs, and SCRs following the FHWA guide through a case study and compared the results.

CHAPTER 3: SURVEYS

Agency and landowner surveys were conducted to gather information on agencies' snow fence programs and current practices to motivate private landowners, the total costs private landowners take on when participating in a snow fence program, and how landowners perceive snow fences. This chapter presents the procedures followed, including questionnaire development, survey circulation, data collection and compilation, result analysis, and conclusions.

AGENCY SURVEY

During Fall 2018, the research team drafted survey questions and solicited review from the Technical Review Panel (TRP) members and the SIUE Institutional Review Board (IRB). After the TRP was satisfied with the survey and IRB had approved the research procedures, the researchers launched the survey in early 2019. The survey was conducted between January 4–18, 2019, and solicited responses from operations and maintenance engineers working for DOTs within Midwestern states. Surveys were sent via email to 98 officials from 10 states, including Indiana, Iowa, Kansas, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. A copy of the survey questionnaire is included in Appendix A.

A total of 32 complete surveys were returned, including one or more responses from every state. Some states provided responses at the district level, others responded only at the state level, and some provided responses from both perspectives. The response rate was approximately 33%.

Agency Plans for Snow Fence Deployment

The first section of the survey aimed to identify current trends in snow fence programs. One of the first questions asked, "How frequently does your agency/jurisdiction/district use snow fences?" Most respondents (71%) reported plans to either maintain or expand their agency's snow fence program. Figure 2 shows the responses in each category. Of the 20% that reported "other," many described past experiences or trials with snow fences and no plans for restarting a snow fence program.

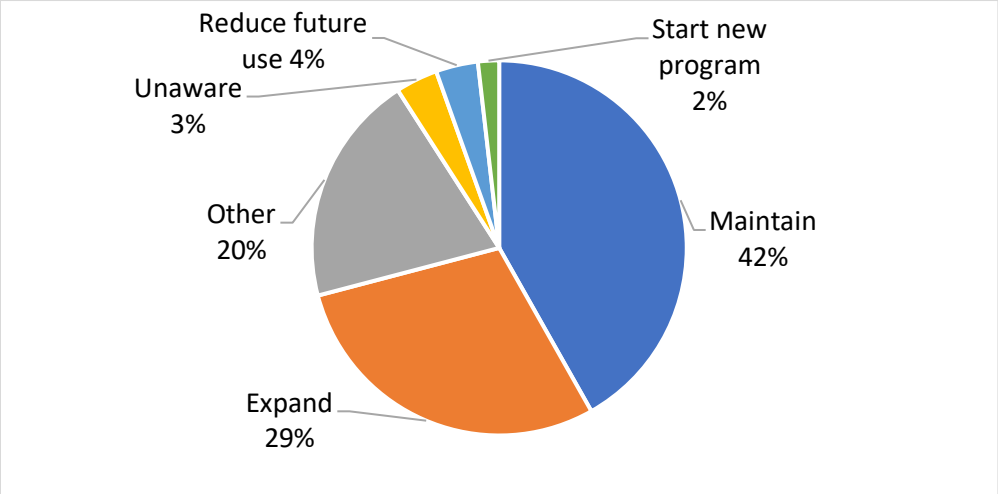


Figure 2. Chart. Agencies' responses about frequency of snow fence use.

Other questions in this section asked, “Approximately how many miles of roadway does your agency/jurisdiction/district operate?” and “Approximately how many miles of roadway have snow drifting problems in your agency/jurisdiction/district?” Presenting these findings is challenging because some respondents represented districts and others represented entire states. Some respondents also provided answers in lane miles and others answered in centerline miles. The overall responses to these questions suggested that snow drifting was a problem on more miles of highway than freeway. These results parallel the operational responsibilities of most road transportation agencies.

Agency Practices

The next section of the survey gathered information about the practices followed by agencies using snow fences. The section started by asking, “Approximately how many miles of roadway have living or structural snow fences in your agency/jurisdiction/districts?” Most answers to this question were dispersed, as some respondents answered with interstate values and others gave state highway values. Nearly half of the respondents did not have documentation about the length of the snow fence installed in their state/jurisdiction. As a result, it was not possible to synthesize the data or compare the proportion of snow drifting areas where snow fences were applied. The respondents provided more firm answers when asked about how they identified the need to install a snow fence in a particular location. About 60% responded that the location is generally identified by visual observation of drifting on the roads. In addition, 16% of respondents analyzed weather-related crash data to identify locations where snow fences might be needed. Figure 3 illustrates the distribution of the responses to this question.

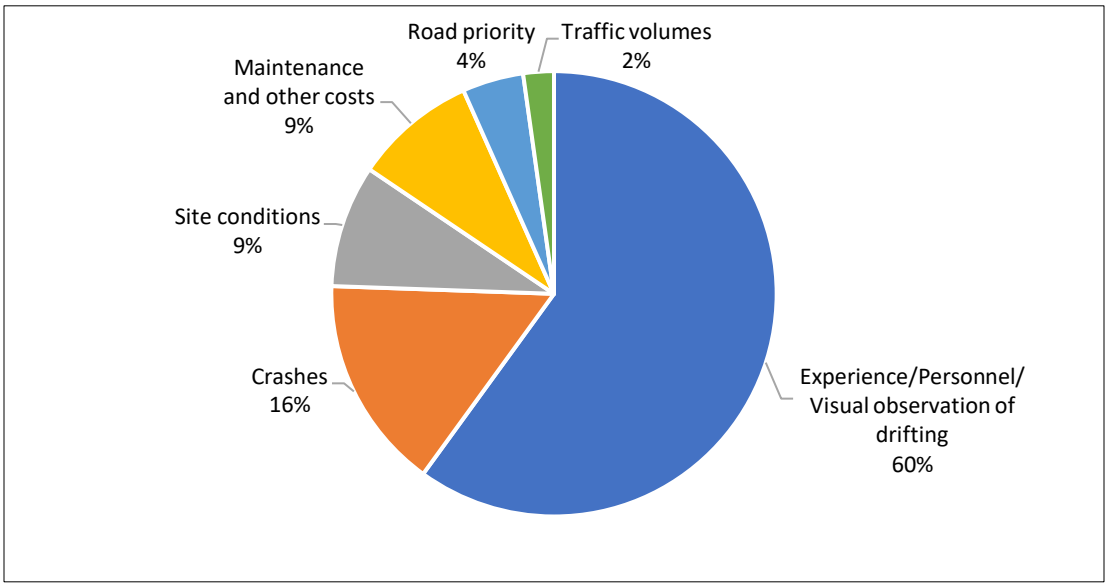


Figure 3. Chart. Agencies’ responses about how they identify snow fence locations.

Next, the survey asked if respondents could provide details or examples of their snow fence contract with landowners. Based on the responses, 12 agencies were willing to share copies of their landowner contracts. The researchers contacted these agencies and reviewed the example contracts.

Many contracts focused on clarifying the responsibilities between the agency and landowners. Details could include land transfer specifics, liability (such as details about flooding), contract termination (e.g., what happens if the DOT has to cut their snow fence program in a certain year), maintenance, rejuvenation, replanting, and/or distance from the right-of-way to the snow fence. One agency included information within their contract about the GPS location of the snow fence. Appendix B includes the received example contracts.

Survey respondents were also asked to recommend best practices to other agencies interested in starting a snow fence program. The top three responses (13% each) were:

- Have plow operators meet landowners face-to-face.
- Snow fence type is a site-specific decision and all options should be considered.
- Establish snow fence location design procedures for the type (e.g., when to consider living versus structural) and distance (from edge of road).

Other recommendations suggested by more than one respondent (6% each) were:

- Use public outreach to share information about the benefits of snow fences.
- Include snow fences within larger projects.

Costs and Benefits of Snow Fences

This section of the survey asked respondents about the annual expenditure of their snow fence program. When asked if changes in land value had any effect on the agency's participation in the snow fence program, the responses suggested little or minor impact. The reported annual costs ranged from less than $1,000 at the district level to $325,000 at the state level. Unfortunately, too few respondents shared this information and no trends were apparent. Most respondents were not aware of the annual expenses of their snow fence program, likely because those costs were included or considered as part of winter maintenance activities.

Next, the survey asked about agency practices using GIS (Geographic Information System) in identifying snow fence location. Responses suggested that more than half had not used GIS for this purpose; 31% were unaware and 28% had never. As shown in Figure 4, the responses indicate limited GIS use for snow fence applications.

Participants were also questioned about the cooperation from local landowners and their attitudes regarding structural and living snow fences. The survey results suggested that landowners do not consider living snow fences as positively as structural snow fences. The responses indicated that 47% of landowners responded negatively and did not plan to participate after being contacted about living snow fences, compared to 17% for structural snow fences. Similarly, 21% of landowners responded positively and participated in a living snow fence program, compared to 66% for structural snow fences. These results suggest a notable difference in public opinion between living and structural snow fences. Responses to other questions indicated that landowners were cautious about the responsibility and liability of maintaining landscaping. The responses for living and structural snow fences are shown in Figure 5 and Figure 6, respectively.

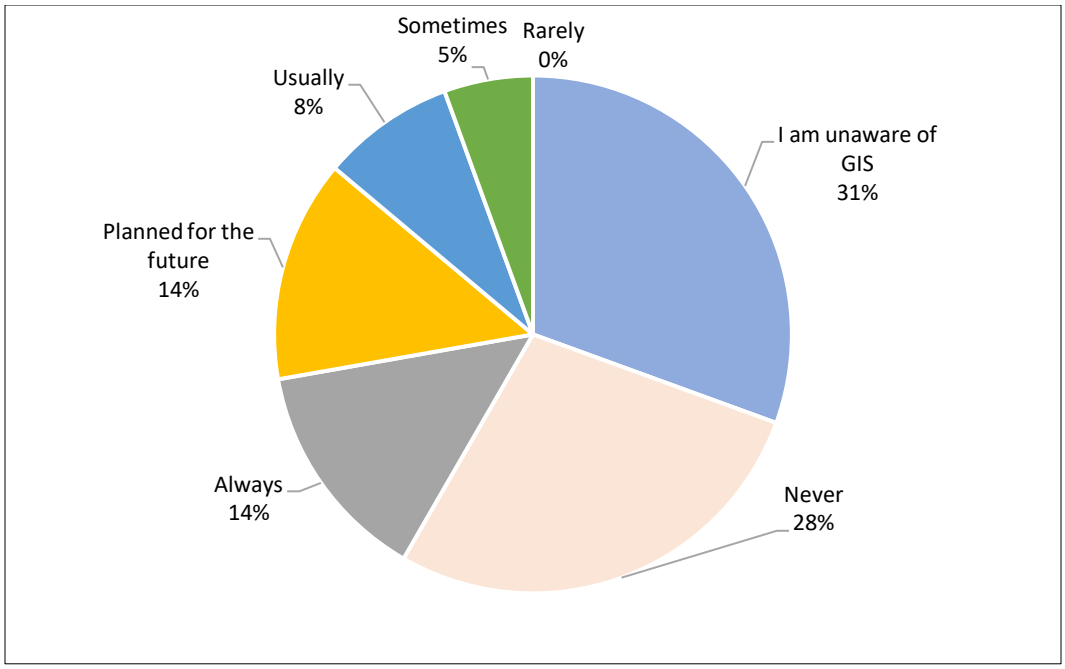


Figure 4. Chart. Agencies' responses about GIS use to identify snow trap/drift locations.

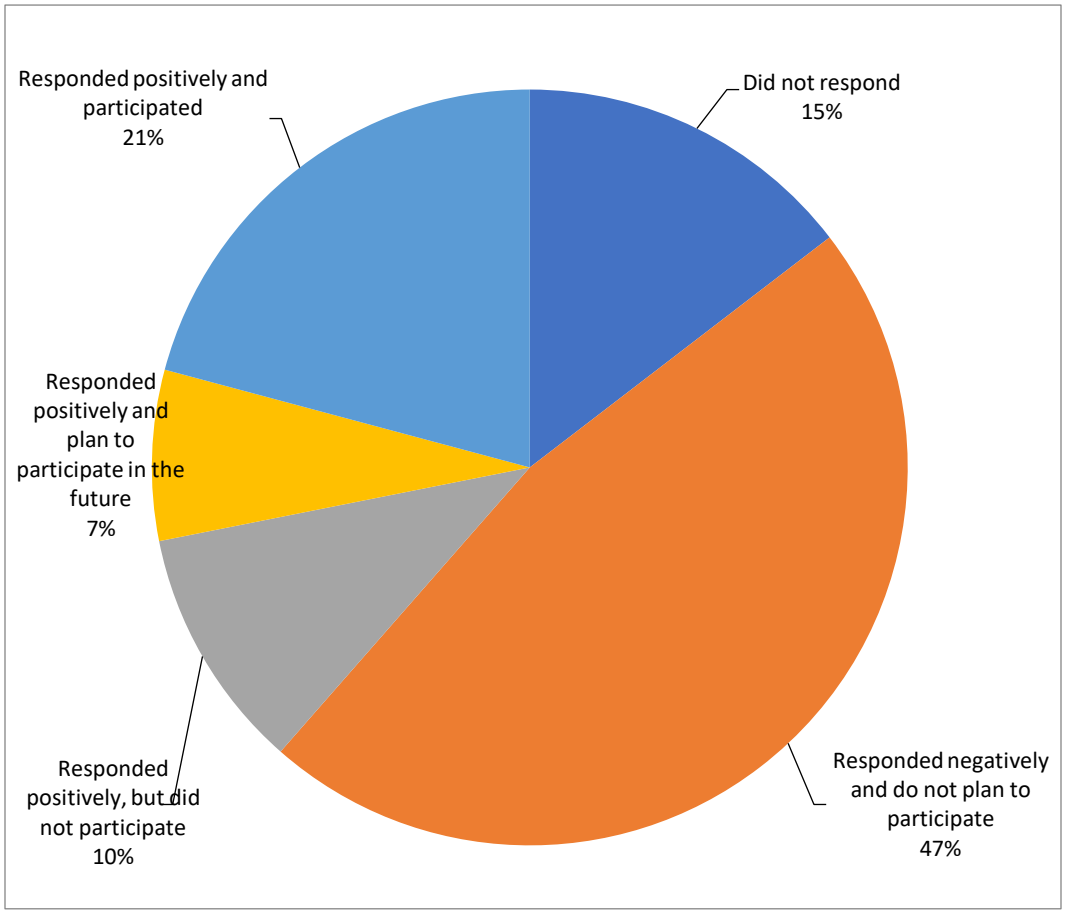


Figure 5. Chart. Agencies' responses about landowners' attitudes toward living snow fences.

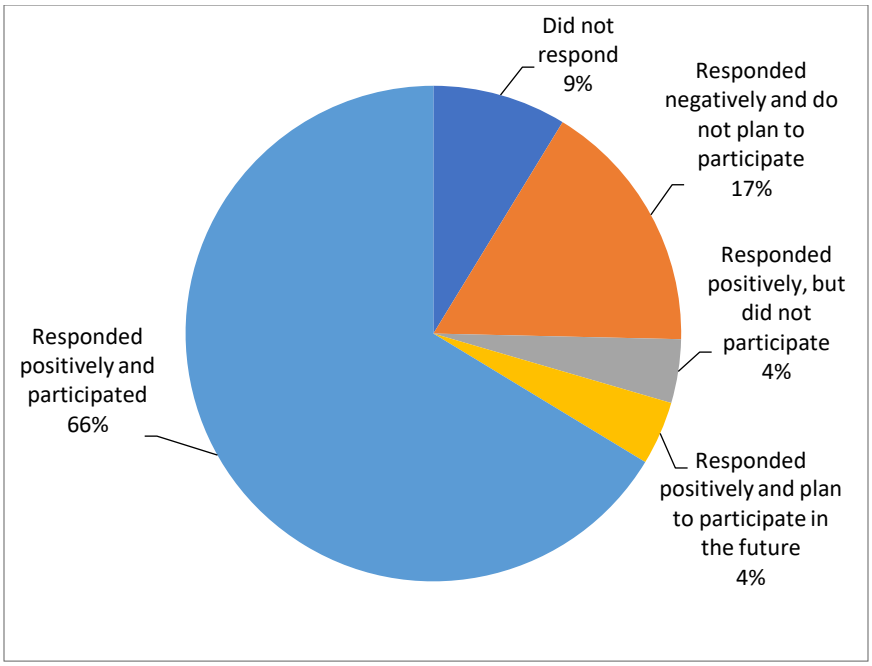


Figure 6. Chart. Agencies' responses about landowners' attitudes toward structural snow fences.

The research team also wanted an updated estimate of the kinds of snow fences used by transportation agencies. The responses revealed that most Midwest DOTs used a form of living snow fence; 35% used plantings of trees and/or shrubs, and 18% used unharvested rows of corn. Many DOTs (29%) reported the use of structural snow fences and several (17%) reported other snow fences, including tall grasses, stacked hay bales, snow ridges, or round bales of corn stalks or hay. Details are shown in Figure 7.

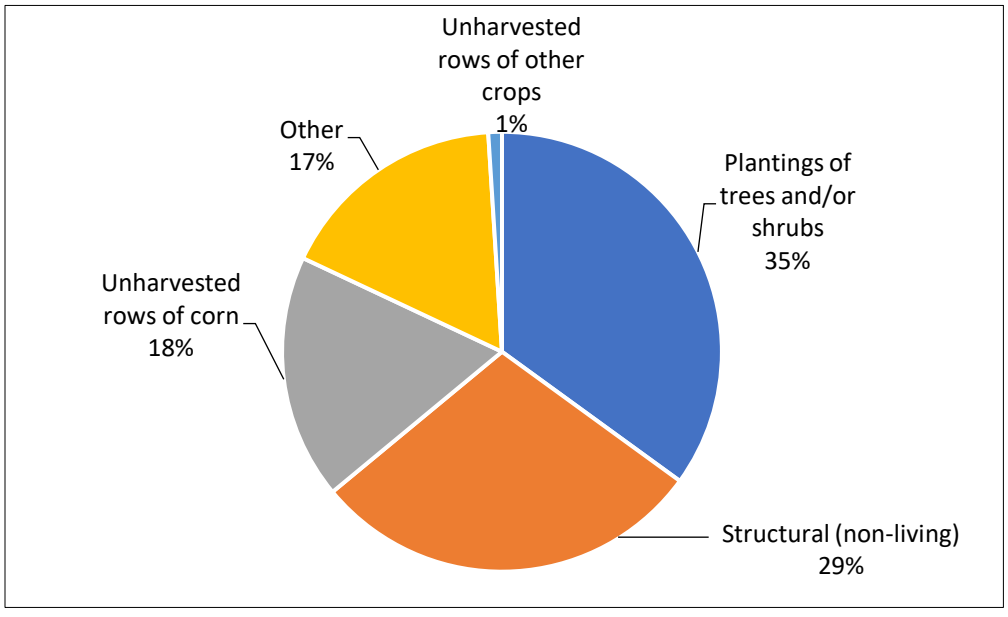


Figure 7. Chart. Agencies' responses about types of snow fences used in their agency/jurisdiction/district.

In response to a request from the project's TRP, the researchers investigated the funding structure of snow fence programs of the surveyed states. The findings suggested an array of practices.

- **Including snow fences as a part of other projects:** For example, when resurfacing a roadway section that has a history of snow drifting, a snow fence should be considered as an addition to that project.
- **Including snow drifting locations into safety improvement projects:** Because of the safety benefits of reducing snow drifting, some agencies leverage these funds to implement snow fences at certain locations.
- **Operation funds:** Some agencies report that traffic operation funds are used to support snow fence installation and maintenance.
- **Creating a pooled fund for snow fences:** One agency has established a pooled fund to support snow fence installation. Deposits are made to this fund when contracts require vegetation be removed from the state right-of-way.
- **Leveraging funding from the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS):** Some agencies leverage funding from the USDA Environmental Quality Incentives Program or the Continuous Conservation Program. In particular, respondents noted that living snow fences are included in NRCS's Continuous Conservation Reserve Program High Priority Practices as number CP17A (USDA n.d.).

The last question in this section of the survey aimed to learn about evidence of snow fence benefits. The survey asked, "Has there been any documented reductions in your agency/jurisdiction/district from implementing snow fences?" The responses indicated that 20% of the respondents had some form of evidence. The researchers contacted these respondents and learned the following:

- A section of I-90 in Wisconsin was evaluated along a horizontal curve before and after snow fence installation. The officials compared the winter-related crashes and saw a 69% reduction. These benefits were estimated to save their agency approximately $1.9 million in incident management costs. Plowing benefits were not assessed.
- A 2.5 mi section of I-94 was evaluated in Minnesota, where the average daily traffic was approximately 30,000. Examining a short period, this agency found a 40% reduction in crash severity, particularly because of less blow-ice events at horizontal curve sections. They also used between 30% and 50% less chlorides. This site will be examined in more detail over a longer period in a forthcoming study to determine these benefits with more certainty.

Landowners' Participation

The final section of the survey aimed to learn how Midwest DOTs solicited landowner participation in their snow fence programs. The survey asked, "How does your agency/jurisdiction/district arrange the use of private lands for your living snow fence program?" Nearly 50% always or regularly used monetary compensation as their primary form of compensation. Approximately 26% always or regularly used easements, and few (4%) regularly purchased land for snow fences. Figure 8 presents these responses.

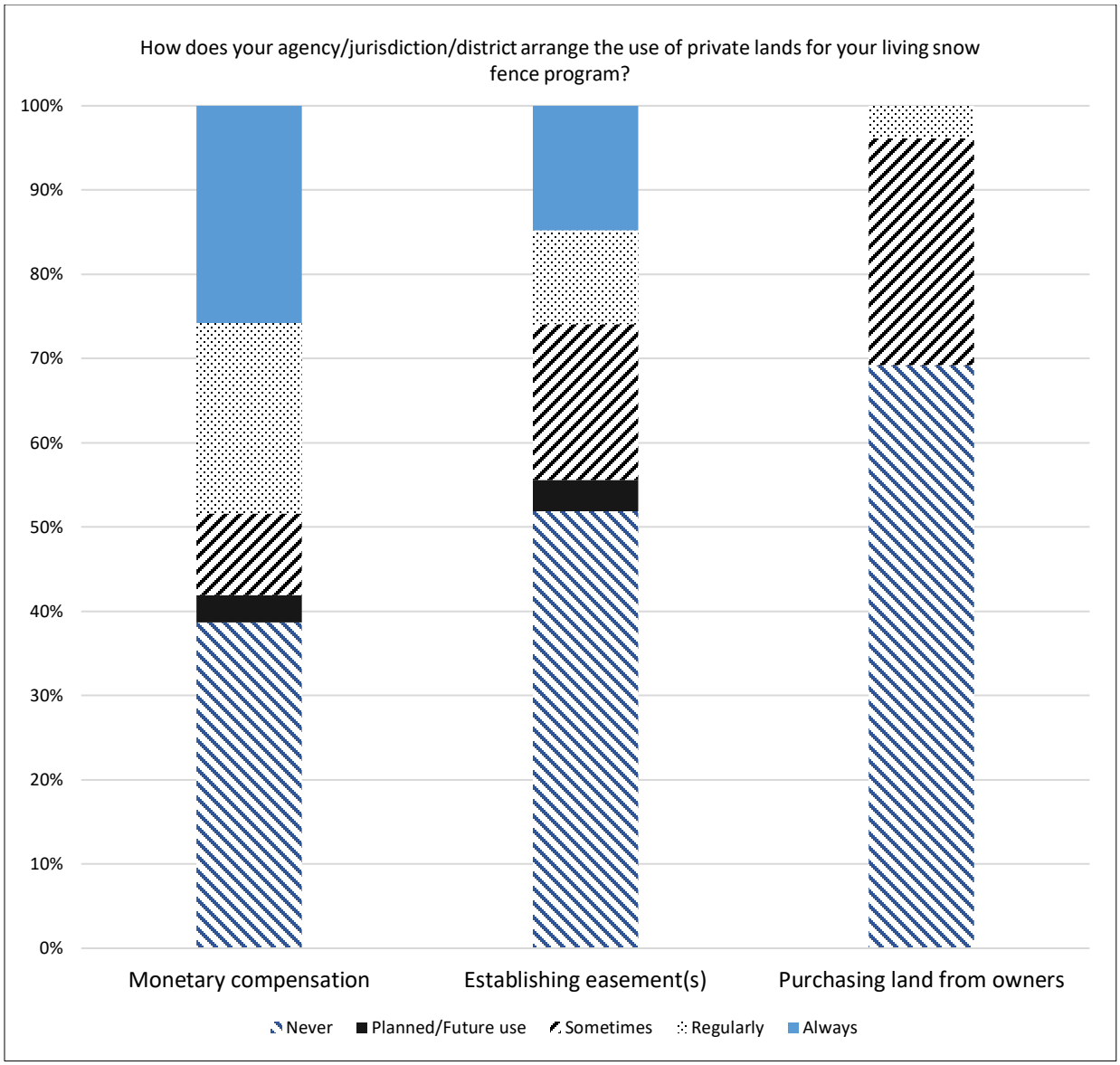


Figure 8. Chart. Agencies' responses about the use of private land for living snow fence programs.

Participants were next asked about how their agency contacted landowners about snow fences and solicited their participation. The findings suggest that field personnel were the most common employees to directly talk with landowners about snow fences, with 6% frequently, 10% regularly, and 39% sometimes. Next, office personnel would sometimes talk to landowners in person (28%) and sometimes or regularly call them on the phone (25%).

The responses also imply that online media was not commonly used to communicate information about snow fences. More than 50% of the respondents selected "never" when they were asked about sharing information on their website or via social media for landowners. More details are shown in Figure 9.

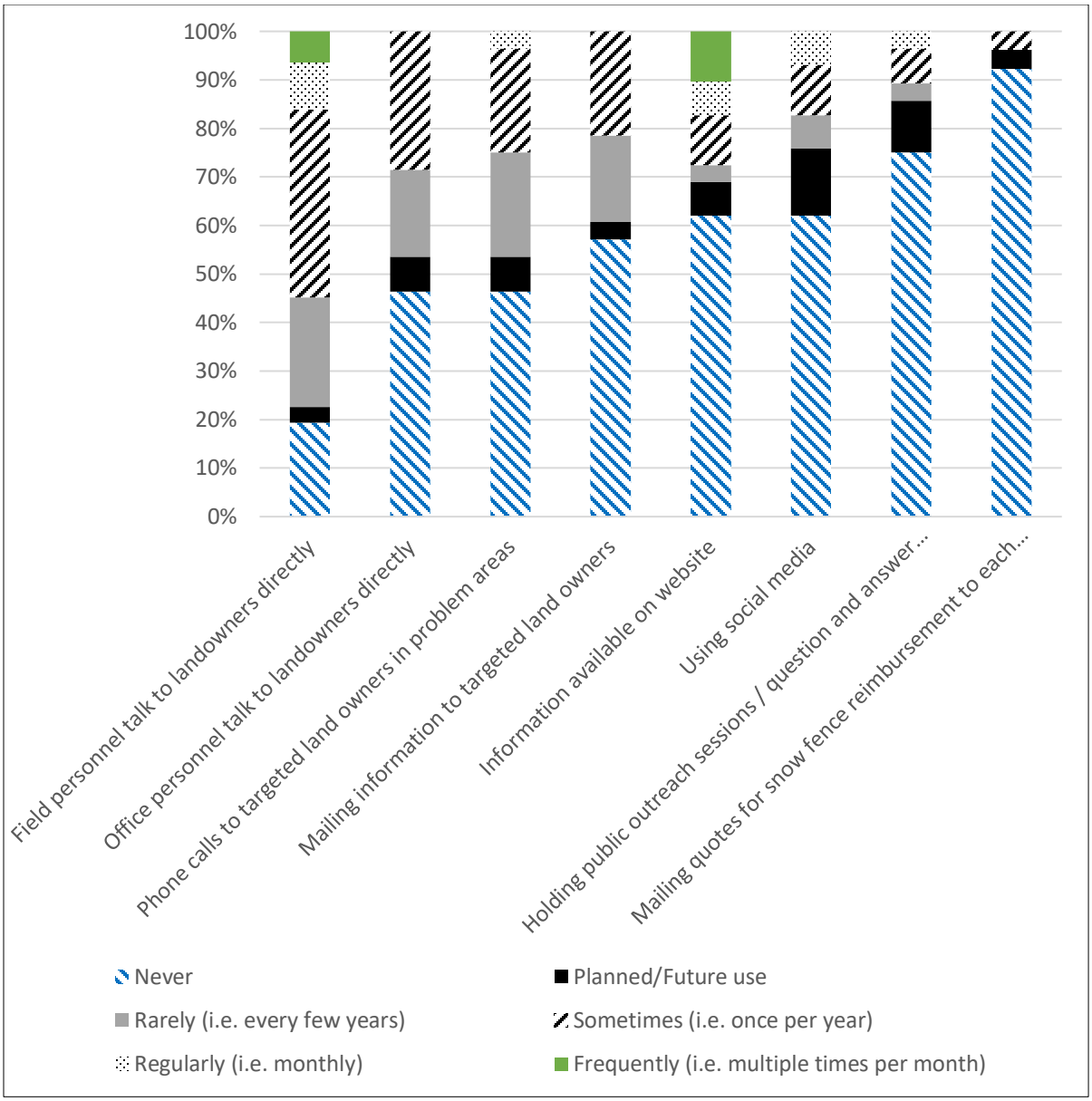


Figure 9. Chart. Agencies' responses about managing contracts with landowners for living snow fence programs.

Because previous studies on snow fences suggested that the type of landowner contact was an important factor, the survey asked about best practices. The importance of this factor was evident by the number of responses we received. This question was rarely skipped.

The top three responses (mentioned by four respondents each) were:

- Knowledgeable: Responses suggest the person be knowledgeable about the benefits of snow fences and about the local history of snow drifting and crashes.

- Farming background: To enable friendly conversation, a farming background was also frequently mentioned.
- Local field staff: This factor is linked to knowledge of the local area and its history.

Other frequent responses (three mentions each) included:

- Friendly
- Outgoing
- Empathetic
- Willing to listen
- Well-spoken

These responses suggest that rapport-building is an important part of the process of developing a business relationship with landowners and farmers. Having common knowledge of farming and local road problems are both important factors.

Summary of Findings

Overall, this survey helped the researchers identify current snow fences practices used by Midwest state transportation agencies. Most respondents (71%) planned to maintain or expand their snow fence programs and many shared best practices learned by their agencies. The best practices included identifying appropriate sites, contacting landowners, considering snow fence types (such as structural versus living), and compensating landowners. To identify prospective snow fence locations, most (60%) relied on experience and feedback from road maintenance personnel. When contacting landowners about installing a snow fence on their property, survey responses hinted that rapport-building was important and recommended face-to-face contact from local DOT personnel. When considering the type of snow fence, survey respondents suggested that although snow fence design decisions are heavily influenced by site-specific factors, a design procedure should be established to help ensure consistency. To fund snow fence construction and to compensate landowners, respondents demonstrated creativity in their funding sources but commonly provided monetary compensation to landowners.

LANDOWNER SURVEY

During 2019, the research team drafted survey questions and solicited review from the TRP members and SIUE IRB. After the TRP was satisfied with the survey and IRB had approved the research procedures, the researchers launched the survey in fall 2019. The survey was conducted between October 17 and December 2, 2019. With assistance from IDOT and the Illinois Farm Bureau, the survey was announced in *Farm Week*, an online publication. The target audience was those owning land adjacent to state and county highways in the state of Illinois.

A total of 375 attempted the survey, but many reported their land was not near state or county highways/freeways. To collect responses only from the target audience, the survey was designed to disqualify those reporting that their land was only adjacent to local roads (not county or state highways/freeways). Those survey participants were sent to the end of the survey where they were thanked for their time. Survey participants were not required to answer all questions and some respondents skipped certain questions. The core questions in the survey received answers from 141

to 79 respondents. The responses included landowners in 46 different counties in Illinois but were more commonly from northern parts of the state. The following sections describe the responses in the same order as the survey. A copy of the survey questionnaire is included in Appendix A.

Landowners' General Opinions of Snow Fences

The first section of the survey aimed to identify common landowner perspectives about snow fences. The first question asked, "If your land was adjacent to a roadway with snow drifting problems and a snow fence was recommend for placement on your land, what types of snow fence would be least intrusive on you and/or your leases? Rank the following, where the rank of one (1) is the least intrusive (most preferred)." Because this question included five categories, the maximum rank was five. Survey respondents could rank all suggested categories (assigning ranks of 1–5) or suggest ranks for only some of these categories (i.e., assigning a rank of five to piles of hay bales). When respondents selected "not a concern," those responses were counted separately.

This question received 138 responses (n = 138) and the average rankings are shown as a grey cross in Figure 10. The vertical line displays the extents of the 95% confidence interval for each average ranking. If the vertical lines of different categories do not overlap (vertically), then the difference in ranking can be considered statistically significant. Categories with overlapping lines cannot be considered different. Overall, these responses suggest that standing corn and structural snow fences were considered the least intrusive and their rankings were statistically similar. Living snow fences with trees were considered the most intrusive and were ranked significantly higher than the other categories.

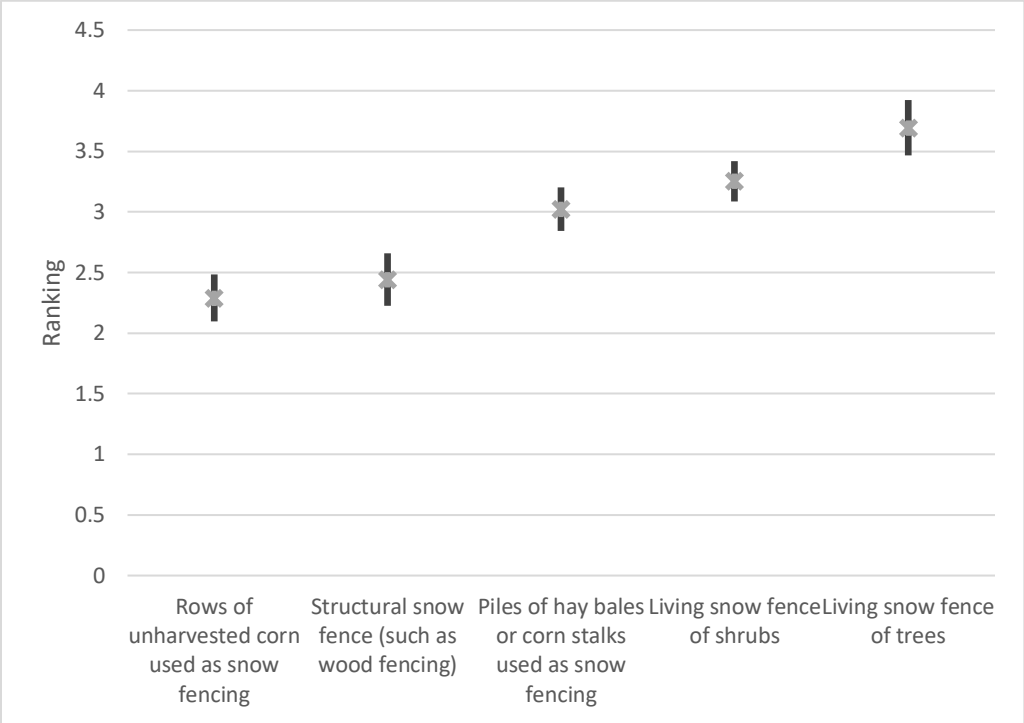


Figure 10. Graph. 95% confidence intervals of types of snow fences considered least intrusive by landowners.

Next, the researchers reviewed the number of respondents who chose “not a concern” to these different types of snow fences. These results are shown in Table 2 and suggest similar opinions as displayed in Figure 10. For example, the most selected category as “not a concern” was structural snow fence.

Table 2. Respondents choosing “not a concern” to “what types of snow fence would be least intrusive”

Type of Snow Fence	Number of Respondents
Structural snow fence (such as wood fencing)	10
Rows of unharvested corn used as snow fencing	9
Piles of hay bales or corn stalks used as snow fencing	6
Rows of unharvested corn used as snow fencing	6
Living snow fence with shrubs	3

Next, the survey asked, “What concerns do you have about entering into a snow fence contract with IDOT or another state agency?” This question was open-ended and allowed respondents to type their answers (n = 98). Researchers identified themes among the responses and created categories for common concerns. The most common concerns are shown in Figure 11 and the most frequent responses related to proper or timely compensation (23 respondents). Several respondents were cautious about receiving timely and/or adequate compensation for their participation. Other frequent responses related to the timing of snow fence installation (21 respondents) and snow fence removal (21 respondents). These findings indicate that respondents were thinking of temporary snow fences. Although the survey had a video describing the types of snow fences in the survey, these responses suggest the participants either did not watch the video or returned to their preconceptions about snow fences. The responses related to snow fence installation frequently identified soil moisture (mud) and crop harvest as key constraints. Responses about removal frequently mentioned soil preparation and planting activities as possible constraints. These are certainly factors to consider when planning a permanent snow fence installation, albeit not an annual issue like for temporary fences.

Less common concerns were combined into the category titled “other” and included the Illinois state budget, drainage problems, the length of the contract, landowner responsibilities, the sturdiness of a structural snow fence, injury to livestock, crop insurance reporting, wildlife impact, aesthetics, and liability. None of these categories had more than two comments. A complete listing of specific comments is included in Appendix C.

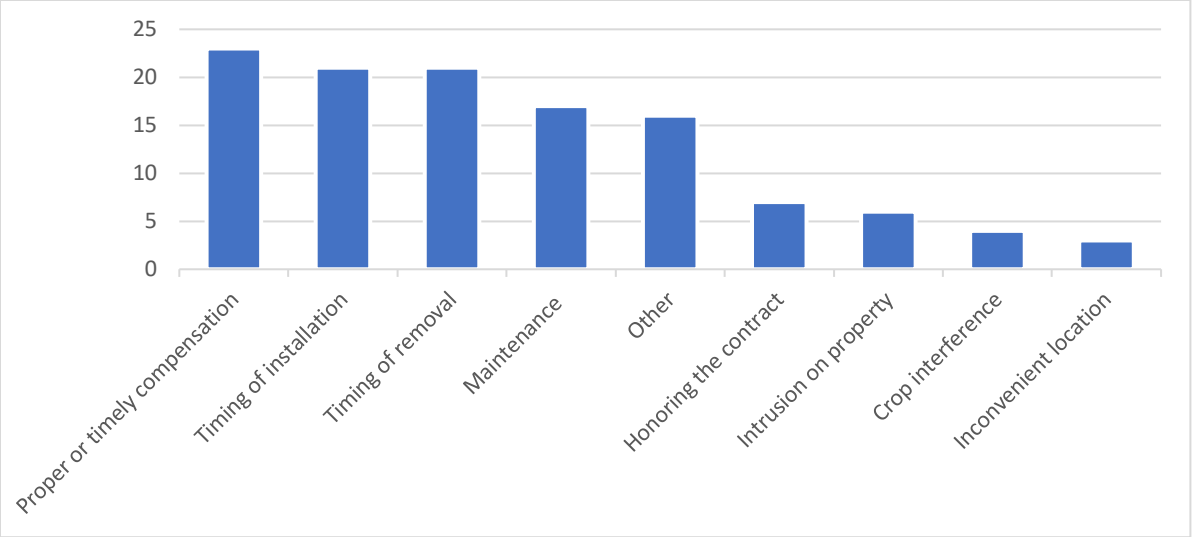


Figure 11. Chart. Landowners' responses about concerns entering into a snow fence contract with IDOT.

The following question in the survey asked, "When considering a payment structure for compensating landowners who participate in living snow fence programs, rank the following factors, where the rank of one (1) is the most important to you." The responses (n = 127) indicate that the most important factor is the acres used (1.9 average ranking), followed by the average crop yield per acre (2.4 average ranking). The survey suggested that the least important factors were updated market prices and which crops were planted.

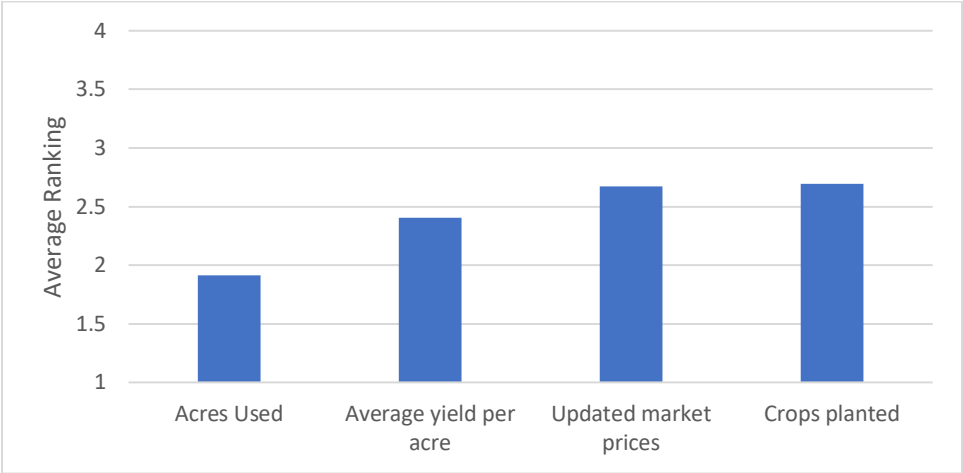


Figure 12. Chart. Landowners' ranked factors when considering a payment structure for living snow fence programs.

The last question in this section was open-ended and asked, "What else should IDOT consider when approaching landowners about possible snow fence partnerships?" The researchers identified themes among the responses and created categories for common concerns. The reported concerns (n = 60) are shown in Figure 13 and have a similar trend as Figure 11. The "other" category included

the following topics, each from just one respondent (See Appendix D for a complete list of these responses):

- Liability concerns
- Willingness to mow standing crops in the spring
- Prefer temporary wooden fence
- Concern about future changes in land ownership
- Provide an option for landowner to install and remove temporary fences
- Could serve as a buffer between organic production crops
- Should investigate the benefits of temporary versus permanent snow fences
- Interested in knowing where LSF seedlings are sourced
- Talk with the tenant first and let them contact the owner
- LSFs should include compact trees/shrubs

Two survey comments suggested that a snow fence program should be coordinated with other government agencies or programs. One respondent said, "potential monetary partnering with FSA on living snow fences within the CRP program." The researchers assume these acronyms mean the Farm Service Agency and the Conservation Reserve Program. The other comment suggested partnering with a Soil and Water Conservation District (SWCD).

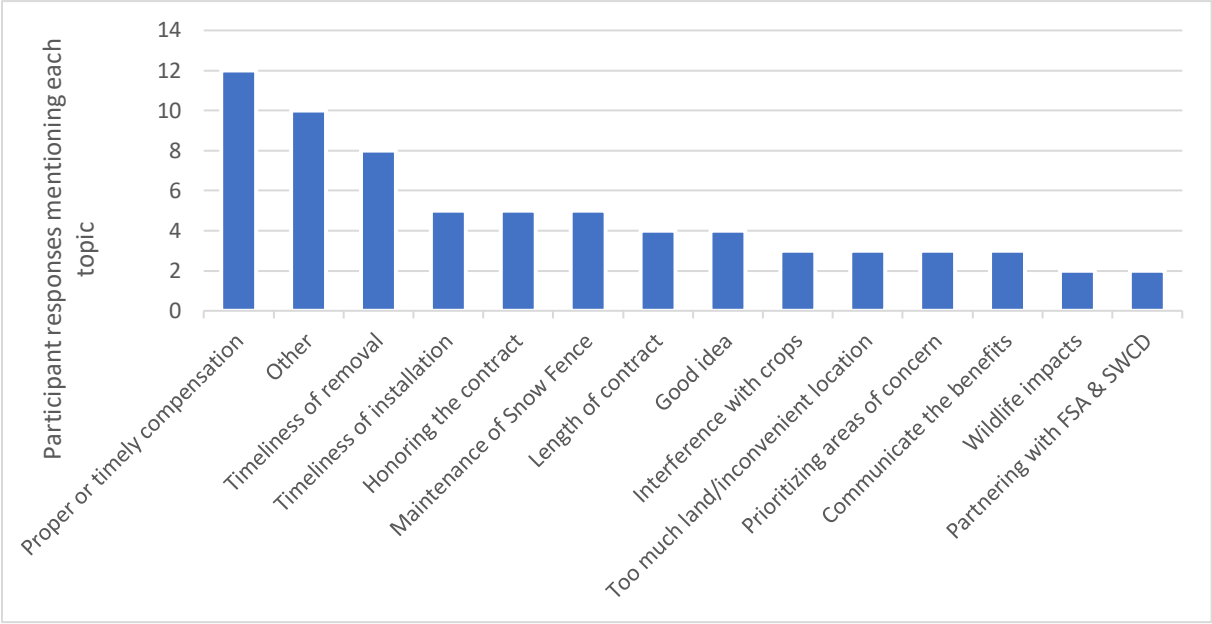


Figure 13. Chart. Landowners' responses to considerations IDOT should have when approaching them.

Although the responses in Figure 11 indicated that timeliness was important for installation and removal of snow fences, the information in Figure 13 indicated that the timing of removal is more important. Many of the comments noted soil moisture content and/or the need to avoid working when the field is muddy. Other comments suggested that some farmers will need annual contracts for living snow fences with corn because of crop rotation, particularly between corn and soy. These responses were, "corn is not a yearly option," "contract lengths will have to be yearly due to corn/soy

rotation," "length of time of contracts and land ownership changes," and "length of contract and removal."

Living Snow Fences with Trees and Shrubs

The next section of the survey asked three questions about living snow fences constructed with trees and shrubs. The first question asked, "What factors would concern you about a living snow fence of trees and shrubs on your land (where you are compensated for maintaining the plantings)? Identify and rank the factors, where the rank of one (1) is the most concerning to you." Respondents had an option to select "not a concern" for any factor and could add their own factor in a category titled "other." Figure 14 displays the responses to this question (n = 98). Note that the grey cross represents the average ranking (where one is the most concerning) and the vertical lines represent the 95% confidence interval of the responses.

The responses indicate a lack of consensus among respondents. The top concern was that LSF plantings could take resources (water, nutrients) needed by growing crops, but this category had an average ranking of 3.3, where 1 was the most concerning. In addition, 10 respondents identified this category as "not a concern." In general, higher rankings (less concerning) were accompanied by an increase in the number of respondents that chose "not a concern." Last, the responses to this question indicated that landowners were not concerned about the application of herbicide near the living snow fence plantings.

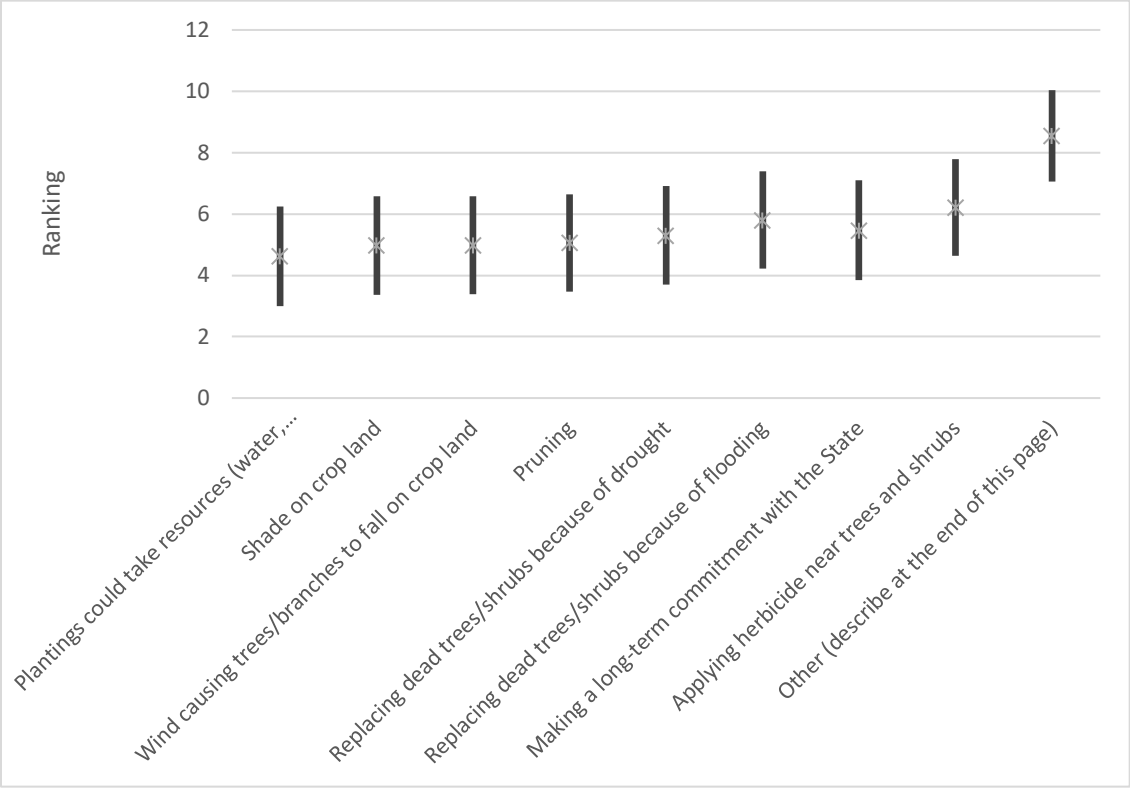


Figure 14. Chart. Landowners' ranked concerns about having a living snow fence with trees and shrubs on their land.

Table 3. Respondents choosing "not a concern" to "living snow fence of trees and shrubs"

Concerns Regarding Living Snow Fences	Number of Respondents
Plantings could take resources from crops	10
Shade on crop land	11
Wind causing trees/branches to fall on crop land	6
Pruning	7
Replacing dead trees/shrubs because of drought	10
Replacing dead trees/shrubs because of flooding	15
Making a long-term commitment with the State	7
Applying herbicide near trees and shrubs	9
Other	25

The survey also asked, "For living snow fences that consist of planted trees and shrubs, which costs concern you most? Identify and rank the cost categories, where the rank of one (1) is the most concerning to you." The responses (n = 95) are shown in Figure 15 and, similar to the previous question, the grey cross represents the average ranking and the bars represent the 95% confidence interval (where one is the most concerning). The responses show a clear trend and indicated that the top concerns were loss of revenue (2.3 average ranking) as well as maintaining (2.6 average ranking) and implementing (2.6 average ranking) living snow fences. Because the confidence intervals overlap, these categories cannot be considered different. Removing and rejuvenating these types of snow fences were considered significantly less concerning to the survey respondents. The "other" category was significantly less concerning than any other category.

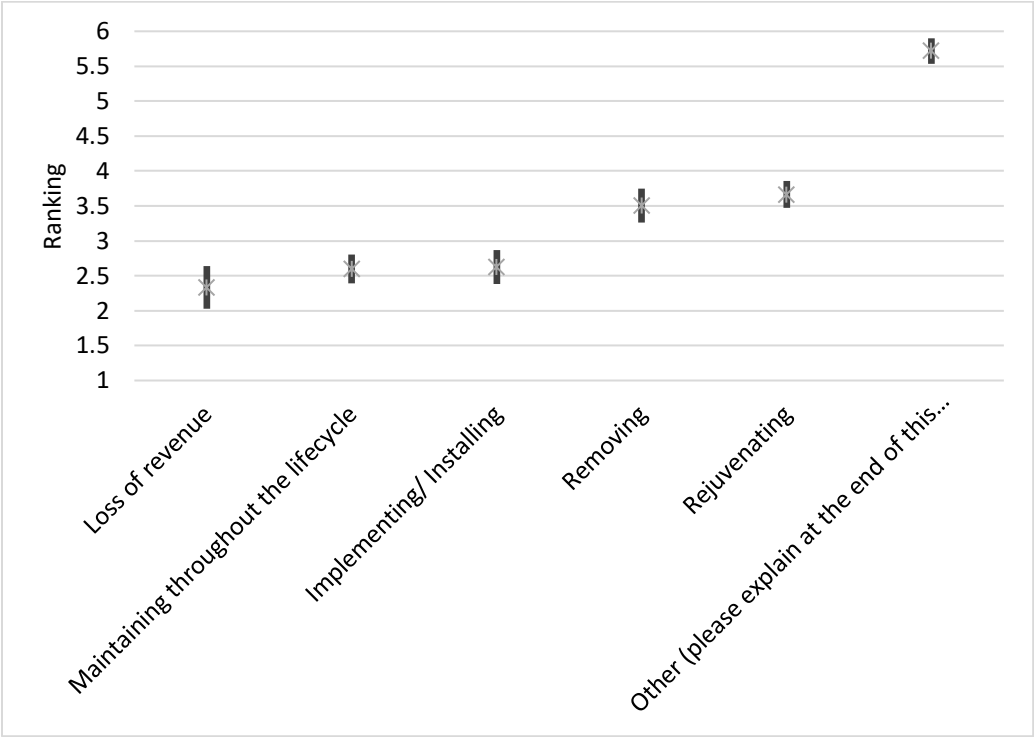


Figure 15. Graph. Landowners' ranked cost concerns about living snow fences with planted trees and shrubs.

Table 4. Respondents choosing "not a concern" to "living snow fences that consist of planted trees and shrubs"

Cost Concerns Regarding Living Snow Fences	Number of Respondents
Loss of revenue	9
Maintaining throughout the lifecycle	5
Implementing/ Installing	3
Removing	5
Rejuvenating	4
Other	23

Respondents who chose the "other" category for LSF questions were asked to provide details in an open-ended question. Analysis suggested a large variety of answers, and the researchers were challenged to identify patterns in the responses (n = 23). Table 4 shows categories for common responses. Topics identified by only one respondent were combined into the "other" category and included the following general phrases about LSFs:

- Might worsen existing drainage problems
- Might require chemical application
- Could be a wildlife benefit
- Concerned about lack of maintenance by DOT
- Not visually appealing
- Difficult to remove when contract expires
- Needs appropriate compensation
- Establish a boundary program for the open crop land
- DOT should maintain LSF for first few years
- CRP programs should be consolidated
- No problem with this option

Living Snow Fences with Standing Corn Rows

The next section of the survey measured landowner opinions about using standing corn rows (SCRs) for living snow fences. The first question in this section asked, "If your land was identified as a great place to leave rows of corn standing for snow fencing, what factors would concern you? Identify and rank the factors, where the rank of one (1) is the most concerning to you." Responses (n = 89) are displayed in Figure 16 and suggest that removing corn rows in the spring (average ranking 2.2) and crop rotation (average ranking 2.4) were the two most concerning factors. Like previous figures, the responses are shown in 95% confidence intervals.

These rankings relate to comments in other parts of the survey. Several comments noted that high soil moisture complicates the ability to work in the fields during the spring. Farmers also commonly rotate crops and do not grow corn in consecutive years. The number of respondents selecting "not a

concern" is shown in Table 5 and reveals a similar trend. For example, the most concerning factor (removing corn rows) had the fewest survey respondents who selected "not a concern" (10).

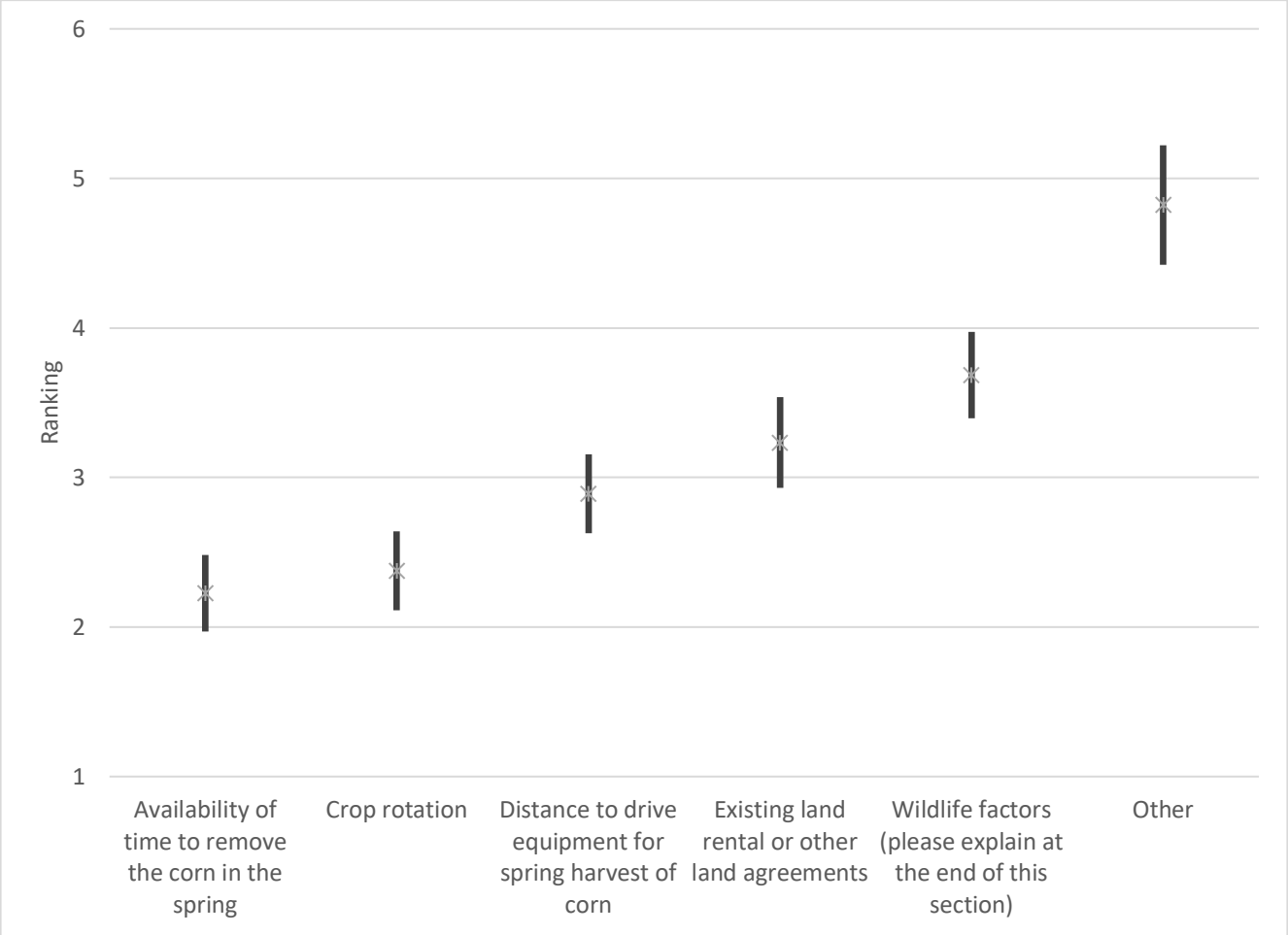


Figure 16. Graph. Landowners' ranked concerns about leaving rows of corn standing for snow fencing.

Table 5. Respondents choosing "not a concern" to "if your land was identified as a great place to leave rows of corn standing for snow fencing, what factors would concern you?"

Factors of Concern Regarding SCR Snow Fencing	Number of Respondents
Availability of time to remove the corn in the spring	10
Crop rotation	13
Distance to drive equipment for spring harvest of corn	17
Existing land rental or other land agreements	19
Other	19
Wildlife factors	21

The survey then asked, "For snow fences created from corn rows left standing, which costs concern you most? Identify and rank the cost categories, where the rank of one (1) is the most concerning to you." The results (n = 88) indicate that the costs of snow fence removal (1.5 average ranking) and the

loss of revenue (average 1.5 average ranking) were the two most important concerns, as shown in Figure 17. Although soil moisture was identified as a strong concern (see Figure 16) in previous questions, these findings suggest that soil moisture is not well correlated to the costs of living snow fences of standing corn rows.

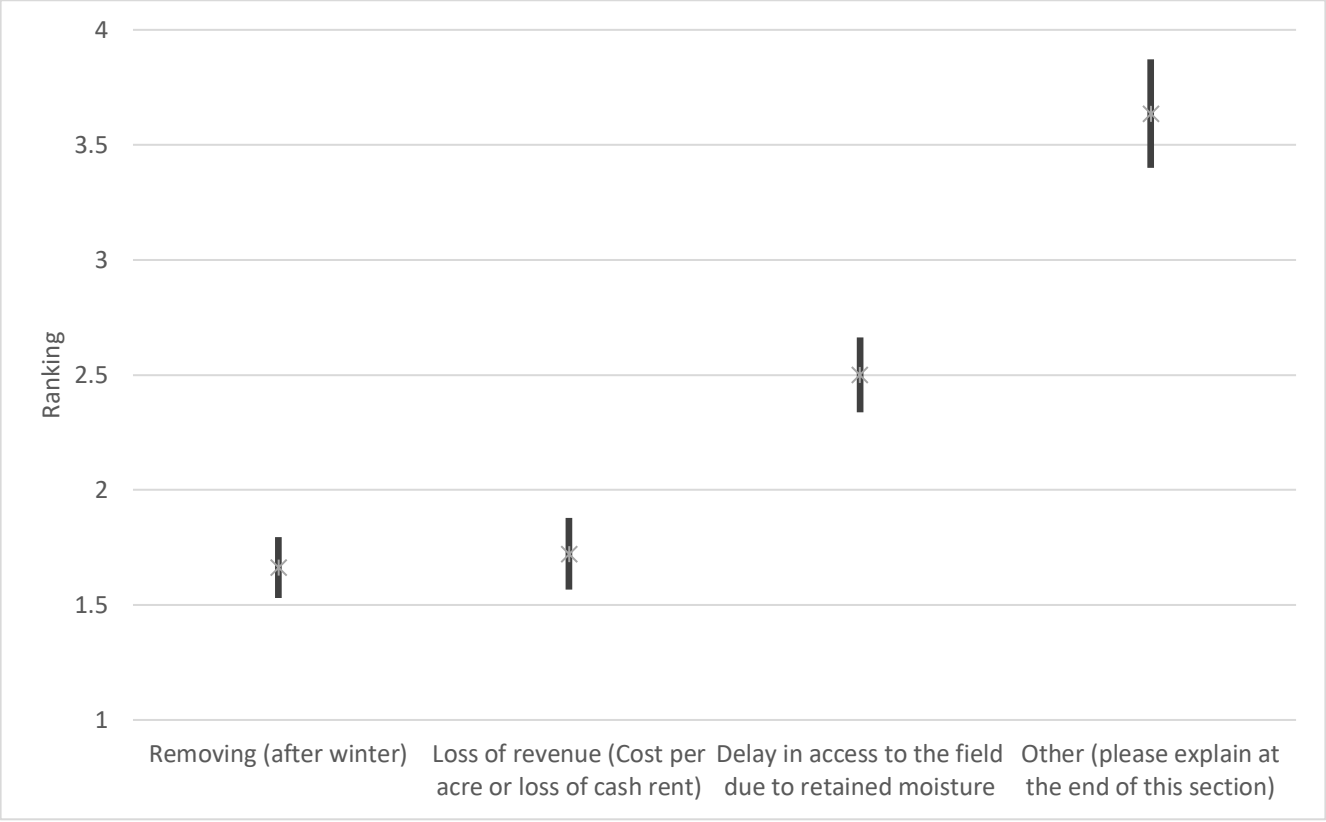


Figure 17. Graph. Landowners' ranked cost concerns about snow fences created from corn rows left standing.

Table 6. Respondents choosing "not a concern" to "snow fences created from corn rows left standing, which costs concern you most?"

Cost Concerns Regarding SCR Snow Fencing	Number of Respondents
Removing (after winter)	10
Loss of revenue (cost per acre or loss of cash rent)	11
Delay in access to the field due to retained moisture	10
Other (please explain at the end of this section)	21

The last question in this section asked respondents to provide details about any of their LSF responses, including their use of the "other" option (n = 24). The most frequent suggestion (four respondents) was that IDOT should consider crops other than only corn. Suggestions included soy, sorghum, Sudan hybrids, and sunflowers. Similar to responses to other questions, removing standing corn in the spring was a key concern. In addition, some commented about the difficulty of cleaning a combine a second time in the spring.

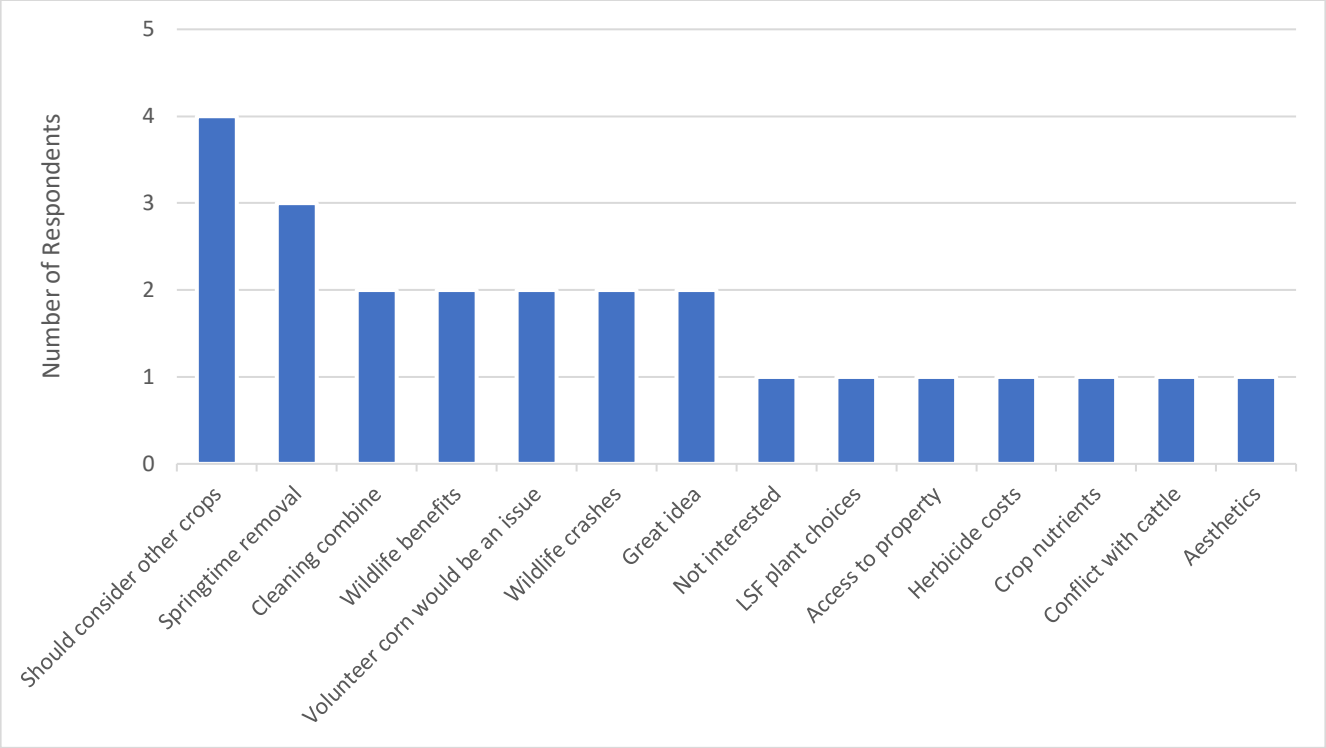


Figure 18. Chart. Survey comments about leaving corn standing to serve as snow fencing.

Structural Snow Fences

The next section of the survey aimed to measure landowner perspectives on structural snow fences (SSFs). The first question in this section asked, "If your land was identified as a great place for a structural snow fence (i.e., made from metal or wood), what factors would concern you? Identify and rank the factors, where the rank of one (1) is the most concerning to you." Figure 19 displays the responses (n = 81), where the grey squares represent the average ranking for each factor and the lines represent the 95% confidence intervals. The responses suggest that respondents were similarly concerned about property damage caused during installation or removal of a SSF (2.2 average ranking), difficulty harvesting crops near a SSF (2.3 average ranking), and making a long-term commitment with the state (2.6 average ranking). Because the confidence intervals of these rankings overlap, they cannot be considered statistically different.

The remaining categories were ranked significantly higher, indicating they are more concerning. These include existing land rental agreements (3.4 average ranking), the impact on livestock, etc. (3.8 average ranking), and other factors (5.4 average ranking). The other factors are summarized at the end of this subsection, but their rankings indicated significantly less concern than all other categories.

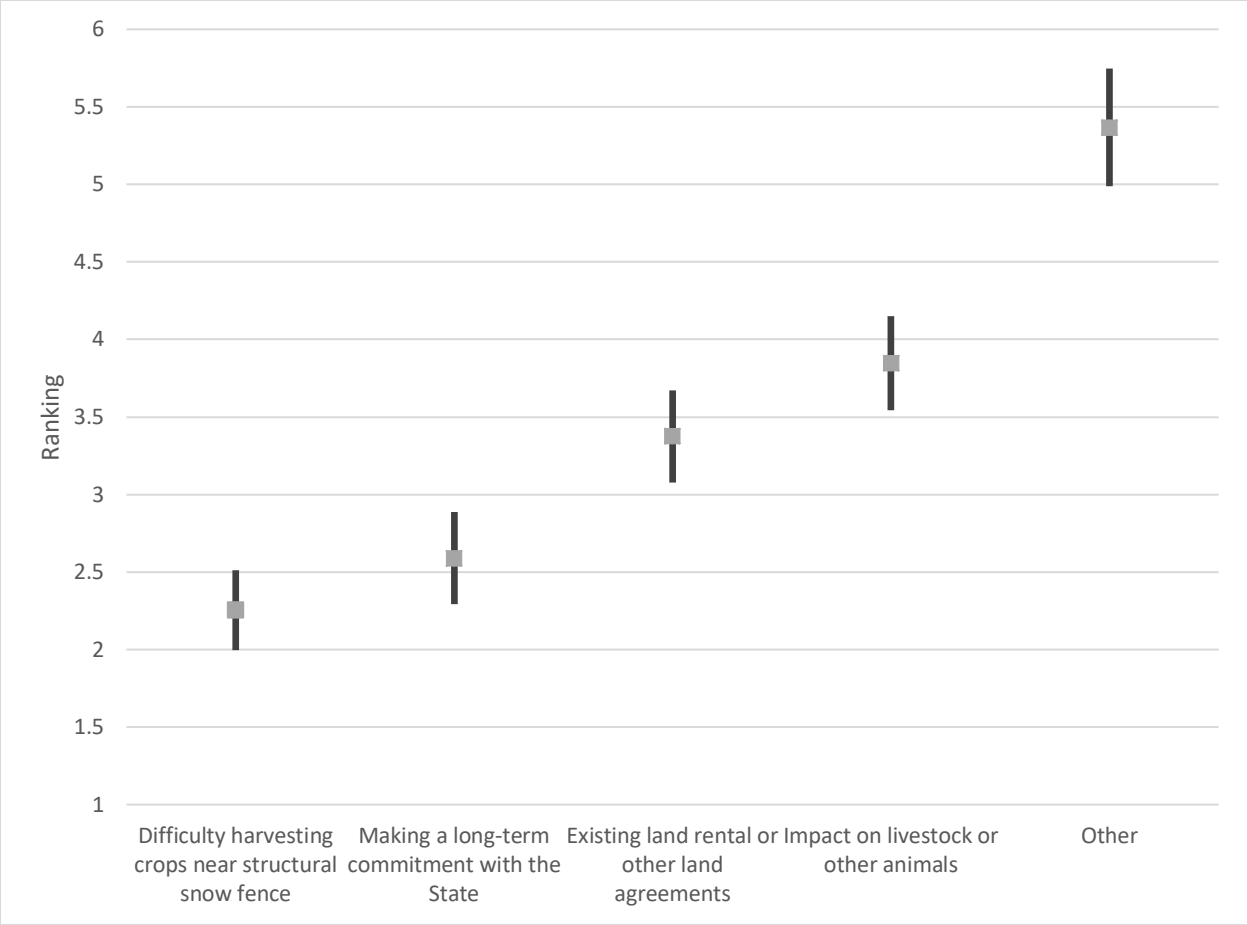


Figure 19. Graph. Landowners' ranked concerns about the use of structural snow fences on their land.

Table 7 shows the number of respondents choosing "not a concern." These responses suggest a similar ranking of concerns. Specifically, "property damage," "making a commitment," and "difficulty harvesting" were the least frequently marked as "not a concern." In addition, the "other" category was most frequently marked "not a concern."

Table 7. Number of respondents choosing "not a concern" to structural snow fence factors

Factors of Concern Regarding Structural Snow Fences	Number of Respondents
Property damage during installation and removal of structural snow fence	9
Making a long-term commitment with the State	9
Difficulty harvesting crops near structural snow fence	13
Existing land rental or other land agreements	18
Impact on livestock or other animals	25
Other	29

The next question in this section of the survey focused on the perceived landowner costs of allowing SSFs on private property. This question asked, "For structural snow fences, which costs concern you most? Identify and rank the cost categories, where the rank of one (1) is the most concerning to you."

Figure 20 illustrates the responses (n = 81), where the confidence intervals are the same as the previous figures. The responses identified that implementing the snow fence (1.8 average ranking) and loss of revenue (1.9 average ranking) were the two most concerning costs. Removing the snow fence (2.3 average ranking) was significantly less concerning than the first two categories and other factors (3.8 average rating) were significantly less concerning than all other categories.

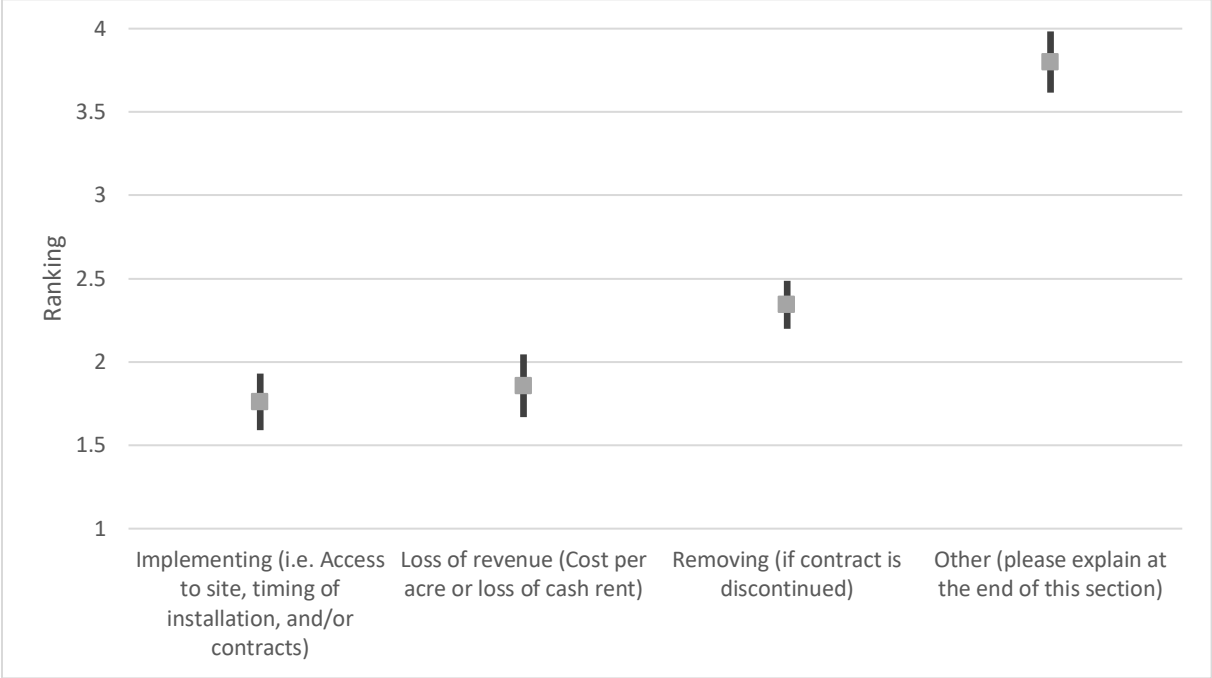


Figure 20. Graph. Landowners' ranked cost concerns for structural snow fences.

The number of respondents choosing "not a concern" suggests a different ranking of the cost concerns. Specifically, the costs of removal and the loss of revenue traded places in the ranking. Implementation remained the most concerning cost and the "other" category remained the least concerning. Because the ranking in Figure 20 is supported by a larger sample size and includes a consideration of statistics, the trends are a better predictor of landowner opinion.

Table 8. Number of respondents choosing "not a concern" to structural snow fence cost concerns

Cost Concern Regarding Structural Snow Fences	Number of Respondents
Implementing (i.e. access to site, timing of installation, and/or contracts)	5
Removing (if contract is discontinued)	6
Loss of revenue (cost per acre or loss of cash rent)	12
Other (please explain at the end of this section)	22

The last question in this section of the survey allowed respondents to provide comments or give details about the "other" option from the previous two questions about SSFs. The responses (n = 10) were reviewed and categorized. Figure 21 shows the responses, where the most common feedback was concerns that the transportation agency would not properly maintain the SSF and several noted they prefer temporary SSFs.

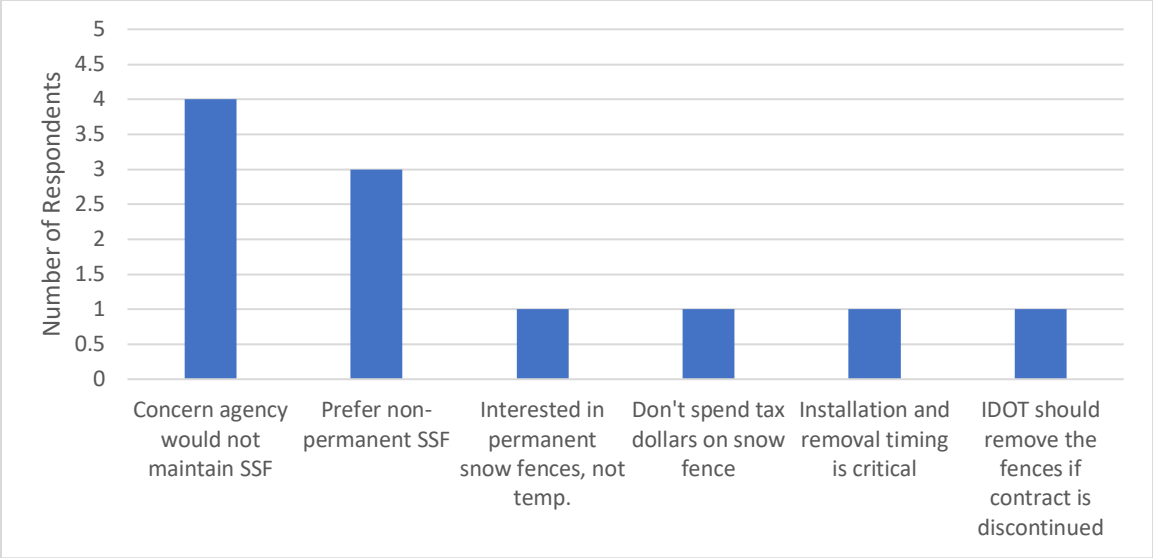


Figure 21. Chart. Details about landowners' responses regarding structural snow fences.

Respondent Information

The last section of the survey asked several questions about the respondents, their knowledge of snow drifting problems, and the general location of their land. The first question asked, "Based on your local knowledge of local weather and snowfall, are you aware of locations in your community where snow drifting onto the roads is an issue? If so, please describe where." The survey received input from 40 respondents, but no patterns emerged. The responses are listed in Appendix D. Next, the survey asked, "How is your land used currently? Select all that apply." The responses (n = 83) were overwhelmingly farming, which is likely a result of advertising the survey in *Farm Week*. Of those choosing "other," several noted their land is simply residential property or was previously, but not currently, used for farming.

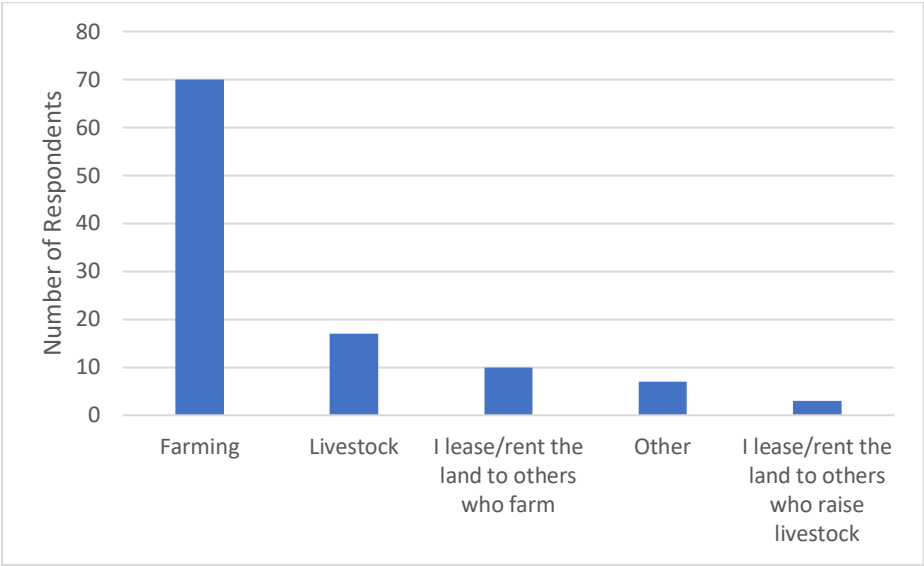


Figure 22. Chart. Landowners' responses about their current land use.

The next question asked, “How important is nature conservation to you?” The responses (n = 85) suggest an overwhelming majority (88%) considered nature conservation important, as shown in Figure 23.

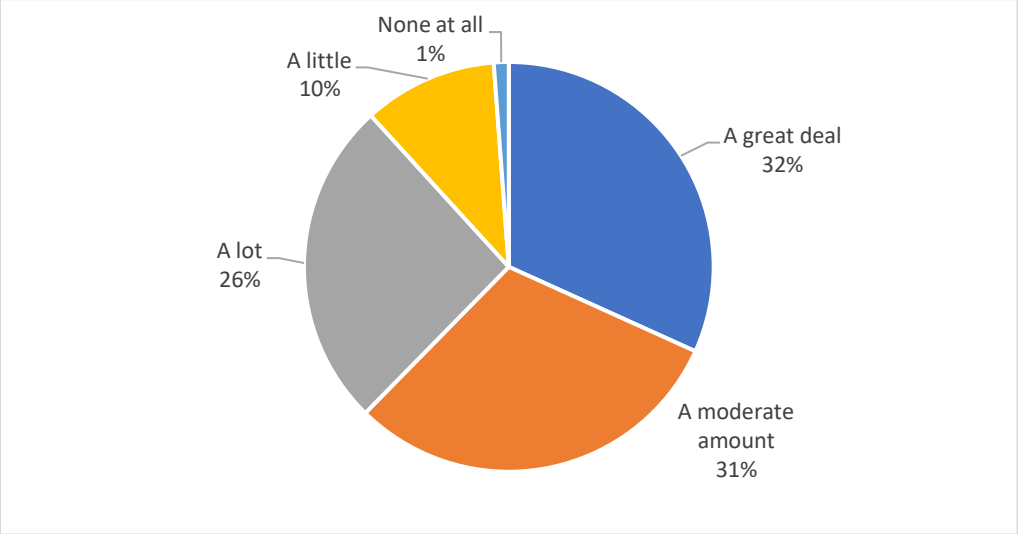


Figure 23. Chart. Landowners’ responses about the importance of nature conservation.

Next, the survey asked respondents which Illinois county they reside in and if they own land in other Illinois counties. Figure 25 displays the responses (n = 83) on an IDOT district map. The responses for residence and secondary land ownership were combined. As shown, the responses are well-distributed throughout the northern parts of Illinois, including 46 counties, which supports the validity of the survey sample.

The next question asked, “If your land is used for farming, what is usually planted? Select all that apply.” Figure 24 shows more than 97% of respondents (n = 76) reported growing corn, 93% reported growing soy, and 21% reported growing wheat. Based on the known agricultural activities in Illinois, these responses are expected and support the validity of the survey sample.

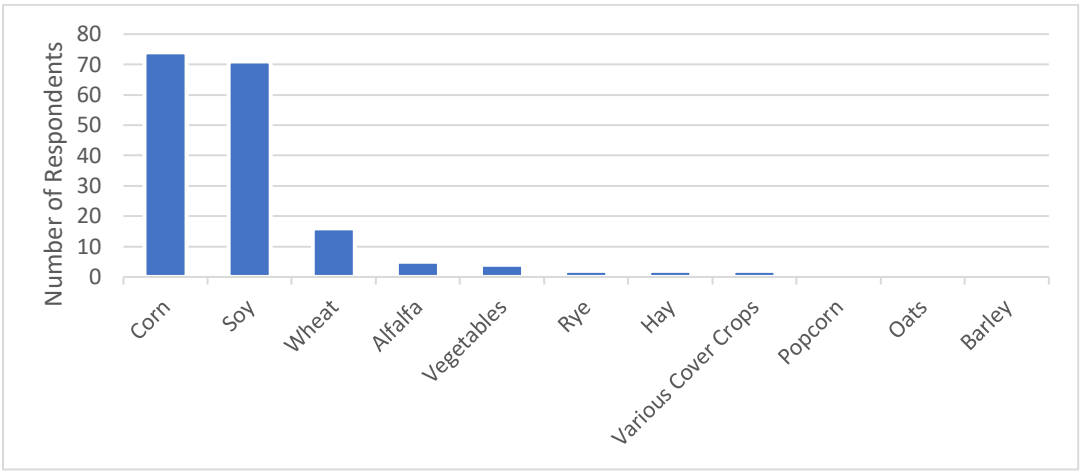


Figure 24. Chart. Landowners’ responses about types of crop planted if their land is used for farming.

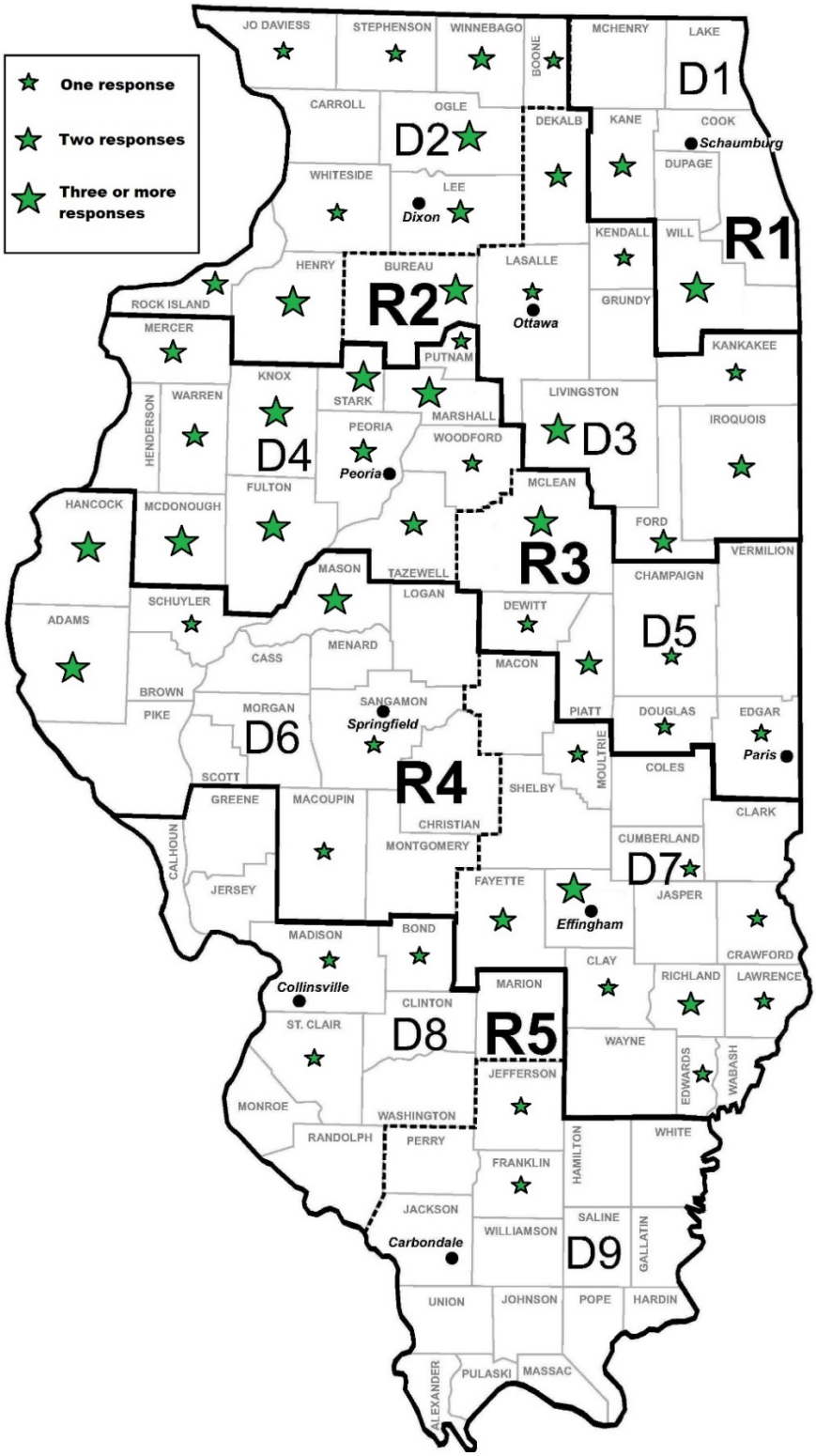


Figure 25. Map. Survey respondents' land locations.
Source: Adapted from IDOT

Summary of Findings

Overall, the survey responses provide valuable information about Illinois landowner perspectives of snow fences. The distribution of landowner locations throughout Illinois and the crops they grow indicate the survey reached the target audience. Analysis of the responses and consideration of the sample size both support the assertion that the survey results represent a valid sample of landowners adjacent to highways or freeways in Illinois.

Key landowner concerns included compensation, implementation, and maintenance. Proper and timely compensation was the most common concern when considering whether to enter into a snow fence contract, and the number of acres used was the most important factor to include in a payment structure. Implementation was also a common concern among landowners. Specifically, the timing of installation was mentioned in several comments about interference with harvest or avoiding periods when fields are too wet. Last, landowners frequently reported concerns that IDOT would maintain the snow fence adequately.

The survey also asked questions specific to different types of snow fence. Responses suggest that standing corn rows and structural snow fences were the least intrusive options and trees were the most intrusive. Specific to living snow fences with trees and shrubs, landowners expressed a desire to play a role in the plant-selection process. Responses indicated shrubs were more preferred than trees, the source of the seedlings was important to landowners, and the compactness of the plantings was important. Landowners expressed some concerns about plantings taking resources (water, nutrients, etc.) from adjacent crops.

When asked about living snow fences made from standing rows of corn, responses frequently noted the challenges of removing the corn after winter. Challenges included timing the removal around fertilizing and other spring work, timing the removal between rain events so the soil is not too wet, and mobilizing/cleaning a combine again. Respondents suggested that IDOT should consider other crops, in addition to corn, for living snow fences.

For structural snow fences, concerns included harvesting adjacent crops, damaging property during installation, and making commitments with the state. Responses about property damage indicated concerns about construction activities compacting soil in the farm field and timing activities to avoid periods of high soil moisture.

The survey responses also identified several locations in Illinois where snow fences might be considered to address blowing snow issues. A copy of the survey questionnaire and the recommended locations are included in Appendix A and B, respectively.

CHAPTER 4: DATA DESCRIPTION

Four sets of data were obtained from IDOT for this research. These datasets included snow- and ice-related crash data, blowing snow segment data, snow fence segment data, and blowing snow removal cost by team sections across the state for the 2017–18 winter season. Crash, blowing snow segment, and snow fence segment data were used to calculate the snow fence crash modification factor (CMF). Cost data were used to determine the blowing snow removal per lane-mile cost. This chapter describes the data used in the study and presents the procedure followed to determine the snow fence CMF as well as blowing snow removal per lane-mile cost and results.

CRASH AND SEGMENT DATA

Snow- and ice-related crash data were collected from IDOT districts 2, 3, 4, and 5 from 2012 to 2016. Data about blowing snow segments were obtained from IDOT districts 4 and 5. Last, snow fence segment data were gathered from IDOT districts 2, 4, 5, and 6. The data were cleaned, filtered, and compiled. Then, the cross-sectional method was applied to calculate the Illinois snow fence CMF.

Data Preparation

All crash and segment data acquired were in .shp files and were visualized in GIS using the 2018 Illinois roadway system as a base layer. Figure 26 and Figure 27 present the locations of blowing snow and snow fence segments, respectively, based on available data obtained from IDOT. Note that only a small portion of blowing snow segments are protected by snow fences. Figure 28 shows the locations of snow- and ice-related crashes that occurred in IDOT districts 2 through 5 during 2016. Most of the crashes occurred in urban areas. Similar patterns were obtained for snow- and ice-related crashes in 2012–2015.

Snow fences only work during blowing snow events; therefore, the calculation of the snow fence CMF only requires blowing snow crashes, not all snow- and ice-related crashes. To identify only the blowing snow crashes, the snow- and ice-related crashes were filtered using the following criteria:

- Crashes that occurred between October 1 and April 1.
- Crashes that occurred during and within two days of a snowstorm (defined as any snow event with snow precipitation >= 2 in. and a wind speed >= 5 mph).

Historical weather data were obtained from the National Center for Environmental Information by the National Oceanic and Atmospheric Administration to identify snow event dates based on the above criteria.

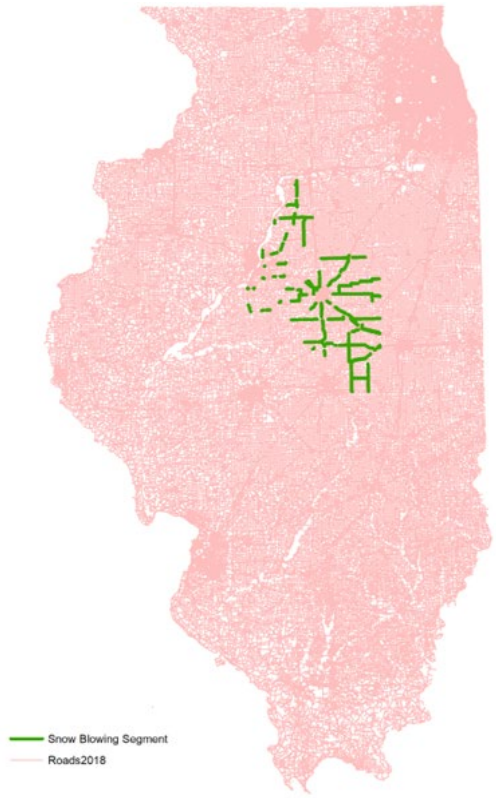


Figure 24. Map. Blowing snow segments in districts 4 and 5.

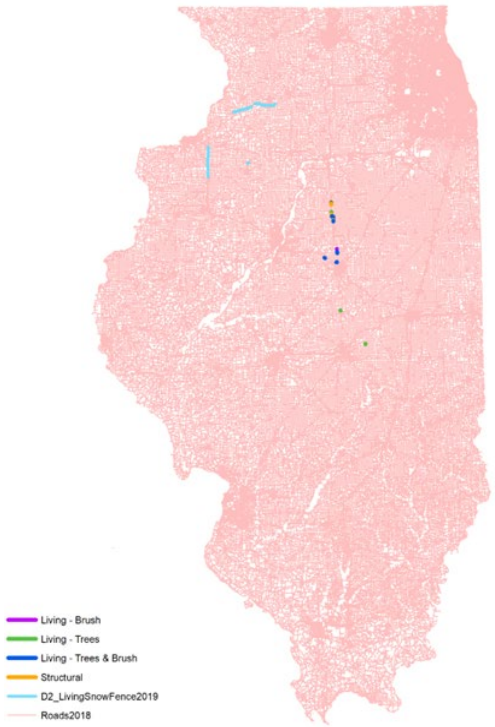


Figure 25. Map. Snow fence segments in districts 2, 4, 5, and 6.

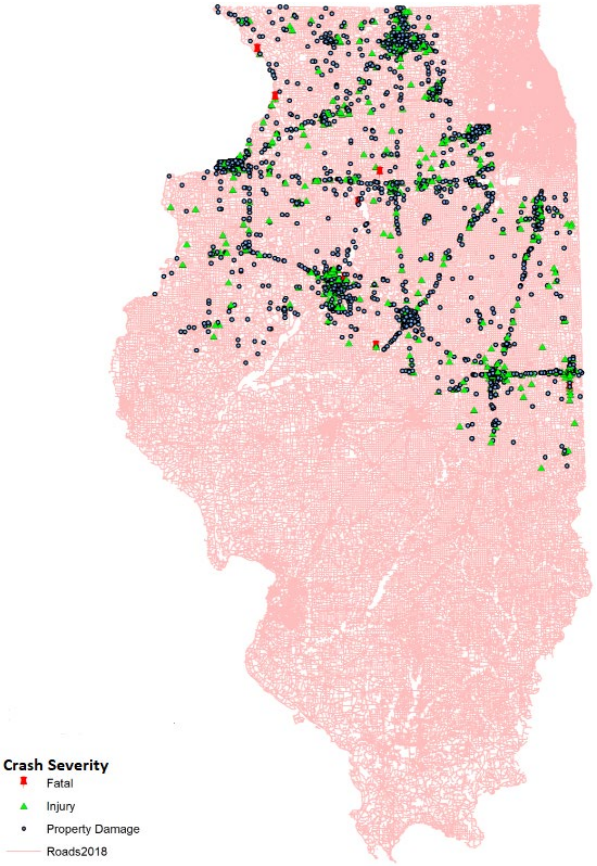


Figure 26. Map. Crashes in districts 2 through 5 in 2016.

Combining the filtered crash data, data from blowing snow and snow fence segments were compiled in terms of location, segment length, roadway classification, number of lanes, average annual daily traffic (AADT), as well as crash frequency and severity (see Table 9 and Table 10).

Table 9. Snow fence segment characteristics

Fence type	County	District	Length (ft)	AADT	Classification	Lane condition	Crashes	KABCO
LSF	Marshall	4	1,896	17,700	Interstate	2 lanes in each direction with median strip	3	3 PDO
LSF	Marshall	4	15,578	17,700	Interstate	2 lanes in each direction with median strip	2	2 PDO
SSF	Woodford	4	5,349	16,500	Interstate	2 lanes in each direction with median barrier	4	4 PDO
LSF	Woodford	4	938	16,500	Interstate	2 lanes in each direction with median barrier	1	1 PDO
LSF	Woodford	4	3,604	16,500	Interstate	2 lanes in each direction with median barrier	1	1 PDO
LSF	McLean	5	4,237	20,700	Interstate	2 lanes in each direction with median barrier	3	3 PDO
LSF	McLean	5	1,785	No info	Exit Ramp	Exit ramp from I-39 to I-55 a normal	3	3 PDO

Table 10. Blowing snow segment characteristics

County	District	Length (ft)	AADT	Classification	Lane condition	Crashes	KABCO
Marshall	4	4,306	2,000–2,600	Undivided rural	1 lane in each direction	5	1 B, 4 PDO
Marshall	4	33,793	2,300	Undivided rural	1 lane in each direction	2	1 B ,1 PDO
Marshall	4	26,812	<1,000	Undivided rural	1 lane in each direction	2	1 C, 1 PDO
Woodford	4	16,484	3,550	Undivided rural	1 lane in each direction	1	PDO
Woodford	4	15,277	3,000	Undivided rural	1 lane in each direction	1	B
Woodford	4	9,941	6,000	Major collector (non-rural)	1 lane in each direction	4	3 PDO, 1 K
Woodford	4	34,627	800	Major collector (non-rural)	1 lane in each direction	1	PDO
McLean	5	12,867	22,200	Interstate	2 lanes in each direction with median barrier	1	PDO
McLean	5	6,588	46,000	Interstate	2 lanes in each direction with median barrier	28	19 PDO, 2 A, 5 B, 2 C
McLean	5	6,779	20,700	Interstate	2 lanes in each direction with median barrier	2	1 A, 1 K
McLean	5	4,475	20,700	Interstate	2 lanes in each direction with median barrier	2	2 PDO
McLean	5	17,148	18,200	Interstate	2 lanes in each direction with median barrier	9	7 PDO, 2 B
McLean	5	35,929	3,050	Principal arterial	2 lanes in each direction with median barrier	6	4PDO, 1 B, 1 K
McLean	5	7,677	24k–26k	Interstate	2 lanes in each direction with median barrier	16	13 PDO, 2 A, 1 C
McLean	5	41,129	26,600	Interstate	2 lanes in each direction with median barrier	31	28 PDO, 1 A, 2 B
McLean	5	8,579	24,300	Interstate	2 lanes in each direction with median barrier	5	4 PDO, 1 A
McLean	5	10,983	24,300	Interstate	2 lanes in each direction with median barrier	7	4 PDO, 2 A, 1 B
McLean	5	3,575	24,300	Interstate	2 lanes in each direction with median barrier	1	PDO
McLean	5	10,429	26,700	Interstate	2 lanes in each direction with median barrier	10	7 PDO, 3 B
McLean	5	12,930	38,00	Interstate	2 lanes in each direction with median barrier	8	8 PDO
McLean	5	12,197	25,100	Interstate	2 lanes in each direction with median barrier	7	7 PDO
McLean	5	4,732	24,000	Interstate	2 lanes in each direction with median barrier	2	2 PDO

Calculation of Crash Modification Factor

The cross-sectional approach was applied in the study to calculate the snow fence CMF, because no crash data before the implementation of snow fences were available to use the *Highway Safety Manual* (*HSM*) recommended Empirical–Bayesian (EB) method. CMFs from cross-sectional studies were developed by comparing the safety of a group of sites with and without a treatment. The CMF can be derived by taking the ratio of the average crash frequency of sites with treatment to the average crash frequency of sites without treatment. For this method to work, the two groups should have similar characteristics, except for the treatment. This is difficult to accomplish in practice, and multiple variable regression models are used. These cross-sectional models are also called safety

performance functions (SPFs). SPFs are mathematical equations that relate crash frequency with site characteristics. The coefficient of the variable associated with a treatment from the SPF is used to estimate the CMF associated with the treatment (Carter et al. 2012).

The facility types considered by SPFs in the *HSM* are two-lane road, multi-lane road, and different types of intersections in rural and urban areas. In this study, all snow fence segments are on interstates; therefore, the SPF for rural multi-lane roadway segments was used, which is in an exponential function format (Figure 29). After incorporating the snow fence treatment variable, the SPF is expressed in Figure 30.

$$N = e^{(a+b.Ln(AADT)+Ln(L))}$$

Figure 27. Equation. Rural multi-lane roadway segment SPF.

where, N is number of crashes, AADT is average annual daily traffic, L is length of the road section in miles, and a and b are model coefficients.

$$N = e^{(a+b.Ln(AADT)+Ln(L)+c.S)}$$

Figure 28. Equation. Rural multi-lane roadway segment SPF incorporating snow fence treatment variable.

where, S is snow fence treatment variable and c is model coefficient.

Take the *Ln* of both sides of the equation and then the SPF was in a linear format as shown below:

$$Ln(N) = a + b\ Ln(AADT) + Ln(L) + c.S$$

Figure 29. Equation. Rural multi-lane roadway segment SPF in a linear format.

All snow fence and blowing snow segments with two lanes in each direction were used to estimate the model coefficients a, b, and c. For snow fence segments, S was coded as "1," while S was coded as "0" for blowing snow segments (no snow fence treatment). The generalized linear regression procedure in SAS was used to fit the model (equation), and the maximum likelihood method was used to estimate the model coefficients (Table 11).

Table 11. Estimated coefficients of SPF

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	**DF**	**Estimate**	**Standard error**	**Wald 95% confidence limits**		**Wald chi-square**	**Pr > chiSq**
Intercept	1	−1.1236	4.3681	−9.6850	7.4377	0.07	0.7970
LogAADT	1	0.1650	0.4354	−0.6884	1.0183	0.14	0.7048
Snow Fence	1	−0.4218	0.9766	−2.3359	1.4923	0.19	0.6658
Dispersion	1	0.0000	0.0049				

The snow fence CMF was calculated as shown below:

$$CMF = e^{c} = e^{-0.4218} = 0.656$$

Figure 30. Equation. CMF calculation.

The standard error of CMF was calculated as follows:

$$Std(CMF) = \frac{\exp\big(c + standard\ Error\ of\ S \times (1-0)\big) - \exp\big(c - standard\ Error\ of\ S \times (1-0)\big)}{2}$$

$$= \frac{\exp\big(-0.4218 + 0.9766 \times (1-0)\big) - \exp\big(-0.4218 - s0.9766 \times (1-0)\big)}{2}$$

$$= 0.7473$$

Figure 31. Equation. Calculation of snow fence CMF standard deviation.

BLOWING SNOW REMOVAL COST DATA

Blowing-snow-removal expenditure data of different team sections in each district were acquired from IDOT for the 2017–18 winter season. The data contains the date, labor, equipment, and material costs. Considering consecutive days as one blowing snow event, the average total cost (labor, equipment, and material) per snow event of each team section was calculated. Then, the average unit cost per lane mile per event was determined as the ratio of the average total cost per event and total blowing snow segment lane mile for different team sections in each district.

The lane-mile data of blowing snow segments used in this study were from a survey conducted in 2016 during the Phase I study (Petrie et al. 2020). The survey gathered blowing snow lane miles and total lane miles for different team sections across the state. Because not all team sections responded to the survey, the unit cost calculation for blowing snow removal per lane mile only used data from those who responded. The unit costs were averaged for each district (Table 12). Note that the numbers for district 6 and district 8 are not available, as no blowing snow segments were reported by those two districts.

Table 12. Average blowing snow removal cost per lane mile per snow event by district

District	Average blowing snow cost per lane mile per event
District 1	$390.07
District 2	$228.94
District 3	$412.20
District 4	$231.43
District 5	$273.15
District 6	N/A
District 7	$265.83
District 8	N/A
District 9	$294.65

SUMMARY

Snow- and ice-related crash data of IDOT districts 2, 3, 4, and 5 from 2012 to 2016, blowing snow segment data of districts 4 and 5, and snow fence segment data of districts 2, 4, 5, and 6 were obtained from IDOT. The data were filtered, combined, and compiled to get blowing snow crashes on snow fence segments and blowing snow segments. The cross-sectional method was applied in the study to determine the snow fence CMF. The calculated snow fence CMF was 0.656 with a standard deviation of 0.7473. Because of the small sample size, the standard deviation of the calculated CMF is relatively high. However, the CMF value of 0.656 is comparable to the snow fence CMFs developed by (Peet et al. [2017] and Larson et al. [2019]).

Using the 2017–18 winter expenditure data for blowing snow removal and blowing snow segment lane-mile data obtained in the Phase I study (Petrie et al. 2020), the average blowing snow removal cost per lane mile per snow event was determined by district. Note that the calculated unit cost may underestimate the blowing snow removal per lane-mile cost, because the calculation used the total blowing snow segment lane miles instead of the blowing snow segment lane miles affected by each blowing snow event. The blowing snow segment lane miles affected by each snow event were not recorded by team sections, so the data were not available.

CHAPTER 5: SNOW FENCE BENEFIT-COST ANALYSIS

This chapter presents a case study to illustrate how to conduct a benefit-cost analysis (BCA) of a snow fence project. The case study was done for living and structural snow fences as well as standing corn rows. The cost and benefit items considered in the study, the way to monetize the costs and benefits, and benefit-cost ratio calculation are detailed in the following sections.

CASE STUDY SEGMENT

A 1.3 mi (6,780 ft) blowing snow segment in McLean County (district 5) along I-39 near Hudson, Illinois, was selected for the case study (Figure 34). The segment's geometric, traffic, and crash data were acquired from IDOT. The segment is straight and level, with two lanes in each direction and a right-of-way of 60 ft. The posted speed limit is 65 mph. The AADT is 20,200 vehicles per day with 20% trucks. The average number of snowstorms per year is five. During 2012–2016, 18 motor vehicle crashes occurred on this segment, two of which were related to blowing snow. Hypothetically, a snow fence will be implemented to protect this blowing snow segment. The BCA was conducted to compare three alternative snow fence projects—LSFs, SSFs, and SCRs—to provide data and information for decision-making.

Figure 32. Image. Blowing snow segment along I-39 in Illinois.
Source: Google Earth

BENEFIT-COST ANALYSIS METHODOLOGY

The BCA procedure used in the study is as follows:

- Determine the analysis period.
- Itemize costs and benefits of each alternative project.
- Monetize the itemized costs and benefits through assigning currency values.
- Convert all currency values over the analysis period to present values.
- Sum up all cost and benefit present values over the analysis period.
- Calculate the benefit-cost ratio for each alternative.
- Compare benefit-cost ratios to reveal the most economically efficient option.

Analysis Period

A well-maintained SSF can work for more than 20 years, and the lifetime of LSFs (trees and/or shrubs) is even longer. However, an analysis period of 15 years was chosen for the study, as agreements between landowners and transportation agencies are usually shorter than a snow fence's lifetime and it takes 5–10 years for LSFs to mature. As SCRs are left on the farmland every winter and removed every spring, the length of the analysis period will not affect the results, so the BCA of SCRs was performed over a one-year period.

Itemized Costs and Benefits

Figure 35 through Figure 38 list the cost items of LSFs, SSFs, and SCRs, as well as snow fence benefit items and ways to monetize them. The same benefit items were used for all three snow fence types, because their work as windbreakers to deposit snow before it reaches the roadway is the same. No cost data are available for Illinois snow fences, so snow fence cost information from the literature was referenced in the analyses. Note that the rates for labor and equipment, land rental, corn yield, and snow removal cost used in the analyses are prevailing local county/district values. The corn price rate, snow fence CMF, and the comprehensive crash cost per severity level used are prevailing Illinois statewide values; while, the travel time value, fuel consumption/value of emission per crash, and social cost of carbon used are FHWA-recommended values. All rate values were converted to present values in 2019.

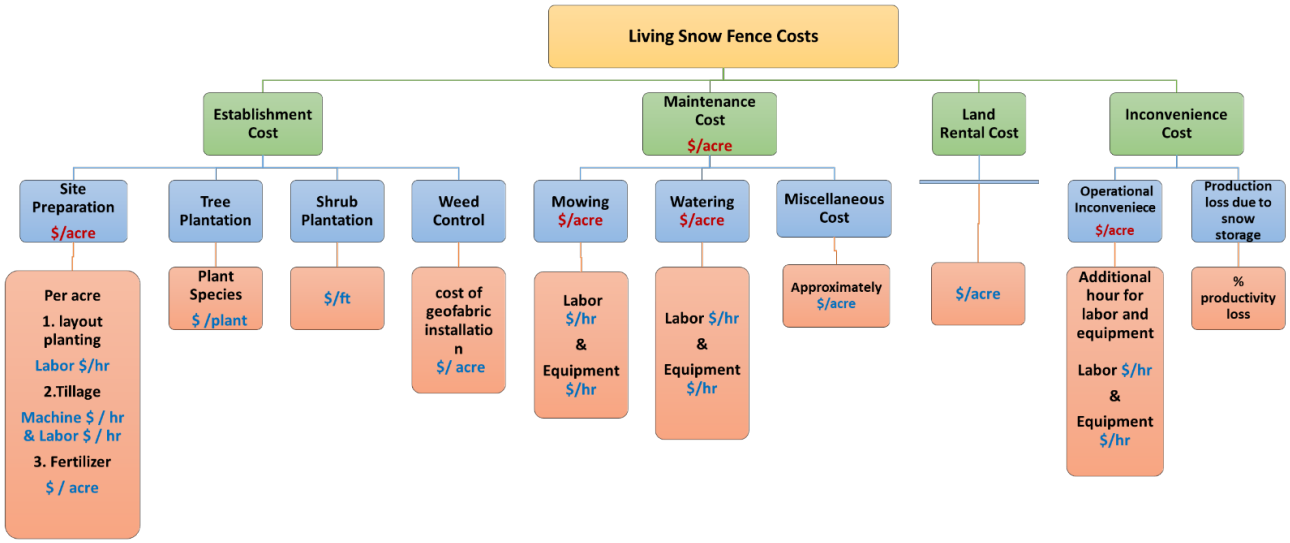


Figure 33. Image. Living snow fence cost items.

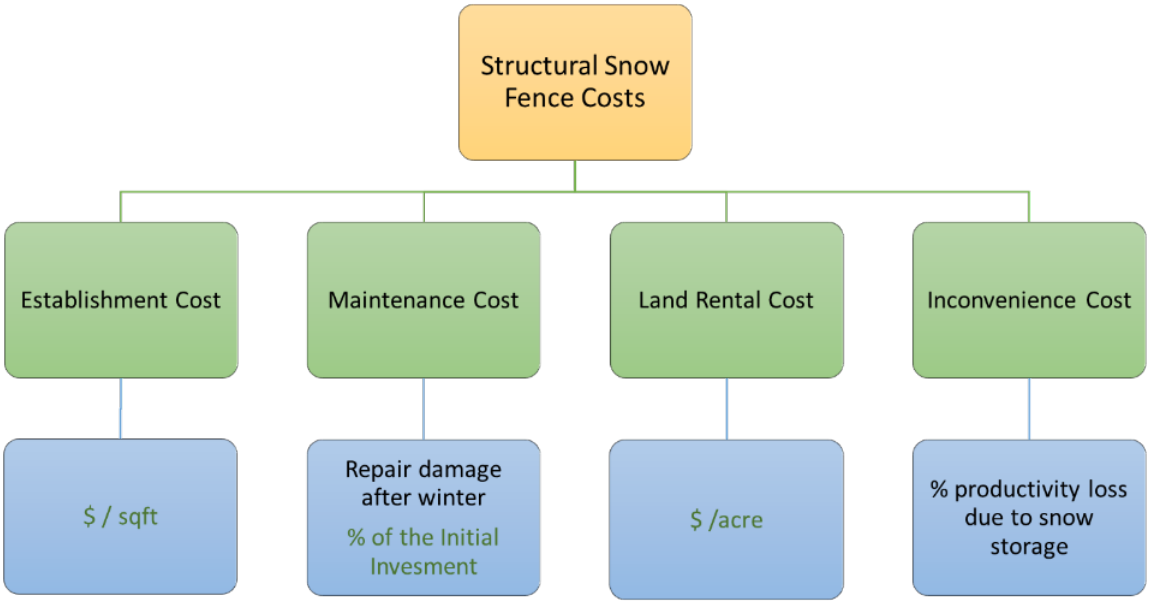


Figure 34. Image. Structural snow fence cost items.

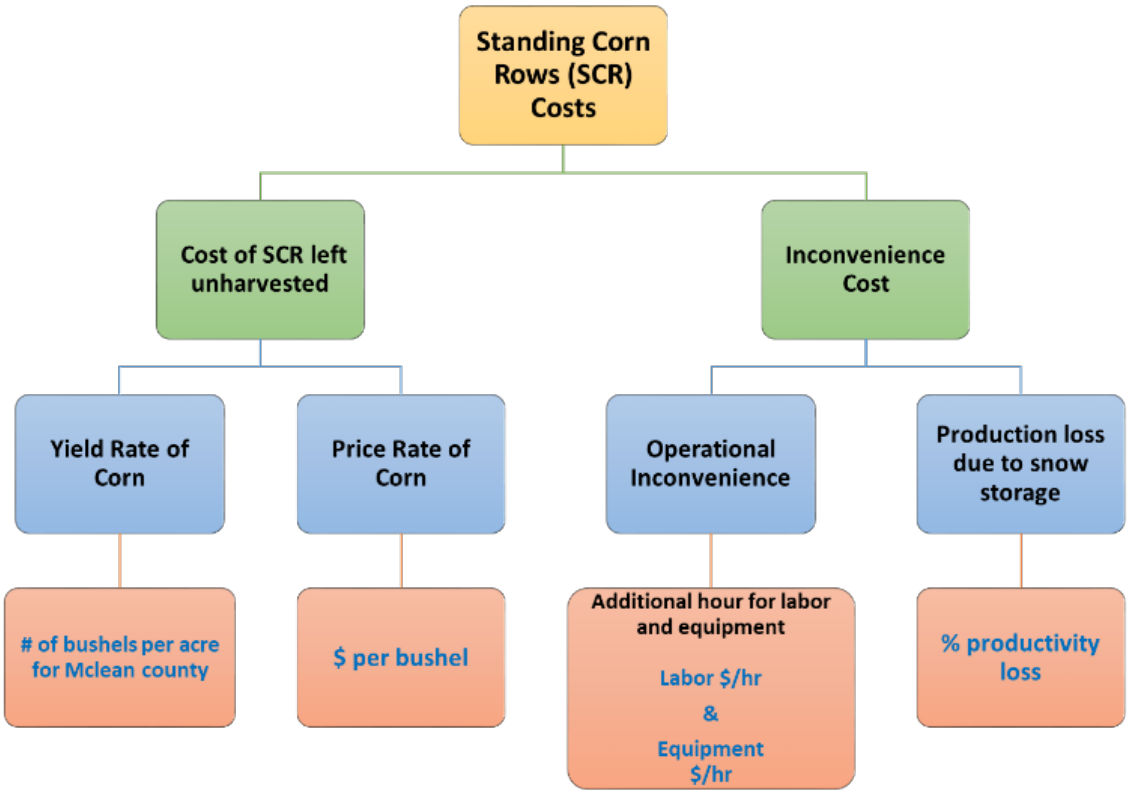


Figure 35. Image. Standing corn rows cost items.

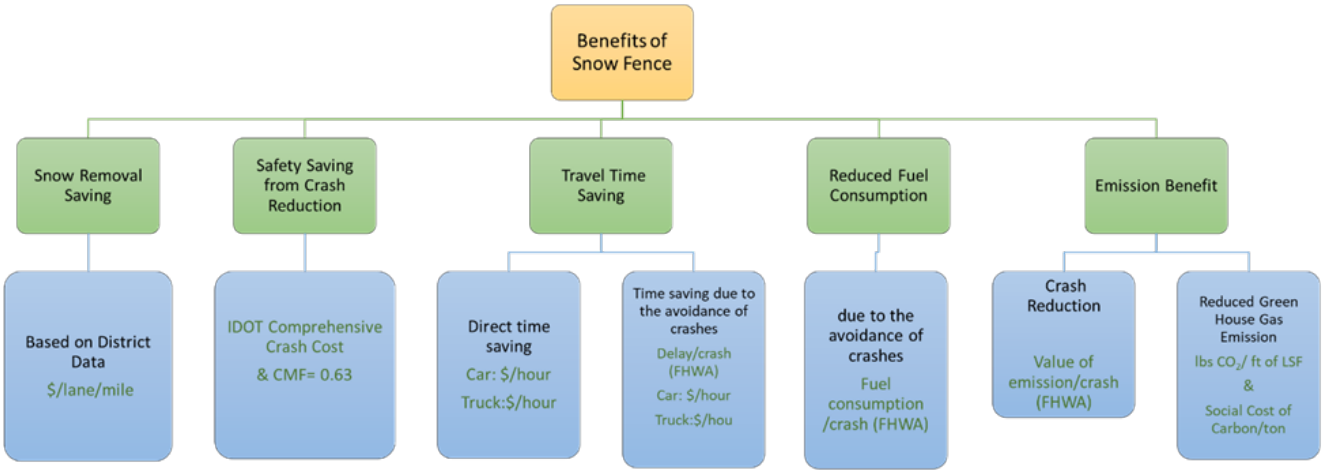


Figure 36. Image. Snow fence benefit items.

Benefit-Cost Ratio

The benefit-cost ratio was used in the study to compare the three snow fence alternatives. It was calculated as the ratio of the total present value of project benefits during the analysis period over the total present value of project costs during the analysis period. The future value of any cost or benefit over the analysis period was obtained by applying the inflation rate to the current year value. When converting to the present value, however, the future value needs to be divided by the inflation rate. During this process, the inflation rate was canceled out. Therefore, the inflation rate was not used in the study, as suggested by the FHWA guide (Lawrence et al. 2018). Further, considering the time value of costs and benefits, a discount rate was used to convert future values to present values. In other words, benefits and costs that occur sooner are more highly valued than those that occur in the distant future. The converted present value at the base year was calculated using the equation in Figure 39. FHWA recommends selecting a discount rate between 3% to 7% (Lawrence et al. 2018). A 3% discount rate was selected in this project.

$$PV = \left(\frac{1}{(1+r)^t}\right) A_t$$

Figure 37. Equation. Present value calculation.

Where, *PV* is present value at time zero (the base year), *r* is discount rate, *t* is time (year), and A_t is amount of costs or benefits in year t.

BENEFIT-COST ANALYSIS RESULTS

This section presents the BCA results for LSFs, SSFs, and SCRs. The annual costs were calculated for LSFs, SSFs, and SCRs, respectively. The calculation of annual benefits was detailed for LSFs, and the calculated values were also used for SSFs and SCRs. Note that the maintenance costs were only considered for the first several years before the LSF plants were fully grown and the benefits for LSFs

were included only over the years after the plants were mature. The maintenance costs and benefits for SSFs were included in the total values over the entire analysis period.

Living Snow Fences

Usually, snow fences are kept longer than the intended protected roadway segments, with additional lengths added at both ends (IOWADOT 2005). The required additional length of the fence at each end was calculated as the snow fence offset distance times tangent 30°. The LSF species, number of rows of trees, number of rows of shrubs, row spacing, and setback distance are obtained from LSF design.

The LSF considered in the case study consists of one row of Washington Hawthorne trees and two rows of Nannyberry Viburnum shrubs. As suggested by the LSF plant characteristics from the Phase I study, the spacing between the trees is 10 ft along the roadway (Petrie et al. 2020), and the distance between the row of trees and rows of shrubs is 20 ft (Wyatt 2019). Similarly, for the shrubs, the spacing of 10 ft and 10 ft is along and between the rows of shrubs, respectively. The height of LSF trees is 20 ft. The setback distance was calculated as 15 times the height of LSF, i.e., 15 × 20 ft = 300 ft (IOWADOT 2005). The calculated LSF length is 1.37 mi. The LSF site layout is depicted in Figure 40.

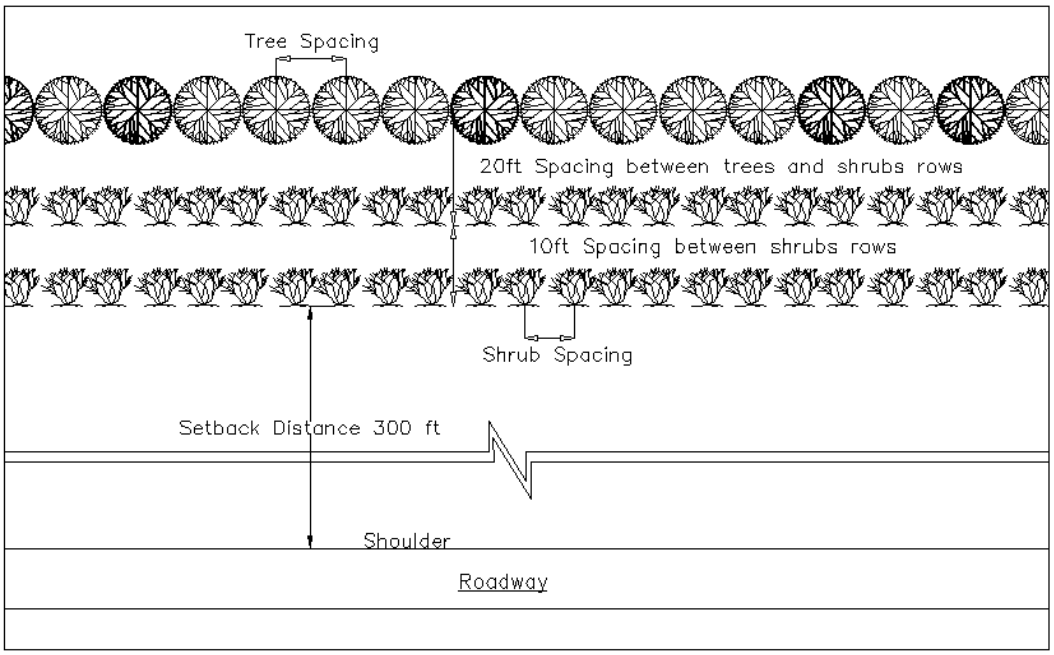


Figure 38. Image. Living snow fence site layout.

Living Snow Fence Costs

Installation Costs

Site Preparation

An overview of the approximate site-preparation cost for various activities is given in Table 13 (Wyatt et al. 2012). Labor rate values were taken from the website of the Illinois Department of Labor (IDOL 2019) for McLean County. The machine rate cost was determined based on information from ("Illinois

Truck" 2019) including the fuel operating cost. Considering the labor, equipment, and material, a rate of $329/acre was calculated.

Table 13. Site-preparation cost for a living snow fence

Description of Items for Site Preparation	Labor Time (per acre)	Average Unit Labor Rate $/hour	Material/ Machine (hour)	Machine Rate ($/hour)	Total Cost /Acre ($)	Remarks
Lay Out Planting	1	$32.49			$32.49	30 min. 2 people
Tillage	2	$37.72	2	$100.48	$276.40	
Fertilizer					$20	
Approximate Total Cost for Site Preparation					**$328.88**	Per acre

Tree and Shrub Planting

A unit price of $47.5 per plant was obtained using $12.5 per tree cost from the Forrest Keeling Nursery ("Forrest Keeling" 2020)and approximately $45 was used in the calculation for transportation, labor, and miscellaneous supplies. The roadside trees' annual survival rate ranged from 94.9% to 96.5% (Roman and Scatena 2011). A replanting rate of 5% is assumed. Similarly, a $10.30 average rate for the shrub from Forrest Keeling and Schott Nursery ("Forrest Keeling" 2020; "Schott Nurseries" n.d.) and $20 for labor and miscellaneous supplies were used, which gave $25.95 per shrub plantation.

Weed Control

The cost of weed control includes the geofabric based on the size and material, labor to put and fix the geofabric mat on the ground, and maintenance. The approximate cost of fabric installation varies from $1,200 to $2,800 per acre (Wyatt et al. 2012). In the study, $2,800 per acre was used in the calculation.

Maintenance Cost

The maintenance cost is generally required in the first few years (3–6 years) before the plants become mature. It is associated with activities such as trimming (weeds), watering, etc. (Wyatt et al. 2012). Considering the labor and equipment used for mowing and watering, the estimated maintenance cost rate was $1,577 acre/year (Table 14).

Table 14. Maintenance cost of a living snow fence per acre

Item Description	Average Service Hours Required (hours/acre)	Labor Cost ($/hour)	Machinery/ Equipment (hours)	Machinery/ Equipment rate ($/hour)	Annual Total Cost ($/acre)
Mowing	2	$37.72	2	$88.23	$251.90
Watering	10	$37.72	10	$74.75	$1124.70
Miscellaneous Cost	-	-	-	-	$200.00
Total Maintenance Cost per Acre					$1,576.55

Land Rental Cost

The US Department of Agriculture's National Agricultural Statistics Service provides the standard rental cash rate per acre for all counties. The rental rate for McLean County was found to be $255 per acre for the year 2019 for irrigated lands in Illinois (NASS 2019). In the study, it was considered that the agency rent the land occupied by the LSF and the buffer zone (5 ft wide) area on both sides.

Inconvenience Cost

The operational inconvenience cost involves the additional time needed to maneuver farm machinery around the snow fence along with the respective additional labor cost (Wyatt et al. 2012). The estimated inconvenience cost is $89.40/acre (Table 15).

Table 15. Operational inconvenience cost of a living snow fence per acre

Description of Items	Labor Time (minutes)	Average Unit Labor Rate $/hour	Material/ Machine (minutes)	Machine Rate ($/hour)	Total Cost /Acre ($)
Tillage	10	$37.72	10	$100.48	$23.03
Combining	10	$37.72	10	$322.77	$60.08
Spraying in the Crop	10	$37.72			$6.28
Inconvenience Cost per acre					**$89.40**

In addition, the area close to LSFs experiences a loss in productivity or a reduction in yield. One acre of a LSF area causes a 10%–15% productivity loss of the nearby acre's crop field (Wyatt et al. 2012). Typical yields for corn in McLean County are 220–300 bushels per acre (Schnitkey 2019) and a baseline price for corn in 2019/2020 is $4.00 per bushel (Hubbs 2019). In this study, an average of 260 bushels per acre was considered. Table 16 presents the calculation of LSF costs.

Table 16. Living snow fence costs

Cost	Item	Rate	Quantity	Cost
Installation	Site Preparation	$328.88/acre	1.37 mi × (20 ft + 10 ft + 5 ft + 5 ft) = 6.62 acre	**$2,177**
	Tree Planting	$47.5/tree	1.37 mi × 5280 ft /10 ft = 725 trees	**$34,295**
	Tree Replanting	5%	$26,180	**$1,147**
	Shrub Planting	$30.3 per shrub	2 × 1.37 mi × 5280/10' (spacing) = 1447 shrubs	**$43,844.1**
	Weed Control	$ 2800 per acre	3 (Number of trees and shrubs rows) × 1.37 mi × 5 ft = 2.472 acres	**$6,921**
Maintenance/year		$1,579/acre	6.64 acre	**$10,484**
Land rental/year		$255	6.64 acre	**$1,693**
Inconvenience/year a. Operational cost		$89.40/acre	6.64 acre	**$593**
b. Production loss		15%	$4.0 × 260 × 38.19 acre	**$5,957**

Living Snow Fence Benefits

Cost Saving for Blowing Snow Removal

The cost rate is $273/lane mile for district 5 in 2017–2018 (Table 12); therefore, the annual snow removal cost saving is $273 × 1.30 mi × 4 lanes × 5 snowstorms = **$7,102**.

Safety Benefit

The safety benefit of the snow fence was calculated following the FHWA guidelines for benefit-cost analysis (Lawrence et al. 2018). First, the expected number of annual total crashes was determined using the method from the FHWA guidelines. Second, a CMF of 0.656 (Figure 32) was used to determine the reduction of total crashes due to the snow fence. Third, the equivalent dollar values of reduced crashes were calculated based on the Illinois comprehensive crash cost value for different severity levels obtained from IDOT. Table 17 summarizes the annual monetary benefits due to reduced crashes.

Table 17. Average annual monetary benefits of reduced crashes

Crash Severity	Estimated Annual Crashes without a snow fence (N)	Estimated Annual Crashes with Treatment (N × CMF)	Estimated Annual Reduction in Crashes	Illinois Comprehensive Crash Cost Value ($ 2019/unit) by severity	Estimated Annual Monetary Benefits
k-fatal crash	0.0062	0.004	0.002	$6,824,884	$14,561
A-injury	0.0256	0.017	0.009	$367,726	$3,239
B-injury	0.0516	0.034	0.018	$134,492	$2,388
C-injury	0.0686	0.045	0.024	$76,439	$1,804
PDO	0.3212	0.211	0.111	$12,598	$1,392
Total Crash Cost Value Saving					**$23,387**

Travel Time Saving

Direct Travel Time Saving

The direct travel time saving was calculated as the product of number of events/year, difference in travel time before and after the installation of snow fence (hours/event), AADT, and travel time unit cost ($/hour). The Federal Motor Carrier Safety Administration suggests a 33.3% reduction in traffic speed in snow/ice conditions (FMCSA 2015). In the calculation, it is considered that vehicles travel at the posted speed limit of 65 mph after snow fence implementation and at 45 mph before implementation. Then, 0.0099 hours per vehicle were calculated to be saved along the segment.

The traffic composition of the study segment is 80% cars and 20% trucks. Based on the monetary value of travel time per hour provided by the National Highway Traffic Safety Administration (NHTSA), the 2019 monetary travel time cost values were calculated as $27.36/hr for passenger cars and $41.59/hr for trucks (Lawrence et al. 2018). The study segment has an AADT of 20,200 vehicles per day and an average of five annual snow events. The direct travel time saving was calculated as 5 × 20,200 × 0.0099 × (80% × $27.36+20% × $41.59) = **$30,507/year**.

Indirect Travel Time Savings from Crash Reduction

The NHTSA provides factors for average vehicle delay hours by crash severity level and road functional classification (Lawrence et al. 2018). Multiplying those factors by the estimated annual reduction in crashes of different severity levels, the indirect travel time saving was quantified. Table 18 presents the calculation of travel time saving due to crash reduction.

Table 18. Monetization of travel time benefits from crash reduction

Crash Severity	Expected Annual Crashes without a Snow Fence (N)	Estimated Annual Reduction in Crashes (N × CMF)	Estimated Annual Crash Reduction	Vehicle Delay per Crash (hours)	Delay Reduction (Hours)
k-Fatal crash	0.0062	0.004	0.002	1780.31	3.80
A-injury	0.0256	0.017	0.009	207.68	1.83
B-injury	0.0516	0.034	0.018	207.68	3.69
C-injury	0.0686	0.045	0.024	207.68	4.90
D-property damage crash	0.3212	0.211	0.111	146.25	16.17
Total Annual Delay Reduction					30.38
Unit Value of Time per person					$30.21
Total Annual Benefit					**$917.92**

Emission Benefits

Snow fences reduce the emission of greenhouse gases (GHG) by reducing the operational activities of snow maintenance vehicles during winter. The amount of GHG avoided is usually measured in terms of a reduced amount of CO_2 emission. The US Environmental Protection Agency (EPA) recommends using the social cost of carbon (SCC) to monetize reduced GHG emissions. The SCC value is $52/metric ton of CO_2 per year in 2019 value (Malmgren 2016). A Minnesota study estimated that, on average, 11 lb of carbon dioxide per foot of snow fence length is avoided by preventing the fuel consumption caused by winter maintenance vehicles (Wyatt et al. 2012). Multiplying the SSC value, the monetary benefits of GHG avoided by the snow fence in the case study is **$1,782** per year.

Another benefit is the reduced emissions resulting from the reduction in crashes after snow fence implementation. In the study, the monetary emission benefit was estimated following FHWA's BCA guidelines (Lawrence et al. 2018). Because of the small number of crashes reduced by snow fence implementation along a short segment (1.30 mi), the calculated value is only **$12** per year.

Table 19. Summary of snow fence benefits per year

Itemized Benefits	Per Year
Snow Removal Benefit	$7,102
Crash Benefit	$23,387
Travel Time Benefit	$31,425
Emission Benefit	$1,794

Living Snow Fence Benefit-Cost Ratio

LSF plants usually take 5–10 years to mature. In the study, six years was used. Accordingly, the maintenance costs only applied for the first six years and the benefits applied after year six. Figure 41 presents the cumulative present values of costs and benefits of LSF over the 15-year analysis period. The figure shows that the reduced snow removal cost, safety and travel time savings, and GHG emissions avoided by LFSs will amortize its installation and maintenance costs within 10 successive

years. The benefit-cost ratios for LSF is **$415,419/$244,272= 1.70**. Appendix E shows the LSF amortization table.

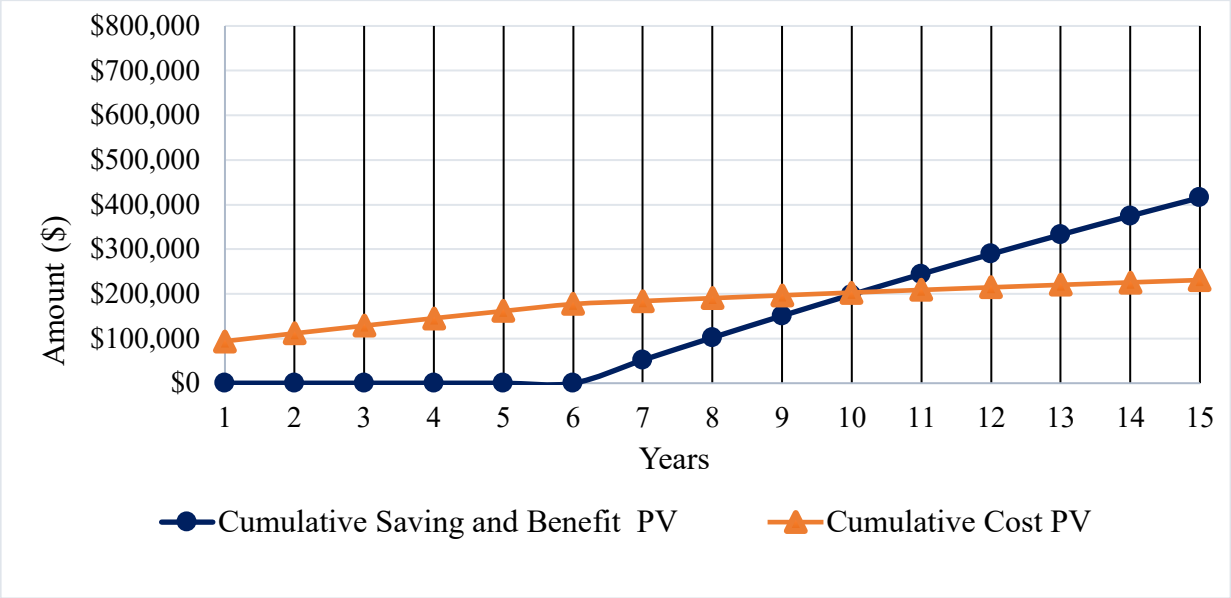


Figure 39. Graph. Cumulative cost and benefit in the present value of LSF.

Structural Snow Fences

The structural snow fence width, height, and setback distance are obtained from the SSF design. In the study, a 12 ft high fence was used. The setback distance is 35 × 12 ft = 420 ft (Tabler 1991). The additional length needed at each end was calculated as 420 ft × tan (30°) = 242 ft or 0.05 mi. Therefore, the total length of the snow fence is 1.3 mi + 2 x 0.05 mi or 1.40 mi.

Installation Cost

The SSF installation cost varies largely, depending on the type, brand, material, height, and site properties. In the study, a rate of $24/lf was chosen to represent a typical wood fence used in the Midwest.

Maintenance Cost

An annual maintenance cost of 5% of the initial capital investment was used in the study (Tabler 2003). Unlike the LSF, the SSF would require maintenance throughout the analysis period.

Land Rental Cost

The land rental payment was for the area occupied by the SSF, including the area for bracing the structure (10 ft) and area for the maintenance vehicle and crew to access the fence (15 ft on each side), as shown in Figure 42. As described in the Living Snow Fence section, the average cash land rental rate (irrigated land) of $255/acre/year was obtained from the National Agricultural Statistics Service's (NASS 2019).

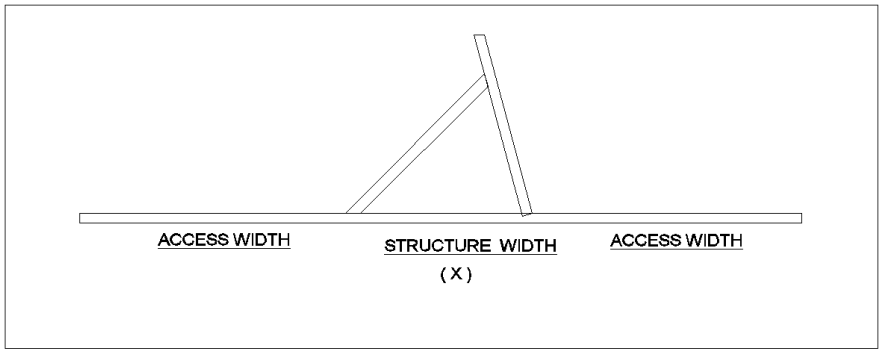


Figure 40. Image. Typical section of a structural snow fence.

Inconvenience Cost

The operational inconvenience cost involved is the additional time needed to maneuver the farm machinery around the snow fence. The estimated inconvenience cost is the same as the LSF ($89.40/acre).

Similarly, a 15% reduction in crop production (Wyatt et al. 2012) was used to quantify the production loss in the snow storage area. As stated in the Living Snow Fence section, an average of 260 bushels per acre was considered (Schnitkey 2019) in the study, and a baseline price for corn in 2019/2020 was $4.00 per bushel (Hubbs 2019). Table 20 presents the calculated SSF costs.

Table 20. Structural snow fence costs

Item	Rate	Quantity	Cost
Installation	$24/lf	7,392 ft = (1.4mi × 5280)	**$177,408.00**
Maintenance	5%	$177,408.00	**$8,870/year**
Land Rental	$255/acre	6.79 acres = (7,392 ft × (10ft SSF width +2 × 15 ft access width)	**$1,731/year**
Inconvenience a. Operational Cost b. Production Loss	 $89.40/acre 15%	 6.79 acres $60,892 = (58.55 acres × 260 bushels per acre × $4 per bushel)	 **$ 607/year** **$ 9,133/year**
Affected area of 58.55 acres =		1.4 mi × (420 ft setback dist. −60 ft ROW −15 ft access width)	

Benefit-Cost Ratio of Structural Snow Fences

As mentioned above, the benefits calculated for LSFs also apply for SSFs. Unlike LSFs, SSFs require maintenance over the entire analysis period and yield benefits immediately after installation. Figure 43 presents the cumulative present values of costs and benefits of SSFs over the 15-year analysis period. The benefits of SSF will amortize its installation and maintenance costs within five successive years. The benefit-cost ratio for the SSF is $760534/$420,238 = 1.81. The amortization table for the SSF is shown in Appendix E.

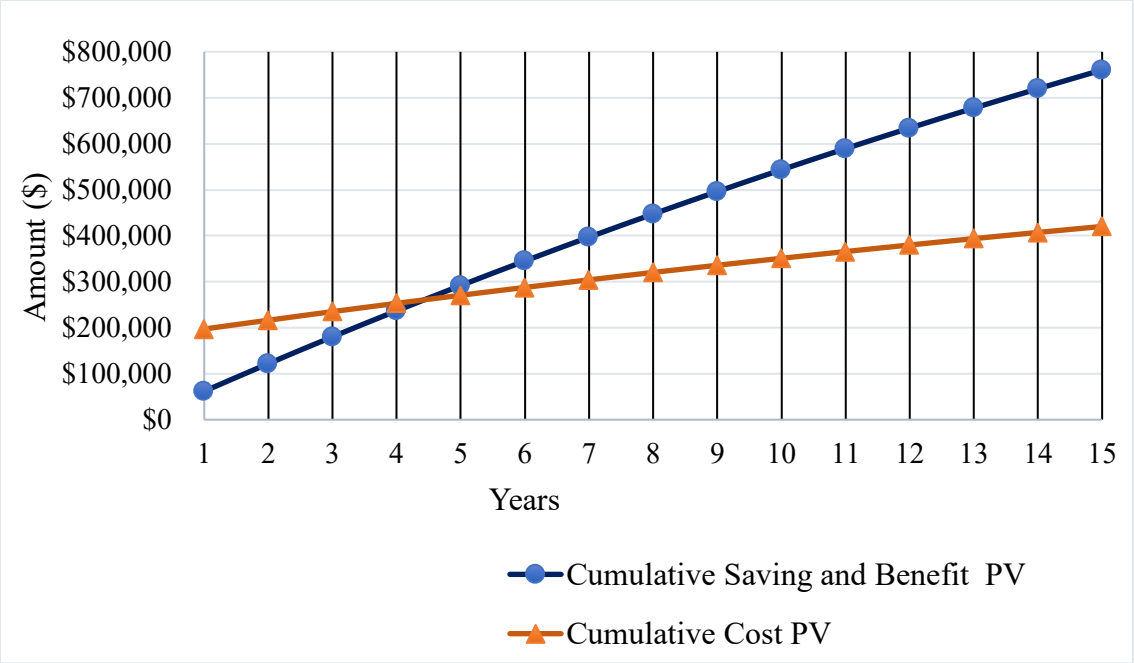


Figure 41. Graph. Cumulative cost and benefit in the present value of SSF.

Standing Corn Rows

The number of strips, number of rows of corn in each strip, the spacing between strips, and the setback distance are obtained from the standing corn row design. In this study, two strips with eight rows of 6 ft high corn per strip were used, with 150 ft between the strips and 30 in. spacing between the corn rows (Figure 44). The setback distance for the SCR is 35 times the height of the corn rows (Tabler 1991). Similarly, an additional length of tangent 30° of the setback distance was added onto each end of the SCRs.

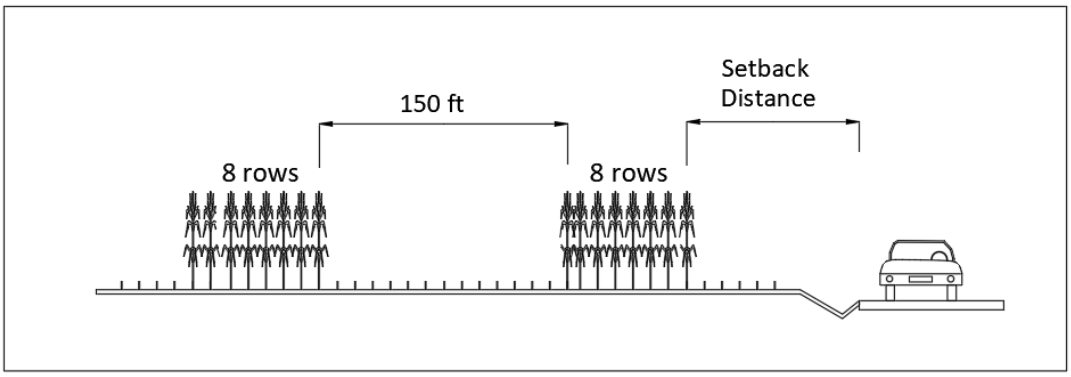


Figure 42. Image. Standing corn row layout.
Source: Tabler (2003)

Cost of Standing Corn Rows

The cost calculation was based on the market value associated with the corn left unharvested in the field. Similar to the calculations for living and structural snow fences, an average of 260 bushels per

acre (Schnitkey 2019) and $4.00 per bushel (Hubbs 2019) were used in the calculation. The farmers can harvest their corn in the SCR fence by either handpicking in the fall/spring or leaving the corn unharvested to provide a food source to wild animals.

Inconvenience Cost of Standing Corn Rows

Operational Inconvenience Cost

The inconvenience cost related to leaving standing corn rows in the winter covers the additional hassle of using a combine in the spring, additional plowing, and needing extra time to farm around the standing corn rows. Table 21 provides a detailed breakdown for the cost estimation of the inconvenience cost (Wyatt et al. 2012). Labor rate values were taken from the Illinois labor rate website (IDOL 2019) for McLean County. Note that current state law prohibits IDOT from paying a premium for standing corn when used as a living snow fence (ILGA 2019).

Table 21. Inconvenience costs of standing corn rows

Description of Items	Labor Time (minutes)	Average Unit Labor Rate $/hour	Material/ Machine (minutes)	Machine Rate ($/hour)	Total Cost /Acre ($)
Tillage	10	$37.72	10	$100	$22.95
Combining	10	$37.72	10	$322	$59.95
Spraying in the crop	10	$37.72			
Spraying herbicides in the spring	20	$45			$15.00
Stalk chopping	30	$25			$12.50
Inconvenience cost per acre					**$110.40**

Production Loss

The relatively high soil moisture content around the SCR because of snow storage leads to a delay in spring plowing and fieldwork. Late planting in the spring in addition to the effect of snow storage can result in a 10%–15% reduction in spring crop production (Wyatt et al. 2012). Because the farmers get full yield payment for the corn row strip, only the area between the SCR strips was considered for calculating the production reduction area. Table 22 presents the estimated costs of SCRs.

Table 22. Estimated costs of standing corn rows

Item	Calculation
Length	(1.3 mi + 2 × tan (30°)) =1.35 mi
SCR area	1.35 mi × 2 × (30 in. × 7) = 5.73 acres
Setback dist.	(6 ft × 35) = 210 ft
Snow storage area	150 ft (spacing between the strips) × 1.35 mi = 24.55 acres
SCR cost	5.73 acre × 260 bushel/acre × $4 /bushel = **$5,960**
Operational inconvenience	5.73 acre × $111/ acre = **$636**
Production reduction	15% of 24.55 acre × $260 bushel/acre × $4 /bushel = **$3,829**

Benefit Cost-Ratio of SCRs

The calculated benefits for LSFs also apply for SCRs. Unlike SSFs and LSFs, the SCR contract between DOTs and landowners is generally seasonal/short term. Therefore, the annual benefit-cost ratio was

estimated for the corn row snow fence. Table 23 summarizes the costs and benefits of SCRs, along with the calculated benefit-cost ratio. The results show that SCRs have the highest B/C among the three snow fence types. This is because the SCR does not require installation and maintenance investments to achieve the same benefits as LSFs and SSFs.

Table 23. Costs and benefits of standing corn rows

Description of Items	**Cost per season**
Itemized Cost	
Cost for Unharvested Corns	$5,960.00
Inconvenience Cost	$4,465.00
Total Cost	**$10,425.00**
Itemized Benefits	
Snow Removal Benefit	$7,102.00
Crash Benefit	$23,387.00
Travel Time Benefit	$31,425.00
Emission Benefit	$1,794.00
Total Benefit	**$63,708.00**
Benefit-cost Ratio	**6.11**

SUMMARY

The costs and benefits of LSFs, SSFs, and SCRs were evaluated and compared through a BCA case study following FHWA guides. The analyses also considered snow fence installation and maintenance costs as well as farmland rental, operational inconvenience, and production reduction costs. The benefits considered include snow removal cost saving, travel time saving, as well as safety and emission benefits.

Prevailing rates in Illinois were used to monetize the itemized costs and benefits. Then, all currency values over the analysis period were converted to present values by applying a deflation rate. The present values of costs and benefits over the analysis period were summed up to obtain the total net present values of costs and benefits. Note the LSF maintenance cost is required only for the first several years before plants are mature and the LSF benefits start after plants are mature. The SSF maintenance cost is required through the entire analysis period, but it yields benefits immediately after installation. The SCR was analyzed over a one-year period, because it is removed every spring. The benefit-cost ratios were calculated and used to evaluate the three alternatives.

Living snow fences require a lower initial investment than structural ones but take several years before yielding benefits. In contrast, SSFs need a higher initial investment but can produce benefits immediately after installation. The BCA shows that the benefit-cost ratios for living and structural snow fences are comparable. However, LSFs are favorable over SSFs, considering their potential environmental benefits and that little maintenance is needed after plants mature. SCRs are the most economical among the three alternatives. This is because a SCR can achieve the same benefits as living and structural snow fences but does not require installation and maintenance investments. Although a SCR is an appealing option based on the BCA results, the need to renew agreements between landowners and agencies annually as well as the alteration of crops planted in the farmland may limit its snow-control effectiveness and large-scale implementation.

CHAPTER 6: DEVELOPMENT OF THE BENEFIT-COST ANALYSIS TOOL

The research team developed a tool to facilitate the benefit-cost analysis of living and structural snow fences as well as standing corn rows. The BCA tool was developed using MS Excel for ease of use and access. A user-friendly interface was designed with the basic worksheet types and navigation tabs. This chapter serves as the user instructions for the snow fence BCA tool.

USERS

The targeted users of the BCA tool are winter operation engineers or field engineers who oversee snow fence projects in their jurisdictions. When using the BCA tool, users are recommended to save the original file as another file name so the original file will not be affected if any links are altered.

WORKSHEETS

In addition to the home page, four visible worksheets are included in the BCA tool, including project introduction, user input, parameters, and output. The project introduction worksheet contains basic project information regarding title, date, agency, along with a brief introduction of the BCA tool and color scheme used in the tool. The user input worksheet allows users to enter data on the project site and snow fence characteristics from the snow fence design. The parameter worksheet contains the cost and benefit structure used in the BCA, as well as the way each cost/benefit item is monetized. The output worksheet provides the summary of BCA results, the annual benefit and cost values, and the cumulative benefit and cost values over the analysis period.

Home Page

The home page is provided with the navigation icons shown in Figure 45: project introduction, user input, analysis parameters, and benefit-cost summary.

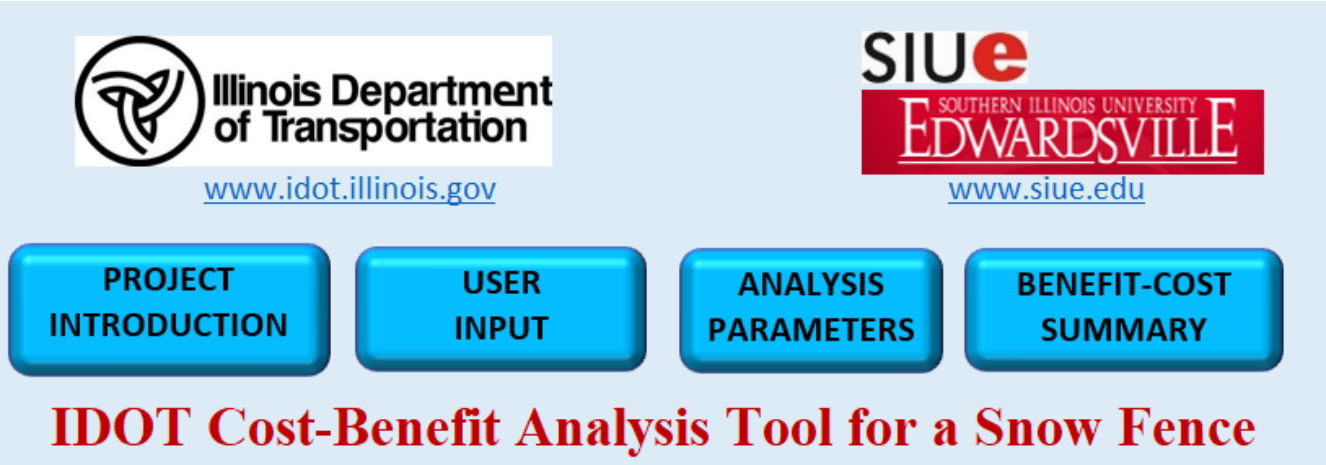


Figure 43. Image. Navigation icons on the home page.

Project Introduction

The project introduction worksheet contains fields for project-related information as well as a brief introduction to the BCA tool worksheets and color-coding. In the tool, a four-color coding scheme was used to represent cell functions (Figure 46). Yellow cells require users to input values based on site characteristics and snow fence design. All yellow cells must be completed, or the calculator will not be able to compute certain cost and benefit values. Blue cells, which are next to the yellow cells, offer users recommended values for a range of values when site-specific characteristics or snow fence design are not available. The green cells display values that were calculated using an Excel function based on input values. These values can be changed directly, and then the values are no longer dependent on the input values. Users should change green cell values indirectly, by revising the inputs in yellow cells. The pink cells display values that are linked to other values within the Excel file. The values in the pink cells can be changed directly (breaking the link between the pink cell and other values), or indirectly by changing the values to which the pink cells are linked.

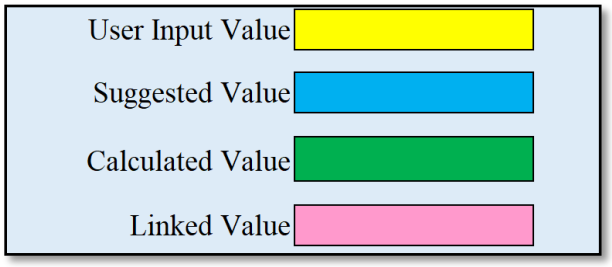


Figure 44. Image. Four categories of color coding.

Some input cells have a drop-down list. When the cursor is moved to the upper right corner, the instructions will pop up in a comment box, as shown in Figure 47. When the field is clicked, a drop-down list will show. Users should select the appropriate option according to the instructions.

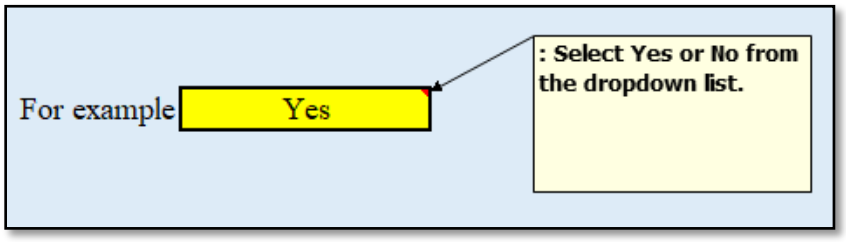
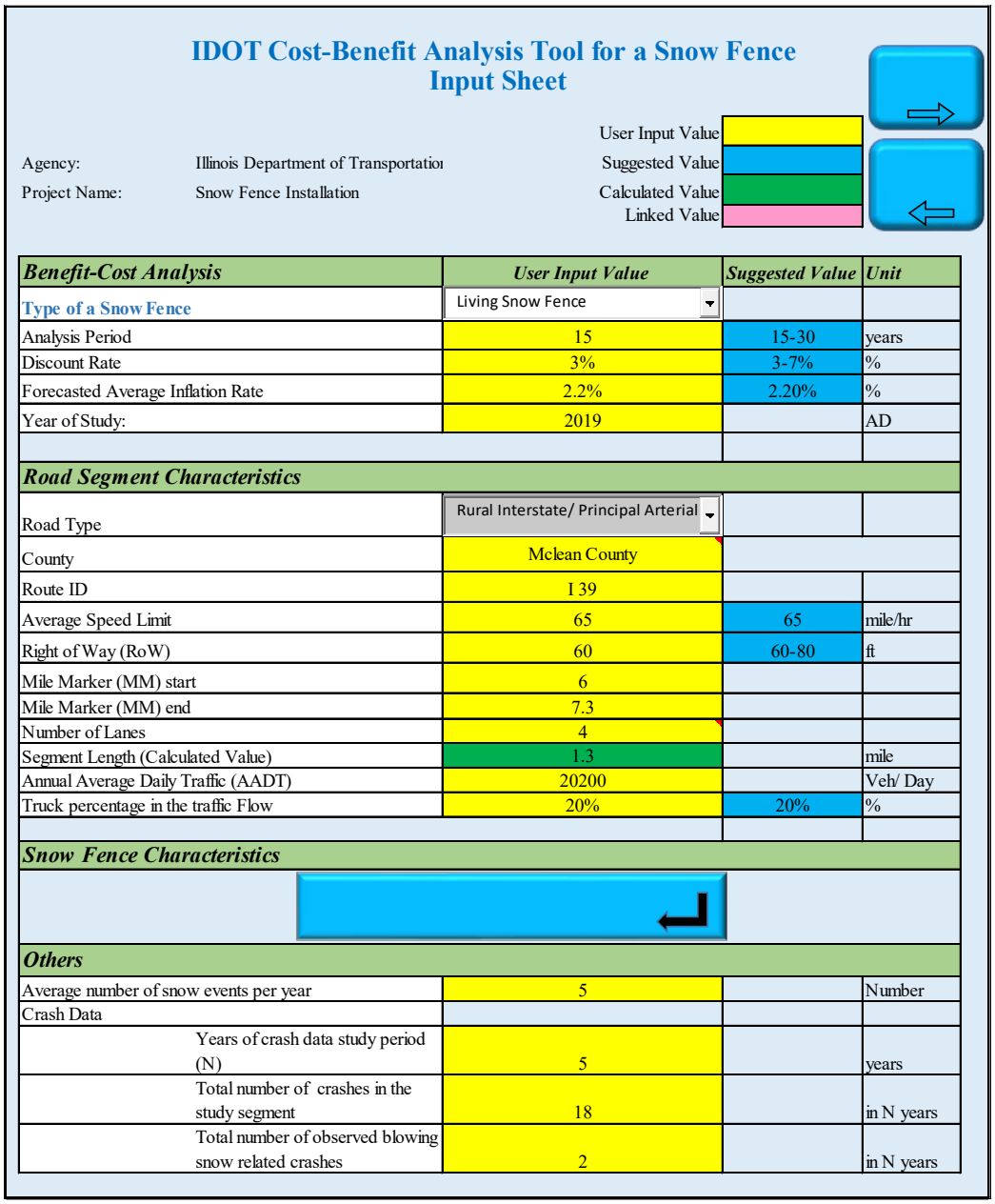


Figure 45. Image. Input cell with instruction.

User Input

Users will enter BCA inputs such as BCA parameters, snow fence site roadway segment characteristics, snow fence characteristics from snow fence design, historical snow events, and crash data in the user input worksheet. The user input worksheet consists of four sections, as shown in Figure 48. For detailed inputs of snow fences' features, users are navigated to the detail input worksheet through the navigation tablet.



IDOT Cost-Benefit Analysis Tool for a Snow Fence
Input Sheet

User Input Value
Suggested Value
Calculated Value
Linked Value

Agency: Illinois Department of Transportatio
Project Name: Snow Fence Installation

Benefit-Cost Analysis	*User Input Value*	*Suggested Value*	*Unit*
Type of a Snow Fence	Living Snow Fence		
Analysis Period	15	15-30	years
Discount Rate	3%	3-7%	%
Forecasted Average Inflation Rate	2.2%	2.20%	%
Year of Study:	2019		AD
Road Segment Characteristics			
Road Type	Rural Interstate/ Principal Arterial		
County	Mclean County		
Route ID	I 39		
Average Speed Limit	65	65	mile/hr
Right of Way (RoW)	60	60-80	ft
Mile Marker (MM) start	6		
Mile Marker (MM) end	7.3		
Number of Lanes	4		
Segment Length (Calculated Value)	1.3		mile
Annual Average Daily Traffic (AADT)	20200		Veh/ Day
Truck percentage in the traffic Flow	20%	20%	%
Snow Fence Characteristics			
Others			
Average number of snow events per year	5		Number
Crash Data			
Years of crash data study period (N)	5		years
Total number of crashes in the study segment	18		in N years
Total number of observed blowing snow related crashes	2		in N years

Figure 46. Image. Input sheet of the snow fence calculator.

Benefit-Cost Analysis

Type of Snow Fence

This field is used to select the type of snow fence from the drop-down list. The BCA tool can analyze living and structural snow fences as well as standing corn rows.

Analysis Period

The analysis period is the period over which the BCA is conducted. It usually starts with the first project expenditures and extends through the useful life of the project or its most long-lived

alternative, or some future time at which meaningful estimates of effects are no longer possible (Transportation BCA 2020). In the BCA tool, this field allows values from 1 to 30 years and must be an integer. The analysis period will depend on the type of fence selected, so users should proceed accordingly. Note that the analysis period for SCR is one year.

Year of Study

This field is used to choose the current year to get the current value of each cost and benefit over the analysis period. The most recent year users can enter is 2019.

Segment Characteristics

Road Type

This field is used to choose the facility type of the snow fence segment in the BCA. The facility types considered in the BCA tool are listed below:

- Urban Interstate/Expressway
- Urban Arterial
- Urban Other
- Rural Interstate/Principal Arterial
- Rural Other

County

Because this BCA tool is intended specifically for Illinois, the 102 counties of Illinois are listed. The selected county is used to lookup county-level data such as land rental, labor, and snow removal costs, as well as crop yield rate.

Route ID and Mile Marker

This field indicates the road route identification number and mile markers on the two ends of the study segment. The mile markers are used to calculate the segment length.

Number of Lanes

This field indicates the total number of lanes in both directions of the study segment.

Right-of-Way

This field indicates the right-of-way of the study segment.

Segment Length (Calculated Value)

Segment length is calculated in miles based on the user input of the mile markers on the two ends of the study segment.

Annual Average Daily Traffic and Truck Percentage

The annual average daily traffic (AADT) is the total number of vehicles travelling along the study segment in both directions in a year divided by 365. The AADT of state-maintained roads can be obtained from the Getting Around Illinois site ("Getting Around" n.d.). The AADT includes all types of traffic, including heavy commercial traffic. The truck percentage is an indicator of the traffic composition of the study segment. If the traffic composition information is not available, users can enter the suggested value from the adjacent blue cell. The suggested truck percentage value changes by road type.

Snow Fence Characteristics

Living Snow Fence

Figure 49 shows the inputs of LSF characteristics. There is a list of tree and shrub species in the drop-down. Species are selected based on the LSF design. If the designed LSF only contains shrubs, then the number of rows of trees should be entered as "0." A buffer zone width (A) and (B) are considered on either side for the LSF. Similarly, the tree spacing, shrub spacing, and spacing between trees and shrubs are entered based on the LSF design.

1) Characteristics of Living Snow Fence (LSF)

Tree species	Washington Hawthorne	Obtained from Snow Fence Design		
Number of Rows of Trees	1	Obtained from Snow Fence Design		
Height of Trees	20	Obtained from Snow Fence Design	20-30'	ft
Setback Distance	300	Obtained from Snow Fence Design	300 (15 Times Ht.)	ft
Length of LSF	1.37	Calculated Value	1.37	Miles
Tree Spacing along the Roadway	10	Obtained from Snow Fence Design	10' OC	ft
Trees Row Spacing (X)	20	Obtained from Snow Fence Design	ft	
Buffer Zone Width (A)	10		ft	
Buffer Zone Width (B)	10		ft	
Shrub Species	Nannyberry Viburnum	Obtained from Snow Fence Design		
Number of rows of shrubs	2	Obtained from Snow Fence Design		
Height of mature shrubs	15	Obtained from Snow Fence Design	15-20'	ft
Shrub Spacing along the Roadway	10	Obtained from Snow Fence Design	10' OC	ft
Shrub rows spacing (Y)	10	Obtained from Snow Fence Design	ft	
Spacing between tree and shrub (C)	20	Obtained from Snow Fence Design	ft	
If the landowner will perform the LSF installation and maintenance?	No			
Incentive Percentage	0.00%			

Figure 47. Image. Characteristics of living snow fences.

In the tool, there is a drop-down list of “yes” or “no” to specify if the landowner will perform the LSF installation and maintenance. If yes, then a 5% incentive will be added to the LSF cost.

The BCA tool also considers two options regarding farming in the snow fence catch area through a drop-down list. If the snow catch area is used in farming, then the operational inconvenience and productivity loss will be included in the cost. If the snow catch area is not used in farming, then the land rental cost will be included in the cost.

Structural Snow Fence

The height, setback distance, access width on either side of the fences, and structure width are inputs in the SSF, as shown in Figure 50. Similar to the LSF input section, the SSF input section also provides options regarding farming in the snow storage area.

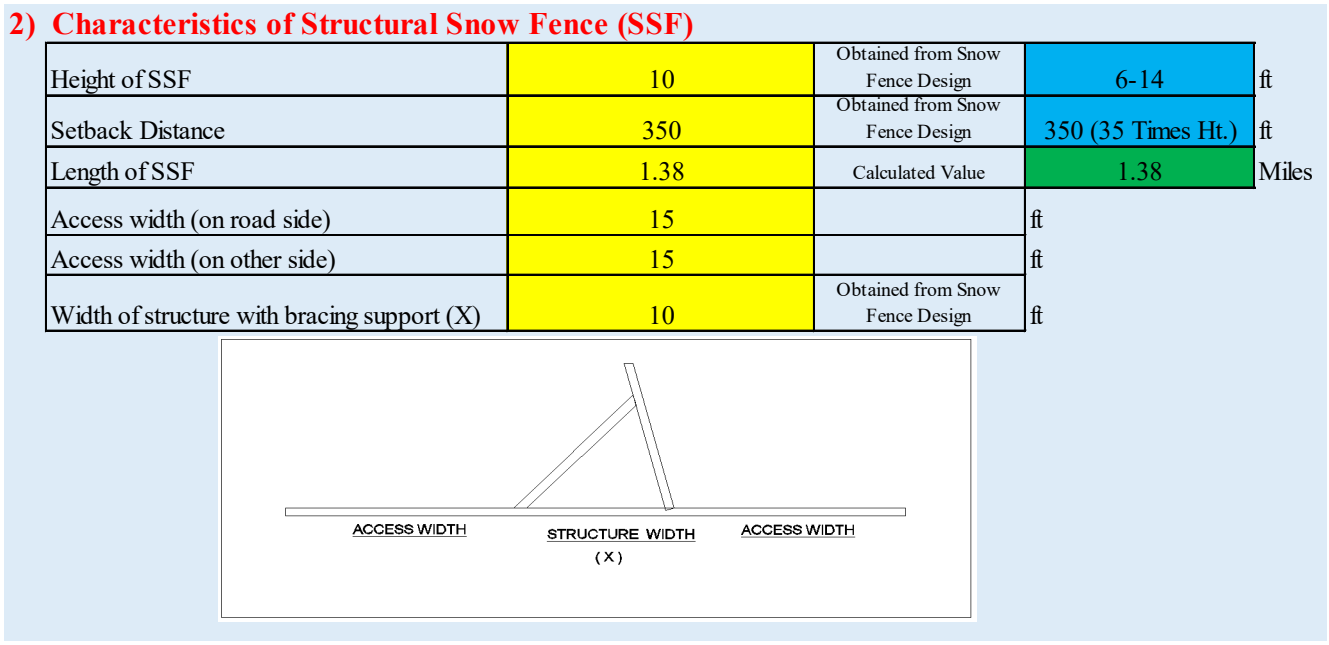
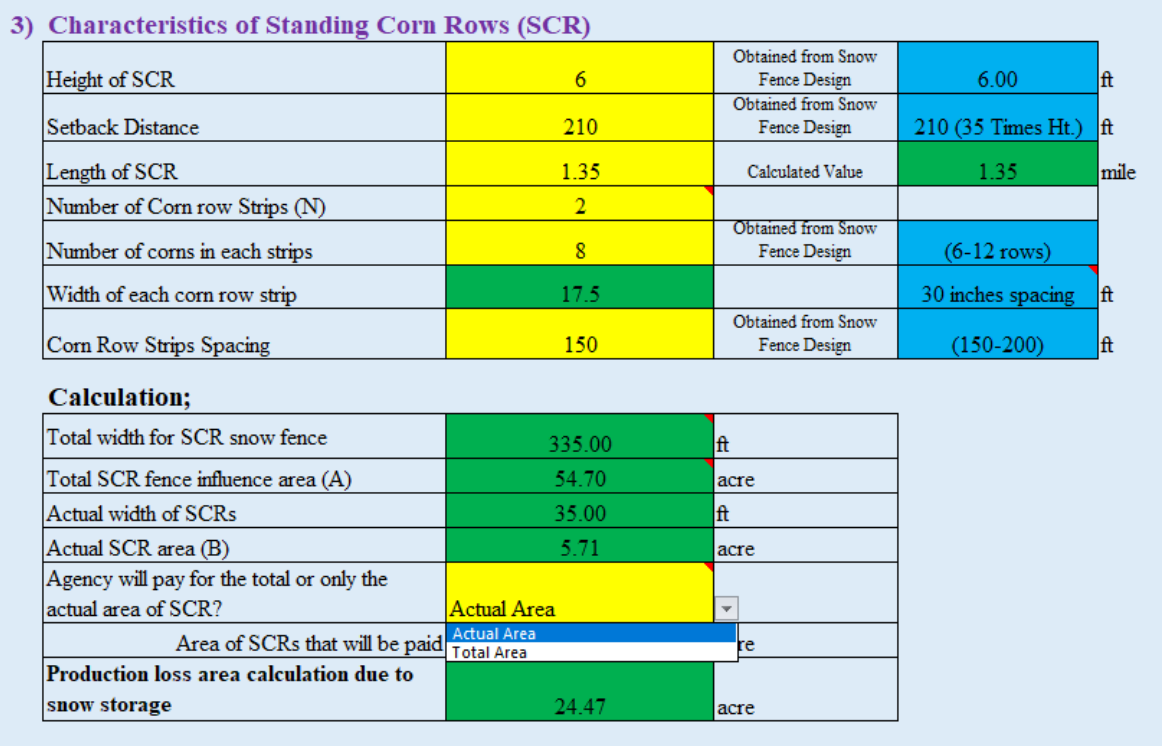


Figure 48. Image. Characteristics of structural snow fences.

Standing Corn Rows

There is the drop-down list in “Number of Corn Row Strips (N)” to select “1” or “2.” Users can enter the SCR characteristics based on its design (Figure 51). If “2” is selected, then the corn row strip spacing value will be calculated and considered in the SCR cost. The BCA tool considers two options regarding the snow storage area. If the agency pays for the total area (SCR area and the snow storage area), then productivity loss will not be included in the cost. If the agency only pays for the actual area of SCR, then the productivity loss for the snow storage area will be included in the cost.



3) Characteristics of Standing Corn Rows (SCR)

Height of SCR	6	Obtained from Snow Fence Design	6.00	ft
Setback Distance	210	Obtained from Snow Fence Design	210 (35 Times Ht.)	ft
Length of SCR	1.35	Calculated Value	1.35	mile
Number of Corn row Strips (N)	2			
Number of corns in each strips	8	Obtained from Snow Fence Design	(6-12 rows)	
Width of each corn row strip	17.5		30 inches spacing	ft
Corn Row Strips Spacing	150	Obtained from Snow Fence Design	(150-200)	ft

Calculation;

Total width for SCR snow fence	335.00	ft
Total SCR fence influence area (A)	54.70	acre
Actual width of SCRs	35.00	ft
Actual SCR area (B)	5.71	acre
Agency will pay for the total or only the actual area of SCR?	Actual Area	
Area of SCRs that will be paid	Actual Area / Total Area	re
Production loss area calculation due to snow storage	24.47	acre

Figure 49. Image. Characteristics of standing corn rows.

Other Characteristics

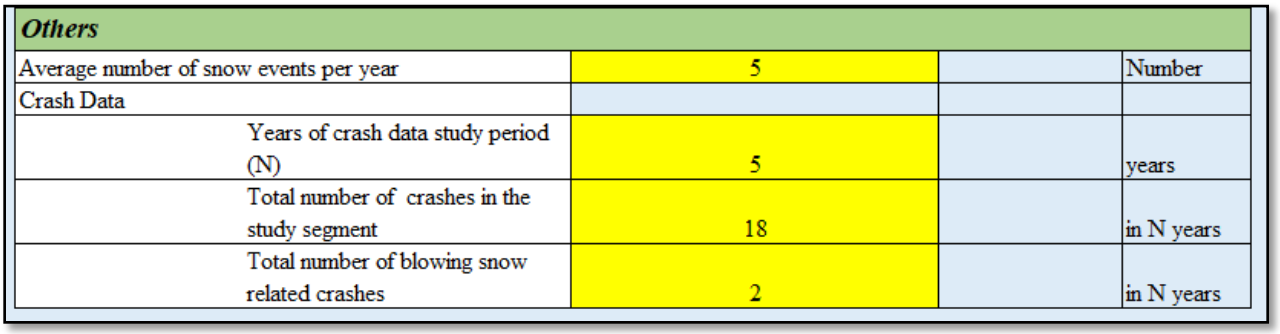
Users shall enter snow events and crash data of the study segment in this section (Figure 52).

Snow Events

The number of snow events can vary over years. So, users shall enter the average number of snow events per year over the most recent five years of the study segment.

Crash Data

Users shall enter the total number of crashes and the number of crashes related to blowing snow along the study segment.



Others			
Average number of snow events per year	5		Number
Crash Data			
Years of crash data study period (N)	5		years
Total number of crashes in the study segment	18		in N years
Total number of blowing snow related crashes	2		in N years

Figure 50. Image. Crash data in a study segment.

Analysis Parameter

The analysis parameter worksheet contains data items for calculating the costs and benefits of snow fences, along with the unit rates, such as land rental, labor, equipment, fuel, crop yield, etc. These rates depend upon locations and are time-sensitive, so users shall go to the respective lookup sheet to update those values periodically.

Snow Fence Costs

The BCA tool considered installation, maintenance, land rental, and inconvenience costs for snow fences. Prevailing local market values were used in the calculation of costs.

Land Rental Rate

The land rental rate is the market rental rate of an acre of farmland adjacent to the blowing snow segment. The rate values were obtained from the USDA's National Agricultural Statistics Service (NASS 2019) and vary based on the county where the segment is located. The rate values can be updated from the hidden worksheet "Land Rental Rate."

Labors Cost

Labor rates are taken from the Illinois Department of Labor website (IDOL 2019). The rates vary across counties and can be updated from the hidden worksheet "Labor Wage and Equipment Rate."

Equipment Rate

The equipment rate was determined using the rental rate of the machinery ("Illinois Truck" 2019) maneuvering tractor if needed (Lattaz and Schnitkey 2019) and fuel consumption per hour based on the current gasoline rate of each county in Illinois. The labor and equipment rates can be updated from the hidden worksheet "Labor Wage and Equipment Rate."

Crop Yield and Price of Corn

The yield for the crop is measured in bushel per acre. This information was obtained from the farmdocdaily website (Schnitkey 2019). It varies across counties and can be updated from the hidden worksheet "Corn_Yield." The corn price in $/bushel also varies across counties and can be updated in the "Analysis Parameter" hidden worksheet.

Snow Fence Benefits

The snow fence benefits considered in the BCA tool include blowing snow removal cost saving, direct and indirect travel time saving, reduced fuel consumption, as well as safety and emission benefits.

Blowing Snow Removal Cost Saving

The blowing snow removal cost saving was calculated as the product of blowing snow removal cost per lane mile and the total lane miles of the study segment. The unit cost of blowing snow removal in each district is given in Table 12 (Chapter 4).

Safety Benefit

The safety benefit of snow fences was calculated following the FHWA guidelines for benefit-cost analysis (Lawrence et al. 2018). First, the expected number of annual total crashes was determined. Then, the CMF was used to determine the reduction of total crashes due to the snow fence. Last, the equivalent dollar values of reduced crashes were calculated based on the Illinois comprehensive crash cost value for different severity levels obtained from IDOT (Table 24). Users can update crash cost values in the "Benefit Related Linked Value" worksheet and the snow fence CMF in the "CMF" worksheet.

Table 24. Illinois comprehensive crash cost value (2019 USD)

Severity	Illinois Comprehensive Crash Cost Value
	2019 USD
k-Fatal Crash	$6,824,884
A-Injury	$367,726
B-Injury	$134,492
C-Injury	$76,439
D-Property Damage Crash	$12,598

Direct Travel Time Saving

The Federal Motor Carrier Safety Administration (2015) suggests a 33.3% reduction in traffic speed under snow/ice conditions. The travel time saved for each vehicle is determined as the difference between travel times calculated (segment length/traffic speed) under normal conditions and snow/ice conditions. The NHTSA suggested monetary travel time cost values of passenger vehicles, and trucks (Table 25) were used to monetize the direct travel time saving. These values can be updated in the "Benefit Related Linked Value" hidden worksheet.

Table 25. NHSTA recommended values of travel time (2019 USD)

Road Type	Value of Time for Passenger Vehicles	Value of time for trucks
Urban Interstate/ Expressway	27.11	40.25
Urban Arterial	27.17	38.47
Urban Other	27.31	37.35
Rural Interstate/ Principal Arterial	27.36	41.59
Rural Other	27.71	39.08

Indirect Travel Time Savings from Crash Reduction

NHTSA provides factors for average vehicle delay hours by crash severity level by road facility (Table 26) (Lawrence et al. 2018). These values can be updated in the "Benefit Related Linked Value" hidden worksheet. Indirect travel time saving was quantified by multiplying those factors by the estimated annual reduction in crashes of different severity levels.

Table 26. Vehicle delay hours by crash severity and roadway type

Crash Severity	Urban Interstate/ Expressway	Urban Arterial	Urban Other	Rural Interstate/ Principal Arterial	Rural Other
Fatal	5147.7	1258.26	207.88	1780.31	104.82
Injury	345.29	68.56	15.4	207.68	13.86
PDO	215	49.94	10.32	146.25	10.33

Reduced Fuel Consumption

The fuel saved due to the avoidance of crashes based on crash severity and roadway facility type was determined following the FHWA guide (Table 27) (Lawrence et al. 2018). These values can be updated in the "Benefit Related Linked Value" hidden worksheet. The saved fuel was monetized using the current market price of fuel.

Table 27. Net increase in fuel consumption per crash

Facility Type	Type of Severity		
	Fatal Crashes	Injury Crashes	PDO Crashes
	Fuel (Gallons)	Fuel (Gallons)	Fuel (Gallons)
Urban Interstate/ Expressway	1951	412	351
Urban Arterial	504	112	68
Urban Other	39	17	10
Rural Interstate/ Principal Arterial	294	54	55
Rural Other	36	9	8
Average All Roadway Types	376	81	64

Emission Benefit

The emission benefit was calculated by quantifying the reduction in emissions of greenhouse gases (GHG) due to decreasing operational activities of snow maintenance vehicles and reduction in crashes after snow fence implementation. The emission benefit due to reduced winter maintenance activities was calculated based on an average 11 lb of carbon dioxide emission reduction per foot of snow fence (Wyatt et al. 2012) and the social cost of carbon \$52/ metric ton of CO_2 recommended by US EPA (Malmgren 2016). These values can be updated in the "Analysis Parameter" worksheet. The emission benefit due to reduced crashes was calculated based on crash severity, as per FHWA guidelines from the estimated value of emission per crash shown in Table 28 (Lawrence et al. 2015). These values can be updated in the "Benefit Related Linked Value" hidden worksheet.

Table 28. Estimated value of emission per crash for different crash severity and road facility

Estimated Value of Net Emissions/Crash by Facility Type, All Fatal Crashes (2019 USD)							
	CO_2	CO	NOx	PM10	PM2.5	SO_2	VOC
Urban Interstate/ Expressway	$897.00	$0.00	$214.08	$0.00	$970.27	$76.69	$25.58
Urban Arterial	$231.49	$0.00	$54.46	$0.00	$144.99	$19.60	$4.33
Urban Other	$17.74	$0.00	$4.28	$0.00	$9.67	$1.53	$0.29
Rural Interstate/ Principal Arterial	$135.00	$0.00	$64.71	$0.00	$193.56	$11.25	$2.64
Rural Other	$16.76	$0.00	$6.80	$0.00	$19.00	$1.39	$0.30
Estimated Value of Net Emissions/Crash by Facility Type, All Injury Crashes (2019 USD)							
Urban Interstate/ Expressway	$189.51	$0.00	$45.23	$0.00	$204.94	$16.23	$5.40
Urban Arterial	$51.34	$0.00	$12.07	$0.00	$31.59	$4.35	$0.95
Urban Other	$7.78	$0.00	$1.87	$0.00	$4.08	$0.68	$0.13
Rural Interstate/ Principal Arterial	$24.90	$0.00	$11.94	$0.00	$35.81	$2.10	$0.48
Rural Other	$4.26	$0.00	$1.72	$0.00	$4.75	$0.35	$0.07
Estimated Value of Net Emissions/Crash by Facility Type, All PDO Crashes (2019 USD)							
Urban Interstate/ Expressway	$161.18	$0.00	$38.47	$0.00	$174.02	$13.73	$4.59
Urban Arterial	$31.11	$0.00	$7.32	$0.00	$19.87	$2.62	$0.58
Urban Other	$4.69	$0.00	$1.13	$0.00	$2.44	$0.39	$0.08
Rural Interstate/ Principal Arterial	$25.33	$0.00	$12.14	$0.00	$36.17	$2.07	$0.49
Rural Other	$3.56	$0.00	$1.45	$0.00	$3.89	$0.30	$0.06

Benefit-Cost Summary

The benefit-cost summary worksheet is the output worksheet, which contains the itemized costs and benefits based on the snow fence type, the overall benefit-cost ratio, IDOT B/C ratio, the annual cost table, as well as the charts of the annual present value and the cumulative present values of cost and benefit over the study period (Figure 53).

SUMMARY

The research team developed a tool to facilitate the benefit-cost analysis of snow fences, including living and structural snow fences as well as standing corn rows. The BCA tool was developed using MS Excel for ease of use and access.

Four visible worksheets were included in the BCA tool. The introduction worksheet gives a brief overview of the project and each worksheet, along with the coloring scheme used to represent different cell functions. Site-specific geometry, traffic, safety, and weather information as well as snow fence characteristics obtained from the snow fence design are entered by users in the user input worksheet. The analysis parameter worksheet contains data items for calculating the costs and benefits of snow fences, along with the unit rates used in monetizing each cost and benefit, such as land rental, labor, equipment, fuel, crop yield, etc. Those rate values can be updated in their corresponding hidden worksheets. The benefit-cost summary worksheet provides the BCA results, including the itemized costs and benefits based on the snow fence type, the overall benefit-cost ratio, IDOT benefit-cost ratio, the annual cost and benefit over the analysis period table, as well as the charts of annual present values and cumulative present values of cost and benefit over the study period. The annual cost over the analysis period can be used to develop the snow fence payment structure.

		Year of Study:	*2019*
Agency:	Illinois Department of Transportation	*Road ID:*	*I 39*
Project Name:	Snow Fence Installation	*MM start:*	*6*
County:	Mclean County	*MM end:*	*7.3*

Type of a Snow Fence	***Living Snow Fence***
Present Value Costs ($)	$231,804.36
Present Value Benefit ($)	$415,578.48
Benefit - Cost Ratio:	1.79
IDOT Benefit- Cost Ratio:	0.20
Analysis Period (years)	15
Discount Rate	3%
Project Feasibility	Feasible

Itemized Costs	***per year***	***15 years PV***
Installation Cost	$59,247.16	$59,247.16
Maintenance Cost	$10,468.32	$56,708.90
Land Rental Cost	$2,116.50	$25,266.64
Inconvenience Cost	$7,587.72	$90,581.66
Itemized Benefits	***per year***	***15 years PV***
Blowing Snow Removal Cost Saving	$7,101.64	$46,307.97
Safety Benefit	$23,386.73	$152,498.86
Travel Time Benefit	$31,425.38	$204,916.88
Vehicle Operating Cost Benefit	$23.54	$153.50
Emission Benefit	$1,794.47	$11,701.27

PV:Present Value

Forecasted Average Inflation Rate	2.20%	(https://knoema.com/kyaewad/us-inflation-forecast)

Year	Annual Cost					Annual Benefit
	Installation	Maintenance	Land Rental	Inconvenience	Total	
2019	$59,247.16	$10,468.32	$2,116.50	$7,587.72	$79,419.70	$0.00
2020	$0.00	$10,698.62	$2,163.06	$7,754.65	$20,616.33	$0.00
2021	$0.00	$10,933.99	$2,210.65	$7,925.25	$21,069.89	$0.00
2022	$0.00	$11,174.54	$2,259.28	$8,099.60	$21,533.43	$0.00
2023	$0.00	$11,420.38	$2,308.99	$8,277.79	$22,007.16	$0.00
2024	$0.00	$11,671.63	$2,359.79	$8,459.91	$22,491.32	$0.00
2025	$0.00	$0.00	$2,411.70	$8,646.02	$11,057.73	$72,620.85
2026	$0.00	$0.00	$2,464.76	$8,836.24	$11,301.00	$74,218.50
2027	$0.00	$0.00	$2,518.98	$9,030.63	$11,549.62	$75,851.31
2028	$0.00	$0.00	$2,574.40	$9,229.31	$11,803.71	$77,520.04
2029	$0.00	$0.00	$2,631.04	$9,432.35	$12,063.39	$79,225.48
2030	$0.00	$0.00	$2,688.92	$9,639.86	$12,328.79	$80,968.44
2031	$0.00	$0.00	$2,748.08	$9,851.94	$12,600.02	$82,749.75
2032	$0.00	$0.00	$2,808.54	$10,068.68	$12,877.22	$84,570.24
2033	$0.00	$0.00	$2,870.32	$10,290.20	$13,160.52	$86,430.79
2034	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2035	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2036	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2037	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2038	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2039	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2040	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2041	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2042	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2043	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2044	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2045	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2046	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2047	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2048	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

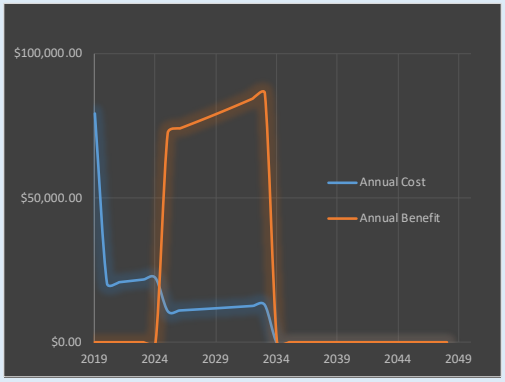


Fig: Annual Benefit- Cost Curve of Living Snow Fence

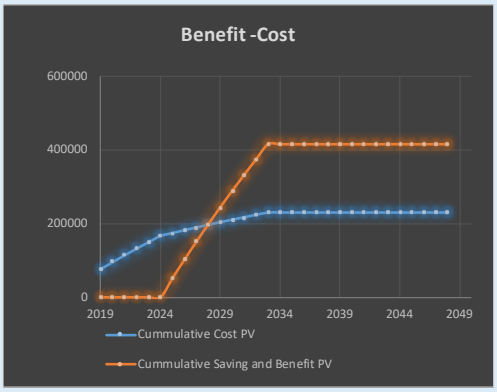


Fig: Cummulative PV Benefit- Cost Curve for Living Snow Fence

Figure 51. Image. Benefit-cost summary worksheet.

CHAPTER 7: CONCLUSIONS AND OBSERVATIONS

Blowing snow and snowdrifts have long been known to have negative impacts on winter roadway safety, mobility, and maintenance. Serving as wind breakers, properly sited and designed snow fences have been proven effective in mitigating the negative impacts of blowing and drifting snow, while providing low-cost snow storage. To achieve the best snow-control effects, the ideal locations for snow fences are usually outside the roadway right-of-way. Therefore, buy-in by private landowners must occur for snow fences to be effective snow-control devices. The objective of this project is to develop methodologies for evaluation of the costs and benefits of snow fences in Illinois and identify ways to motivate and reward private landowners' participation in the snow fence program while keeping it cost-effective. To achieve the objective, a literature review on snow fence economic analysis was conducted, followed by surveys of transportation agencies in the Midwest and landowners in Illinois. Then, a benefit-cost analysis of snow fences was illustrated through a case study. A tool was developed using MS Excel to facilitate the benefit-cost analysis of snow fences in Illinois.

The agency survey was conducted online, and the survey link was sent to state transportation agencies in the Midwest. Responses were compiled to identify best practices of agencies in implementing snow fence programs. The landowner survey was conducted online as well. Responses were solicited via the online publication *FarmWeek*. Its purpose was to gather private landowners' opinions on snow fence programs and their suggestions on how to encourage participation.

Available data from snow fence and blowing snow segments, snow- and ice-related crashes over 2012–16, and blowing snow removal expenditure for the 2017–18 season were obtained from IDOT. The segment and crash data were used to develop the snow fence crash modification factor to quantify the safety benefit of snow fences. The expenditure data for blowing snow removal, in conjunction with blowing snow segment lane-mile data obtained from the Phase I study, were used to determine the blowing snow removal per lane-mile cost to quantify snow removal savings from snow fence implementation.

Following FHWA guides, the benefit and cost analyses were conducted for living and structural snow fences as well as standing corn rows. The costs considered in the study included snow fence installation, maintenance, land rental, and inconvenience, while benefits included snow removal cost saving, travel time saving, as well as safety and emission benefits. All costs and benefits over the analysis period were monetized into present values. The benefit and cost ratios were calculated to evaluate snow fences.

A benefit-cost analysis tool was developed using MS Excel. The tool has four visible worksheets: introduction, user inputs, parameters, and outputs. The inputs required are the snow fence design and site-specific characteristics. The parameter worksheet contains the cost and benefit structures, as well as ways to monetize each snow fence cost and benefit. All background calculations are included in hidden worksheets. The benefit-cost analysis tool can analyze living and structural snow fences as well as standing corn rows. The tool outputs include a summary table containing total net present values of costs and benefits, overall benefit-cost ratio, agency benefit-cost ratio, as well as

the table of annual costs and benefit values and the figure of cumulative cost and benefit value over the analysis period.

FINDINGS

The findings of the literature review are listed below:

1. All previous studies on the economic efficiency of snow fences confirmed the benefits of snow fences, particularly snow removal savings and crash reduction.
2. No previous studies have conducted a benefit-cost analysis of snow fences following the USDOT *Economic Analysis Primer* and FHWA *Highway Safety Benefit-Cost Analysis Guide*.
3. No previous studies have conducted a benefit and cost analysis of all three types of snow fences: LSFs, SSFs, and SCRs.

The findings of the data preparation are listed below:

4. No severe crashes occurred during 2012–2016 at snow fence segments, while several fatalities and A-injuries occurred at blowing snow segments, according to available data on blowing snow and snow fence segments as well as crashes.
5. The snow fence CMF calculated using the available snow fence segment, blowing snow segment, and crash data is comparable to those developed by two previous studies (Peel et al. 2017; Larson et al. 2019), although the standard deviation of the calculated CMF is relatively high because of the small sample size.
6. District 3 has the highest blowing snow removal cost per lane mile, based on the 2017–18 blowing snow removal expenditure data and the total blowing snow segment lane miles reported.

The findings of the agency survey are listed below:

7. Most respondents planned to maintain or expand their snow fence programs.
8. Best practices for snow fence implementation in the Midwest included identifying appropriate sites, contacting landowners, considering snow fence types (such as structural versus living), and compensating landowners.
9. Experience and feedback from road maintenance personnel were the most common sources for identifying blowing snow road segments.
10. When contacting landowners about installing a snow fence on their property, face-to-face contact from local DOT personnel was the most common method.
11. Monetary compensation was the most common method of compensating landowners whose land was used for snow fence installation.

The findings of the landowner survey are listed below:

12. The primary concerns expressed by Illinois landowners about entering into a snow fence contract with IDOT were compensation (proper amount and timeliness), implementation (timing must avoid harvest and wet periods), and maintenance (adequacy).
13. Structural snow fences were the least intrusive options for landowners and living snow fences with trees were the most intrusive. Some LSF concerns could be reduced by allowing landowners to play a role in the design (e.g., compact plantings are preferred) and plant-selection process (e.g., shrubs were preferred over trees).

The findings of the benefit-cost analysis are listed below:

14. The benefit-cost ratios for all three types of snow fences are larger than one.
15. The benefit-cost ratio number of SCRs is the highest among the three and the numbers are comparable for LSFs and SSFs.
16. It takes longer to amortize installation and maintenance costs of LSF than SSF because several years are needed for LSF plants to mature before yielding benefits.

In conclusion:

- Snow fence programs are common tools used by transportation agencies in the Midwest, and monetary compensation is the most frequent method for reimbursing landowners for the use of their land.
- Findings 14 and 16 suggest that SSFs and SCRs might be the best snow fence design options for Illinois landowners.
- Per findings 3 and 4, existing snow fences implemented along Illinois freeway and rural highways are effective in reducing the total number of crashes related to blowing snow and crash severity.
- Per findings 13 and 14, snow fences can be valuable investments for managing blowing snow along Illinois roadways, considering both agency and non-agency benefits (safety as well as travel time and emission savings).

OBSERVATIONS

Several observations and recommendations related to snow fence CMF, snow fence cost data, snow removal savings, and snow fence BCA were offered in this section.

Agency and Landowner Surveys

- Monetary compensation was by far the most common method used by Midwestern state transportation agencies for reimbursing landowners for the inconvenience of hosting a snow fence on their property.
- Illinois landowners considered standing corn rows and structural snow fences as the least intrusive options.

- Costs that concerned Illinois landowners included reduced productivity of crops adjacent to snow fences because of reduced resources (LSF) or soil compaction (SSF).

Snow Fence Crash Modification Factors

- More crash data are needed from existing snow fence segments in Illinois to increase the precision of Illinois snow fence CMF calculated using the cross-sectional method.
- To determine the snow fence CMF using the *HCM*-recommended E–B method, either up to five years of crash data before existing snow fences were implemented need to be retrieved, or if any new snow fence is planned for an existing blowing snow segment, up to five years of crash data before and after snow implementation need to be collected.
- The snow fence CMF calculated in the study is the CMF for the total crashes related to blowing snow. The CMF in terms of severe crashes related to blowing snow was not calculated, because no severe crashes occurred on snow fence segments during 2012–2016. If severe crash data are available, it is expected that the snow fence CMF values in terms of severe crashes will be even lower.

Snow Fence Cost Data

- No cost data are available for Illinois snow fences. To illustrate how to conduct the benefit-cost analysis of snow fences, snow fence cost information from literature and other states were used in the BCA. All the referred numbers were converted to 2019 values and prevailing Illinois rates (e.g., labor, equipment, corn yield, etc.) were used when applicable.
- Other states (Minnesota, Wyoming, etc.) have implemented snow fences for years to get the numbers suitable for their states. A similar approach is needed to get suitable numbers regarding snow fence costs in Illinois.

Cost Savings for Blowing Snow Removal

- The blowing snow removal per line cost used in the study was calculated as the ratio of the blowing snow removal cost over the total blowing snow segment lane mile in a team section. A more accurate way to determine the unit cost is using the segment lane miles where blowing snow occurred, instead of the total blowing snow lane mile in the team section. This method was not used because the segment lane miles that encountered blowing snow during each snow event are not available.
- A direct way to quantify the blowing snow removal cost saving is to compare the cost of blowing snow removal per lane mile to snow fence segments and blowing snow segments. To get these unit costs, blowing snow affected segment length during each snow event needs to be collected in addition to the blowing snow removal expenditure.

Snow Fence Benefit-Cost Analysis

- The parameters used in the BCA (e.g., labor rate, equipment rate, corn yield rate, corn market value, the comprehensive value of a crash of different severity, etc.) are time sensitive. Those numbers need to be updated periodically in the BCA tool.

- The benefit-cost ratios of LSFs and SSFs are comparable. However, LSFs are favorable over SSFs, considering the potential environmental benefits and maintenance costs saved after the plants mature.
- Although SCR is an appealing option based on the BCA results, the need to renew the agreements between landowners and agencies annually and the alternating of crops planted in the farmland may limit its effectiveness and large-scale implementation.

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APPENDIX A: AGENCY SURVEY QUESTIONNAIRE

IDOT Snow Fence Survey

Welcome

The Illinois Department of Transportation (IDOT) in association with the Illinois Center for Transportation has commissioned a research study to provide IDOT with guidance on the best practices of using snow fences (both living and structural). The project team is led by Southern Illinois University Edwardsville (SIUE). We have identified you as the initial point of contact that could provide insight that will help IDOT. If necessary, please delegate this survey to another individual from your staff or advise us on a better contact. The results from this research project are vitally important to assist IDOT in future plans for snow fence deployments.

The following survey will take approximately 15 minutes and our procedure has been approved by the Institutional Research Board at Southern Illinois University Edwardsville to protect your privacy. Please be assured that individual responses will remain confidential. Although we will request your contact information at the end of this survey, we will only use this information to contact you if we need to clarify your responses. The compiled survey findings will be reported, but individual responses will not be published or distributed.

Thank you for contributing to this important study, your time and effort are appreciated. If you have any questions, please contact the survey manager below. Survey respondents will be notified when the compiled results are available. Questions with asterisks require a response to proceed.

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* 1. Do you consent to continue?

- ◯ Yes
- ◯ No

IDOT Snow Fence Survey

Snow Fence Usage

* 1. How frequently does your agency/jurisdiction/district use snow fences?

- ◯ Unaware of past or future plans
- ◯ We plan to expand our current program
- ◯ We have some, but plan to reduce future use
- ◯ We have plans to start a program
- ◯ We have some and plan to maintain the current program
- ◯ Other (please specify)

* 2. Approximately how many miles of roadway does your agency/jurisdiction/district operate?

Interstate/Freeway/Expressway (miles)	
State Highway/Arterial (miles)	
Other (miles)	
Unknown (If unknown, enter 1 here)	

* 3. Approximately how many miles of roadway have snow drifting problems in your agency/jurisdiction/district?

Interstate/Freeway/Expressway (miles)	
State Highway/Arterial (miles)	
Other (miles)	
Unknown (If unknown, enter 1 here)	

* 6. What best practices would you recommend to other agencies interested in starting a snow fence program?

7. What best practices would you recommend to other agencies starting a **living** snow fence program?

8. Please provide any website your organization has concerning your snow fence program.

IDOT Snow Fence Survey

Costs and Benefits of Snow Fences

Please answer the following questions about snow fences.

1. What annual cost does your agency incur for your existing snow fence program?

2. Please provide details about your annual costs for your **living** snow fence program? (numerical response in dollars)

Creating contracts with landowners	
Payments to landowners	
Living snow fence materials	
Installation/construction and maintenance	
Program management	
Other (Please explain)	
If your agency has living snow fences, but you do not have access to this information, enter 1 here	

3. Please provide details about your annual costs for your **structural** snow fence program? (numerical response in dollars)

Creating contracts with landowners	
Payments to landowners	
Structural snow fence materials	
Installation/construction and maintenance	
Program management	
Other (Please explain)	
If your agency has structural snow fences, but you do not have access to this information, type 1 here	

4. Does your agency/jurisdiction/district use GIS (Geographical Information Systems) to identify snow trap/drift locations? Select the best option.

- ◯ Always
- ◯ Usually
- ◯ Sometimes
- ◯ Rarely
- ◯ Never
- ◯ Planned for the future
- ◯ I am unaware of any GIS use related to snow fences

5. How far from the roadway are snow fences recommended in your agency/jurisdiction/district (feet)? If your agency has no recommendations, please say "no recommendations."

Living snow fences	
Structural snow fences	

6. At locations where your agency/jurisdiction/district has worked to implement a **living** snow fence program, what percent (%) of landowners participated after being contacted? Please enter whole numbers, adding to 100 (no symbols or decimals).

Did not respond (%)	
Responded negatively and do not plan to participate (%)	
Responded positively, but did not participate (%)	
Responded positively and plan to participate in the future (%)	
Responded positively and participated (%)	
If this information is not available, respond 100 here	

7. At locations where your agency/jurisdiction/district has worked to implement a **structural** snow fence program, what percent (%) of landowners participated after being contacted? Please enter whole numbers, adding to 100 (no symbols or decimals).

Did not respond (%)	
Responded negatively and do not plan to participate (%)	
Responded positively, but did not participate (%)	
Responded positively and plan to participate in the future (%)	
Responded positively and participated (%)	
If this information is not available, respond 100 here	

8. Of the snow fences used in your agency/jurisdiction/district, what types are used? Please enter whole numbers, adding to 100 (no symbols or decimals).

Plantings of trees and/or shrubs (%)	
Unharvested rows of corn (%)	
Unharvested rows of other crops (%)	
Structural (non-living) (%)	
Other	
If this information is not available, type 100 here	

9. If your answer to the previous question included "unharvested rows of other crops" or "other," please explain.

10. Has there been any documented reductions in your agency/jurisdiction/district from implementing snow fences? Please enter whole numbers (no symbols or decimals).

Percent reduced total crashes?	
Percent less salt/brine used?	
Percent less labor hours needed?	
Percent less equipment costs?	
Percent reduced delay/congestion	
Other	
If no information is available about these categories, type 1 here	

11. How does your agency/jurisdiction/district estimate benefits from snow fences?

12. Has your agency/jurisdiction/district documented the benefits of your snow fence program in any reports, memos, or other forms?

- ◯ Yes
- ◯ No
- ◯ Other (please specify)

IDOT Snow Fence Survey

Landowner Participation

Please answer the following questions to help us learn more about landowner participation in your snow fence programs.

1. How does your agency/jurisdiction/district arrange the use of private lands for your**living** snow fence program?

	Never	Planned/Future use	Sometimes	Regularly	Always
Monetary compensation	◯	◯	◯	◯	◯
Establishing easement(s)	◯	◯	◯	◯	◯
Purchasing land from owners	◯	◯	◯	◯	◯
Other (please explain)	◯	◯	◯	◯	◯

If you answered to "Other," please explain.

2. What is the average contract length for landowners participating in your**living** snow fence program? Please answer with a number of years.

3. Please explain your department's reimbursement structure for land owners participating in your**living** snow fence program?

4. What constraints do you think limit landowner participation in your snow fence program?

5. How does your agency manage contracts with landowners for your **living** snow fence program?

	Never	Planned/Future use	Rarely (i.e. every few years)	Sometimes (i.e. once per year)	Regularly (i.e. monthly)	Frequently (i.e. multiple times per month)
Field personnel talk to landowners directly	○	○	○	○	○	○
Office personnel talk to landowners directly	○	○	○	○	○	○
Mailing information to targeted land owners	○	○	○	○	○	○
Information available on website	○	○	○	○	○	○
Mailing quotes for snow fence reimbursement to each targeted land owner	○	○	○	○	○	○
Phone calls to targeted land owners in problem areas	○	○	○	○	○	○
Using social media	○	○	○	○	○	○
Holding public outreach sessions / question and answer sessions	○	○	○	○	○	○
Other (please explain)	○	○	○	○	○	○

If you answered to "Other," please explain.

6. What personality traits or experience do you recommend for employees who directly contact landowners about participating in **living** snow fence programs?

IDOT Snow Fence Survey

Agency and Contact Information

Please share the following information about you and your agency so we can add context to your responses.

1. What is your Name

* 2. What agency/employer do your represent?

3. What is your title/position?

* 4. What is your email address?

5. Would you like a copy of these survey results when the study is finished?

- Yes
- No

6. What is your office phone number?

7. Please provide any additional information you think would support our research, including others we could contact.

IDOT Snow Fence Survey

Thank you!

We appreciate your time and effort in completing our survey. If you have questions for us, please contact:

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APPENDIX B: EXAMPLE LANDOWNER CONTRACTS SHARED WITH THE RESEARCHERS

DEPARTMENT OF TRANSPORTATION

MnDOT Contract No.

CP-17A LIVING SNOW FENCE AGREEMENT

First Winter Season of Protection	Trunk Highway	Drift Identification	Control Section		Reference Post to	Plow Route #
County	Truck Station	Township Name	¼	Section	Township	Range

Participant(s) agree(s) to provide a living snow fence along Trunk Highway _____ by establishing and maintaining living snow fence plantings certified by the Natural Resources Conservation Service and set back _____ feet from the Right of Way line of the above Trunk Highway.

In consideration for this service, the Minnesota Department of Transportation (MnDOT) agrees to pay Participant(s) according to Section 1, Payment Formula, below providing that MnDOT certifies that the terms and conditions contained in this Contract have been met.

1. PAYMENT FORMULA

(Round all numbers to the second decimal point)

- The number of years the living snow fence practice is enrolled in the Continuous Conservation Reserve Program-CCRP = _____.
- The year planted = _____.
- The length in feet of the living snow fence = 2240 lineal feet.
- The Snow Storage acres are 2250 lineal feet x 150 feet ÷ 43,560 square feet = 7.02 acres. *(Round to the second decimal point.)*

MnDOT Snow Storage Rental Rate Formula

The CCRP Soil Rental Rate = $ 111 acre.

Is the snow catch area planted in a native grass pollinator species mix?

☒ Yes or ☐ No

If yes – then MnDOT provides compensation at a rate equal to 100% of the CCRP soil rental rate, but not less than $50 per acre.

If no – then MnDOT provides compensation at a rate equal to 50% of the CCRP soil rental rate, but not less than $50 per acre

---

The MnDOT Snow Storage Rental Rate = $ 111 acre.

I. Annual compensation for Snow Storage is MnDOT's Snow Storage Rental Rate of $ 111 per acre x # 7.02 of Snow Storage acres

= $ 779.73

II. Annual compensation for growing a living snow fence using agroforestry principles such as watering, mowing, weed control, pruning re-anchoring landscape fabric, and scouting to assess the condition of the living snow fence.

a. Compensation for growing the living snow fence is MnDOT's annual compensation rate of $ 155 per acre x total # 7.02 of living snow fence acres planted = $ 1088.10.

III. Total annual payment (lines I and II a) made under this agreement is $ 1867.85.

The baseline payment (P_0) will be annually adjusted by the Producer Price Index for Farm Product Commodities. MnDOT agrees to not pay less than the baseline payment dollar amount at sign up for the remaining life of this agreement.

The Farm Product Price Index ($WPU01_0$) from previous year of sign up 161.8.

a. Annual payment in year (t).

$$P_t = P_0\left(\frac{WPU01_{t-1}}{WPU01_0}\right)$$

Example: Payment in Year 5.

$$P_5 = P_0\left(\frac{WPU01_{5-1}}{WPU01_0}\right)$$

The Farm Product Price Index WPU01 values can be obtained by visiting the MnDOT living snow fence website at:

http://www.dot.state.mn.us/environment/livingsnowfence/forms.html

Appropriate payment is to be made on or before April 30th each year of this agreement.

---

2. LENGTH OF THIS AGREEMENT IS _____ YEARS.

Agreement period is from State fiscal years _____ to _____

Agreement period starts on the date on which all the necessary signatures for executing this Agreement have been obtained.

Inspected And Approved For Payment

Year	Initial	$	Year	Initial	$	Year	Initial	$
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____

** *See formula for $ amount in the right column at 1.III.a.*

FOR MnDOT SNOW FENCE COORDINATORS USE

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3. TRANSFER OF LAND

A. Participant(s) must notify MnDOT within 30 days when a new owner or operator purchases or obtains the right and interest in, or right of occupancy to the land subject to this agreement. Any new owner(s) or operator(s), must be approved by MnDOT in order to become a participant to a new Snow Fence Agreement under the same terms and conditions of this Contract;

B. If any new owner(s) or operator(s) become an heir, successor, or assign to the existing Snow Fence Agreement the new owner(s) or operator(s) shall assume all obligations under such agreement of the previous participant;

C. If the new owner or operator becomes a successor to a Snow Fence Agreement with MnDOT;

(1) Cost-share payments shall be made to the participant who installed the planting and;

(2) Annual rental payments paid in the fiscal year the land was transferred shall be divided equally, as determined by MnDOT.

---

4. TERMINATION

In the event that the Minnesota Legislature does not appropriate to the **Department of Transportation** funds necessary for the continuation of this agreement, this agreement may be terminated by the **Department of Transportation** upon giving thirty (30) days written notice to the Participant(s).

In the event that the living snow fence dies off during the length of this agreement from neglect, lack of care-by not using agroforestry principles, and/or herbicide damage the **Department of Transportation** will cease making its annual payment within thirty (30) days written notice to the Participant(s).

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5. DATA PRACTICES

Books, records, documents, and accounting procedures and practices of the participant(s) relevant to the agreement shall be subject to examination by the contracting department or agency and the legislative auditor.

---

6. PARTICIPANTS – SIGNATURE(S)

By signing below, Participant(s) agree(s) to the terms and conditions in this Contract and that the information I have provided is the amount on lines III, of the Payment Formula.

Participant(s) may receive a W-9 verification form requiring further information to register as a vendor with the State of Minnesota. Participant(s) will receive a 1099 form, which reports the amount received from the State of Minnesota from this Contract within the calendar year.

Participant(s) have read and understand the terms and conditions of the Contract and agree to its terms and conditions.

A(1). Participants Name: Phone #, Address (Zip Code)	(2) Share in %	(4) Signature	Date (mm-dd-yyyy)
B(1). Participants Name: Phone #, Address (Zip Code)	(2) Share in %	(4) Signature	Date (mm-dd-yyyy)
C(1). Participants Name: Phone #, Address (Zip Code)	(2) Share in %	(4) Signature	Date (mm-dd-yyyy)
Signature of Area Maintenance Engineer (with delegated authority)			Date (mm-dd-yyyy)

TO BE COMPLETED BY THE MNDOT DISTRICT BUSINESS OFFICE

Purchase Order No.	Vendor No. & Location No.	Category
FUND:	FIN DEPT ID:	APPROP ID:
ACCOUNT:	PROJECT ID:	SOURCE TYPE:
TAXABLE: NO		

Note to Business Office: **This signed form serves as the invoice** **Use the vendor number as the invoice number**

DOT-997
(02/2017)

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
LIVING SNOW FENCE
STANDING CORN ROW AGREEMENT

This Agreement is made and entered into between Name of Participant, of Address, City, State Zip Code, referred to in this Agreement as the "Participant," and the State of South Dakota, acting by and through its Department of Transportation, referred to in this Agreement as the "State."

1. PURPOSE:

   The Participant agrees to leave standing corn rows along South Dakota Highway , by refraining from harvesting acres of corn stalks setback feet from the right of way until Date. After this date, the Participant may remove the standing corn rows without notification from the State. In consideration for this service, the State will pay the Participant according to Paragraph 3., below, provided the State certifies the terms and conditions of this Agreement have been met.

2. TERM:

   The term of this Agreement will be from October 1, Year, through April 30, Year.

3. PAYMENT:

   The State will pay the Participant the lump sum amount of $, based on the formula provided in line 3.d., on or before April 30, Year, upon certification that the terms and conditions of this Agreement have been met.

   a. Acres of corn left standing = Length feet X width feet ÷ 43,560 feet ² = acres (round to the second decimal point)

   b. Average bushel yield = per acre

   c. Cost per bushel = Market value per bushel $ + $3 = per bushell

   d. Multiply line 3.a., 3.b., and 3.c., above, X X = $

4. The Participant will allow the State, and any servant, agent, contractor, or worker authorized by the State, the right of ingress and egress from the public highway to the subject real property, to inspect the standing corn rows.

5. Participant will receive a W-9 verification form requiring further information to register as a vendor with the State of South Dakota. Participant will receive a 1099 form, which reports the amount received from the State of South Dakota from this Agreement and agrees to its terms and conditions.

This Agreement is binding on the State, the Participant, and the Participant's successors and assigns.

State of South Dakota
Department of Transportation

_____
Name of Participant

By: _____

Its: _____

Date: _____

Date: _____

Page 1 of 1

DOT-998
(01/2017)

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
LIVING SNOW FENCE
HAY BALE/SILO BAG AGREEMENT

This Agreement is made and entered into between Name of Participant, of Address, City, State Zip Code, referred to in this Agreement as the "Participant," and the State of South Dakota, acting by and through its Department of Transportation, referred to in this Agreement as the "State."

1. PURPOSE:

   The Participant agrees to place hay bales/silo bags along South Dakota Highway , by placing the hay bales/silo bags in a row setback feet from the right of way until Date. After this date, the Participant may remove the hay bales/silo bags without notification from the State. In consideration for this service, the State will pay the Participant according to Paragraph 3., below, provided the State certifies the terms and conditions of this Agreement have been met.

2. TERM:

   The term of this Agreement will be from October 1, Year, through April 30, Year.

3. PAYMENT:

   The State will pay the Participant the lump sum amount of $, based on a rate of ($) per linear foot of hay bale/silo bag, on or before April 30, Year, upon certification that the terms and conditions of this Agreement have been met.

4. The Participant will allow the State, and any servant, agent, contractor, or worker authorized by the State, the right of ingress and egress from the public highway to the subject real property to inspect the hay bales.

5. Participant will receive a W-9 verification form requiring further information to register as a vendor with the State of South Dakota. Participant will receive a 1099 form, which reports the amount received from the State of South Dakota from this Agreement and agrees to its terms and conditions.

This Agreement is binding on the State, the Participant, and the Participant's successors and assigns.

State of South Dakota
Department of Transportation

_____
Name of Participant

By: _____

Its: _____

Date: _____

Date: _____

DEPARTMENT OF TRANSPORTATION

MnDOT Contract No.

SNOW FENCE AGREEMENT

First Winter Season of Protection 2018	Trunk Highway 34	Drift Identification	Control Section 5611	Plow Route # TP4B0341	Reference Post 13 to 13.4	
County Otter Tail	Truck Station Barnesville	Township Name Scambler	¼ SE, SW & SW, SE	Section 20	Township 137	Range 43

Participant(s) agree(s) to provide a snow fence set back 80 feet from the Right of Way line of the above Trunk Highway in the area indicated on the diagram on the reverse side of this form.

In consideration for this service, the Minnesota Department of Transportation (MnDOT) agrees to pay Participant(s) according to Section 1 Payment Formula, below providing that MnDOT certifies that the terms and conditions contained in this Contract have been met. When structural snow fencing is used MnDOT is responsible for installing and repairing the snow fence. Through this agreement participant(s) grant MnDOT right to enter and egress their property for structural snow fence installation and maintenance purposes at a mutually agreed upon location found in the plan diagram. Participant(s) agree(s) to avoid intentionally damaging the structural snow fence and if the damage is determined to be intentional and excessive the repair costs will be deducted from MnDOT's annual payment. Participant(s) agree(s) to perform weed control surrounding the structural snow fence. For living snow fences it is the participant(s) responsibility to maintain the planting health and vigor.

1. PAYMENT FORMULA

(Round all numbers to the second decimal point)

I. The length of the snow fence = 1,953 lineal feet.

II. Annual compensation for protecting the snow fence, providing snow storage and the inconvenience of farming around it.

Annual compensation for snow fence of $ 0.60 per lineal foot of snow fence installed for 1,953 lineal feet, for a baseline payment of $ 1168.02.

III. The baseline payment (p_0) will be annually adjusted by the Producer Price Index for Farm Product Commodities. MnDOT agrees to not pay less than the baseline payment dollar amount at sign up for the remaining life of this agreement.

The Farm Product Price Index ($WPU01_0$) from previous year of sign up 161.5.

a. Annual payment in year (t).

$$P_t = P_0\left(\frac{\text{WPU01}_{t-1}}{\text{WPU01}_0}\right)$$

Example: Payment in Year 5.

$$P_5 = P_0\left(\frac{\text{WPU01}_{5-1}}{\text{WPU01}_0}\right)$$

The Farm Product Price Index WPU01 values can be obtained by visiting the MnDOT living snow fence website at: **http://www.dot.state.mn.us/environment/livingsnowfence/forms.html**

Appropriate payment is to be made on or before April 30th each year of this agreement.

---

2. TERMINATION

If the Minnesota Legislature does not appropriate funds required for this agreement, MnDOT may terminate this Contract by giving Participants thirty (30) days written notice to the Participant(s).

If the living snow fence dies off resulting from neglect, lack of care-by not using agroforestry principles, and/or herbicide damage MnDOT will cease payments within thirty (30) days written notice to the Participant(s).

If MnDOT determines that the snow fence is no longer needed at the end of this Contract than MnDOT will remove the snow fence (living or structural).

If MnDOT fails to properly maintain the structural snow fence per the fencing manufacturer's specifications, the Participant(s) may terminate this Contract within (30) days written notice to MnDOT. Upon receipt of Participant's termination notice, MnDOT must remove the fence within 60 days.

---

3. RENEWAL

At the end of this Contract if MnDOT has interest in renewing a snow fence agreement and the participant(s) choose not too than it is the responsibility of the participant(s) to bear the cost of removing the living snow fence and/or removing, salvaging and delivering the structural snow fence components to the nearest MnDOT Truck Station.

---

4. LENGTH OF THIS AGREEMENT IS 15 YEARS.

Payments made from State fiscal years 19 to 34

Agreement period starts on the date on which all the necessary signatures for executing this Agreement have been obtained.

INSPECTED AND APPROVED FOR PAYMENT:

Year	Initial	$	Year	Initial	$	Year	Initial	$
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____
20____	____	____	20____	____	____	20____	____	____

*** See formula for $ amount in the right column at 1.III.a.*

FOR MnDOT SNOW FENCE COORDINATORS USE

5. TRANSFER OF LAND

A. Participant(s) must notify MnDOT within 30 days when a new owner or operator purchases or obtains the right and interest in, or right of occupancy to, the land subject to this agreement. Any new owner(s) or operator(s) must be approved by MnDOT in order to become a participant to a new Snow Fence Agreement under the same terms and conditions of this Contract;

B. If any new owner(s) or operator(s) becomes an heir, successor, or assign to the existing Snow Fence Agreement, the new owner(s) or operator(s) shall assume all obligations under such agreement of the previous participant;

C. If the new owner or operator becomes a successor to a Snow Fence Agreement with MnDOT;

(1) Cost-share payments shall be made to the Participant who installed the living snow fence, and;

(2) Annual rental payments paid in the fiscal year the land was transferred shall be divided equally, as determined by MnDOT.

6. DATA PRACTICES

Books, records, documents, and accounting procedures and practices of the participant(s) relevant to the agreement shall be subject to examination by the contracting department or agency and the legislative auditor.

7. PARTICIPANTS – SIGNATURE(S)

By signing below, Participant(s) agree(s) to the terms and conditions in this Contract and that the information I have provided is the amount on lines III, of the Payment Formula.

Participant(s) may receive a W-9 verification form requiring further information to register as a vendor with the State of Minnesota.

Participant(s) will receive a 1099 form, which reports the amount received from the State of Minnesota from this Contract within the calendar year.

Participant(s) have read and understand the terms and conditions of the Contract and agree to its terms and conditions.

A(1). Participants Name: Phone #, Address *(Zip Code)*	(2) Share in %	(4) Signature	Date *(mm-dd-yyyy)*
	50		05/03/18
B(1). Participants Name: Phone #, Address *(Zip Code)*	(2) Share in %	(4) Signature	Date *(mm-dd-yyyy)*
	50		05/03/18
C(1). Participants Name: Phone #, Address *(Zip Code)*	(2) Share in %	(4) Signature	Date *(mm-dd-yyyy)*
Signature of Area Maintenance Engineer *(with delegated authority)*			Date *(mm-dd-yyyy)*

TO BE COMPLETED BY THE MNDOT DISTRICT BUSINESS OFFICE

Purchase Order No.	Vendor No. & Location No.	Category
FUND:	FIN DEPT ID:	APPROP ID:
ACCOUNT:	PROJECT ID:	SOURCE TYPE:
TAXABLE: NO		

Note to Business Office: **This signed form serves as the invoice** **Use the vendor number as the invoice number**

Tree & Shrub Planting Plan

Purpose: Living Snow Fence
Cooperator: [redacted]
Address: [redacted]
[redacted]
Township: Scambler **Section:** 20

Date: [redacted]
Phone No: [redacted]
Design By: [redacted]
MilePost: [redacted]

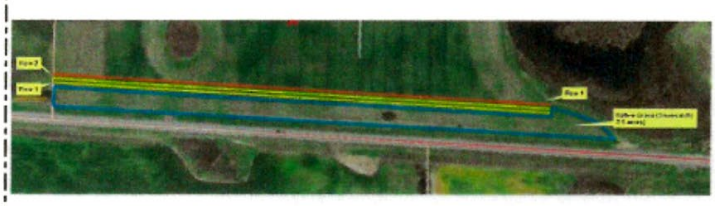
Row No.	Row Length	Species	Spacing		Number of Trees	
			In Row	Betw. Row	Planned	Planted
1	1,736	Dogwood	4	16.5	434	
2	1,736	W. Spruce	12	16.5	144	
3	1736	W. Spruce	12	16.5	144	

APPLICATION

Agreement No. _____

Speices	No.
Dogwood	450
W. Spruce	300
Total:	750

Sketch



Date Planted: _____
Fabric Installed: _____
Feet: 5,208 Acres: _____
Field Condition: Alfalfa

Maintenance Required

Control noxious and undesirable weeds. Have mower, preferably a rotary mower if necessary to clip weeds. Herbicides may be used to control weeds especially in the row.

Legal

Town._____
Range. _____

N

Site Preparation: Area where trees and native grass are to be planted will be worked.

Customer(s):

Legal Description: Scambler 20

West Otter Tail Soil & Water Conservation District
506 Western Ave N, Fergus Falls MN 56537
Phone: 218-739-4694 ext. 4 Fax: 218-739-1309

3/5/2018

West Otter Tail SWCD
Living Snowfence Installation Bid
Tucker and Mandi Hibbert
Mile Post 13 State Hwy 34
Scambler 20

Services to be completed by West Otter Tail SWCD:
Trees:
Redosier Dogwoods – 450 @ $1.25/tree = $562.50
White Spruce – 300 @ $1.25/tree = $375.00

Planting:
750 trees @ $.50/tree = $375.00

Fabric Installation:
5208 ft @ $.50/ft = $2,604.00

Native Grass Seed:
4 acres @ $150.00/acre = $600.00

Total SWCD Installation Cost: $4,516.50

Services to be completed by Landonwer (estimates):
Site Prep:
Trees: 3 acres @ $50.00/acre = $150.00
Native Grass: 4 acres @ $50.00/acre = $200.00
Native Grass Planting: 4 acres @ $25.00/acre = $100.00

Total Landonwer Estimated Cost: $450.00

Total Project Estimated Project Cost: $4,966.50

This estimate was prepared by SWCD staff for the above referenced site. If you would like more detailed information please contact Aaron Larsen at 218-739-4694 ext. 4.

Regards,

Aaron Larsen
Project Manager

Designing A Snow Fence

Introduction

Snowfall

Snow Water Equiv.

Relocation Coefficient

Wind Direction

Fetch Distance

Snow Transport

Porosity

Height

Attack Angle

Setback

Fence Extension

References

Glossary

Snow Fence Design Summary

Your selected Location:

Snowfall over Snow Accumulation Season: 2.88 ft

Snow Water Equivalent Ratio: 0.088

Relocation Coefficient: 0.37

Direction of greatest snow transport*: 320°

Fetch Distance*: 1700 ft

Mean seasonal snow transport: 4.14 Tons/foot

Fence Porosity*: 0.275

Fence Height: 4.49 ft

Attack Angle*: 45°

Fence Setback: 80.14 ft

Your fence must extend **298.3 ft** from the acute angle side of the problem area and **21.5 ft** from the obtuse angle side to prevent drifting.

Date/Time Run: 5/9/2017 1:01:07 PM

Run by*:

Project Number*:

***user specified**

:: print this summary page ::

Back to Start

Road Design

References

Change and Recalculate

DEPARTMENT OF TRANSPORTATION

TEMPORARY BLOWING SNOW CONTROL AGREEMENT FORM

Winter Season of Protection	Trunk Highway	Drift Identification #	Plow Route /Road Segment #	Control Section #	Reference Post to	
County		Truck Station	Township Name	Section	Township	Range

Participant(s) agree(s) to provide blowing snow control on private property near the Right of Way line of the above Trunk Highway in the area indicated above and/or on the diagram on the reverse side of this form. Participant(s) agree(s) to leave the temporary blowing snow control practices in place until_____ (date). After this date the Participant(s) may remove the temporary blowing snow control practice(s) without notification from MnDOT.

In consideration for this service, the Minnesota Department of Transportation (MnDOT) agrees to pay Participant(s) according to Section 1 Payment Formula below providing that MnDOT certifies that the terms and conditions contained in the Contract have been met.

1. PAYMENT FORMULA

(Round all numbers to the second decimal point)

	Lineal feet (ft)	No of acres	Cost per acre or Lineal Foot ($)	Sub-Total ($)
Payment for Standing Corn Rows				
Payment for Temporary Snow Fence		X		
Payment for Bales		X		
Total Payment	X	X	X	

Appropriate payment is to be made after final inspection on or before:

April 30, ____.

2. LENGTH OF THIS AGREEMENT IS ONE WINTER SEASON.

Agreement period starts on the date on which all the necessary signatures for executing this Agreement have been obtained.

INSPECTED AND APPROVED FOR PAYMENT:

Year	Initial	$
20____	____	____

*** See formula for $ amount above.*

FOR MnDOT DISTRICT BLOWING SNOW CONTROL COORDINATORS USE

3. TRANSFER OF LAND

A.Participant(s) must notify MnDOT within 30 days when a new owner or operator purchases or obtains the right and interest in, or right of occupancy to the land subject to this agreement. Any new owner(s) or operator(s), must be approved by MnDOT in order to become a participant to a new Snow Fence Agreement under the same terms and conditions of this Contract;

B.If any new owner(s) or operator(s) become an heir, successor, or assign to the existing Snow Fence Agreement the new owner(s) or operator(s) shall assume all obligations under such agreement of the previous participant;

C.If the new owner(s) or operator (s) becomes a successor to this Agreement with MnDOT; the annual rental payments paid in the fiscal year the land was transferred shall be divided equally, as determined by MnDOT.

4. TERMINATION

In the event that the Minnesota Legislature does not appropriate to the **Department of Transportation** funds necessary for the continuation of this agreement, this agreement may be terminated by the **Department of Transportation** upon giving thirty (30) days written notice to the Participant(s).

5. DATA PRACTICES

Books, records, documents, and accounting procedures and practices of the participant(s) relevant to the agreement shall be subject to examination by the contracting department or agency and the legislative auditor.

6. PARTICIPANTS – SIGNATURE(S)

By signing below, Participant(s) agree(s) to the terms and conditions in this Contract and that the information I have provided is the amount on lines III, of the Payment Formula.

Participant(s) may receive a W-9 verification form requiring further information to register as a vendor with the State of Minnesota. Participant(s) will receive a 1099 form, which reports the amount received from the State of Minnesota from this Contract within the calendar year.

Participant(s) have read and understand the terms and conditions of the Contract and agree to its terms and conditions.

A(1). Participants Name: Phone #, Address *(Zip Code)*	(2) Share in %	(4) Signature	Date *(mm-dd-yyyy)*
B(1). Participants Name: Phone #, Address *(Zip Code)*	(2) Share in %	(4) Signature	Date *(mm-dd-yyyy)*
C(1). Participants Name: Phone #, Address *(Zip Code)*	(2) Share in %	(4) Signature	Date *(mm-dd-yyyy)*
Signature of Area Maintenance Engineer *(with delegated authority)*			Date *(mm-dd-yyyy)*

TO BE COMPLETED BY THE MNDOT DISTRICT BUSINESS OFFICE

Purchase Order No.	Vendor No. & Location No.	Category
FUND:	FIN DEPT ID:	APPROP ID:
ACCOUNT:	PROJECT ID:	SOURCE TYPE:
TAXABLE: NO		

Note to Business Office: **This signed form serves as the invoice** **Use the vendor number as the invoice number**

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

LIVING SNOW FENCE AGREEMENT

I. PURPOSE:

This Agreement, entered into between the North Dakota Department of Transportation, hereinafter referred to as the "NDDOT", and **David Lackoduck**, hereinafter referred to as the "Landowner", is to detail the cooperative arrangement between the Parties to establish and maintain living snow fences to protect documented priority problem sites on the interstate or state road system or a BIA route.

II. LANDOWNER INFORMATION:

Name: SS#*:

Mailing Address: City, State, Zip:

*Social Security Number is required for reimbursement purposes. If this information is not provided, reimbursement cannot be completed.

III. LIVING SNOW FENCE LOCATION: ¼ Section: SE ¼

Section: Township: Range: County:

IV. TERM OF AGREEMENT: The term of this Agreement shall be ten (10) years, commencing on June 1, 2016 and ending on June 1, 2026.

V. ALLOWABLE LAND RENTAL COSTS: The following allowable land rental rate is based on USDA County soil classifications and includes a $5 per acre annual maintenance allowance. Rental fee is paid to the landowner.

Soil Classification	Acres	Annual Soil Rental / Acre	Maintenance Allowance / Acre	Total Allowable Land Rental (10 years)
	5.1	$50.00	$5	$2,805

VI. ALLOWABLE TREE INSTALLATION COSTS: Tree planting and fabric weed barrier installation rates are based on actual costs. The costs are reimbursed to **Ward County Soil Conservation**.

Tree Planting	7320 FT	TOTAL	$2,196
Weed Barrier	7320 FT	TOTAL	$4,392
Cover Crop		TOTAL	$0
Total Installation Costs			$6,588

VII. REIMBURSEMENT PROCEDURE

The NDDOT will provide up to **$2,805** for land rental following completion of the tree planting. The NDDOT will make payments after receiving a(n):

a. Signed NDDOT –LSF Agreement,
b. Copy of the final NRCS approved planting plan (ND CONS-4, As planted),
c. Aerial photo showing location of the planting and adjacent identified road, and
d. Invoices from Ward County Soil Conservation District showing the amount and cost of tree planting performed.

VIII. REIMBURSEMENT DEADLINE:

For 2016 projects, all agreement reimbursement forms must be submitted by October 1, 2016, to the following address:

Living Snow Fence – Agreement Reimbursement
State Maintenance Engineer
North Dakota Department of Transportation
608 East Boulevard Avenue
Bismarck, ND 58505

IX. RESPONSIBILITIES:

The following other responsibilities are accepted by each Party as noted below:

1. **North Dakota Department of Transportation:**
   - The NDDOT will provide up to **$6,588** in financial incentives for tree planting and fabric weed barrier installation. The final payment will be made directly to the Ward County Soil Conservation District upon practice completion and be based on actual performance and invoices.
   - The NDDOT will also provide a lump sum reimbursement up to **$2,805** for a ten-year land rental and maintenance allowance directly to the landowner upon receipt of invoices.
   - The NDDOT will Stake tree locations prior to planting.
   - The NDDOT will review NRCS planting plan.
2. **Landowner:**
   - Provide the land and permission to establish the living snow fence.
   - Properly prepare the site for tree and weed barrier installation.
   - Provide access to the site area by NDDOT and Ward County Soil Conservation District authorized representatives.
   - Maintain the trees during the term of this agreement including the replacement of plant materials to a minimum of 80% of the original stocking level.
   - Protect the site from burning and domestic livestock grazing.
3. **Ward County Soil Conservation District**
   - The Ward County Soil Conservation District will install the trees and weed barrier in accordance with NRCS approved planting plan.

X. Liability:

The Landowner shall indemnify and hold harmless and save the State of North Dakota, its officers, employees, agents, bureaus, commissions, and assigns from any and all liability claims expenses, loss or damage for work or any other obligations performed or incurred under this agreement or arising upon the above described property, excepting claims resulting from the sole negligence of the state.

XI. Termination:

In the event of default by Landowner under this Agreement, the NDDOT may terminate the Agreement at any time by giving written notice. The Landowner agrees to refund all or part of the funds paid as determined by the approving Official, if, before expiration of the term of this agreement: a (the site is destroyed, or; b) the Landowner voluntarily relinquishes the control or title to the land on which the

approved site has been established and the new owner/operator of the land does not agree in writing to properly maintain the site for the remainder of the term of this Agreement. The parties to this Agreement do hereby execute this contract, and agree to abide by its terms.

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION		LANDOWNER	
_____	_____	_____	_____
Brad Darr, P.E.	**Date**	**(Name)**	**Date**
State Maintenance Engineer		**Landowner**	

STATE OF SOUTH DAKOTA
JOINT POWERS
LIVING SNOW FENCE AGREEMENT

This Joint Powers Agreement (Agreement) is made by and between the South Dakota Department of Transportation, of 700 East Broadway Avenue, Pierre, South Dakota 57501-2586, referred to in this Agreement as "DOT," and the South Dakota Department of Agriculture, of 523 East Capitol Avenue, Pierre, South Dakota 57501-2586, referred to in this Agreement as "SDDA."

1. JOINT POWERS

   This Agreement does not establish a separate legal entity, as contemplated by SDCL 1-24-5. The cooperative undertaking described in this Agreement will be financed and conducted under the provisions of this Agreement by DOT and SDDA. Each party has responsibilities under the terms of this Agreement and no joint board or administrator will be used. No real property will be purchased for use for this Agreement.

1. DOT will provide to SDDA an amount up to $300,000 for use in establishing living snow fences along local routes, county routes, and state or US highways, and for the development of the Transportation Enhancement Program pursuant to the terms and conditions set forth in this Agreement, and as described in the work plans attached to and incorporated in this Agreement as Exhibits A and B.

2. DOT will reimburse SDDA 100% of eligible costs for the technical assistance SDDA provides for the Living Snow Fence Program.

3. In consideration of DOT's agreement to provide the funding, and its observance and performance of the covenants, agreements, terms, and conditions set forth in this Agreement, SDDA and DOT agree to carry out the provisions of the Living Snow Fence Program and the Transportation Enhancement Program in accordance with the work plans of each program attached to this Agreement as Exhibits A and B.

4. SDDA will review and submit a detailed work plan for each site to DOT for review and concurrence.

5. SDDA and DOT will each comply with all applicable state, federal, and local laws and regulations in its respective use of the funds.

6. This Agreement depends upon the continued availability of appropriated funds and expenditure authority from the Legislature for this purpose. If for any reason the Legislature fails to appropriate funds or grant expenditure authority, or funds become unavailable by operation of law or federal funds reductions, then this Agreement may be terminated by either party. Termination for any of these reasons is not a default by either party nor does it give rise to a claim against either party.

7. This Agreement will commence upon the execution by both parties and end on the ____ day of _____, 20__, unless amended or terminated or extended pursuant to the terms of this Agreement.

8. This Agreement may not be assigned by either party without the express prior written consent of the other. This Agreement may not be amended except in writing, which writing will be expressly identified as a part of this Agreement, and be signed by an authorized representative of each party.

9. This Agreement can be terminated upon thirty (30) days written notice by either party and may be terminated for cause by either party at any time with or without notice.

10. The rights and remedies conferred under this Agreement will be cumulative and not alternative and will be in addition to and not in substitution of or in derogation of rights and remedies conferred by any other agreements between the parties or by any applicable law. The failure of a party to enforce strict

performance of any covenant, promise, term, or condition contained in this Agreement, will not operate as a waiver of that party's right to require the terms of this Agreement be strictly performed.

11. The approval of the Secretary of DOT, and the Secretary of SDDA, as required by SDCL 1-24-6, is signified by execution of this Agreement. The parties acknowledge that SDDA will file a true copy of this Agreement with the Office of Attorney General and the Legislative Research Council within 14 days of the execution of this Agreement, as required by SDCL 1-24-6.1.

12. Any notice or other communication required under this Agreement will be in writing and sent to the address set forth above. Notices will be given by and to the Program Manager, Office of Administration on behalf of DOT, and by and to the Agroforestry Specialist on behalf of SDDA, or such authorized designees as either party may from time to time designate in writing. Notices or communications to or between the parties will be deemed to have been delivered when mailed by first class mail, emailed or, if personally delivered, when received by such party.

13. Any officer, employee, or agent engaged in joint action under this Agreement will remain an employee with his or her agency during participation in joint action under this Agreement. Each agency will retain exclusive responsibility for its officers, agents, and employees while these officers, agents, and employees are engaged in joint action under this Agreement, including but not limited to responsibility for regular or overtime wages and salaries, unemployment benefits, workers' compensation coverage, health insurance, or other benefits, and liability coverage and indemnity, except as otherwise specifically provided in this Agreement.

14. If any provision of this Agreement is held unenforceable or invalid by any court of competent jurisdiction, such holding will not invalidate or render unenforceable any other provision of this Agreement.

15. All other prior discussions, communications, and representations concerning the subject matter of this Agreement are superseded by the terms of this Agreement, and, except as specifically provided in this Agreement, this Agreement constitutes the entire agreement with respect to its subject matter.

16. This Agreement will be governed and construed in accordance with the laws of the State of South Dakota.

By signature of its representative below, each party certifies approval of this Agreement by ordinance, resolution, or other appropriate means has been obtained by that party's governing body or officer pursuant to SDCL § 1-24-3 and § 1-24-6.

South Dakota Department of Agriculture

By: _____
Lucas Lentsch

Its: Secretary

Date: _____

South Dakota Department of Transportation

By: _____
Darin Bergquist

Its: Secretary

Date: _____

Approved as to Form:

_____
Special Assistant Attorney General

EXHIBIT A

Living Snow Fence Program

The South Dakota Department of Transportation (DOT) and South Dakota Department of Agriculture (SDDA) will provide assistance to producers for the development of Living Snow Fences as outlined below.

1. DOT and SDDA will jointly determine the number of producers to be assisted.
2. DOT and SDDA will jointly select the producers for assistance, giving priority to operators in the most problematic areas for snow accumulation on roads.
3. The level of assistance provided to any operator will range from 80 to 100 percent of the cost of the planting and maintenance.
4. SDDA will provide technical assistance to the producers based on Forest Management Plans. SDDA will be responsible for answering questions pertaining to technical issues related to these plans.
5. DOT will provide financial assistance to the producers through grant agreements. DOT will be responsible for answering questions pertaining to grant agreements and payments.
6. SDDA will be reimbursed by DOT for eligible technical assistance costs (site visits, plan preparation, project certification, and compliance spot checks) up to 100% upon receipt of proper documentation.
7. Conservation Districts may be used as local sponsors as determined by SDDA.
8. SDDA will submit requests for reimbursement to DOT quarterly, with documentation in a format and using forms required by DOT.
9. DOT will handle cultural resources with the appropriate cultural resources agency (SD State Historical Preservation Office or Tribal Historical Preservation Office) as needed.

EXHIBIT B

Transportation Enhancement Program

The South Dakota Department of Transportation (DOT) and the South Dakota Department of Agriculture (SDDA) will provide assistance to operators for the development of the Transportation Enhancement program as outlined below:

1. DOT and SDDA will jointly determine the number of communities to be assisted.

2. DOT and SDDA will jointly determine the communities selected for assistance, giving priority to communities on a competitive basis to stimulate the development of innovative and effective community highway corridor beautification projects.

3. DOT will accept applications from communities on a year-round basis.

4. DOT will fund projects under two qualifying enhancement activities, as defined by the U.S. Department of Transportation under the Transportation Equity Act for the 21st Century (TEA-21): landscaping and other scenic beautification; or scenic or historic highway programs.

5. DOT will provide financial assistance to communities through grant agreements. DOT will be responsible for answering questions pertaining to grant agreements and payments.

6. SDDA will be reimbursed by DOT for eligible technical assistance costs (site visits, plan preparation, project certification, and compliance spot checks) up to 100% upon receipt of proper documentation.

7. The communities must provide provisions for long-term management and protection of the project.

8. SDDA will submit requests for reimbursement to DOT quarterly, with documentation in a format and using forms required by DOT.

10. DOT will handle cultural resources with the appropriate cultural resources agency (SD State Historical Preservation Office or Tribal Historical Preservation Office) as needed.

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
HIGHWAY USE EASEMENT
FOR CONSTRUCTION AND MAINTENANCE OF A SNOW FENCE

This Highway Use Easement ("Easement") is made and entered into by and between the State of South Dakota, acting by and through its Department of Transportation, referred to in this Easement as the "STATE," and Name of Landowner, referred to in this Easement as the "LANDOWNER."

1. PURPOSE

   The STATE, for the purpose of reducing highway maintenance costs, providing greater service to the traveling public, and promoting conservation, wants to enter into agreements for highway use easements with private landowners for allowing the construction, inspection, repair, and maintenance of a Description of snow fence (material, height, design) snow fence ("snow fence"). The LANDOWNER, possessing the necessary suitable land, shares these concerns and is willing to enter into an agreement for a highway use easement as further defined in this agreement.

2. HIGHWAY USE EASEMENT

   The LANDOWNER grants to the STATE a highway use easement for the construction of the snow fence and the STATE, in turn, agrees to maintain a highway use easement from the LANDOWNER for the real property located in Section Section Number Township Township Number Range Range Number of the 5th P.M., Choose an item. County, South Dakota.

3. TERM OF HIGHWAY USE EASEMENT

   This Easement will run for a term of ten (10) years from the date this Easement is approved and signed by the Choose an item. Region Engineer of the South Dakota Department of Transportation. The STATE will have the exclusive option to renew this Easement for an additional period of ten (10) years by notifying the LANDOWNER of the STATE'S intent to renew, in writing, no later than the date of expiration of this Easement, including any renewal. Such written notice will become a part of this Easement.

4. CONSIDERATION

   In addition to the mutual benefits to be derived from this Easement, the STATE will pay the LANDOWNER annual payments, each in the amount of Amount (text) Dollars ($Amount (numeric)), for this Easement.

5. ACCESS

   The LANDOWNER grants permission to the STATE, the STATE'S agents, representatives, assigns, and any contractor employed by the STATE to enter into the Easement area to construct the snow fence and to make such changes as are necessary for the proper construction or maintenance of the snow fence. The STATE will properly slope, grade, and restore all areas used in the construction or maintenance of the snow fence, as necessary, and will leave the Easement area in a neat and workmanlike condition.

The LANDOWNER grants the STATE the right of ingress to and egress from the Easement area, across other property owned by the LANDOWNER, for the purposes of construction, inspection, maintenance, repair of the

Easement area or the snow fence, or for the purpose of moving the location of the snow fence, if deemed necessary by the STATE. The LANDOWNER reserves the right to designate a reasonable route over which such access may be made.

6. TERMINATION

This Easement may be terminated before the expiration of any ten (10) year period by mutual consent of the LANDOWNER and the STATE. In the event the LANDOWNER breaches any of the terms or conditions of this Easement, the STATE may terminate this Easement, for cause, with or without notice. In the event this Easement is terminated, the snow fence will become the property of the STATE and the STATE is authorized to enter upon the LANDOWNER's property to remove the snow fence.

7. COVENANTS

This Easement and the covenants contained in this Easement will inure to the benefit of and be binding upon the parties to this Easement, their successors, or assigns. If the LANDOWNER fails to comply with any of the terms of this Easement, the STATE will be under no obligation to make payment to the LANDOWNER, and the STATE may remedy the LANDOWNER'S lack of compliance. In the event of termination of this Easement or LANDOWNER'S lack of compliance with the terms of this Easement, the LANDOWNER grants the STATE access to the site of this Easement over other lands the LANDOWNER owns or leases, for the purpose of removing the snow fence or remedying the LANDOWNER'S lack of compliance.

8. SITE PREPARATION, MAINTENANCE AND LOCATION

The STATE will prepare the site for the snow fence, construct the snow fence, and will maintain the snow fence during the term of this Easement. The parties will mutually agree to the location of the snow fence. Any change in the location after this Easement is in effect will be mutually agreed to between the LANDOWNER and the STATE. The LANDOWNER will not be entitled to receive any additional payment beyond the terms of this Easement if the location of the snow fence is changed after the effective date of this Easement.

9. INDEMNIFICATION

The LANDOWNER will indemnify the STATE, its officers, agents, and employees against any and all actions, suits, damages, liability, or other proceedings which may arise as a result of this Easement and construction and maintenance of the snow fence. This section does not require the LANDOWNER to be responsible for or defend against claims or damages arising solely from errors or omissions of the STATE, its officers, agents, or employees.

10. AMENDMENT

DOT Legal: _____

The parties agree that this Easement contains the entire agreement between the parties. This Easement will not be modified, changed, altered, or amended in any way except through a written amendment signed by each of the parties.

11. GOVERNING LAW

This Easement will be governed by and construed in accordance with the laws of the State of South Dakota. Any lawsuit pertaining to or affecting this Easement will be venued in Circuit Court, Sixth Judicial Circuit, Hughes County, South Dakota.

12. SUPERCESSION

All other prior discussions, communications, and representations concerning the subject matter of this Highway Use Easement are superseded by the terms of this Easement, and except as specifically provided in this Easement, this Easement constitutes the entire agreement with respect to the subject matter.

13. SUCCESSORS AND ASSIGNS

This Easement and all the covenants, provisions, and conditions contained in this Easement will inure to the benefit of and are binding upon the successors and assigns of the parties to this Easement, provided, however, that no assignment by, from, through, or under the STATE in violation of any of the provisions of this Easement will vest in the assigns any right, title, or interest whatsoever.

Landowner	State of South Dakota Department of Transportation
_____	By: _____
Name:	Its: Area Engineer
Date: _____	Date: _____
	Approved as to Form:
	_____
	Special Assistant Attorney General

ACKNOWLEDGMENTS FOLLOW

OWNER ACKNOWLEDGMENT

State of South Dakota)
:SS
County of_____)

On this the _____ day of _____, _____, before me, _____, a notary public, personally appeared _____, known to me or satisfactorily proven to be the person whose name is subscribed to the within instrument and acknowledged that he executed same for the purposes therein contained.

In witness whereof I hereunto set my hand and official seal.

_____

Notary Public

(Notary Seal)

My Commission Expires: _____

STATE ACKNOWLEDGMENT

State of _____)
:SS
County of_____)

On this the _____ day of _____, _____, before me, _____, a notary public, personally appeared _____, Right of Way Program Manager of the State of South Dakota, Department of Transportation, known to me or satisfactorily proven to be the person described in the foregoing instrument, and acknowledged that he executed the same in the capacity therein stated and for the purposes there contained.

In witness whereof I hereunto set my hand and official seal.

_____

Notary Public

(Notary Seal)

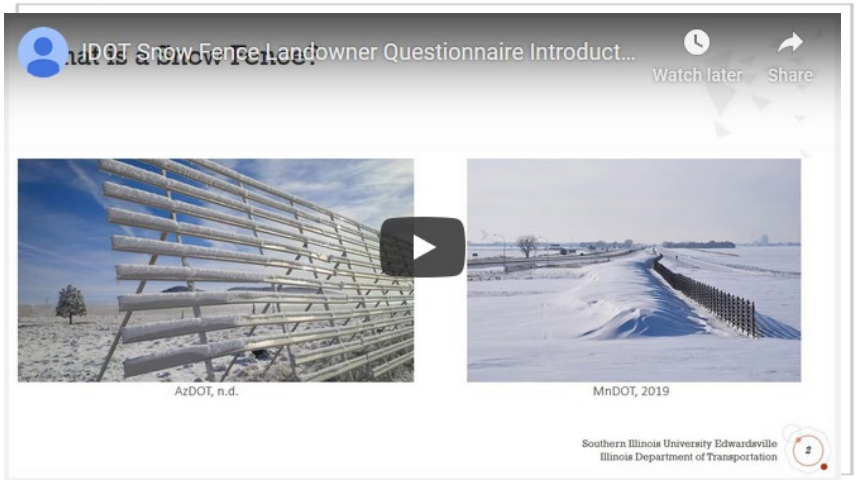
My Commission Expires: _____

APPENDIX C: LANDOWNER SURVEY QUESTIONNAIRE

IDOT Snow Fence Survey for Landowners

Welcome

The Illinois Department of Transportation (IDOT) in association with the Illinois Center for Transportation has commissioned a research study to provide IDOT with guidance on the best practices of using snow fences (both living and structural). The project team is led by Southern Illinois University Edwardsville (SIUE). The compiled survey findings will be reported, but individual responses will not be published or distributed. Please watch the following video for a brief summary of snow fences.



Thank you for contributing to this important study, your time and effort are appreciated. The survey will take 5-10 minutes to complete. If you have any questions, please contact the survey manager below.

Ryan N. Fries, Ph.D., P.E.
Department of Civil Engineering, Box 1800
Southern Illinois University Edwardsville
Edwardsville, IL 62026
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IDOT Snow Fence Survey for Landowners

General Questions about Snow Fences

1. If your land was adjacent to a roadway with snow drifting problems and a snow fence was recommend for placement on your land, what types of snow fence would be least intrusive on you and/or your leasees? Rank the following, where the rank of one (1) is the least intrusive (most preferred).

Structural snow fence (such as wood fencing)	☐ Not a concern
Living snow fence of trees	☐ Not a concern
Living snow fence of shrubs	☐ Not a concern
Rows of unharvested corn used as snow fencing	☐ Not a concern
Piles of hay bales or corn stalks used as snow fencing	☐ Not a concern

2. What concerns do you have about entering into a snow fence contract with IDOT or another state agency?

3. When considering a payment structure for compensating land owners who participate in living snow fence programs, rank the following factors, where the rank of one (1) is the most important to you.

Acres Used	☐ Not a conern
Crops planted	☐ Not a conern
Average yield per acre	☐ Not a conern
Updated market prices	☐ Not a conern

4. What else should IDOT consider when approaching landowners about possible snow fence partnerships?

3

IDOT Snow Fence Survey for Landowners

Questions about Living Snow Fences with Trees and Shrubs

This section focuses only on living snow fences that include trees and shrubs.

1. What factors would concern you about a **living snow fence of trees and shrubs** on your land (where you are compensated for maintaining the plantings)? Identify and rank the factors, where the rank of one (1) is the most concerning to you.

⠿	Replacing dead trees/shrubs because of drought	☐ Not a concern
⠿	Plantings could take resources (water, nutrients) needed by growing crops	☐ Not a concern
⠿	Replacing dead trees/shrubs because of flooding	☐ Not a concern
⠿	Pruning	☐ Not a concern
⠿	Wind causing trees/branches to fall on crop land	☐ Not a concern
⠿	Shade on crop land	☐ Not a concern
⠿	Applying herbicide near trees and shrubs	☐ Not a concern
⠿	Making a long-term commitment with the State	☐ Not a concern
⠿	Other (describe at the end of this page)	☐ Not a concern

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2. For **living snow fences that consist of planted trees and shrubs** which costs concern you most? Identify and rank the cost categories, where the rank of one (1) is the most concerning to you.

⋮⋮	Implementing (i.e. Plants, Matting, and Contracts)	☐ Not a concern
⋮⋮	Maintaining throughout the lifecycle (i.e. mowing, weeding, watering)	☐ Not a concern
⋮⋮	Rejuvenating (i.e. replacing dead plants, and trimming shrubs)	☐ Not a concern
⋮⋮	Removing (if contract is discontinued)	☐ Not a concern
⋮⋮	Loss of revenue (Cost per acre or loss of cash rent)	☐ Not a concern
⋮⋮	Other (please explain at the end of this section)	☐ Not a concern

3. If you would like to provide details about your responses regarding **living snow fences made with trees and shrubs**, please use this space.

5

IDOT Snow Fence Survey for Landowners

Snow Fences made from Standing Corn Rows

This section focuses on your opinions of using standing corn rows as snow fencing. Based on practice in other states, you may assume that 12 or more rows of corn are required

1. If your land was identified as a great place to leave rows of **corn standing for snow fencing**, what factors would concern you? Identify and rank the factors, where the rank of one (1) is the most concerning to you.

Crop rotation		☐ Not a concern
Distance to drive equipment for spring harvest of corn		☐ Not a concern
Wildlife factors (please explain at the end of this section)		☐ Not a concern
Existing land rental or other land agreements		☐ Not a concern
Availability of time to remove the corn in the spring		☐ Not a concern
Other (please explain at the end of this section)		☐ Not a concern

2. For **snow fences created from corn rows left standing**, which costs concern you most? Identify and rank the cost categories, where the rank of one (1) is the most concerning to you.

Removing (after winter)		☐ Not a concern
Loss of revenue (Cost per acre or loss of cash rent)		☐ Not a concern
Delay in access to the field due to retained moisture		☐ Not a concern
Other (please explain at the end of this section)		☐ Not a concern

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3. If you would like to provide details about your responses to **leaving corn standing to serve as snow fencing**, please use the following area.

7

IDOT Snow Fence Survey for Landowners

Questions About Structural Snow Fences

This section focuses on structural snow fences only.

1. If your land was identified as a great place for a **structural snow fence** (i.e. made from metal or wood), what factors would concern you? Identify and rank the factors, where the rank of one (1) is the most concerning to you.

⋮⋮	Difficulty harvesting crops near structural snow fence	☐ Not a concern
⋮⋮	Property damage during installation and removal of structural snow fence	☐ Not a concern
⋮⋮	Impact on livestock or other animals	☐ Not a concern
⋮⋮	Existing land rental or other land agreements	☐ Not a concern
⋮⋮	Making a long-term commitment with the State	☐ Not a concern
⋮⋮	Other (please explain at the end of this section)	☐ Not a concern

2. For **structural snow fences**, which costs concern you most? Identify and rank the cost categories, where the rank of one (1) is the most concerning to you.

⋮⋮	Implementing (i.e. Access to site, timing of installation, and/or contracts)	☐ Not a concern
⋮⋮	Removing (if contract is discontinued)	☐ Not a concern
⋮⋮	Loss of revenue (Cost per acre or loss of cash rent)	☐ Not a concern
⋮⋮	Other (please explain at the end of this section)	☐ Not a concern

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3. If you would like to provide details about your responses regarding **structural snow fence**, please use the following area.

9

IDOT Snow Fence Survey for Landowners

Your Background

Although this survey is anonymous, sharing your background can help our study learn more.

1. Based on your local knowledge of local weather and snowfall, are you aware of locations in your community where snow drifting onto the roads is an issue? If so, please describe where.

2. How is your land used currently? Select all that apply.

- [ ] Farming
- [ ] Livestock
- [ ] I lease/rent the land to others who farm
- [ ] I lease/rent the land to others who raise livestock
- [ ] Other (please specify)

3. How important is nature conservation to you?

- ( ) A great deal
- ( ) A lot
- ( ) A moderate amount
- ( ) A little
- ( ) None at all

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IDOT Snow Fence Survey for Landowners

Questions about your background

1. Which Illinois county do you claim residence?

Other (if your county is not listed, please specify)

2. Besides your residence, if you own property in another Illinois county, which one(s)?

If you own property in more than one other county, you may type them here.

3. If your land is used for farming, what is usually planted? Select all that apply.

- [ ] Corn
- [ ] Soy
- [ ] Wheat
- [ ] Other (please specify)

4. Does your property border any of the following roads?

- ( ) Interstate, Expressway, or Freeway
- ( ) State Highway
- ( ) County Highway
- ( ) Local Road
- ( ) Other (please specify)

5. Are you aware of state roads that experience snow drifting problems? If so, please identify the state route number and location.

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IDOT Snow Fence Survey for Landowners

Thank you!

We appreciate your time and effort in completing our survey. If you have questions for us, please contact:

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Southern Illinois University Edwardsville
Edwardsville, IL 62026
rfries@siue.edu
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+1 (618) 650-2555 fax

APPENDIX D: RAW SURVEY RESPONSES TO SELECT QUESTIONS

This appendix provides raw responses for the open-ended survey questions and comment boxes.

Open-ended responses to the following question: What concerns do you have about entering into a snow fence contract with IDOT or another state agency?

- Will they uphold their end of the bargain or will lack of a budget/funding get in the way?
- IL is not paying their bills on time. I'm sure a snow fence isn't going to be much of a payment priority.
- That the water will not drain from my field and they will not let me change it.
- The state of Illinois is not the most reliable agency to try and do business with.
- none
- GETTING THEM DOWN FOR SPRING WORK
- length of contract, what my responsibilities would be
- Cleanup in spring
- Who determines proper compensation?
- they will do what they please no matter what i may think.
- That it's not permanent.
- if its a live fence who will keep up the over growth of the fence in the future
- A lot of stipulations.
- Trees and shrubs create shade robbing crops of needed sunlight. Their roots reach out into crop fields using water for crops. The state has larger and much better snow removal equipment, snow removal should not be a concern, you just have to do it!
- Getting it placed in a timely manner without interfering with crop harvest and getting it removed before spring work starts
- Any snow fence program that imposes some time of structure living or man made or otherwise will be an intrusion on my property
- Will they be sturdy or fall over first time the wind blew
- Length of contract?
- Payment and who is responsible for maintaining it
- Maintenance
- Landlord displeasure, extra work, timeliness
- I remember the mess made in the past when fence was put up or taken down way to late in the spring. Do not want to be part of it!
- Because the placement of snow fences has to be so far off the highway, my concern is that they would take a significant proportion of land out of production.
- None. I think it is a good natural barrier
- cost
- Soil compaction and timing of the installation and spring removal.
- It is a hay field that we have next to a state highway. The fence would need to go up when it's not muddy so our crop for the coming year that is already planted will not be damaged.
- Maintenance along fence lines

- Either it's where existing fence is or if they have to put one up, they do it when it's not muddy.
- encroachment on property. living snow fences would decrease property values with no compensation
- potential compaction caused during installation and removal when soil conditions are not fit.
- Being able to utilize the right of way for plantings
- Working with the government and them having a say of what needs to be done on my land. Also, once they are on the land, going back and wanting to do more than they originally said they would.
- If the snow fence is installed and removed timely
- None with IDOT. Not sure about other state agencies.
- it would be difficult to do more than leaving crops standing or putting up a fence. on most land in our area - Peoria and Stark County
- If snow fence was installed, would it be permanent or would it be installed every year. How would IDOT go about installing the fence in wet conditions- tracking up the field is a concern.
- Timeliness of set up & removal, as well as damage to property.
- That I will not get compensated
- Getting paid upfront. The state can be slow to pay.
- That it wont be taken care of
- Why should I do the work that I already pay taxes for?
- Hard to get field work done now
- Fair and timely compensation without a bunch of government red tape.
- Maintenance issues
- Who's providing the hay? Will the trees and shrubs he put on my land or the ditches? Will I get paid for the corn I didn't harvest for the living fence?
- None
- No concerns
- Payment for lost revenue for leaving crop standing.
- I would like to see natural habitat as it supports the nesting and housing of birds.
- Just getting paid...
- The issue of IDOT equipment rutting up the field to place or remove the snow fencing.
- It not being taken down in a timely manner in the spring or not properly maintained.
- My livestock could damage, or be hurt by the snow fence. Also, would workers make sure not to leave gates open and allow livestock to escape.
- Animals getting caught in the fencing
- Structural fence could be a barrier to wildlife migration and mobility. Living barriers may not, though, and might provide habitat for them, which would be desirable.
- Timely installation and removal
- Not a farmer, but my family and I all travel these roads. It's been a huge concern for the last 15 years we've lived here. Especially once our children started driving.
- Compensation and look
- None
- Nothing permanent if not living

- No concerns
- Tearing up our property to place the snow fence
- Actually getting paid in a timely manner.
- Looks/upkeep, and other trash that might collect in the fence. Who is responsible for keeping the fence clean/cleaned out?
- Land value going down, field access, liability due to trees
- None, unharvested corn would be a great idea. Maybe, Pheasants Forever would help offset the cost.
- Who's paying for it
- unknown
- How much the payment would be. who would erect the fence and where would it be stored.
- Enforce fencing that will not be able to be cleared for planting in the spring.
- Effective compensation and worrying about the timeliness of working with a unit of government.
- maintenance
- Timeliness of fence removal
- Government red tape, failure to achieve results because of such. Loss of liberty, property rights
- none
- The state would not maintain the living fence of shrubs or trees and it would hurt crop production yields
- Payment, if any. State has a problem paying timely.
- Maintenance who's responsible
- We used to allow IDOT and the County to put up snow fences. But we were forced to stop because the departments would not set up or tear down the fences within our guidelines of when the soil was fit to drive on or stay out of the fields with their motor vehicles. It would result in many large ruts. Then the USDA would fine us for tilling up the ruts on NHEL ground.
- That the snow fence would not be taken swim in a timely manner.
- Lack of input and disregard for revenue-generating property (farm ground).
- I live in Illinois.... enough said
- Not being compensated for damages or crops left standing
- More government control of my land
- That it will not be properly maintained. There are T posts around trees they planted along the interstate that the tree has grown around. There is also brush growing through structural snow fence in our area.
- actually getting paid
- I feel that the IDOT should keep the snow fence on the property of the state with trees or shrubs as it would cut down on mowing as well. It should not be on the property owners side.
- Timing of install and removal
- That the state would not maintain it
- It's the state. The state inefficiently using tax dollars. All of the paperwork.

- Timing of set up and removal of fence. Maintenance of living snow fence (trees/shrubs) Payment for leaving corn rows
- Maintenance and liability
- Construction in fence after crops and fertilization is done and removed before planting Concern about soil conditions when they are on fields Living fences would work but someone has to harvest in spring and equipment is washed and waxed and would hate to do again or risk rodents in combine doing damage. Also would present a issue reporting crop insurance because we have to report before spring
- With what money
- Just so it is removed by planting time & after harvest.
- If it is a living snow fence of trees or shrubs, then I would need to be compensated for the loss of crop acres and for any time or expenses involved in installed or maintaining it.
- My concern with a living snow fence is maintenance....my road ditches are part of a prairie plant "restoration" area...I'm not allowed to mow or spray them, and they are all weeds. There's no management done at all. Prescribed spring burns etc.

Open-ended responses to the following question: What else should IDOT consider when approaching landowners about possible snow fence partnerships?

- To use snow fences that are put up after harvest and taken down in the spring.
- Honesty, working together.
- Timely removal
- Timing of when put up and take down
- STEWARDSHIP OF LAND
- the payments will have to be similar to CRP to get participation
- Be willing to mow standing/remaining crops in spring
- Prioritizing areas of concern.
- what is wrong with the temporary picket fences. you have a lot of high paid labor that could accomplish this with no trouble at all!
- same answer as before
- Be consider it.
- This is a poorly written survey! The state is making the assumption in questions 1 and 3 that only one answer is the largest concern and other options are better, not correct. Number 1 would have at least three scored 5 and question three would have more than one 4. Typical state survey so they can make the data show what they want it to.
- They shouldn't
- Fee for being on your land
- Length of contract and removal
- Be mindful that farmers are under terrible pressure at this time - the weather has created poor conditions for crops and low yields; tariffs are killing the market; and depression, suicides, and farm bankruptcies are surging. Anything you say that might adversely affect farmer's incomes is not likely to be well received.

- Just give the landowner/tenant the full detail as to what is expected of the participants and when the fence can be terminated
- could approach also serve as a buffer for organic production which is my farm
- Length of time of contracts and land ownership changes
- the timeliness of the installation and removal of snow fence
- potential monetary partnering with FSA [Farm Service Agency] on living snow fences within the CRP program.
- Temporary vs permanent. Where to get seedlings for planting living fences
- Don't force it on anyone, come with a good offer.
- Is it really necessary to have a snow fence right there?
- Will IDOT maintain the snow fence areas? If it is anything other than living crops, will IDOT spray these areas for weeds? Managing waterways, ditches and roadsides is an important part of integrated pest management for farmers.
- How bad they have screwed them in the past
- I am not a landowner of any land adjacent to a roadway but I travel north/south highway 78 in Carroll & Whiteside Counties and would love to see any one of these options put in place.
- Most residential rural people will want it but most farmers wont because they are only for making themselves money
- Why are we asking them to do our work for us?
- Always make sure the farmer knows payment upfront
- I saw lots of songbird nests mowed down in the ditches over the summer. I know mowing must happen to keep ditches free and clear but if the red wing blackbird had shrubs or trees, they might use those to build nests instead of tall grasses. I support natural snow barriers. Driving on some rural highways is suicidal in winter with the blowing snow off the flat fields. Plows do not salt or sand and only plow ONCE after the snow event is over. Sometimes you CAN'T get out or in. I think snow fence will be very helpful and make roads more safe!!!
- Not sure. Communicate the benefit to all traffic through area.
- Overall ecosystem impact.
- Neighboring homes and those that travel the roads on a regular basis
- Effectiveness, amount of traffic on road
- Not a problem for me
- Cost, land damage to install, maintenance,
- Contract lengths. Will have to be yearly due to corn/soy rotation
- Who installs and uninstalls?
- Tax breaks
- How much snow the state would like to keep off the road.
- Maintenance on whatever structure they decide to use
- maintenance assistance
- Trees rob soil moisture, nutrients, and shade adjacent acres.
- Keep shrubs and trees on state property or ditch with a 6-8 foot space from crops so a mower can be used between field and fence to keep unwanted trees and weeds down
- Work with the tenant first and let him talk to his or hers landlord.

- The most ideal situation on our farm would be IDOT providing the materials such as the fence and posts and paying us to put up and take down the fence. This would allow us to manage when the fields are touched and with what, if any, equipment.
- Miscellaneous costs associated with snow fences (leaving crop, working around crop left, impact on fertilizer applications/fieldwork, using equipment usually put away for a season to return in spring to harvest, etc.)
- They need to stop harassing farmers and grain haulers with DOT checks. Why would a farmer work with IDOT?
- The edge of a farm field is the most productive part of the field because of the added sunlight and less competition, so that is something for them to consider.
- Why not play trees along the interstates where there is nothing anyway
- Corn is not a yearly option. Trees are too large and will cause yield loss. Shrubs need to be planted well back and keep entrances clear
- I think it should be mandated. We can't even get out on the highway when it's extremely bad and they shut the plows off. Close down the whole road. It's a major safety concern for all of us...
- Making it worthwhile for all parties involved. Only doing this in necessary places. Partnering with the local Soil and Water conservation districts.
- The payment needs to reflect more than just the lost revenue of the unharvested crop. There would need to be compensation for the inconvenience of not being able to perform fall tillage and nitrogen application to those areas of the field.
- Liability concerns
- The fence would have to be out in the field some distance to allow the snow to drift before it gets to road. Thus trees and shrubs are not a good option on fields that I farm.
- Just don't
- Tree or shrub species selected as options should be compact and not spreading, even if the species are not indigenous to Illinois.
- Timely removal of any kind of a bale program. Has to be out my March 1
- What else should IDOT consider when approaching landowners about possible snow fence partnerships?

Open-ended responses to the following statement: If you would like to provide details about your responses regarding living snow fences made with trees and shrubs, please use this space.

- I would be concerned about equipment damage from working close to the trees.
- The lack of drainage. I currently have 2 fields with flooding problems caused by tree snow fences made by the state. They will not help with the issue.
- Not sure I'd like this solution long term
- Other concerns I have would be about the varieties of trees and or shrubs chosen and whether I would have input into this choice, and What chemicals, etc. could be used for upkeep on these plantings. I am committed to organic planting of crops and wonder how this could affect my personal food source.
- This could be a wildlife benefit as well

- many state and county roads already have “living snow fences” that we call “brush” and the controlling agencies do little to maintain or remove problems.
- Not a good deal.
- Once again, this is a poorly written survey. Options should not automatically receive a better score because the most concerning number was used. Each box should be its own question with any score available for each statement.
- This is a bad idea
- Sources of seed stock
- No way I would want the living snow fences on my property, especially trees.
- I don’t think most farmers will want to manage the living snow fences.
- If the state decides to void the contract it would be difficult and expensive to tear out the trees / shrubs.
- It’s all about the economic value (lost revenue + reimbursement for costs/inconvenience + profit)
- Seems like a waste of space, resources, and time
- I would prefer shrubs over trees
- No problem
- Not real sure trees and shrubs would be the best visual effect on our property.
- I believe that IDOT should pay for and install the living snow fence. They should also maintain for the first 3 years. Also CRP programs should be paid for acreage along routes, they perform the same function.
- Wild life in the shrubs making road hazards
- Horrible idea, would increase deer and vehicle collisions, cause branches and leaves on roadways etc. Why would you not establish a boundary program for the open crop land with native grass plantings like the existing edge programs? Or just pay farmers to leave some rows of crop? Better yet plant the ditches to native grasses and not involve any private parties? That would establish wildlife habitat and take care of the snow issue
- I like the idea of a living fence, but I would like to see it be mostly shrubs that would need little maintenance.
- Farming around the fence and the amount of extra time and inefficiency it would create

Open-ended responses to the following statement: If you would like to provide details about your responses to leaving corn standing to serve as snow fencing, please use the following area.

- After harvest all harvesting equipment is thoroughly cleaned out to prevent rodent damage to cab interiors and electric wires. This is a highly unpleasant, time consuming process that I hate. No way am I going to get the combine out again in the spring for a few acres only to have to clean it all out again. You would have to pay me a ridiculous amount of money for my time. But if field is fit for combining, then I probably need to start spring field work. Therefore regardless of compensation I don’t have time and won’t be interested.
- I have done in past this works well Springtime removal a concern
- Access to my property and varieties used.
- standing corn could be beneficial to wildlife

- Ranked good up above!
- Volunteer corn would be an issue from all the dropped ears.
- I do not produce corn, but my neighbor does/ don't think he is getting this survey and I would be interested if she would participate since it would help out with drifting on Jericho Road.. can be a real safety hazard.. (Ingrid O'Brien, Jericho Road, Big Rock
- One problem is wildlife would use as cover and have the potential of running across roads
- Corn is definitely not the only and definitely not the best option for standing crop snow fences. Consider sorghum Sudan hybrids, sunflowers,
- I think a "Standing Crops" would be better suited to get commitments from growers. Having to plant 6 or 12 rows of corn on the outside of a soybean field would not only be a pain, but also a would discourage me from participating in a program. Iowa uses soybeans and corn as a snow fence and it seems that the soybeans work just as well when I drive across Iowa.
- I think it is a great idea for standing corn, but you will essentially have to buy those bushels left standing in order to get compliance. Just too much risk leaving it out all winter and to many factors that would cause a loss of the crop.
- Value and additional herbicide costs (volunteer corn) as well as lost yield due to spring tillage
- Concern would be deer jumping from standing corn onto highway
- I have no wildlife concerns
- Impacts for missing nutrient applications for the following crop.
- Leaving corn standing could conflict with allowing cattle to graze the corn stubble.
- Wouldn't apply
- Tried it couple years ago. Barely snowed but seemed to work for the few we had. I think leaving beans would accomplish similar would just need wider strip. I left 8 rows corn.
- I think it would be a great idea as well as saving the state
- Crop would be basically useless in spring and would need to be mowed off. On late springs no one has time for that. Idot would need to agree to mow the crop off and only when field conditions are dry
- I don't care about the aesthetics of it, but some landowners might be concerned with that.
- Depending on the winter, there may not be much to harvest in the spring, leading to volunteer corn issues. Also typical corn-soy rotations may change or be hard to communicate which years are beans to the state.... organization will be key
- Going to harvest the 'snow fence' will be more costly than the revenue reaped by spring time.
- As I said using cleaned equipment to harvest crop and crop insurance issues that would need to be addressed

Open-ended responses to the following statement: If you would like to provide details about your responses regarding structural snow fence, please use the following area.

- Not clear if you mean temporary or permanent structures. Would not be interested in permanent.
- This would be a blight! Please NO! I wouldn't trust the state to maintain these properly. Also, there is the cost to install, remove, and store. Who pays annually for all that?

- I am thinking of temporary fence, not a permanent fence. a fence or standing corn or trees will have to be far enough from the road not to drift snow on the road
- Not permanent.
- Spending tax dollars the state doesn't have, they will increase taxes for another program that is not needed.
- Would not maintain the fence, if contract was discontinued I would expect the IDOT to remove the fences
- weeds and trees growing up in fence
- Maintaining.
- Install and removal times are critical
- I think the fences should be constructed and removed yearly to avoid loss of revenue and not having obstacles to create inefficiencies for farmer

Open-ended responses to the following question: How is your land used currently?

- I also rent farm land to farm.
- Residential and personal gardening.
- Currently land is an unworking farm
- I am a commuter
- Unused
- Homes
- I am a property owner. I do not own any ground that is used for crop farming.
- homestead; no farming or livestock.

Open-ended responses to the following question: If your land is used for farming, what is usually planted?

- All types of vegetables for human consumption.
- Popcorn
- organic vegetables , pasture for sheep
- Various cover crops
- alfalfa
- Rye, barley
- alfalfa
- Hay, oats, peas, and rye.
- Alfalfa, Perennial cool season grasses, cereal rye/other cover crops
- Alfalfa, grass hay,
- Hay
- Alfalfa
- Vegetables.

APPENDIX E: REPORTED SNOW DRIFTING LOCATIONS

The raw survey data was reviewed and only the specific and related responses are included here. For example, “Yes, on various curves” was omitted from the following list because it lacks clear, actionable direction.

1. All along rt52, Shorewood to rt 47.
2. ALONG RT 78 IN YORKTOWN TOWNSHIP
3. Yes, the curve on Rt45 south of Pesotum
4. 360 Palmyra Rd, 61021
5. Yes, state highway 94 between Taylor Ridge to Aledo.
6. 7S027 Jericho Road, Big Rock
7. 1155 e 3300 n Rd Mansfield IL
8. Route 26 south of Foreston s curves rt 64 west of rt 26 north side of road
9. East of Princeville, IL between Slane road and Feucht road on State Route 90-91 is always bad.
10. Yes, Route 9 from LaHarpe, IL to Bushnell, IL would largely benefit from snow fences on the north side of the road.
11. Several spots throughout South Grove township in DeKalb County.
12. Route 40 north between Bradford, Il and Sterling, Il and south between Bradford, Il and Peoria Il snow drifts significantly across highway
13. Yes, on 116 between middle grove and Farmington
14. Route 40, Between Teutopolis and Montrose
15. County road 9, between Route 49 and Route 1. Route 49, N/B, to Route 24. Route 24, from Route 49, to Watseka.
16. US 51 curves around Maroa
17. Yes, along 117 South of Toluca.
18. US 67 from Macomb to Monmouth. 336 from Macomb to Quincy
19. All along Highway 34 between Galesburg and Galva.
20. Route 251 north of 46th Road for 2 miles. Curve on 251 South of Compton where road runs east and west
21. Rt. 64 & 38 between DeKalb and I-39
22. Yes!!! Illinois highway 92, from 178-Illinois route 26. Illinois highway 172 from 92 all the way north on 172 of Tampico.
23. State Route 40 roughly one half of a mile south of state route 172

Locations identified in the last survey question:

1. IL47 (Kane County) Between Plank Rd and McDonald Rd
2. 136, Topeka
3. IL 78 YORKTOWN TOWNSHIP
4. Yes, IL Route 26 South of Polo
5. IL 104 southeast of Liberty
6. State Route 91 between Slane road and Feucht Road East of Princeville, IL

7. Route 9 from Laharpe, IL to Bushnell, IL is terrible and has to be shut down several times a year from drifting snow.
8. State road 9 between Elliott and Bloomington
9. Rt 23 & 38 in DeKalb Co

APPENDIX F: COST AND BENEFIT OVER THE ANALYSIS PERIOD

Table 29. Present value benefit and cost of living snow fences over the analysis period

		PV cost of LSF					PV Benefit of LSF				
Design Year	**Discounting Factor (1/(1+D)^N**	**Installation Cost**	**Maintenance Cost**	**Land Rental Cost**	**Inconvenience Cost**	**Total Cost**	**Snow Removal Saving**	**Safety Benefits**	**Travel Time Benefit**	**Emission Benefit**	**Total Savings and Benefits**
		$88,384									
1	0.97		$10,179	$1,644	$6,360	$107,245	$0	$0	$0	$0	$0
2	0.94		$9,882	$1,596	$6,175	$17,653	$0	$0	$0	$0	$0
3	0.92		$9,594	$1,549	$5,995	$17,139	$0	$0	$0	$0	$0
4	0.89		$9,315	$1,504	$5,820	$16,640	$0	$0	$0	$0	$0
5	0.86		$9,044	$1,460	$5,651	$16,155	$0	$0	$0	$0	$0
6	0.84		$8,780	$1,418	$5,486	$15,684	$0	$0	$0	$0	$0
7	0.81		$0	$1,377	$5,327	$6,703	$5,774	$19,016	$25,551	$1,459	$51,800
8	0.79		$0	$1,336	$5,171	$6,508	$5,606	$18,462	$24,807	$1,416	$50,291
9	0.77		$0	$1,298	$5,021	$6,318	$5,443	$17,924	$24,085	$1,375	$48,826
10	0.74		$0	$1,260	$4,875	$6,134	$5,284	$17,402	$23,383	$1,335	$47,404
11	0.72		$0	$1,223	$4,733	$5,956	$5,130	$16,895	$22,702	$1,296	$46,024
12	0.70		$0	$1,187	$4,595	$5,782	$4,981	$16,403	$22,041	$1,258	$44,683
13	0.68		$0	$1,153	$4,461	$5,614	$4,836	$15,925	$21,399	$1,222	$43,382
14	0.66		$0	$1,119	$4,331	$5,450	$4,695	$15,461	$20,776	$1,186	$42,118
15	0.64		$0	$1,087	$4,205	$5,292	$4,558	$15,011	$20,171	$1,152	$40,891
Present Value Cost		**$88,384**	**$56,794**	**$20,211**	**$78,205**	**$243,594**	**$46,308**	**$152,499**	**$204,914**	**$11,698**	**$415,419**
Benefit-Cost Ratio		1.71									

Table 30. Present value benefit and cost of structural snow fences over the analysis period

		PV Costs of SSF					PV Benefits of SSF				
Design Year	**Discounting Factor (1/(1+D)^N**	**Installation and Establishment Cost**	**Maintenance Cost**	**Opportunity Cost**	**Inconvenience Cost**	**Total Cost**	**Snow Removal Saving**	**Safety Benefits**	**Travel Time Benefits**	**Emission Benefits**	**Total Savings and Benefits**
		177408.00									
1	0.97		$8,612	$1,681	$9,456	$197,157	$6,895	$22,706	$30,510	$1,742	$61,852
2	0.94		$8,361	$1,632	$9,181	$19,173	$6,694	$22,044	$29,621	$1,691	$60,050
3	0.92		$8,117	$1,584	$8,913	$18,615	$6,499	$21,402	$28,758	$1,642	$58,301
4	0.89		$7,881	$1,538	$8,654	$18,073	$6,310	$20,779	$27,921	$1,594	$56,603
5	0.86		$7,651	$1,493	$8,402	$17,546	$6,126	$20,174	$27,107	$1,548	$54,955
6	0.84		$7,428	$1,450	$8,157	$17,035	$5,948	$19,586	$26,318	$1,502	$53,354
7	0.81		$7,212	$1,407	$7,920	$16,539	$5,774	$19,016	$25,551	$1,459	$51,800
8	0.79		$7,002	$1,366	$7,689	$16,057	$5,606	$18,462	$24,807	$1,416	$50,291
9	0.77		$6,798	$1,327	$7,465	$15,590	$5,443	$17,924	$24,085	$1,375	$48,826
10	0.74		$6,600	$1,288	$7,247	$15,136	$5,284	$17,402	$23,383	$1,335	$47,404
11	0.72		$6,408	$1,251	$7,036	$14,695	$5,130	$16,895	$22,702	$1,296	$46,024
12	0.70		$6,221	$1,214	$6,831	$14,267	$4,981	$16,403	$22,041	$1,258	$44,683
13	0.68		$6,040	$1,179	$6,632	$13,851	$4,836	$15,925	$21,399	$1,222	$43,382
14	0.66		$5,864	$1,144	$6,439	$13,448	$4,695	$15,461	$20,776	$1,186	$42,118
15	0.64		$5,693	$1,111	$6,252	$13,056	$4,558	$15,011	$20,171	$1,152	$40,891
Present Value Cost		**$177,408**	**$105,889**	**$20,665**	**$116,275**	**$420,238**	**$84,779**	**$279,189**	**$375,150**	**$21,417**	**$760,534**
Benefit-Cost Ratio		1.81									

Table 31. Amortization benefit and cost of living snow fences over the analysis period

		Amortized Costs of LSF					Amortized Benefits of LSF				
Design Year	Inflation Factor	Installation Cost	Maintenance Cost	Land Rental Cost	Inconvenience Cost	Total Cost	Snow Removal Saving	Safety Benefits	Travel Time Benefit	Emission Benefits	Total Savings and Benefits
		$88,384									
1	1.02		$10,715	$1,730	$6,695	$107,524	$0	$0	$0	$0	$0
2	1.04		$10,950	$1,768	$6,842	$19,561	$0	$0	$0	$0	$0
3	1.07		$11,191	$1,807	$6,993	$19,991	$0	$0	$0	$0	$0
4	1.09		$11,437	$1,847	$7,147	$20,431	$0	$0	$0	$0	$0
5	1.11		$11,689	$1,888	$7,304	$20,881	$0	$0	$0	$0	$0
6	1.14		$11,946	$1,929	$7,465	$21,340	$0	$0	$0	$0	$0
7	1.16		$0	$1,972	$7,629	$9,601	$8,270	$27,235	$36,596	$2,089	$74,190
8	1.19		$0	$2,015	$7,797	$9,812	$8,452	$27,834	$37,401	$2,135	$75,822
9	1.22		$0	$2,059	$7,968	$10,028	$8,638	$28,446	$38,224	$2,182	$77,490
10	1.24		$0	$2,105	$8,144	$10,248	$8,828	$29,072	$39,065	$2,230	$79,195
11	1.27		$0	$2,151	$8,323	$10,474	$9,022	$29,712	$39,924	$2,279	$80,937
12	1.30		$0	$2,198	$8,506	$10,704	$9,221	$30,365	$40,802	$2,329	$82,718
13	1.33		$0	$2,247	$8,693	$10,940	$9,424	$31,034	$41,700	$2,381	$84,538
14	1.36		$0	$2,296	$8,884	$11,180	$9,631	$31,716	$42,617	$2,433	$86,398
15	1.39		$0	$2,346	$9,080	$11,426	$9,843	$32,414	$43,555	$2,486	$88,298

Table 32. Amortization benefit and cost of structural snow fences over the analysis period

		Amortized Costs of SSF					Amortized Benefits of SSF				
Design Year	Inflation Factor	Installation and Establishment Cost	Maintenance Cost	Land Rental Cost	Inconvenience Cost	Total Cost	Snow Removal Saving	Safety Benefits	Travel Time Benefits	Emission Benefit	Total Savings and Benefits
		177408.00									
1	1.02		$9,065	$1,769	$9,954	$198,197	$7,258	$23,901	$32,116	$1,833	$65,109
2	1.04		$9,265	$1,808	$10,173	$21,246	$7,418	$24,427	$32,823	$1,874	$66,541
3	1.07		$9,468	$1,848	$10,397	$21,713	$7,581	$24,964	$33,545	$1,915	$68,005
4	1.09		$9,677	$1,888	$10,626	$22,191	$7,748	$25,514	$34,283	$1,957	$69,501
5	1.11		$9,890	$1,930	$10,860	$22,679	$7,918	$26,075	$35,037	$2,000	$71,030
6	1.14		$10,107	$1,972	$11,099	$23,178	$8,092	$26,649	$35,808	$2,044	$72,593
7	1.16		$10,330	$2,016	$11,343	$23,688	$8,270	$27,235	$36,596	$2,089	$74,190
8	1.19		$10,557	$2,060	$11,592	$24,209	$8,452	$27,834	$37,401	$2,135	$75,822
9	1.22		$10,789	$2,105	$11,847	$24,742	$8,638	$28,446	$38,224	$2,182	$77,490
10	1.24		$11,026	$2,152	$12,108	$25,286	$8,828	$29,072	$39,065	$2,230	$79,195
11	1.27		$11,269	$2,199	$12,374	$25,842	$9,022	$29,712	$39,924	$2,279	$80,937
12	1.30		$11,517	$2,248	$12,646	$26,411	$9,221	$30,365	$40,802	$2,329	$82,718
13	1.33		$11,770	$2,297	$12,925	$26,992	$9,424	$31,034	$41,700	$2,381	$84,538
14	1.36		$12,029	$2,348	$13,209	$27,586	$9,631	$31,716	$42,617	$2,433	$86,398
15	1.39		$12,294	$2,399	$13,500	$28,193	$9,843	$32,414	$43,555	$2,486	$88,298


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