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U.S. DEPARTMENT OF AGRICULTURE

Great Plains Initiative 2

Cooperative project with the Kansas Forest Service, Nebraska Forest Service, North Dakota Forest Service, South Dakota Department of Agriculture, and sponsored by the USDA Forest Service.

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Background — Great Plains Initiative 2

The Great Plains Initiative 2 (GPI 2, 2018 – 2019), is a limited continuation of the 2008 – 2009 Great Plains Tree and Forest Invasives Initiative[1], now referred to as Great Plains Initiative 1 (GPI 1). Both Initiatives were funded by the USDA Forest Service in cooperation with state forestry agencies in Kansas, Nebraska, North Dakota, and South Dakota.

GPI 1 prepared these Great Plains states for the arrival of emerald ash borer, (*Agrilus planipennis* Fairmaire), and other invasives that threatened tree resources in the northern Great Plains. The earlier initiative assessed both rural and urban forest resources. Participants developed educational programs that involved citizens in prevention, detection and mitigation efforts by establishing citizen-based monitoring and detection networks. GPI 1 also worked to identify and cultivate markets for the anticipated waste wood from invasive species caused tree mortality.

The trees outside of forests (TOF) inventory is a significant outcome of GPI 1, and now GPI 2. TOF are trees that occur on lands that do not meet the USDA Forest Service, Forest Inventory and Analysis (FIA), definition of forest land (1-acre in size, 10% stocked, and at least 120 feet in width). Before GPI 1, this resource was not inventoried. Limited information was known about its size and condition and yet it represents 5.1 million acres compared to 6.4 million acres of forestland in the four states. These 5.1 million acres of TOF provide important environmental, social, and economic benefits.

The initial GPI 2 proposal included assessment of riparian forests; however, the total funding request was not approved. Therefore, GPI 2 focuses exclusively on Phase 1 of the proposal, assessing the windbreak component of TOF in the rural landscapes of the Great Plains. Assessment and especially protection of riparian forests is still a significant need because of the ecosystem benefits associated with water quality and quantity issues.

Why GPI 2?

In the 1930s, at the height of the Dust Bowl, the federal government invested $13.8 million to establish more than 200 million trees and shrubs in windbreaks throughout the Great Plains. Today this green infrastructure exceeds 80 years of age and is in a state of age- and climate-related decline. Since 2000, large numbers of windbreaks have been actively removed by landowners during periods of high land and crop prices.

Decades of research and more recent results from GPI 1 confirm that windbreaks are critically important economic and ecosystem service providers in the Great Plains. In Nebraska, the increased crop yields and energy conserved due to wind protection from windbreaks are estimated to be worth more than $100 million per year. This figure does not include the value of many other economic and environmental benefits generated by windbreaks.

Although the science of windbreaks is clear, the inherent perception by many landowners and resource professionals is to regard these conservation plantings as nuisances to contemporary agriculture, contributing to decreased profits. Perceived as such, they are being removed from the landscape at an ever-increasing rate. This accumulating loss of agroecosystem protection is expected to cause severe environmental impacts in a climate projected to have increasing temperatures and drought.

1 *Summary of Findings from the Great Plains Tree and Forest Invasives Initiative Dacia M. Meneguzzo, Andrew J. Lister, and Cody Sullivan. USDA FS, NRS April 2018. General Technical Report NRS-177. https://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs177.pdf.*

Under projected future conditions, by 2050, major dust storms and severe soil erosion may be much more frequent. Indeed, dust storms are now beginning to reoccur with increasing frequency during drought periods, dramatically reducing air quality. The Kansas Forest Action Plan identified 2.9 million acres of cultivated cropland in Kansas that exceeds tolerable limits for erosion. Kansas subsequently forecasted that unaddressed windbreak decline will continue creating economic losses due to soil erosion, declining crop yields, increased energy use, and greater losses of livestock.

In South Dakota, the increased crop yields and energy conserved due to wind protection from windbreaks are estimated to be worth over $100 million per year. South Dakota is an agricultural state with an area of 77,047 square miles; approximately 90% of South Dakota is classified for agricultural use (cropland and rangeland). South Dakota has approximately 12,762,482 acres of cultivated cropland that is considered highly erodible. It is estimated that 2.4 tons of soil per acre per year is lost in South Dakota due to wind erosion. Most windbreak trees, 71%, are in fair condition with 7% of the trees being classified in poor condition. The percentage of trees in poor condition is expected to increase rapidly over the next 10 to 20 years given their current age. The South Dakota Forest Action Plan prioritizes the need for better inventory and analysis of prairie windbreaks.

The North Dakota Forest Action Plan identifies the loss of windbreaks as a serious concern for soil conservation and wildlife habitat. An estimated 55,000 linear miles of windbreaks[2] provide significant benefits to agricultural systems by reducing soil erosion, increasing crop yields and filtering water runoff from croplands. Based on a survey conducted for the state's forest action plan, the linear miles of field windbreaks decreased 3.7% over a five-year period from 2010-2015 with the greatest losses in agricultural areas of eastern North Dakota.

GPI 2 Goals and Deliverables

The goal of GPI 2 is to protect windbreaks from harm by characterizing and documenting their current health and condition in the Great Plains. Risks and potential economic impacts from invasive pests such as the emerald ash borer, thousand cankers disease of walnut, Asian longhorned beetle, and other non-native and indigenous plants, insects and diseases are all concerns. Public benefits will be enhanced through the establishment of windbreaks where wind-blown soil erosion on cropland exceeds NRCS "tolerable limits" standards. Windbreak renovation, establishment and adoption will be increased creating ecological, economic, and agricultural benefits.

This project created GIS-ready tree canopy layers using Trimble eCogntion and ArcGIS software, and 4-band digital aerial photos acquired from the National Agriculture Imagery Program (NAIP) for each state. Windbreaks were identified by segmenting images into objects with similar spectral, textural, and geometric properties using ArcGIS software. This report documents changes in condition and area of windbreaks since GPI 1. After initial training, GIS personnel within the region's state forestry agencies identified total area, location, and classification of windbreak condition into good, fair, or poor classes using the same condition criteria that qualifies windbreaks as an NRCS resource concern for renovation (Kansas Forestry Technical Note No. K-11).

Landowner parcel data will be applied to condition assessments to target landowners with windbreaks in need of renovation and locations for new windbreaks. As part of "ground-truthing," inventory data was collected using windshield surveys, rapid field checks, and low-intensity sampling for tree

2 *North Dakota Forest Action Plan, May 2020. https://www.ag.ndsu.edu/ndfs/documents/2020-north-dakota-forest-action-plan-final.pdf*

and shrub species, diameter, height, windbreak width, invasive species, and land use adjacent to the windbreaks.

Ecosystem service values for soil conservation, crop yield, energy savings, and livestock operations were considered as part of the project. A GIS layer was created identifying highly erodible soils on cropland with wind erodibility index of 87 or higher to target potential locations for new windbreak establishment. Target Marketing and Tools for Engaging Landowners Effectively (TELE) was used to develop an outreach plan to engage "uninvolved" landowners in windbreak establishment and renovation.

GPI 2 — Trees Outside of Forests – Rural Tree Canopy Methodology and Results

History

The USDA Forest Service defines a forest as a treed area at least 1 acre in size, with a minimum width of 120 feet by 363 feet and 10% canopy cover. This definition works for most of the country, but it has severe limitations in the Great Plains where forested areas are often not 120 feet wide. A substantial part of the forested resource in Kansas, Nebraska, North Dakota, and South Dakota are linear windbreaks and riparian corridors.

Methodology

The USFS Northern Research Station (USFS-NRS) developed a methodology to create a high-resolution land-cover layer that emphasizes rural tree canopy and would capture USFS defined forests and also linear features. This methodology included analysis using eCognition, ArcGIS software and the R statistics program. Staff created the segmentation file for eCognition and several tools using ArcGIS software and R programing language to streamline the process for all four states.

Data Creation

The high-resolution land cover layers were created using an object-based image analysis (OBIA) approach and supervised classification. Basically, OBIA is a two-step process that consists of image segmentation and classification. Each state obtained National Agricultural Imagery Program (NAIP) imagery from 2014 (2015 for Kansas) at 1-meter resolution. Each image tile covers approximately 15 square miles. As an example, Kansas has more than 6,000 tiles. Note: a county-by-county approach was used to keep the vast amounts of image and other data organized and more manageable, so the steps described below were carried out for each county. USFS-NRS staff created an ArcGIS Plains Mapping Toolbox to help carry out the classification process and finalize the GIS data for publication and distribution.

Individual NAIP tiles were segmented using eCognition software; segmentation is a process that divides an image into "image objects" (polygons) that represent landscape features of interest, such as tree canopies, water bodies, etc., by grouping similar pixels together. The resulting polygons along with attributes that describe their spectral, textural, and other properties were exported in vector (shapefile) format that would then be assigned to different land cover categories during the classification phase of the OBIA process.

A supervised classification approach was used to build a land cover classification model for each county. GIS staff from each state collected good quality representative samples of each of four land cover classes (tree cover, other vegetation, nonvegetated/barren, or water) as training data. These data were used to train a Random Forest model using R statistical software, and the model was then applied to all the vector data for each county. After classification, a series of post-processing steps were carried out using tools in the Plains Mapping Toolbox:

1. Clip and merge – each classified shapefile was clipped to the NAIP tile boundary to remove the 300-m overlap areas and then merged into one county-wide shapefile
2. Reclassify and add cities –the "other vegetation" and "no vegetation" classes were combined into one "other land cover" class and the cities and towns were added using the *Incorporated_Place* layer
3. *Manual editing to correct misclassified areas occurred at this point although it is not a tool in the Toolbox*

4. Finalize county raster –when editing was completed, this step converted the county-level shapefile to a 4-bit raster with the following land cover class codes: 1 = tree cover; 2 = other land cover; 3 = water; 15 = cities and towns. Cities and towns were masked out and assigned to their own class using the US Census Bureau's Incorporated Places layer. Tree cover data are not available for these areas (with the exception of Kansas, see "Further Work" section for more information).

Peer Review

To ensure the quality of the research and data, the USFS – Northern Research Station has guidelines for peer review that include two technical reviews. A minimum of three counties in the state are selected in a spatially balanced manner. The 1-meter data layers undergo technical reviews provided by two independent GIS professionals not associated with the respective project. Reviewers are asked to examine the data and identify readily apparent mapping errors, read over the metadata for missing and/or incorrect information, and provide an overall general sense of accuracy of the data compared to the year of NAIP imagery from which the data were derived.

Metadata

Metadata are data about data. Metadata answer such questions as what data were collected, how they were collected, why they were collected, how reliable they are, and what issues should be accounted for when working with them. Metadata also describe how to get the data, what tools are needed to work with the data, and other related matters. The objective of data documentation is to provide enough information about the data set to allow someone to readily work with the data 20 years from now.

This project used Metavist to create the metadata. Metavist is a research and development software program written by Dave Rugg that is available at no charge. Metavist helps you develop a metadata document that is compliant with the *Biological Data Profile (BDP) https://www.fs.usda.gov/rds/archive/metadata/standards* metadata standard, which works for nearly any type of data. You can also write a metadata document for purely geospatial data that is compliant with the FGDC metadata standard. The documents it creates are in XML format and can be exported as HTML. The metadata documents can be read by ESRI ArcCatalog and by USGS ScienceBase.

Publishing

The Research Data Archive has guidelines for submitting data for publication. Each data set went through this process to be published. The submission package must contain the data set(s), metadata, additional files that should be archived with the data if applicable, associated publications and a data submission form. A member of the archive team assisted in preparing the files and submitting the data package.

Further Work

The research and analysis of trees outside of forests in the Great Plains continues. For the first time, northern Great Plains states have a GIS layer showing the location of all tree resources throughout this state. This is a great improvement on how these states were calculating acreage and location, but other opportunities are available for further work. This work includes creating a similar high-resolution layer for urban and incorporated areas and defining the function of the trees on the rural landscape.

High-Resolution Urban Land Cover

Kansas continued with OBIA to create a high-resolution urban land cover layer with an emphasis on tree cover. While this process is similar to the rural tree canopy and land cover creation, urban areas are much more complex than rural areas. To capture the complex nature of urban spaces, USFS-NRS developed

a new segmentation routine designed to more accurately delineate the finer-scale and diverse features of urban landscapes.

A decision by USFS-NRS and Kansas Forest Service staff was made to have five land cover classes for urban landscapes rather than the four classes in the rural classification scheme. There was a need to delineate bare ground and impervious surfaces. The new classifications are 1 – Trees, 2 – Other Vegetation, 3 – Bare Ground, 4 – Impervious Surfaces and 5 – Water. With the finer resolution segmentation and extra class defined, staff were ready to begin mapping incorporated areas in Kansas.

To be consistent with the high-resolution work done in rural areas, the urban work also used 2015 NAIP imagery and the same incorporated areas boundaries. Kansas has 670 communities with more than 400 communities completed and 250 published. The City of Wichita was mapped separately through a USFS Landscape Scale Restoration grant. All other incorporated areas will be mapped by Kansas Forest Service staff.

Defining the Function of Rural Trees

When high-resolution mapping of rural tree canopies is complete, work will begin on defining the functions of those trees. It is vital to the study of rural trees to assign a function to them whether it is windbreak, riparian forest, woodland, or even woody encroachment. This analysis has similar steps to the high-resolution land cover research.

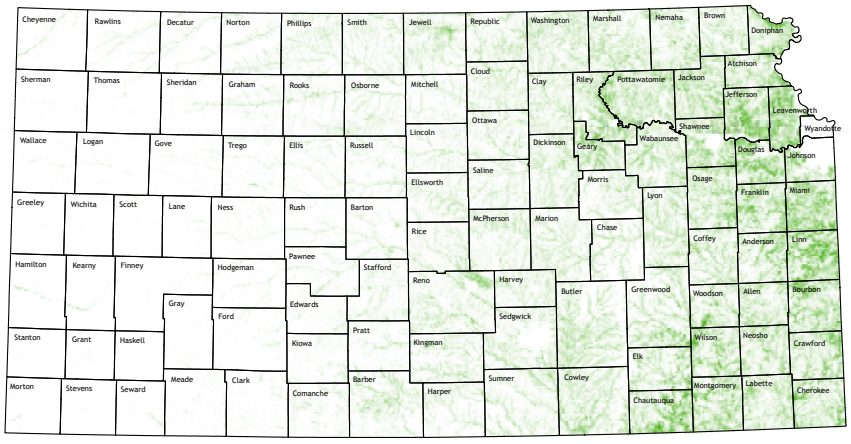
First, the land cover maps will be reclassified so that the non-tree cover classes are merged into one "no-tree" class. Focusing on tree cover only, the data are segmented in a manner that groups "tree" pixels into continuous groups, whether it be single-tree canopies surrounded by non-tree cover or groups of continuous tree cover. These polygons will be analyzed by eCognition to determine the shape characteristics of the polygon. After the eCognition analysis, training will take place in ArcGIS with the training categories consisting of: 1 – north/south windbreaks , 2 – east/west windbreaks, 3 – L-shaped windbreaks, 4 – complex windbreaks, 5 – riparian, 6 – woodlot, and 7 – other.

Again, time will be spent on each county to assess the accuracy of the training and to reassign any shapes incorrectly assigned. This will slow down the process but will make a better and more accurate data set in the end. After finishing all the counties, each state will, for the first time, have an accurate valuation of how many acres of trees fall into riparian forest, windbreaks, woodlots or other forests throughout the state.

Kansas Results

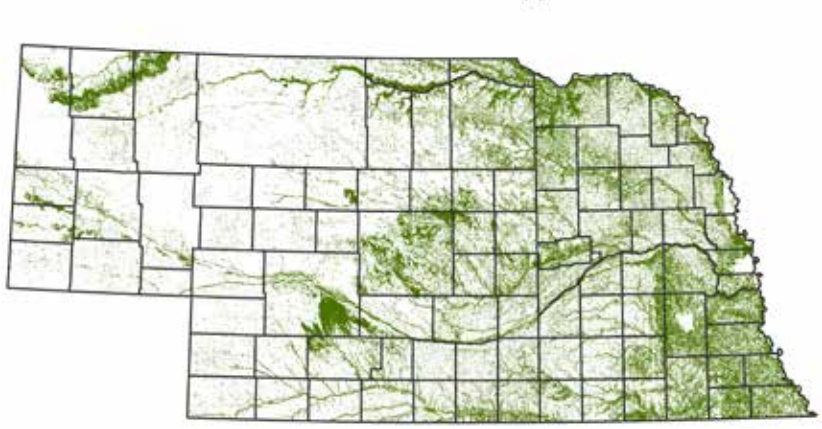
Kansas completed all 105 counties and USFS-NRS published the data in 2017. The data can be found at: *https://www.fs.usda.gov/rds/archive/catalog/RDS-2017-0025*. The final total acreage of the rural tree canopy was 3.8 million acres of trees outside of forests (TOF) comprise the rural tree canopy.

Canopy Cover



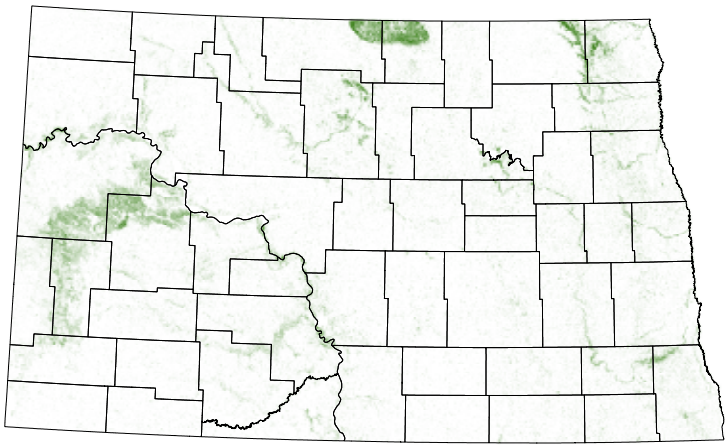
Nebraska Results

Nebraska completed all 93 counties and the USFS-NRS published the data in 2019. The data can be found at: *https://www.fs.usda.gov/rds/archive/catalog/RDS-2019-0038*. The final total acreage is 2.066 million acres with 1.560 million acres of traditional forestland and an additional 506,100 acres of trees outside of forests.



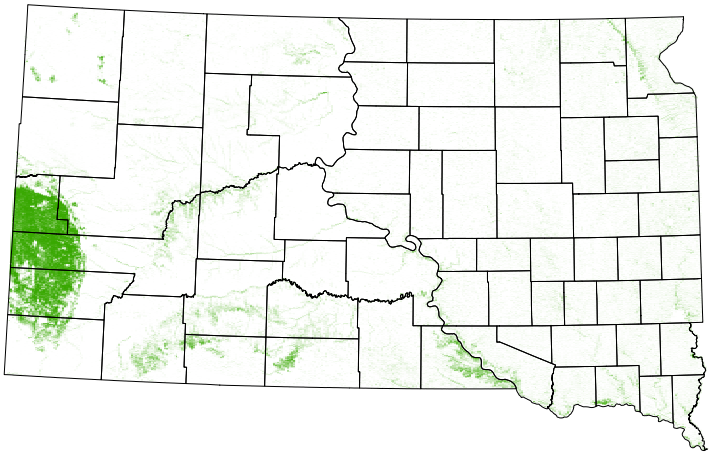
North Dakota Results

North Dakota has 1,556,184 tree-covered acres. According to 2014 Forest Inventory and Analysis 796,878 of those acres qualify as forestland. Therefore, North Dakota has an estimated 759,306 acres of Trees Outside of Forests (TOF).



South Dakota Results

Forested Land calculation for South Dakota based on the final TOFii data submitted is 2,391,890 acres. FIA data estimates that there are 1,943,716 acres of actual forest (based on the 2014 report) Subtracting this from the official TOFii area calculation South Dakota has 448,174 acres of trees outside of forests in South Dakota. That means 18.75 percent (almost 20 percent) of treed land is not being inventoried by conventional FIA Inventories.

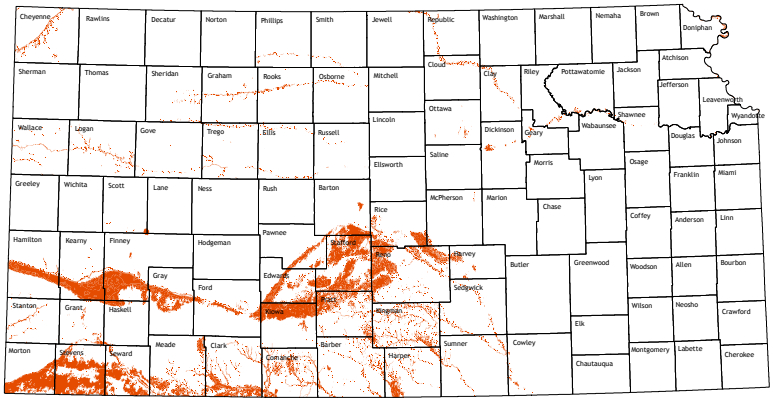


Wind Erodibility Index

The Natural Resources Conservation Service defines wind erodibility index (WEI) as a numerical value indicating the susceptibility of soil to wind erosion or the tons per acre per year that can be expected to be lost to wind erosion. A WEI of 87 or higher indicates areas of cropland particularly susceptible to wind erosion. Each state has mapped their WEI of 87 or higher to focus on the establishment and renovation of field windbreaks to reduce wind erosion and improve crop yields.

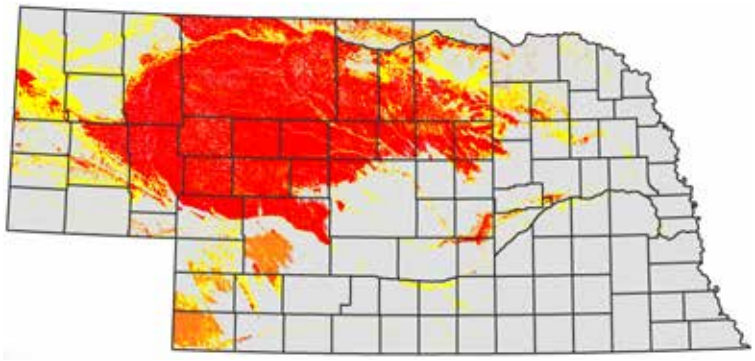
Kansas Results

Kansas has more than 2.5 million acres of cropland on soils with the wind erodibility index of 87 or higher. Most of these soils lie in southwest and south-central Kansas. According to the 2017 NRCS Natural Resource Inventory, Kansas croplands experience 70.69 million tons of wind erosion annually with a rate of 2.68 tons/acre/year.



Nebraska Results

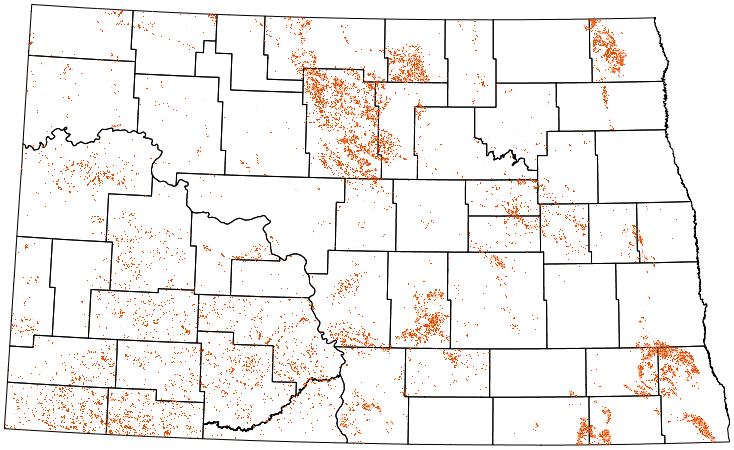
Nebraska has an estimated 6,620 miles of field windbreaks covering 58,070 acres. The area protected by these windbreaks ranges from 6 – 15 times the height on the lee side and 2 – 5 times the height on the windward side. There is an estimated total of 200,640 acres protected by field windbreaks in Nebraska. According to the 2017 Natural Resources Inventory, Nebraska's non-federal croplands experienced nearly 22 million tons of soil loss due to wind erosion, representing a 30% improvement in soil loss since 2007 (USDA, 2017). Based on the annual soil loss in Nebraska and the fertilizer costs associated with wind erosion, wind erosion in Nebraska costs producers an estimated $46,158,000 per year of increased fertilizer costs.



North Dakota Results

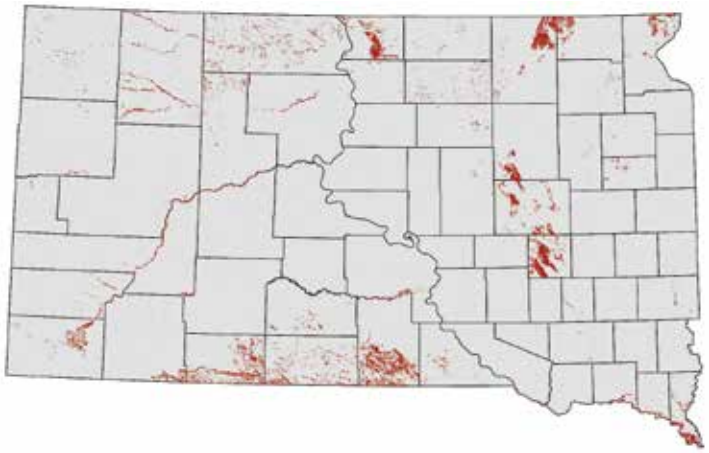
There are 505,817 acres of North Dakota cropland on soils considered highly erodible because the wind erodibility index (WEI) is 87 or higher. These areas will benefit from windbreak establishment.

Sources: North Dakota Forest Service, USDA NRCS, USDA Forest Service, ESRI.



South Dakota Results

There are 157,124 acres of South Dakota cropland on soils considered highly erodible because the wind erodibility index (WEI) is 87 or higher. These areas will benefit from windbreak establishment.



GPI 2 Windbreak Inventory

Methods

GPI 2 windbreak inventory methods are abbreviated compared to GPI 1 methodology due to funding and time constraints. GPI 2 focuses exclusively on windbreaks where GPI 1 included urban trees and riparian forests. GPI 1 methods were developed by USDA Forest Service, National Inventory and Monitoring Applications Center (NIMAC). Detailed information regarding GPI 1 data collection procedures is available in Lister et al. (2012) and in the unpublished GPI 1 inventory field guide. For these reasons, care must be taken when comparing GPI 2 inventory results with the GPI 1, 2008-2009 inventory.

Goals for windbreak data collection for GPI 2 included an evaluation component combined with a more in-depth inventory. The **evaluation** component assessed 10 windbreaks in each county in the 4-state area. Function, condition, age, orientation, number of rows, average height, windbreak porosity were all measured. The **in-depth** portion of the inventory collected tree diameters at 4.5 feet, tree species and tree height from one windbreak in each county in the 4-state area, or approximately 10% of the total windbreaks using a 30-tree transect.

Defining the Data Collected

Function identified the purpose of the windbreak for either fields, rural homesteads, livestock, snow fences or wildlife habitat. **Condition** was classified into Good, Fair or Poor classes based on the following windbreak attributes.

Windbreak Attributes:

1. Less than 25% of the trees are dead
2. Continuous barrier, no gaps (missing trees)
3. 50% density or greater
4. No smooth brome grass or fescue sod present
5. Majority of the tree crowns are healthy with less than 25% of the trees showing insect, disease or herbicide damage
6. None to very little livestock activity in the planting.
7. Tree regeneration is present
8. Trees are expected to live another 20 years

Windbreak condition was classified where the majority of the condition description applied. Good windbreaks met at least six of the attributes listed including less than 25% mortality. Fair windbreaks have four or five of the attributes including one with less than 25% mortality. Poor windbreaks have fewer than four of the attributes including more than 25% mortality.

Age of windbreaks were divided into three classes windbreaks less than 25 years, windbreaks between 25 – 50 years of age and windbreaks older than 50 years.

Windbreak orientation was the primary position of each independent windbreak for the longest component of the windbreak based on functional purpose and primary wind direction. Orientation classified windbreaks into those that ran north to south or east to west, "L" shaped windbreaks, windbreaks located in riparian areas next to streams and complex windbreaks. Complex windbreaks had three or more sides and were generally "U" or "T" shaped.

The **number of tree rows** in the windbreaks was also evaluated and row numbers assigned based on orientation. For windbreaks with north-south orientation Row 1 was the western most row while in east-west windbreaks it was the northern most row. Number of rows informs extent of windbreak benefits for wildlife and carbon.

Windbreak porosity is the ratio of the open portion of the windbreak (where stems, branches, or leaves are missing) to its total volume. For practical purposes, windbreak porosity can be considered equivalent to optical porosity, which is the percentage of open space you see when you stand directly in front of the windbreak. Porosity relates directly to windbreak function and condition. For winter protection of structures and livestock a density greater than or equal to 65% is recommended; for soil and crop protection between 40% to 60% and for snow distribution between 25% and 50%.

Average tree row height was also collected, which helps identify the area the windbreak protects. On the leeward side, the area of protection extends 10 – 30 times the height and 2 – 5 times on the windward side. Height and diameter may also be used to estimate volume and carbon storage.

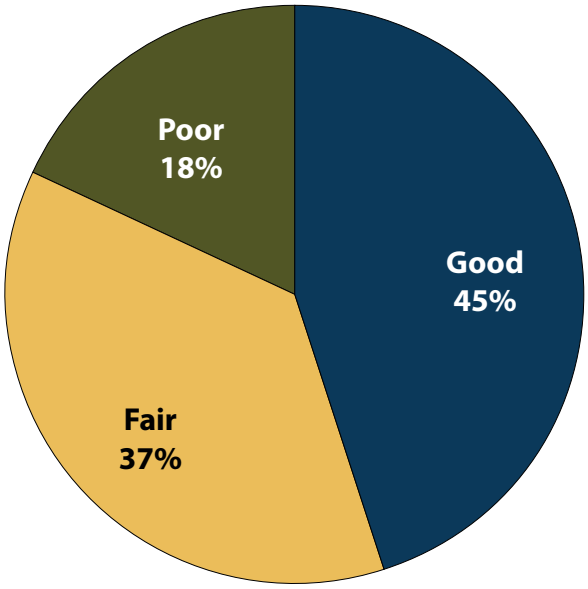
Dominant tree species were measured for each tree row. This information informs wildlife habitat benefits, invasive species, species at risk (green ash and pines) and longevity of the windbreak.

Kansas

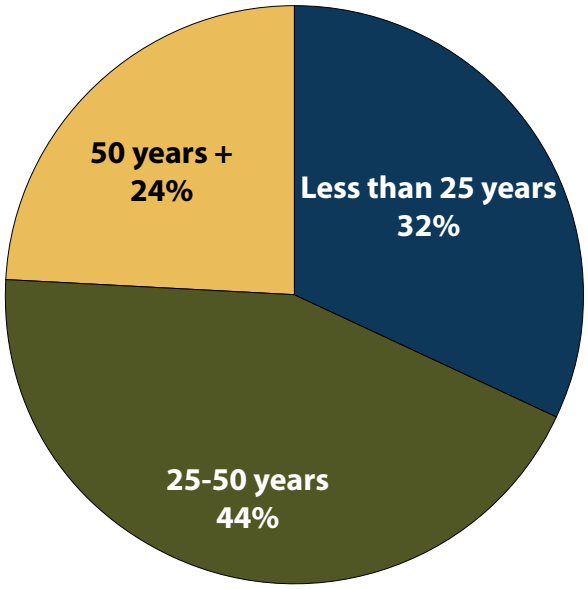
Of the 1.3 million acres of trees outside of forests in Kansas, 118,015 windbreaks comprise 261,536 acres and stretch a total of 31,348 miles in length. The average windbreak size in Kansas is 2.2 acres with a length of 1,403 feet; however, windbreaks provide protection in an area at least 10 times the height of the windbreak on the leeward side and two times the height on the windward side. In Kansas that adds up to a conservative estimate of 949,760 acres of livestock, cropland, and farmsteads protected by this important resource.

Windbreak condition was measured on a sample of 1,115 windbreaks and found 45% in Good condition, 37% Fair and 18% Poor. This suggests that over half the windbreaks

Windbreak Condition



Windbreak Age



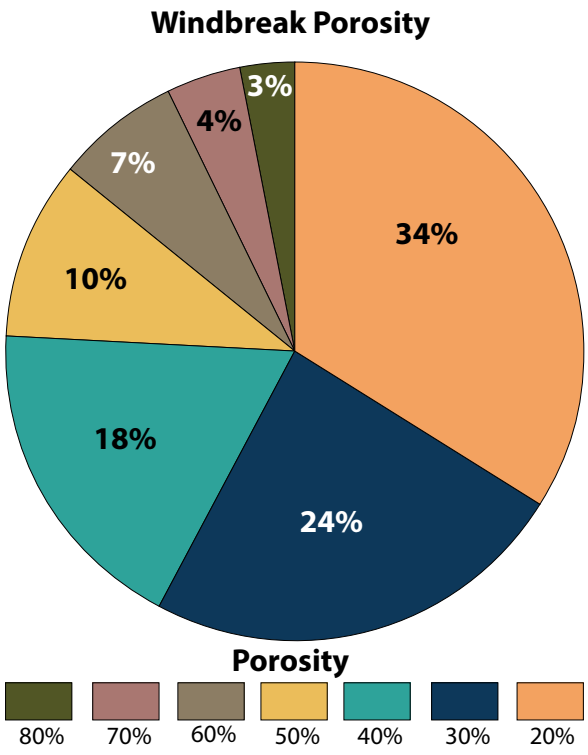
in Kansas (55%) are in need of some form of renovation and are likely to qualify as a "resource concern" under EQIP. Since the GPI 1 inventory (2008 – 2009) there has been a slight decline in overall windbreak condition that found 52% in Good condition, 32% Fair and 11% Poor. **Windbreak age** can also inform condition and sustainability. For example 24% of Kansas windbreaks exceed 50 years of age that contributes to the Poor and Fair condition classes with 44% between 25 – 50 years and 32% less than 25 years old.

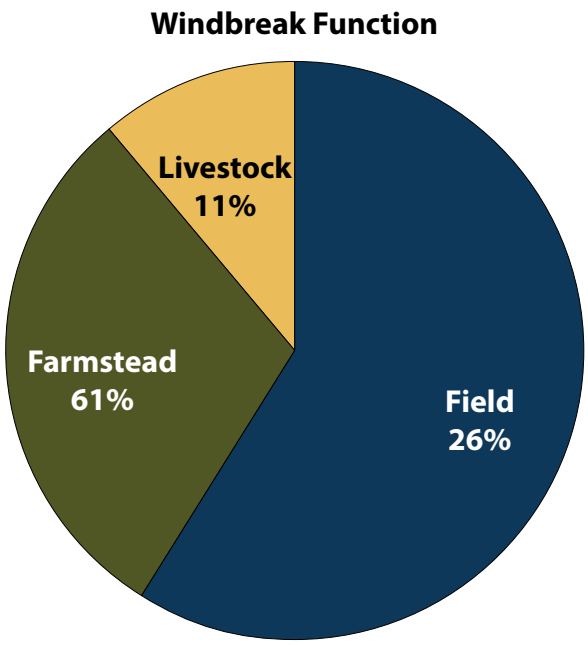
Windbreak porosity is another measure of windbreak health and function. The inventory found 76% of Kansas windbreaks to have a porosity between 20 – 40%, which is below NRCS specifications for field, farmstead, livestock, and living snow fences. This porosity is also inadequate for windbreaks designed to function as screens and for odor control. This is a significant concern since 61% of Kansas **windbreaks function** to protect farmsteads, 25% croplands and 11% for livestock. Porosity data further supports a statewide need for renovating Kansas windbreaks.

The orientation of windbreaks defines the area of protection determined by the height of the windbreak at 20 years of age. On the windward side the protected area is two to five times the height and on the leeward side 10 – 30 times the height. 48% of Kansas windbreaks run in an east-west direction. This is good news considering prevailing wind directions that cause soil erosion or damage crops come from the south or north. 24% of Kansas windbreaks had an L-shape orientation generally on the north and west side of the area of protection and 15% north-south.

The number of rows in windbreaks affects wildlife, carbon, wood products, odor amelioration, and screening benefits. Generally the more rows the more benefits. According to this inventory, 42% of Kansas windbreaks have a single row, 32% two rows, and 12% four or more rows.

Most windbreaks in Kansas (61%) are designed to protect farmsteads and provide important energy and quality of life benefits. About 26% protect crop fields, which increases crop yields and reduces soil erosion. Another





11% of Kansas windbreaks function to protect cattle and other livestock. The other 2% function as living snow fences or for wildlife.

Eastern redcedar (54.4%), the **dominant species** in Kansas windbreaks, is a concern for some people due to its ability to spread when not managed; however, it remains the single best conifer to sustain a healthy functioning windbreak. Nearly 13% of windbreaks are dominated by Scotch, ponderosa, and Austrian pine, which are all susceptible to a variety of pine diseases that put windbreaks with those species at risk. Ideally, many foresters would like to see the percentage of Siberian elm decline, an invasive non-native species and be replaced with native bur oak, which only makes up 1% of Kansas windbreaks.

Windbreak diameter classes and heights were taken from the in-depth inventory that measured one windbreak in each county in Kansas or approximately 10% of the total windbreaks using a 30-tree transect. This inventory found a healthy distribution of diameter classes with 47% of the trees at 6 inches in diameter classes or below, which somewhat correlates to 32% of Kansas windbreaks being 25 years old or younger. Around 11% of Kansas windbreaks include diameter classes of 16 inches and up. All diameters are measured at 4.5 feet.

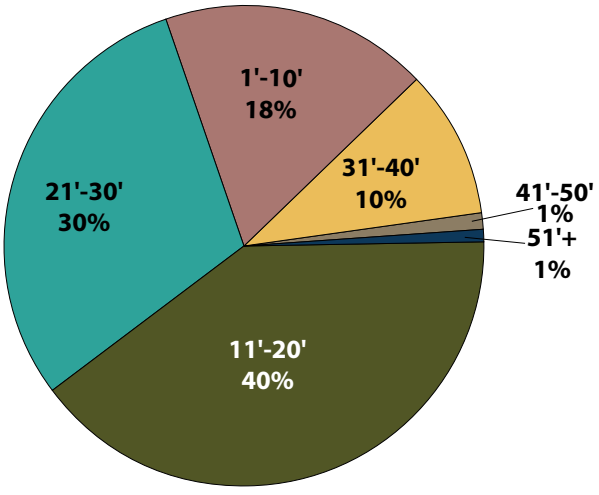
Kansas

Tree Diameter Classes	Percentage of Trees in Each Class
0-0.99"	3%
1-1.99"	11%
2-2.99"	7%
3-3.99"	9%
4-4.99"	11%
5-5.99"	9%
6-6.99"	7%
7-7.99"	6%
8-8.99"	7%
9-9.99"	4%
10-10.99"	4%
11-11.99"	5%
12-12.99"	4%
13-13.99"	2%
14-14.99"	5%
15-15.99"	4%
16-16.99"	1%
17"+	3%

Dominant Species

Species Name	% of Kansas Windbreaks
Eastern redcedar	54.4%
Osage-orange	8.2%
Austrian Pine	7.6%
Other	7.1%
Siberian Elm	5.3%
Honeylocust	3.8%
Ponderosa Pine	3.5%
Rocky Mountain Juniper	2.2%
Broadleaf deciduous small	2.0%
Scotch Pine	1.5%
Broadleaf deciduous medium	1.4%
Mulberry	1.2%
Bur Oak	1.0%
Eastern white pine	0.7%

Windbreak Height



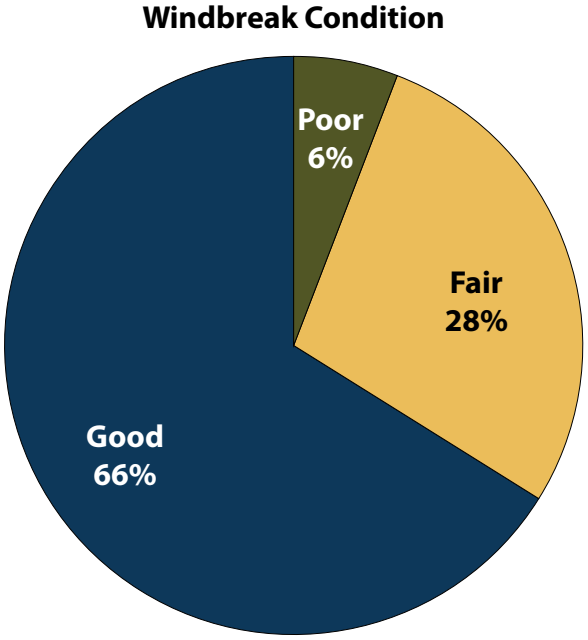
80% of Kansas windbreaks range between 11 and 40 feet in height with 18% less than 10 feet. **Windbreak height** and diameter will help estimate biomass and carbon storage potential.

As indicated earlier, inventory methodology is vastly different from GPI 1 to GPI 2, which may explain the significant **changes since GPI 1** from 30% – 61% of Kansas windbreaks protecting farmsteads. There is also dramatic change in eastern redcedar from 12% – 54% of occurrence in Kansas windbreaks. The differences in species composition are related to different data collection formats. Anecdotal observations would suggest more of a presence of Osage-orange and hackberry than GPI 2 results show. Other attributes such as age and condition do not show significant changes between inventories. The changes observed in condition classes show a decline in Good condition from 57% – 45% and an increase in Fair and Poor condition classes collectively from 43% – 68%. This suggests gradual decline in the health and functioning condition of Kansas windbreaks and the ongoing need for renovation.

Changes Since GPI 1

	GPI 1 (2008-2009)	GPI 2 (2019)
Windbreaks by Function:	30% Farmstead 59% Field 11% Livestock	61% Farmstead 26% Field 11% Livestock
Tree Species:	8% Ash 12% Eastern redcedar 11% Elm 16% Hackberry 18% Osage Orange	8% Austrian Pine 54% Eastern redcedar 2% Eastern White Pine 4% Honeylocust 5% Siberian Elm
Condition:	57% Good 32% Fair 11% Poor	45% Good 37% Fair 18% Poor
Age:	20% less than 25 years 58% 25-50 years 22% 50 years +	32% less than 25 years 44% 25-50 years 24% 50 years +

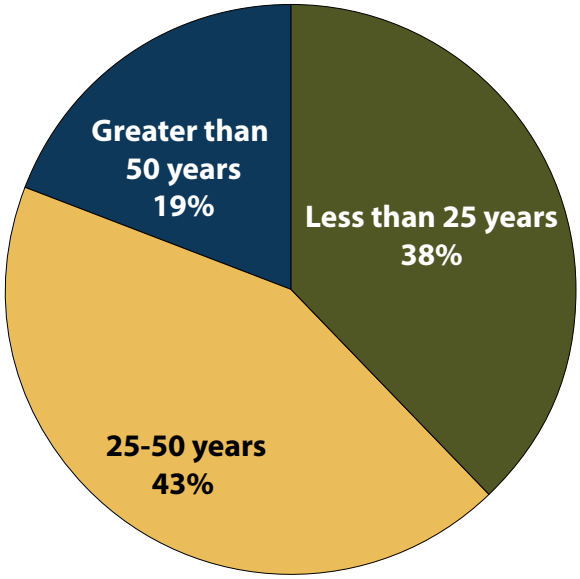
Nebraska



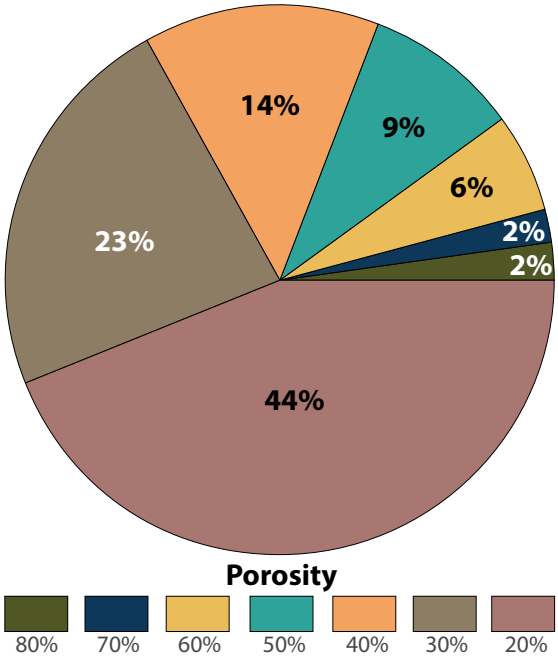
506,100 acres of trees outside of forests; 17,421 miles of windbreaks; 152,815 acres of windbreaks.

Windbreak condition was measured on a sample of 1,053 windbreaks and found 66% in Good condition, 28% Fair and 6% Poor. This suggests that one third of the windbreaks in Nebraska (34%) are in need of some form of renovation and are likely to qualify as a "resource concern" under EQIP. Since the GPI 1 inventory (2008 – 2009) there has been a slight increase in better overall windbreak condition, which found 58% in Good condition, 23% in Fair condition and 21% in Poor condition. **Windbreak age** can also inform condition and sustainability. For example 19% of Nebraska windbreaks exceed 50 years of age, which contributes to the Poor and Fair

Windbreak Age



Windbreak Porosity

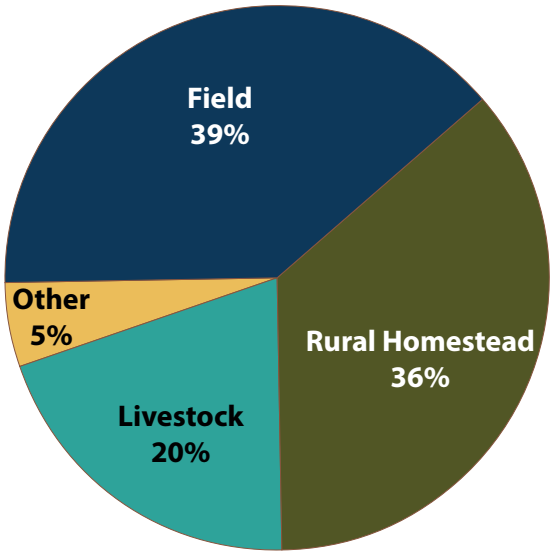


condition classes with 43% between 25 – 50 years and 38% less than 25 years old.

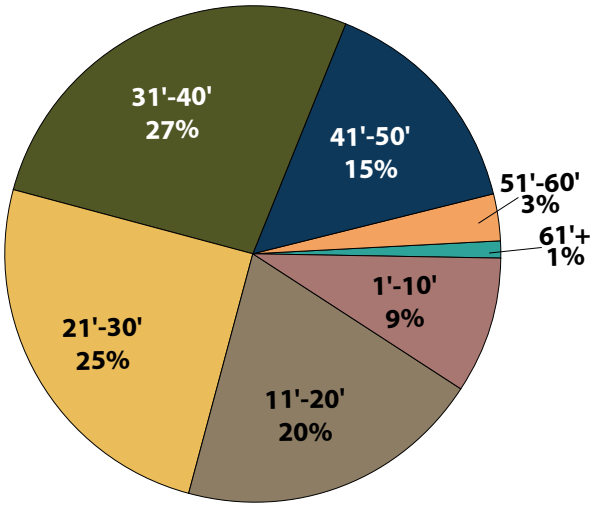
Windbreak porosity is another measure of windbreak health and function. The inventory found 80% of Nebraska windbreaks to have a porosity between 20 – 40%, which is below NRCS specifications for field, farmstead, livestock, and living snow fences. This porosity is also inadequate for windbreaks designed to function as screens and for odor control. This is a significant concern since 38% of Nebraska **windbreaks function** to protect croplands, 36% farmsteads and 20% for livestock. Porosity data further supports a statewide need for renovating Nebraska windbreaks.

The orientation of windbreaks defines the area of protection determined by **windbreak height** at 20 years of age. On the windward side the protected area is two to five times the height and on the leeward side 10 – 30 times the

Windbreak Function



Windbreak Height



Dominant Species

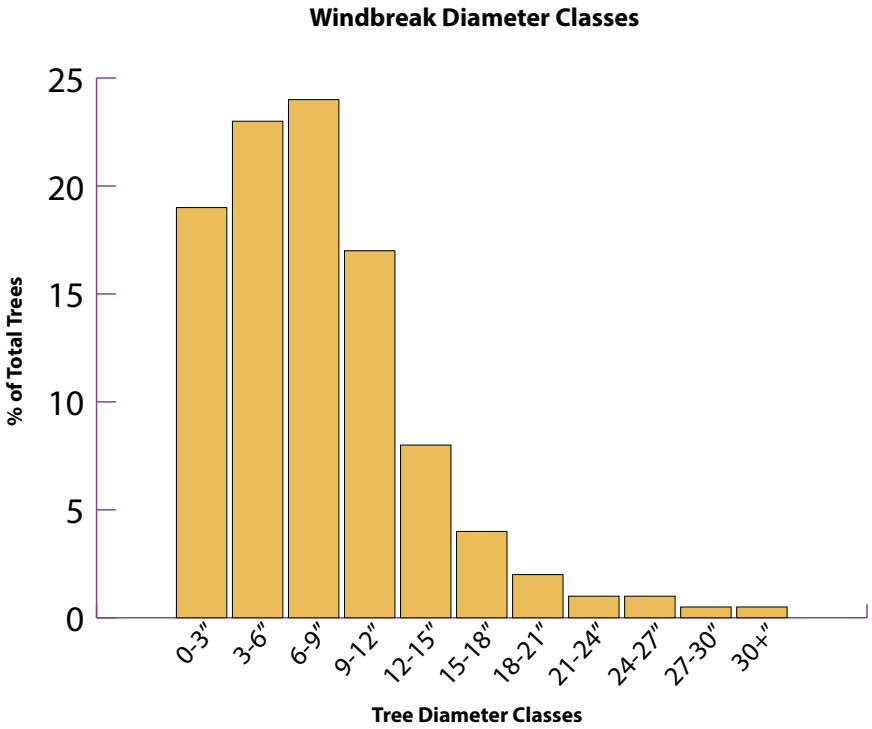
Species Name	% of Nebraska Windbreaks
Eastern redcedar	52%
Other	9%
Ponderosa Pine	8%
Cottonwood	6%
Ash species	6%
Elm species	5%
Other juniper	4%
Blacklocust	4%
Non-native pine	3%
Spruce	3%

height. 37% of Nebraska windbreaks run in an east-west direction. This is good news considering prevailing wind directions that cause soil erosion or damage crops come from the south or north. 24% of Nebraska windbreaks had an L-shape orientation generally on the north and west side of the area of protection and 18% north-south. Inventory data estimates that Nebraska windbreaks protect 528,000 acres of land.

The number of rows in windbreaks affects wildlife, carbon, wood products, odor amelioration, and screening benefits. Generally, the more rows the more benefits. According to this inventory 17% of Nebraska windbreaks have a single row, 34% two rows, 23% three rows, and 26% four or more rows.

Most windbreaks in Nebraska (39%) are designed to provide protection to croplands, which increase crop yields and reduce soil erosion. Another 36% protect farmsteads or rural homesteads. 20% of Nebraska windbreaks function to protect cattle and other livestock. 5% are either snow fences or designed specifically for wildlife habitat.

Eastern redcedar (52%), the **dominant species** in Nebraska windbreaks is a concern for some people due to its ability to spread when not managed; however, it remains the single best conifer to sustain a healthy functioning windbreak. The close to 18% made up of Scotch pine, ponderosa pine, rocky mountain juniper and other conifers are all susceptible to a variety of diseases and pests, which puts windbreaks with those species at risk. Ash species



make up 6% of all rows, which are susceptible to emerald ash borer.

Windbreak diameter classes and heights were taken from the in-depth inventory that measured one windbreak in each county in Nebraska or approximately 10% of the total windbreaks using a 30-tree transect. This inventory found an age distribution skewed towards trees of smaller diameter classes with 42% of the trees measuring less than 6" in diameter, which somewhat correlates to 38% of Nebraska windbreaks being 25 years old or younger. 26% of sampled windbreaks include trees in diameter classes of 16 inches and up. All diameters are measured at 4.5 feet.

71% of Nebraska windbreaks range between 11 and 40 feet in height with 9% less than 10 feet. Windbreak height and diameter will help estimate biomass and carbon storage potential.

As indicated earlier, inventory methodology is vastly different from GPI 1 to GPI 2, which may explain the significant changes in windbreak function between GPI 1 and GPI 2. There was also a dramatic change in eastern redcedar from 22% – 52% of occurrence in Nebraska windbreaks. The differences in species composition are related to different data collection formats. Again anecdotal observations would suggest more of a presence of Siberian elm and hackberry than GPI 2 results show. Other attributes such as age and condition also showed significant **changes since GPI 1.** The changes observed in condition classes show an increase in Good condition from 45% – 66% and a decrease in Fair and Poor condition classes collectively from 55% – 34%.

Changes Since GPI 1

	GPI 1 (2008-2009)	GPI 2 (2019)
Windbreaks by Function:	22% Farmstead 33% Field 9% Livestock	36% Farmstead 38% Field 20% Livestock
Tree Species:	10% Ash 22% Eastern redcedar 11% Hackberry 11% Mulberry 15% Siberian Elm	6% Ash 52% Eastern redcedar 6% Cottonwood 5% Elm 8% Ponderosa Pine
Condition:	45% Good 39% Fair 16% Poor	66% Good 28% Fair 6% Poor
Age:	9% less than 25 years 50% 25-50 years 41% 50 years +	32% less than 25 years 44% 25-50 years 24% 50 years +

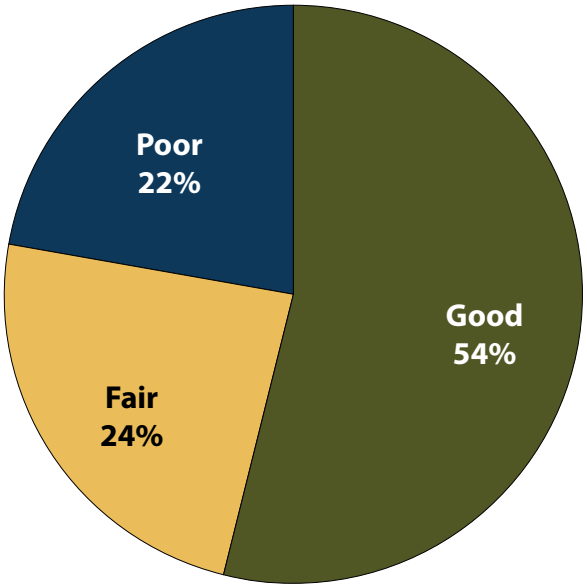
North Dakota

North Dakota has 759,300 acres of trees outside of forests. According to GPI 1, windbreaks occur on 62 percent of that area, or 470,766 acres.

Windbreak condition was measured on a sample of 534 windbreaks and found 54% in Good condition, 24% Fair and 22% Poor.

This suggests that nearly half the windbreaks in North Dakota (46%) are in need of some form of renovation and are likely to qualify as a "resource concern" under EQIP. Windbreak age is often a factor affecting condition and sustainability. For example, 27% of North Dakota **windbreak age** exceed 50 years of age, which contributes to the poor and fair condi-

Windbreak Condition

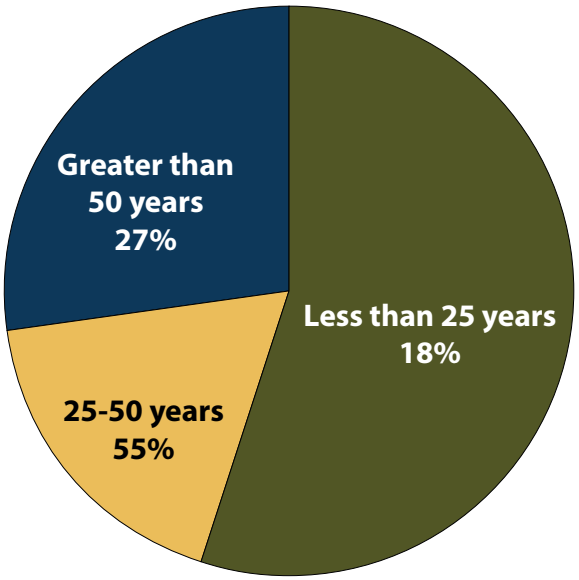


tion classes with 55% between 25 – 50 years and 18% less than 25 years old.

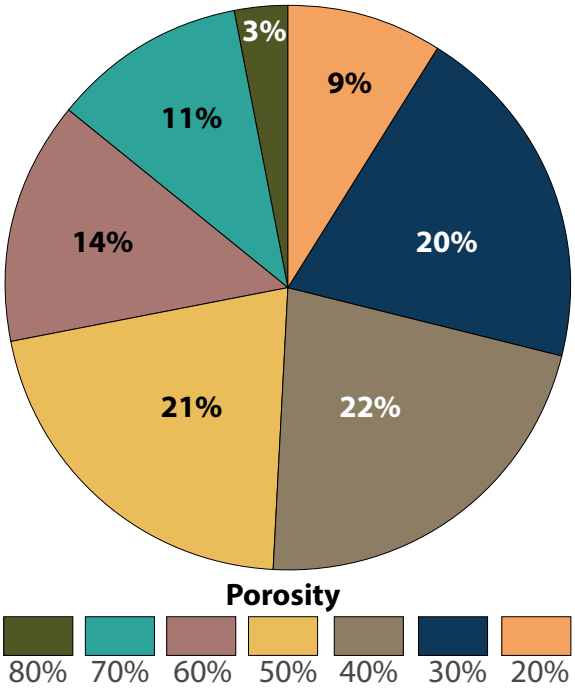
Windbreak porosity is another measure of windbreak health and function. The inventory found 51% of North Dakota windbreaks to have a porosity between 20% – 40%. Porosity, however, is best considered within the context of **windbreak function.** Most (86%) of North Dakota's windbreaks, regardless of their intended function, are less than 60% porous and therefore serve to reduce wind erosion. Many of these windbreaks are not adequate for their intended function, however. 58% of livestock windbreaks and 31% of farmstead windbreaks are too porous (>40% porosity), and 42% of field windbreaks fall outside their effective porosity range (40 – 60%). In addition, most windbreaks planted as snow fences appeared to be too porous, however, most are young and their conifer rows are simply growing more slowly than their deciduous rows. While snow fences will simply grow into their intended function, a large proportion of field, farmstead, and especially livestock windbreaks are in need of renovation.

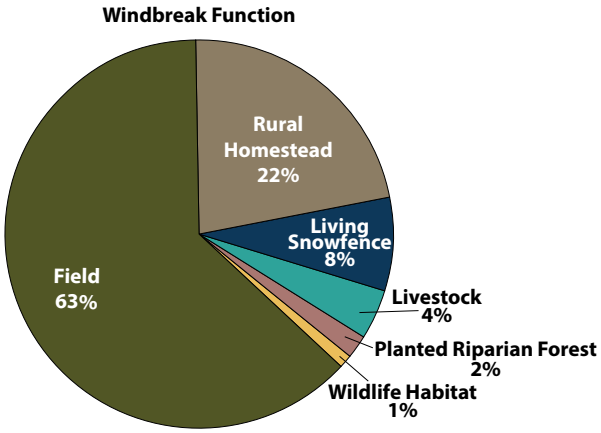
The orientation plus **windbreak height** at 20 years of age defines the area of protection. The protected area on the windward side of a windbreak is 2 – 5 times the height and on the leeward side 10 – 30 times the height. 41% of North Dakota windbreaks run in a north-south direction and 39% run east-west. In most of the state, prevailing winds are from the west, northwest, and north during most of the year. In the east, prevailing winds are from

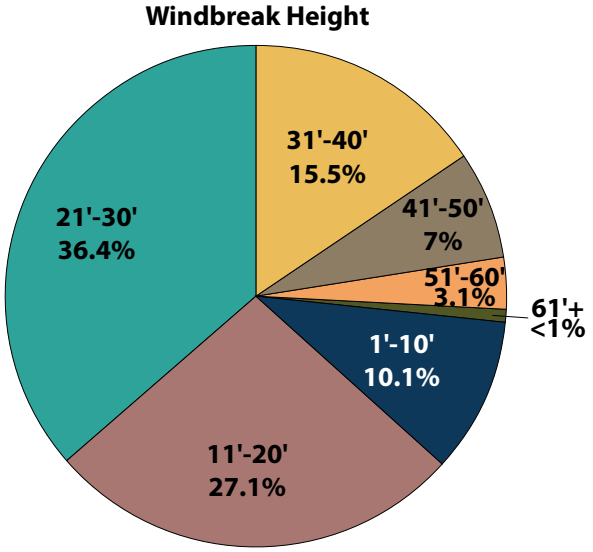
Windbreak Age



Windbreak Porosity







the north to north-northwest during winter and from south to south-southeast in summer. Although the air is rarely calm, the windiest months are April and May before deciduous trees break bud. 18% of North Dakota windbreaks had an L-shape or a more complex orientation generally on the north and west sides of the area of protection.

The number of rows in windbreaks affects wildlife, carbon, wood products, odor amelioration, and screening benefits. Generally, the more rows the more benefits. According to this inventory 41% of North Dakota windbreaks have a single row, 23% two rows, 19% three rows and 17% four or more rows.

Most windbreaks in North Dakota (63%) are field windbreaks, designed to increase crop yields, reduce soil erosion, and more evenly distribute snow across the fields. Another 22% provide protection to farmsteads or rural homesteads. 8% of North Dakota windbreaks function as living snow fences protecting roadways. 4 percent protect livestock, and the remainder are planted riparian buffers or windbreaks designed specifically for wildlife habitat.

Green ash is the most common windbreak **dominant species**, dominating 26% of windbreaks. This is a concern because of its susceptibility to emerald ash borer (EAB), an ash-killing invasive borer found in adjoining states and provinces, although not yet discovered in North Dakota. Cottonwood is the second most abundant species at 13%. Colorado blue spruce (12%), although susceptible to many insect and disease pests, is an important conifer in North Dakota

Dominant Species

Species Name	% of North Dakota Windbreaks
Green Ash	26%
Cottonwood	13%
Blue spruce	12%
Siberian elm	12%
Siberian peashrub	8%
Ponderosa pine	7%
Lilac	5%
Juniper	3%
White spruce	2%
Boxelder	2%
Broadleaf deciduous medium	2%
Willow	2%
Scotch Pine	1%
Broadleaf deciduous small	1%
Chokecherry	1%
Dogwood	1%

Changes Since GPI 1

	GPI 1 (2008-2009)	GPI 2 (2019)
Windbreaks by Function:	10% Farmstead 46% Field 3% Livestock	22% Farmstead 63% Field 4% Livestock
Tree Species:	46% Ash 12% Boxelder 9% Cottonwood/poplar 20% Siberian elm 6% Willow	12% Colorado Blue Spruce 13% Cottonwood 26% Green Ash 12% Siberian elm 8% Siberian peashrub
Condition:	23% Good 60% Fair 17% Poor	54% Good 24% Fair 22% Poor
Age:	6% less than 25 years 70% 25-50 years 24% 50 years +	18% less than 25 years 55% 25-50 years 27% 50 years +

because it tolerates soils that have a high pH. Siberian elm (12%) and Siberian peashrub (8%) are non-natives that tend to spread to unmanaged fields in some parts of the state. Ponderosa pine, at 7%, is the only widely-planted native conifer.

37 percent of North Dakota windbreak trees are under 20 feet tall. Half are 20 – 40 feet tall and only 11% are taller. Windbreak height and diameter will help estimate biomass and carbon storage potential.

Windbreak diameter classes and heights were taken from the in-depth inventory that measured one windbreak in each county in North Dakota or approximately 10% of the total windbreaks using a 30-tree transect. This inventory found a healthy distribution of diameter classes with 42% of the trees at 6 inch in diameter classes or below. Around 7% of North Dakota windbreaks include diameter classes of 16 inches and up. All diameters are measured at 4.5 feet.

As indicated earlier, inventory methodology has had **changes since GPI 1**, which may explain most of the differences in results. The differences in species composition, in particular, are related to different data collection formats. GPI 2 noted more young windbreaks than GPI 1. The changes observed in condition classes may partially reflect the larger proportion of young windbreaks surveyed in GPI 2. More significantly, the less experienced surveyors in North Dakota displayed a strong tendency to rate windbreak condition as Good across the board. The condition rating, based on eight separate criteria, may not have been properly applied.

South Dakota

The NRCS currently maintains the only data of tree and shrub plantings by conservation districts in South Dakota. This data includes total acres planted by year from 1940 to 2019. During this period of record nearly 384,000 acres of windbreaks including over 190,324,018 trees have been planted.

Windbreak condition was measured on a sample of 480 windbreaks and found 36% in Good condition, 42% Fair and 22% Poor. This suggests that over half the windbreaks in South Dakota (66%) are in need of some form of renovation and are likely to qualify as a "resource concern" under EQIP. Since the

GPI 1 inventory (2008-2009) there has been a slight decline in overall windbreak condition, which found 22% in Good condition, 71% Fair and 7% Poor. **Windbreak age** can also inform condition and sustainability. For example 6% of South Dakota windbreaks exceed 50 years of age and 58% are between 25 – 50 years of age, all of which contributes to the Poor and Fair condition classes. Only 36% of South Dakota's windbreaks are less than 25 years old.

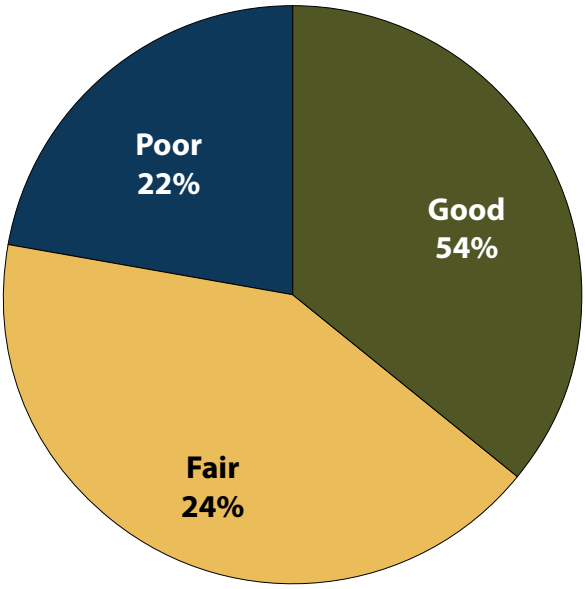
Windbreak porosity is another measure of windbreak health and function. The inventory found 66% of South Dakota's windbreaks to have a porosity between 20 – 40%, which meets the NRCS specifications for field, farmstead, livestock, and living snow fences. This porosity is also inadequate for windbreaks designed to function as screens and for odor control. This is a significant concern since 17% of South Dakota windbreaks function to protect farmsteads, 53% croplands and 8% for livestock. Porosity data further supports a statewide need for renovating South Dakota windbreaks.

The orientation of windbreaks defines the area of protection determined by windbreak height at 20 years of age. On the windward side the protected area is 2 – 5 times the height and on the leeward side 10 – 30 times the height. 49% of South Dakota's windbreaks run in an east-west direction. This is good news considering prevailing wind directions that cause soil erosion or damage crops come from the southern or north. 12% of South Dakota's windbreaks had an L-shape orientation and 34% north-south

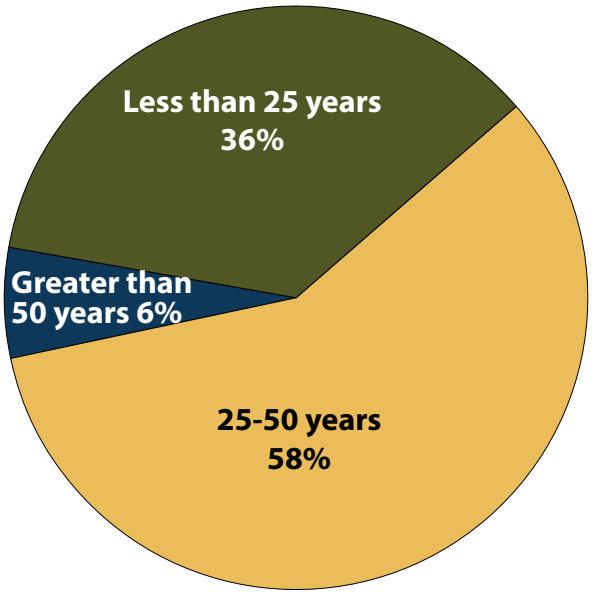
The number of rows in windbreaks affects wildlife, carbon, wood products, odor amelioration, and screening benefits. Generally the more rows the more benefits. According to this inventory 43% of South Dakotas windbreaks have 1 – 3 rows, 44% have 4 – 6 rows and 13% have seven or more rows.

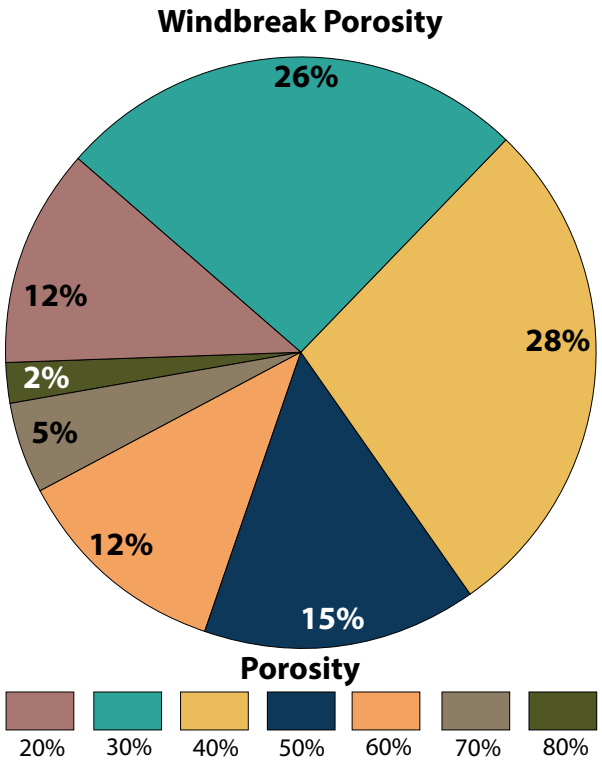
Most **windbreak functions** in South Dakota (53%) are designed to provide field protection, which results in increased crop yields and a reduction in soil erosion. Protection of farmsteads or rural homesteads account for 17% of all windbreak functions, while 11% serve as living snow fences. The remainder of South Dakota's windbreak functions are 9% for wildlife habitat, 8% for livestock protection, and 3% planted riparian buffers.

Windbreak Condition



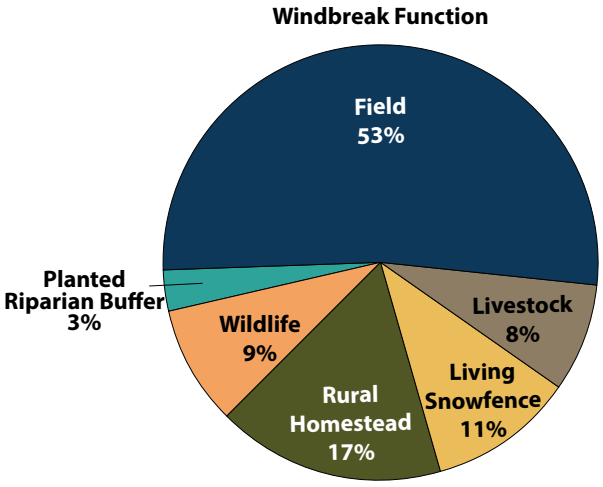
Windbreak Age





There were 39 woody species recorded in the windbreaks. Green ash was found to make up 21% of all species recorded. The second most species recorded was eastern redcedar at 15%. Juniper and Rocky Mountain juniper make up 13%. Elm is the only other species that is in the double digit percentage at 14%.

Windbreak diameter classes and heights were taken from the in-depth inventory that measured one windbreak in each county in South Dakota or approximately 10% of the total windbreaks using a 30-tree transect.

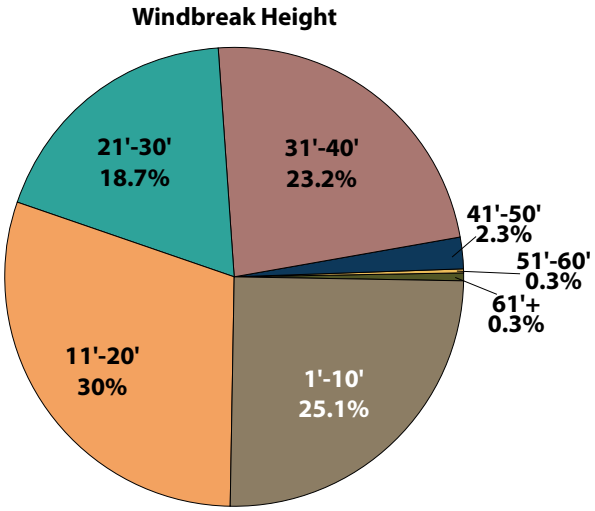


South Dakota

Tree Diameter Classes	Percentage of Trees in Each Class
0-0.99"	13.5%
1-1.99"	9.9%
2-2.99"	10.5%
3-3.99"	11.4%
4-4.99"	9%
5-5.99"	6.5%
6-6.99"	7.1%
7-7.99"	4.4%
8-8.99"	5.5%
9-9.99"	3.2%
10-10.99"	5.4%
11-11.99"	2.3%
12-12.99"	3.9%
13-13.99"	1.8%
14-14.99"	2.3%
15-15.99"	0.6%
16-16.99"	1.1%
17-17.99"	0.4%
18-18.99"	0.4%
19-19.99"	0.2%
20-20.99"	0.2%
21-21.99"	0.2%
22-22.99"	0.3%
23-23.99"	0%
24-24.99"	0.1%

This inventory found that South Dakota's windbreaks were primarily made up of trees in smaller diameter classes with 68% of the trees at 6 inches in diameter or below, which seems to contradict the finding that 35% of South Dakota's windbreaks being 25 years old or younger while 58% are 25 – 50 years old. Only 3% of South Dakota's windbreaks include diameter classes of 16 inches and up. All diameters are measured at 4.5 feet.

75 percent of South Dakota **windbreak height** was 11 feet or greater. This leaves 25% with



a height less than 11 feet. Windbreak height and diameter will help estimate biomass and carbon storage potential.

As indicated earlier, inventory methodology has had **changes since GPI 1**, which may explain some of the significant differences in the table above. There are large differences in percentages of field and livestock windbreaks, but sometimes these functions could be seen as interchangeable. There is a significant difference in ash from 21% – 40% of occurrence in South Dakota windbreaks. The changes observed in condition classes show an increase in Good condition from 22% – 36% and a decrease in Fair and Poor condition classes collectively from 78% – 64%. This may suggest a slight improvement in the health and functioning condition of South Dakota windbreaks with ongoing renovation and new planting efforts.

Changes Since GPI 1

	GPI 1 (2008-2009)	GPI 2 (2019)
Windbreaks by Function:	16% Farmstead 22% Field 47% Livestock	17% Farmstead 53% Field 8% Livestock
Tree Species:	40% Ash 14% Eastern redcedar 16% Elm	21% Ash 15% Eastern redcedar 14% Elm
Condition:	22% Good 71% Fair 7% Poor	36% Good 42% Fair 22% Poor
Age:	10% less than 25 years 40% 25-50 years 50% 50 years +	32% less than 25 years 44% 25-50 years 24% 50 years +

Ecosystem Services Provided by Great Plains Windbreaks

Agricultural producers use windbreaks for a variety of reasons, such as erosion control, livestock protection, protection around farmsteads, snow control, aesthetics, and wildlife habitat. Direct economic benefits, such as increased crop yields or forest products such as posts or lumber, are not often ranked highly as reasons for owning a windbreak.

Valuing ecosystem services attempts to put a price tag on nature. Economists recognize natural resources as capital assets, but as with windbreaks, they are usually considered a cost rather than an investment. This is due to their elusive values, which are often overlooked. Due to limited funding, time constraints, and inventory structure, this project did not apply models that provide dollar values for ecosystem services although evidence would suggest that these values are significant.

Field Windbreaks

Several studies directly link windbreaks to increased crop yields. A recent study in Kansas and Nebraska used combine harvester data from producers to assess yield response of winter wheat and soybeans adjacent to windbreaks. Both winter wheat and soybean production increased significantly when protected by windbreaks, with average yield gains of 10% and 16%, respectively (Osorio et al., 2018). Long-standing research has proven that windbreaks reduce soil erosion, with one study estimating up to $97 million (Kort, AFTA 2005). From 'The REAL Cost of Soil Erosion' written by Joanna Pope of NRCS in Nebraska, "a Natural Resource Conservation Service report of their Environmental Quality Incentive Program from 2002 and 2010 indicated that each ton of soil eroded contains the equivalent of 2.32 pounds of nitrogen and 1 pound of phosphorus. The cost per pound for nitrogen and phosphorus were 0.63 and 0.64 respectively. Mike Duffy, Extension Economist with Iowa State University, published "Value of Soil Erosion to the Landowner" in 2012 that suggested the real cost to the farmer based on those estimates was a loss of fertilizer at $2.10 per ton of soil loss per acre." The cost per acre, paired with the annual soil loss due to wind erosion, results in an estimated annual cost of wind erosion to Nebraska landowners of $46,158,000 per year.

Farmstead Windbreaks

A well-designed farmstead windbreak reduces average energy use of a typical farmstead by 10 – 40% (Dewalle and Heisler, 1988; Brandle et al., 1992b). Individual savings depend on local site and climatic conditions, construction quality, and the design and condition of the windbreak. Farmstead windbreaks are effective in reducing energy needs by affecting air-exchange rates. Air exchange is created by pressure differences between internal and external temperature variations or eternal surface wind force. Windbreaks are only effective in reducing air exchange caused by wind force. Therefore, windbreaks are more efficient in saving energy in windy climates experienced in the Great Plains.

Livestock Windbreaks

With beef cattle, a heavy winter coat will provide protection until temperatures drop below 18 degrees. At that point cattle become stressed and require additional feed to maintain body temperatures. Research data from Kansas cattle producers indicate that on average, calving success increases by 2% if cows are protected by a windbreak. Canadian researchers found that cattle on winter range, in unprotected sites, required a 50% increase in feed for normal activities and an additional 20% increase to overcome the direct effects of exposure to a

combination of cold temperatures and wind. A properly designed windbreak will reduce these needs by half. Researchers at Purdue University found that energy requirements for cows in good condition increased 13% for each 10 degree drop in windchill temperature below 30 degrees. A similar study in Iowa on calves and yearlings indicated that requirements for feed were 7% greater for those in open lots than for similar animals with shelter. Studies in Montana indicated that during mild winters, beef cattle sheltered by windbreaks gained an average of 34 – 35 pounds more than cattle in an open feedlot. During severe winters, cattle in feedlots protected from the wind, maintained 10.6 more pounds than cattle in unprotected lots. In addition to livestock protection, yield improvement, extended forage opportunities, odor management, livestock fencing, visual screening, public relations and aesthetics have all been recognized as beneficial functions by livestock producers. Great Plains farmers and ranchers with good windbreaks for their cattle and dairy operations save money on feed costs, avoid excess weight loss, and benefit from increased milk production.

Kansas

Field Windbreak Summary

Kansas has an estimated 8,150 miles of field windbreaks covering 67,999 acres or 26% of total Kansas windbreaks. The area protected by these windbreaks ranges from 10 – 30 times the height on the leeward/downwind side and 2 – 5 times on the upwind side. There is an estimated total of 246,938 acres protected by field windbreaks in Kansas. Of the 24.6 million acres of cultivated cropland in Kansas approximately 2.9 million acres exceed "tolerable limits" for erosion (Kansas Forest Action Plan, 3.2.3 Sustaining and Protecting Forest and Agroforestry Ecosystems. 2020). According to the 2017 Natural Resources Inventory, Kansas croplands experienced nearly 70.69 million tons of soil loss due to wind erosion.

Farmstead Windbreak Summary

There are an estimated 71,989 farmstead windbreaks in Kansas stretching 19,122 miles in length and covering 159,537 acres or 61% of total Kansas windbreaks. Farmstead windbreaks in Kansas protect an estimated 579,354 acres.

Livestock Windbreak Summary

Kansas livestock windbreaks, account for 11 percent of all Kansas windbreaks. They cover a distance of 3,448 miles and an estimated 28,769 acres.

Nebraska

Field Windbreak Summary

Nebraska has an estimated 6,620 miles of field windbreaks covering 58,070 acres. The area protected by these windbreaks ranges from 10 – 30 times the height on the leeward side and 2 – 5 times the height on the windward side. There is an estimated total of 200,640 acres protected by field windbreaks in Nebraska. According to the 2017 Natural Resources Inventory, Nebraska's non-federal croplands experienced nearly 22 million tons of soil loss due to wind erosion, representing a 30% improvement in soil loss since 2007 (USDA, 2017). Based on the annual soil loss in Nebraska and the fertilizer costs associated with wind erosion, wind erosion in Nebraska costs producers an estimated $46,158,000 per year of additional fertilizer costs.

Farmstead Windbreak Summary

There are an estimated 28,281 farmstead windbreaks in Nebraska, which stretch 6,271 miles in length and cover 55,013 acres.

Livestock Windbreak Summary

Nebraska livestock windbreaks cover an estimated 3,484 miles and 30,563 acres.

North Dakota

Field Windbreak Summary

North Dakota has an estimated 29,000 miles of field windbreaks covering 470,766 acres. The area protected by these windbreaks ranges from 10 – 30 times the height on the leeward side and 2 – 5 times the height on the windward side. There is an estimated total of 1.4 million acres protected by field windbreaks in North Dakota.

Farmstead Windbreak Summary

There are an estimated 33,300 farmstead windbreaks in North Dakota that stretch 5,200 miles in length and cover 50,000 acres. Windbreaks are more efficient in saving energy in windy climates, such as North Dakota, and protect an estimated 245,800 acres.

Livestock Windbreak Summary

North Dakota livestock windbreaks cover an estimated 2,500 miles and 15,000 acres. North Dakota farmers and ranchers with good windbreaks for their cattle and dairy operations save money on feed costs, weight loss and milk production. With beef cattle, a heavy winter coat will provide protection until temperatures drop below 18 degrees. At that point cattle become stressed and require additional feed to maintain body temperatures.

Living Snow Fences

North Dakota has at least 832 miles of living snow fences covering 6,000 acres and protecting 832 miles of roads and approximately 40,000 acres of land. Snow fences offer similar benefits to field windbreaks, and are strategically located to maintain clear roadways by capturing blowing snow and storing the snow over the winter. A study in Minnesota indicated that segments of roads protected by living snow fences have better visibility and road surface conditions than those without, leading to lower road maintenance costs and fewer vehicle crashes. Living snow fences are less expensive to establish and maintain than slatted snow fences, and grow taller, capturing more snow. In addition to protecting the roadway, living snow fences are more aesthetically pleasing than structural snow fences, provide visual screening, reduce road noise and intercept road dust.

South Dakota

Field Windbreak Summary

South Dakota has an estimated 12,655 miles of field windbreaks covering 78,286 acres or 53% of total South Dakota windbreaks. The area protected by these windbreaks ranges from 10 to 30 times the height on the upwind side and two to five times the height on the downwind side. There is an estimated total of 383,435 acres protected by field windbreaks in South Dakota. According to the 2017 Natural Resources Inventory, South Dakota has 19,813,517 acres of croplands.

Farmstead Windbreak Summary

There are an estimated 57,754 acres of farmstead windbreaks in South Dakota, which stretch 4,166 miles in length.

Livestock Windbreak Summary

South Dakota livestock windbreaks cover an estimated 1,960 miles and 27,178 acres or a total of 8% of all South Dakota windbreaks.

The Health of Great Plains Windbreaks

GPI 1 found 72% of windbreaks in the four states to be in Fair or Poor condition, with 48% between 25 – 50 years old and 36% above 50 years. Overall, this suggested that windbreaks in the Great Plains were aging with fewer young trees or windbreaks. Unfortunately, GPI 2 results indicate this trend continues, suggesting general decline in the health of windbreaks and the need for renovation and establishment of new ones. This section provides a summary of windbreak health for each state and the specific issues facing Great Plains windbreaks.

Kansas

Age and Species Composition

Forty-five percent of Kansas windbreaks are in good condition; however, 37% are in fair condition and 18% in poor condition suggesting that over half the windbreaks in Kansas are in need of some form of renovation and are likely to qualify as a "resource concern" under EQIP. GPI 1 revealed 43% in Fair to Poor condition so there is definitely a trend of declining health in Kansas windbreaks. Twenty-four percent of Kansas windbreaks exceed 50 years of age, which contributes to the trend of declining health with 44% between 25 – 50 years old. Seventy-six percent of Kansas windbreaks have a porosity between 40 – 20%, which meets NRCS specifications for field, farmstead, livestock, and living snow fences.

Insect and Disease Diagnosis

Between 2019 and 2020, field foresters reported 190 insect and disease diagnosis points using an ESRI Collector app. This data supports the anecdotal evidence the Kansas Forest Service has relied on for years to guide forest health priorities. The data supports that abiotic and environmental stress represents a major share of the problems Kansas windbreaks face. Significant insects and disease problems such as emerald ash borer (EAB), diplodia tip blight, dothistroma needle blight, iron chlorosis, bagworms, various cankers, and Dutch elm disease (DED) have all adversely effected windbreak health and longevity. Anthropogenic problems such as off-target

Insect and Disease Prevalence

Diagnosis	Number
Abiotic/ Environmental	72
EAB	18
Tip Blight (Diplodia)	15
Dothistroma	14
Herbicide Injury	10
Iron Chlorosis	9
Bagworms	9
Canker	7
Unknown	7
DED	5
Lacebugs	2
Cedar Bark Beetles	2
Bot Canker	2
Other	2
Pine Tip Moth	2
Fusarium	1
Oak Leaf Tatters	1
Bur Oak Blight	1
Hypoxylon	1
Japanese Beetle	1
Leaf Spot	1
Locust Borer	1
Oak Wilt	1
Phomposis	1
Pine Needle Scale	1
Pine Wilt	1
Spider Mites	1
Verticillum Wilt	1

herbicide damage have led to the decline of many windbreaks in the state.

Invasives

Emerald Ash Borer

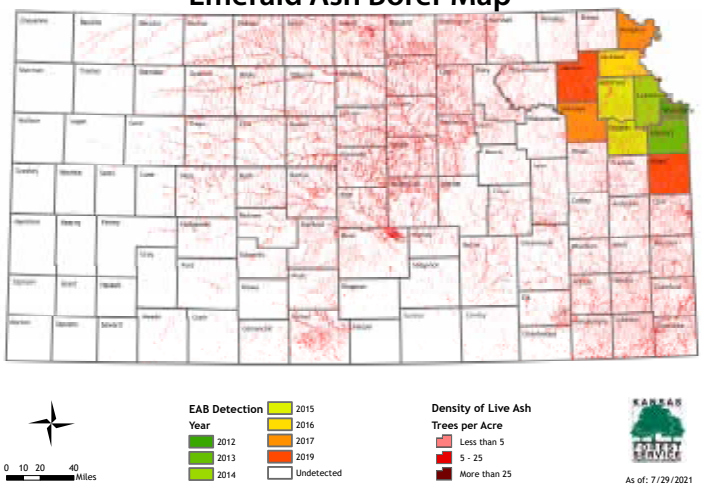
Emerald ash borer (EAB) is an exotic wood-boring beetle. In 2012 it was identified in Wyandotte County, Kansas, and since has been found in Johnson, Leavenworth, Douglas, Jefferson, Atchison, Doniphan, Shawnee, Miami, and Jackson counties. All eastern counties with few windbreaks. Kansas' forest land contains 50.3 million ash trees, or an average of 20 trees per acre. Ash trees account for 271 million cubic feet of volume, or 8% of total net volume of live trees on forest land. Most of the ash trees (93%) are located on privately owned forest land in central and eastern Kansas with the heaviest concentrations in the north-eastern corner of the state. Emerald ash borer is not a significant threat for Kansas windbreaks simply because of the low percentage of ash occurring in the windbreaks. GPI 1 found over 15 million ash in trees outside of forests. GPI 2 found ash making up less than 1.4% of Kansas windbreaks.

In 2021 the Kansas Department of Agriculture rescinded the state's EAB quarantine; however, Kansas Forest Service will continue to monitor for EAB in counties contiguous to infected counties. Outreach and education efforts will continue.

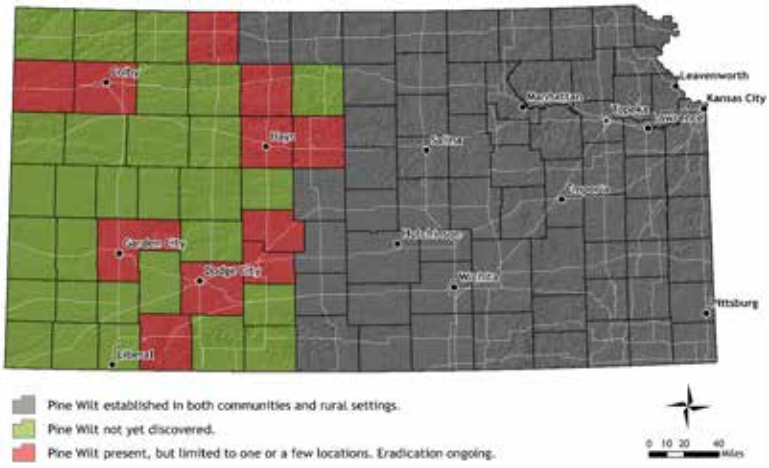
Pine Wilt

Pine wilt is caused by a plant parasitic nematode (*Bursaphelenchus xylophilus*), the pine wood nematode. The nematode is vectored by the pine-sawyer beetle (*Monochamus*), a long-horned borer. They kill pine trees by feeding and reproducing in the resin canals of the branch and trunk. This disease is continuing to spread westward in Kansas causing high mortality in windbreaks containing Austrian pine (*Pinus nigra*) and Scotch pine (*P. sylvestris*), which comprise over 9.1% of Kansas windbreaks. Eradication efforts continue in Goodland (Sherman County), Almena (Norton County) and Hays (Ellis County) among others. In February 2020, a partnership between the Kansas Department of Agriculture (KDA) and Kansas Forest Service did not find any pine wilt positive trees in a survey of more than 27,000 pines in Decatur, Ellis, Ford, Gove, Graham, Gray, Hodgeman, Norton, Osborne, Rooks, Sheridan, and Trego counties.

Emerald Ash Borer Map



Pine Wilt Map



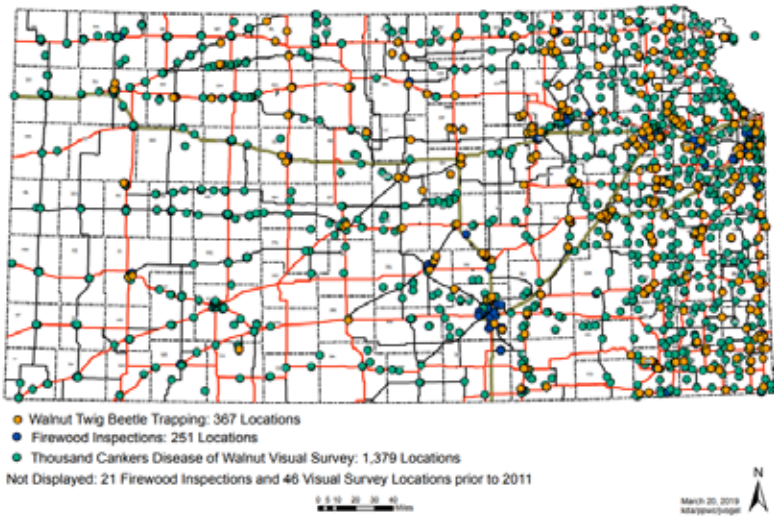
Bush Honeysuckle

Non-native bush honeysuckles (*Lonicera maackii, L. tatarica, and L. x bella*) and their vine counterpart, Japanese honeysuckle (*L. japonica*) have become a serious issue in Kansas woodlands and forests causing decline in species diversity, richness of native ground cover and mid-story vegetation. It has not yet become a significant issue for Kansas windbreaks but should be monitored and controlled when found in windbreaks.

Thousand Cankers Disease

Thousand Cankers Disease (TCD) has yet to be found in Kansas. It does exist in Colorado and has the potential to enter our native range of black walnut, which would have disastrous consequences economically and environmentally. Most black walnut occurs in eastern Kansas in the counties of Doniphan, Bourbon, Franklin, Osage, Linn, Leavenworth and Pottawatomie. Fewer black walnut, less than 1.4%, occur in windbreaks in central and western Kansas. TCD trainings occur annually for arborists, municipalities, and landowners, which greatly increases our detection network and outreach efforts. Walnut Twig Beetle pocket ID cards are distributed to interested parties, including arborists and extension agents.

Thousand Cankers Disease Map



Other Windbreak Health Issues

Diplodia Tip Blight and Dothistroma Needle Blight

Wet weather in 2019 and in the summer of 2020, created an increase in the number of cases of these blights. Diplodia Tip Blight, (*Diplodia pini*), infects Austrian, ponderosa, and Scotch pines and is most common on trees 20 years or older. Repeated infections over time are what causes decline and mortality in these common windbreak trees. Dothistroma Needle Blight, (*Dothistroma septospora*) attacks Austrian and ponderosa pines, especially in high-density plantings like windbreaks. This disease causes premature needle drop the year following infection, thinning out tree crowns over time, which leads to declining health and mortality. Since 11.3% of Kansas windbreaks contain Austrian, ponderosa and Scotch pines these diseases will continue to reduce the functioning condition of Kansas windbreaks.

Abiotic and Environmental Stress

Abiotic and environmental stress represents most of the health problems of Kansas windbreaks in the form of drought and severe weather. August through October of 2020 was one of the driest on record for north-central and northeastern Kansas. This was followed by record cold temperatures throughout the Great Plains, February 6 – 18, 2021. This combination appears to have contributed to additional tree mortality in windbreaks.

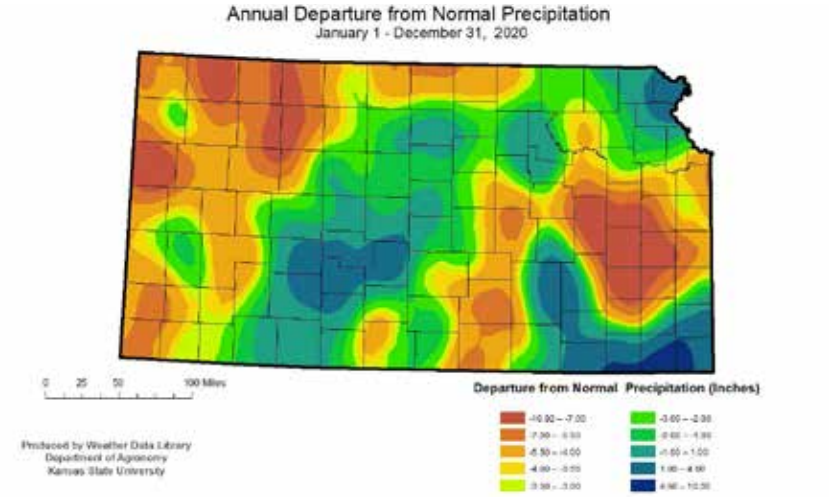
Severe Weather

Severe weather such as hail, tornadoes, high winds, ice storms all contribute to declining windbreak health in Kansas. Some of our high wind events in 2020 exceeded 75 miles per hour.

Anthropogenic Factors

Kansas windbreaks are also damaged by wildfire and off-target herbicide damage on an annual basis.

Severe Weather Map



Nebraska

General Condition

Sixty-six percent of Nebraska windbreaks inventoried during GPI2 are in good condition. Twenty-eight percent of windbreaks were in fair condition, and 6% were in poor condition. While most windbreaks appear healthy, more than a third of all inventoried windbreaks would benefit from renovation and management. This need for management aligns with the Nebraska NRCS, stating that "degraded plant condition" is a priority resource concern for Nebraska.

Age and Species Composition

Thirty-eight percent of inventoried windbreaks were less than 25 years old, while 43% were 25 – 50 years old, and the remaining 19% were greater than 50 years old. This age distribution adds context to the high proportion of windbreaks in good condition, as many have not reached full maturity or begun to decline.

Species diversity in windbreaks contributes to the overall evaluation of health and condition. More variety in tree species is preferred to reduce the impacts of potential insect and disease issues. The lack of diversity in Nebraska's windbreaks is concerning as eastern redcedar (*Juniperus virginiana*) comprised 52% of all inventoried windbreak rows. This lack of diversity is amplified in younger windbreaks (less than 25 years old) as eastern redcedar makes up 63% of all rows in windbreaks of this age class. Generally, older windbreaks showed greater diversity, with eastern redcedar making up only 28% of all rows in windbreaks greater than 50 years old.

This shift towards a greater reliance on eastern redcedar within younger windbreaks is likely due to several factors. Eastern redcedar provides excellent height, density, resiliency, and drought tolerance. It can offer similar protection using only two to three rows than a four to five row windbreak with greater diversity, reducing the footprint and cost of the windbreak. Additionally, its ability to withstand harsh weather conditions and poor soil conditions often make it the best available species for establishing a windbreak, especially across western Nebraska, while sacrificing species diversity.

In addition to eastern redcedar (52.1%), ponderosa pine (*Pinus ponderosa*, 8.4%), cottonwood (*Populus deltoides*, 6.4%), Rocky Mountain juniper (*Juniperus scopulorum*, 4.3%), and Siberian elm (*Ulmus pumila*, 4.4%) make up the top five individual species used in windbreak rows.

Diseases and Insect Pests

Cercospora Needle Blight
Cercospora needle blight (*Pseudocercospora juniperi*) is a foliar disease of Rocky Mountain juniper and eastern redcedar. Defoliation of lower and inner foliage of the crowns occurs, particularly in densely spaced windbreaks. Limited air circulation and shading allow moisture to remain on needles longer, resulting in an increased chance of fungal infection. Historically, Cercospora needle blight has occurred mainly in the eastern third of the state; however, reports of the disease in recent years have increased from central Nebraska, particularly in Rocky Mountain juniper, which is highly susceptible.

Potential impact in Nebraska's windbreaks: 53.3% of all windbreak rows are eastern redcedar or Rocky Mountain juniper.

Dothistroma Needle Blight
Dothistroma needle blight (*Dothistroma pini*) is a fungal disease affecting Austrian and ponderosa pines. Needle browning followed by needle drop of lower inner areas of the crown characterize the disease. Extensive rains and conditions that limit air circulation in the canopy, such as dense spacing and unmown grass, contribute to infection.

Potential impact in Nebraska's windbreaks: 10% of all windbreak rows are ponderosa pine or Austrian pine (*Pinus nigra*).

Diplodia Blight
Diplodia blight (*Diplodia sapinea*) affects Austrian, ponderosa, and occasionally Scotch pine in windbreaks across Nebraska. The fungal disease is characterized by the death of new shoots in the spring. Over the years, multiple infections cause entire branches to die, often beginning low in the tree. Scattered branch death and top kill are also frequently observed. Trees typically develop extensive symptoms by 30 - 40 years. Stressful conditions such as drought and hail damage play a significant role in the development of Diplodia blight.

Potential impact in Nebraska's windbreaks: 11.3% or all windbreak rows are Austrian pine, ponderosa pine, or Scotch pine (*Pinus sylvestris*).

Pine Wilt
Pine wilt (*Bursaphelenchus xylophilus*) is caused by a microscopic nematode that feeds within the wood. Infected trees lose the ability to transport water and very quickly dry up and die. Scotch pine is highly susceptible to pine wilt. Austrian pine can also be affected. Extensive mortality has occurred in the eastern half of the state and is increasing westward.

Potential impact in Nebraska's windbreaks: 2.9% of all windbreak rows are Scotch pine or Austrian pine. Many of these systems have already succumbed to pine wilt over the last 20 years, and relatively few remain.

Thousand Cankers Disease/Walnut Twig Beetle
In late 2019, the Nebraska Department of Agriculture first detected walnut twig beetle (*Pityophthorus juglandis*) in the state. This insect is the vector for the thousand cankers disease (*Geosmithia morbida*) fungus, which infects and kills eastern black walnut (*Juglans nigra*). Beetles were collected from traps in Scotts Bluff County (city of Gering). No diseased trees have been reported.

Potential impact in Nebraska's windbreaks: 0.6% of all windbreak rows are black walnut. While black walnut is a minor component of Nebraska windbreaks, the loss of black walnut in eastern Nebraska hardwood forests could be significant.

Bagworm
Bagworm (*Thyridopteryx ephemeraeformis*) feeds on various trees, including spruce (*Picea species*), juniper, pine, honeylocust (*Gleditsia triacanthos*), maple (*Acer species*), and elm (*Ulmus* species). Heavy infestations on evergreens can result in severe damage

or mortality. Bagworm has historically been found mainly in eastern Nebraska, but reports from central areas have become more frequent.

Potential impact in Nebraska's windbreaks: 78.3% of all rows are spruce, juniper, pine, honeylocust, maple, or elm.

Zimmerman Pine Moth

Reports of Zimmerman pine moth (*Dioryctria spp.*) and related Dioryctria species have increased in recent years. Larvae damage trees by tunneling just beneath the bark of the trunk and branches, most commonly on the trunk just below a branch. The tunnels they make can girdle the trunk or branches and physically weaken them, so they are easily broken by wind or snow. Young, heavily infested trees are often deformed and are sometimes killed. All pines are susceptible. Dioryctria species occur mainly in western and central Nebraska and around the metro areas of Omaha and Lincoln.

Potential impacts in Nebraska's windbreaks: 11.8% of all windbreak rows are pine.

Emerald Ash Borer

The invasive EAB (*Agrilus planipennis*) was first detected in Nebraska in 2016. Nine central and eastern counties have known infestations (Buffalo, Cass, Dodge, Douglas, Hall, Lancaster, Saunders, Seward, and Washington). All ash (*Fraxinus* species) are susceptible.

Potential impacts in Nebraska's windbreaks: 5.5% of all windbreak rows are ash. EAB is of particular concern in Nebraska communities and throughout all natural forest systems.

Abiotic/Environmental Issues

Nebraska's climate and weather extremes impact trees directly and are correlated to an increase in pest problems. Most of the state has experienced early severe fall freezes in 2019 and 2020, which may have triggered canker development in eastern redcedar the following spring. Mortality has been noted in young eastern redcedar windbreaks in the northeast and south central areas of the state.

Past and current drought have stressed trees, making them susceptible to bark beetle attack. Green slash left piled after logging operations/fuels reduction projects or redcedar pasture management has provided breeding material for large populations of Ips engraver beetles (*Ips* species) and cedar bark beetles (*Phloeosinus* species), respectively. Nearby standing trees are then attacked.

Herbicide damage to windbreaks is found across the state, especially in recent years. In particular, trees exhibit symptoms typical of growth regulator type herbicides, such as 2,4-D and dicamba. Leaf cupping and curling; twisted, distorted stems; and thin, pale canopies are especially common in some of the more sensitive species: oaks (*Quercus* species), elms, hackberry (*Celtis occidentalis*), and Kentucky coffeetree (*Gymnocladus dioicus*). Repeated damage over the years may lead to tree decline.

Damage to trees frequently occurs in spring as leaves emerge from buds, coinciding with spring "burndown" applications to crop fields. It also occurs during the appearance of dandelions in lawns—prompting homeowners and landscape professionals to spray. The high volatility of these herbicides makes them prone to long-distance, off-site movement. Of 78 symptomatic trees tested statewide in 2019, all 78 had detectable levels of 2,4-D and dicamba in leaf tissue.

Potential Pests

Several pests not yet known to occur in Nebraska can cause decline or mortality if introduced.

- Asian longhorned beetle (*Anoplophora glabripennis*) and gypsy moth (*Lymantria dispar*) are exotic species with broad host ranges.

- Drippy blight is a disease/insect complex affecting red oaks in Colorado caused by a bacterium (*Lonsdalea quercina*) and a scale insect (*Allokermes galliformis*).
- Spotted lanternflies (*Lycorma delicatula*) feed on a wide variety of trees, shrubs, and woody vines, causing reduced vigor and, occasionally, shoot dieback.

These and other potentially damaging pests are still largely unfamiliar to many of the state's natural resource and green industry professionals and the public.

North Dakota

General Condition

Fifty-four percent of North Dakota windbreaks are in good condition. The rest, however, are in fair or poor condition, suggesting that nearly half the windbreaks in North Dakota need of some form of renovation and are likely to qualify as a "resource concern" under EQIP.

Age and Species Composition

Twenty-seven percent of North Dakota windbreaks exceed 50 years of age and 55% are between 25 and 50 years old. Although most (86%) of North Dakota's windbreaks meet porosity standards for reducing wind erosion, many do not meet the standard for their intended function. Over half of livestock windbreaks and a third of farmstead windbreaks are too porous, and 42% of field windbreaks fall outside of their effective porosity range of 40 – 60%. Tree species diversity is low. One quarter of windbreak rows are green ash, the next quarter is cottonwood and blue spruce together, and a third quarter consists of Siberian elm, Siberian peashrub and ponderosa pine.

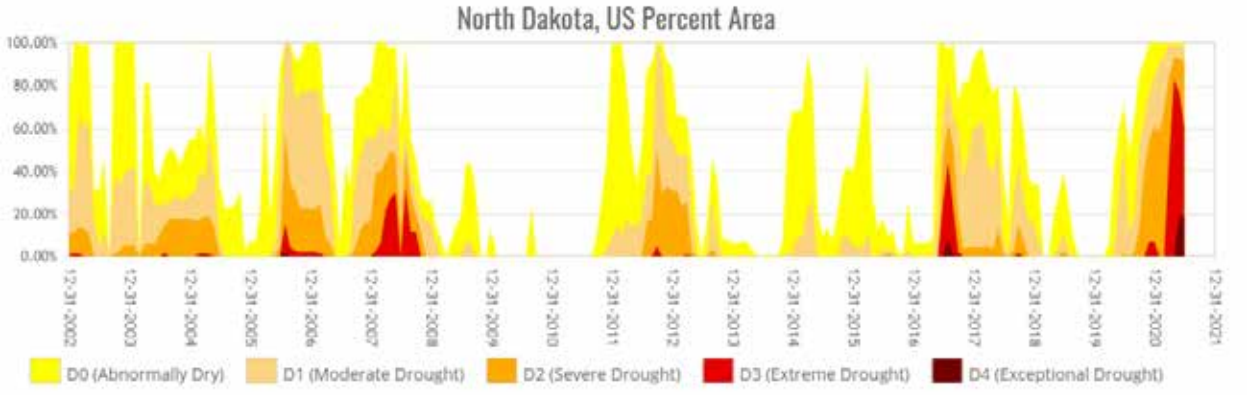
Tree Health Issues

Environmental Stresses

North Dakota is characterized as a prairie state because of the topography, soils and climate that promote perennial grasses and forbs and limit the natural distribution of forest land. North Dakota's climate is dry, with an average of 14 inches of precipitation falling in the west and an average of 22 inches in the east. Snow makes up a significant portion of precipitation, with an average of 51 inches per year.

North Dakota's trees occasionally experience drought conditions. The effects of drought stress increase as a tree grows, annually producing more leaf area and requiring more and more water to transpire and carry out photosynthetic processes. For this reason, many insect and disease issues only appear after trees reach a particular size or age.

Environmental stresses underly many North Dakota forest health issues. The windbreaks critical for meeting the present needs of rural residents and agricultural producers must be drought-tolerant, cold-hardy, and matched to



the soils where the trees are needed. Trees also must be properly planted and well cared for during establishment. Ironically, rising water tables, as a result of an approximately 30-year wet cycle, have affected windbreak health in recent years, especially in the Missouri Cotteau area, which extends diagonally from the northwest corner to the southeast.

Insects and Diseases in General

Insects and disease problems such as spruce needlecasts, diplodia tip blight, yellow-headed spruce sawfly, iron chlorosis, defoliators, various cankers, and Dutch elm disease (DED) have all adversely affected windbreak health and longevity. Anthropogenic problems such as off-target herbicide damage have led to the decline of many windbreaks in the state.

Dutch Elm Disease

North Dakota is still experiencing the severe impacts of the first wave of Dutch elm disease (*Ophiostoma ulmi* and *O. novo-ulmi*). It is common to find a row or two of dead mature American elm trees in farmstead and other multiple-row windbreaks. The loss of American elm in windbreaks has affected windbreak structure and function in addition to reducing species diversity. Windbreak renovation plans often recommend removal of dead American elm trees to make way for replacements.

Needlecasts and Other Spruce Issues

Blue spruce and white spruce (Black Hills spruce), combined, make up 15% of North Dakota's windbreak rows. Stigmina needlecast (*Stigmina loutii*) and Rhizosphaera needlecast (*Rhizoshpaera kalkhofii*) are prevalent in eastern counties, less common in central counties, and are seldom seen in western counties. Stigmina appears to be the predominant pathogen where needlecasts are found, is the most damaging, and occurs on both spruces. Needlecasts increase crown porosity, decrease tree vigor, and kill weakened branches. Valsa canker (*Valsa kunzei*) and spider mites are also very common spruce issues.

Diplodia Tip Blight and other Pine Issues

Aging and overcrowded ponderosa pine windbreak rows are subject to pine tip moth, bark beetles, turpentine beetles, and armillaria root decay. Diplodia tip blight is caused by *Diplodia pini*, an endophyte that exists as a latent pathogen on many pine species in natural and planted stands of trees. Historically, Diplodia causes mortality in conifer stands following a stress inducing condition, either due to climate or when growing conditions limit resources. In most cases, Diplodia is asymptomatic until the tree is weakened enough for its spore-producing structures to form on the new needle growth. Increasing periods of drought, heatwaves, and tree-injuring events such as hail and heavy, wet snow, will result in Diplodia becoming more widespread.

Anticipated Tree Health Issues

Emerald Ash Borer

Emerald ash borer (EAB) is an exotic woodboring beetle that has been found in adjacent states and provinces, but not yet in North Dakota. North Dakota is vulnerable to EAB since green ash is the most abundant tree species by stem count in North Dakota's native, planted, and community forests. Green ash dominates one-quarter of all windbreak rows. Emerald ash borer is a significant threat for North Dakota's windbreaks, many of which have only recently lost a mature American elm component to Dutch elm disease.

Federal emerald ash borer quarantine regulations were removed in January 2021, and were immediately replaced with North Dakota Department of Agriculture (NDDA) Emerald ash borer regulations. All hardwood firewood, a major forest pest pathway, is regulated as well as ash logs, nursery stock, and the insect itself. The NDDA conducts a statewide EAB survey with assistance from the North Dakota Forest Service (NDFS). NDFS, NDDS, and North Dakota State University Extension conduct EAB outreach and education for natural resource managers and tree owners.

Anthropogenic Factors

North Dakota windbreaks are also occasionally damaged by wildfire and frequently damaged by herbicides.

South Dakota

Age and Species Composition

Thirty-six percent of South Dakota's windbreaks are in Good condition; however, 42% are in Fair condition and 22% in Poor condition suggesting that over half the windbreaks in South Dakota are in need of some form of renovation and are likely to qualify as a "resource concern" under EQIP. GPI 1 revealed 71% in Fair condition so the condition of South Dakota windbreaks remains a concern. Six percent of South Dakota windbreaks exceed 50 years of age, 58% between 25 – 50 years and 36% are less than 25 years old. Sixty-six percent of South Dakota's windbreaks have a porosity between 20 – 40%, which meets NRCS specifications for field, farmstead, livestock, and living snow fences.

Insect and Disease Diagnosis

Between FY2019 and FY2020, forest health staff and field foresters responded to 562 insect and disease requests from the public. The data supports that abiotic and environmental stresses, mainly flooding and poor drainage, represents a major share of the problems South Dakota windbreaks face. Significant insects and disease problems such as diplodia tip blight, dothistroma needle blight, various cankers, pinewood nematodeand rhizosphera needle cast have all adversely affected windbreak health and longevity. Anthropogenic problems such as off-target herbicide damage have led to the decline and/or damage of many windbreaks in the state.

Invasives

Emerald Ash Borer

Emerald ash borer (EAB) is an exotic woodboring beetle. EAB was first discovered in South Dakota in May of 2018, in Minnehaha County. Ash trees account for 21% of the trees existing in windbreaks. Emerald ash borer is a significant threat to South Dakota's windbreaks. The insect can fly 5 to 15 miles in search of new ash to infest.

Pine Wilt

Pine wilt is caused by a plant parasitic nematode (*Bursaphelenchus xylophilus*), the pine wood nematode. The nematode is vectored by the pine-sawyer beetle (*Monochamus*), a longhorned borer. They kill pine trees by feeding and reproducing in the resin canals of the branch and trunk. This disease is continuing to spread northward in South Dakota causing high mortality in windbreaks containing Austrian pine (*Pinus nigra*) and Scotch pine (*P. sylvestris*).

Diplodia Tip Blight and Dothistroma Needle Blight

Wet weather in 2019 and in the summer of 2020, created an increase in the number of cases of these blights. Diplodia Tip Blight (*Diplodia pini*) infects Austrian, ponderosa, and Scotch pines and is most common on trees 20 years or older. Repeated infections over time are what causes decline and mortality in these common windbreak trees. Dothistroma Needle Blight (*Dothistroma septospora*) attacks Austrian and ponderosa pines, especially in high-density plantings like windbreaks. This disease causes premature needle drop the year following infection, thinning out tree crowns over time, which leads to declining health and mortality. The presence of ponderosa and Scotch pines in South Dakota windbreaks was recorded at 2.9% and no Austrian pines were identified. These diseases will continue to reduce the functioning condi-

tion of South Dakota windbreaks containing these pine species.

Abiotic and Environmental Stress

Abiotic and environmental stress represents most of the health problems of South Dakota windbreaks in the form of flooding or saturated soils. Approximately 22% of windbreak insect and disease field visits were due to flooding or saturated soils.

Severe Weather

Severe weather such as snow, hail, high winds, and ice storms all contribute to declining windbreak health in South Dakota.

Anthropogenic Factors

South Dakota windbreaks are also damaged by weed fabric girdling and off-target herbicide damage on an annual basis. Trunk girdling from weed fabric is a maintenance issue and continues to be addressed in our planting plans and workshops.

Engaging Farmers and Ranchers through Outreach Plans

To successfully engage farmers, ranchers, and other landowners in windbreak renovation and establishment the GPI 2 Initiative sponsored a two-day strategic planning workshop, *Tools for Engaging Landowners Effectively* (TELE), May 30 – June 1, 2018, at the National Arbor Day Foundation's Lied Conference Center.

The main outcome of the workshop was the creation of a targeted outreach plan for the initiative. TELE combines principles of targeted marketing with relevant data about the landowners the grant hopes to engage.

Twenty-five people attended the workshop from the four respective states. The primary participants were Great Plains state foresters who will implement the outreach plans along with partners from Cooperative Extension, conservation districts, wildlife agencies and the National Agroforestry Center.

Why Care About Windbreaks?

Participants identified a variety of reasons the windbreak initiative is needed: improved soil health, soil protection, increased soil moisture, reduced cost for snow removal, and improved road safety during dust and snowstorms. Participants identified the benefits of aesthetics, improved quality of life around farmsteads, livestock protection, improved crop yields, wildlife habitat, and hunting. The audience we are trying to engage may not perceive these needs or values.

Partners Engagement Status with GPI-2

Wait to Engage	Bring on Board	Engaged	Partners
★			US Fish and Wildlife
	★		Extension – State and County
		★	State Forestry Agencies
	★		Game and Fish/State Wildlife
		★	Conservation Districts and Assoc
★			CO-OPs
	★		Crop Advisors – Associations
★			Multinational agricultural companies
★			Farm Equipment Companies
		★	NGOs – Pheasants Forever; NWTF
		★	ND Rev Trust
	★		Farm Bureau
			Center for Rural Affairs
	★		Kansas Rural Center
	★		Kansas Farmers Union
	★		Arbor Day Foundation
	★		Forestry Contractors
	★		Non-Farmers who Rent/Tenants
	★		NRCS
	★		FSA
★			Insurance Companies
	★		State Legislatures
★			Banks
★			Other Local Entities

Why Windbreaks are Removed

The long-term benefits of windbreaks are unclear to many people. Visible reduction in yield immediately adjacent to windbreaks creates mistaken impressions of overall yield loss. Removing windbreaks is easier than renovation in some cases. Tax credits for farm improvements can result in removals and associated land value assessments can suggest windbreak removal is a "land improvement" providing tax benefits and putting more money into a "land bank" that can be borrowed against. Windbreaks are sometimes perceived as an eyesore and complicate farming operations.

Renovation Observations

Windbreak renovation is more expensive and time-consuming than establishment. Often, landowners do not understand renovation is needed and often wait until renovation is no longer viable. Proactive engagement and outreach are necessary. Most farmers remove rows and replant. Other approaches include under planting in gaps, planting on the end of windbreaks to extend them, coppicing, root plowing, thinning, and pruning.

Establishment Observations

Most landowners consider the cost to establish a windbreak (loss of crop ground, loss of moisture, incompatibility with equipment, and long-term financial returns) to exceed any benefits. This is less true for farmstead and livestock windbreaks.

Drought discourages windbreak planting. Field windbreaks are rarely planted. In addition to cost, some natural-resource professionals believe other conservation practices like no-till have adequately addressed soil erosion and windbreaks are no longer important.

"Hot" natural resource issues like soil health tend to focus on one conservation practice like cover crops without considering field windbreaks. Windbreaks are a more permanent conservation practice compared to other practices. They are more difficult to remove, which may make them less appealing along with their associated maintenance; however, windbreaks also provide protection during drought when there is no residue to hold the soil.

Encroachment of eastern redcedar into grasslands and declines in wildlife populations have resulted in a loss of support from strategic natural resource professionals. Conservation programs often support pivot irrigation system, which often require the removal of windbreaks. Irrigation also creates declining aquifers bringing into question the use of irrigation systems to establish trees. Reminding people of the Dust Bowl and drought projections might encourage establishment.

Other issues are the poor soils where soil erosion is most likely to happen and the difficulties of establishing trees and shrubs in them. Inflexible farming systems with only one- to two-year horizons also limit windbreak planting options. Trees, shrubs and grass are components of most windbreak plantings. Conifers provide the most density and protection. Wider windbreaks provide more benefits, but narrower windbreaks, three rows or fewer, are usually more acceptable to farmers because of less cropland loss. Greater species diversity is needed in windbreak designs.

General Landowner Attributes to Consider

Mary Tyrell, Yale School of Forestry and Environmental Sciences, who provided leadership for the TELE workshop, did not think National Woodland Owner Survey data would be helpful for GPI 2 target marketing considering so many windbreaks do not meet minimum definitions of forestland, the focus of the survey.

At the beginning of the workshop, the participants ascribed general characteristics of the windbreak farmers and ranchers they serve. They described them as professionals with

financial means that don't need land planted to windbreaks to pay for itself. Ownership ranged from large and expansive holdings to smaller and more intensive. These landowners produce livestock, corn, soybeans, and winter wheat. Some windbreak owners included organic farmers who are pollinator reliant. Hunting was also an important recreational use.

Renters or tenants are often primary contacts for landownership. There are some ethnic groups, especially members of the Hispanic community and women who mostly rent their land. Political affiliation and organizations such as the sustainable agricultural community should be considered, as should precision farmers.

State Outreach Plans

For successful target marketing using the six-step TELE approach, it was necessary for each state to design specific strategies and priority areas based on their circumstances. The approach includes:

Step 1. Setting objectives

Step 2. Choosing an audience segment

Step 3. Developing an audience profile

Step 4. Developing your message

Step 5. Choosing channels and materials

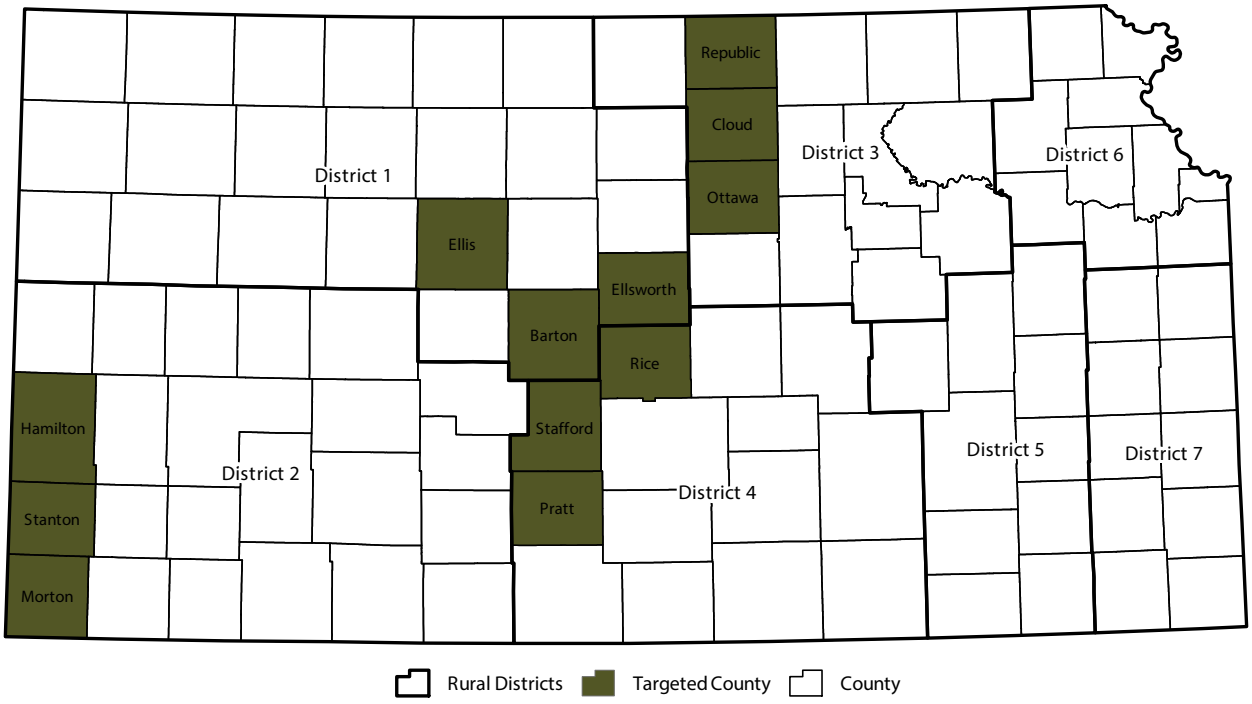
Step 6. Implementing, evaluating, and adapting

Kansas

Kansas Forest Service Outreach Plan for Windbreak Renovation and Establishment

Outreach Objective: Landowners who already have windbreaks, are members of Kansas Farmers Union or Kansas Rural Center and own farms and/or ranches between 300 and 1,000 acres in central and western Kansas will receive a site visit from a Kansas Forest Service forester to consult about windbreak renovation or establishment. Three county areas will be targeted in Kansas Forest Service District 1, 2, 3 and 4 for a total of 12 counties.

Targeted Counties for Outreach — Kansas



General Approach

Kansas outreach focus is in the western and central part of the state in Kansas Forest Service Districts 1, 2, 3, and 4. Three counties in each of these districts will be targeted for outreach. Field windbreaks will be the focus for establishment efforts. Kansas has had some outreach success for windbreak renovation in Kansas Forest Service Districts 1 and 2 where windbreak assessments have geospatially identified windbreaks by condition. Kansas has geospatial information on windbreak location statewide but lacks condition information for individual windbreaks with the exception of Coronado Crossing RC&D and Smoky Hill River watershed. The goal will be to enroll 10 landowners per county in CCRP, EQIP, or the Water Resources Cost-share Program to establish field windbreaks. Kansas has the goal of retaining the estimated 31,348 miles of windbreaks in our state.

Engagement Ladder

Step 1. Landowners receive a letter or postcard from their conservation district or call their local Kansas Forest Service forester about windbreaks.

Step 2. Forester provides information over the phone about services, cost-share and design and schedules a visit.

Step 3. Forester visits property and creates plans.

Step 4. Landowner applies for EQIP or Water Resource Cost-share program.

Step 5. Forester, landowner, or contractor plant or renovate windbreak.

Communication Objective — What we want the landowner to do after receiving the message

Landowners with smaller farms will contact their district forester to request a site visit consultation about field windbreak establishment. They will take this action because they want to be good stewards of their natural resources. Below is the process we will use to engage our landowners.

Choosing the Audience Segment

The audience segment we have selected to tailor communication to are farmers and ranchers that own between 300 and 1,000 acres. We are targeting landowners who are members of the Kansas Farmers Union and the Kansas Rural Center. These organizations are engaged in sustainable agriculture and may be more likely to understand the conservation values and benefits of windbreaks. These landowners tend to optimize, not maximize, agricultural production and are more willing to take risks associated with conservation benefits. We will also attempt to focus on landowners that already have windbreaks.

TELE offers its own audience segmenting of Kansas woodland owners, based on National Woodland Owners Survey (NWOS) data. Our targeted GPI 2 audience was not likely included in the NWOS since many windbreaks do not meet USDA FS FIA definition of forestland. Therefore we offer the following TELE segmenting with that understanding.

- **Supplemental Income Owners:** Own land primarily for timber income and investment. They comprise 14% of woodland owners in Kansas and own 15% of woodland. Best reached by enhancing their financial gains, maintaining land value for future generations, will learn more about forestry if it provides immediate or long-term financial benefits, most interested in forest industry, forestry communities, landowner associations, workshops, events and trade publications.

Continued on page 44

This graphic represents the collective brainstorming at the TELE workshop where Great Plains foresters indicated how they thought farmers and ranchers would express what is important to them, how they spend their time and money, what gets their attention, and what they know and believe about the desired action.

Kansas

Values

- Community Pride
- Independence
- Want to look good/ right to neighbors
- Rain
- Family (Passion)
- Maintaining farm during tough times
- Feeding the world/ Higher calling
- Proud of Farming
- Business Oriented
- Farming the right way
- Conservation Ethic

Knowledge

- Coffee shops
- Threats –wind/ heat
- Extension
- Neighbors - Young trees planting is weedy/ unkept
- The way my dad did it
- No personal experience with WBs (IE: watering as child)
- Wildlife is a driving force
- WB get in the way of equipment
- Farmers from other states
- Branches
- Reduced Yield
- Loss of productive land
- Don't know KFS
- K-State trust

Time / $

- K-State (Football)
- Wheat – Fall
- Corn/Soy beans – Spring Spraying
- Livestock
- Hay
- Planting
- Need site prescription
- Replanting
- Families
- School Sports
- Church
- Vacation
- 4H Fairs-County and State
- Save for equipment
- Pick up/minivan

Attention

- Rain
- Connected (Cell phones)
- Neighbors
- Reluctant to change
- Commodity Prices
- Direct Income (non-farm)
- K-State
- Concerned about GMOs
- Banker

Continued from page 42

- **Uninvolved Owners:** Tend not to care about woods and assign low importance to their financial, recreational, and aesthetic benefits. Willing to sell their land and are less likely to want to see it stay woodland. They comprise 33% of woodland owners in Kansas and own 28% of woodland. Best reached by explaining direct financial benefits that don't require much effort on their part, may be more receptive to programs that provide incentives to both farms and woodlands, by direct mail and traditional channels used to reach farm communities.
- **Woodland Retreat Owners:** Own their woodland primarily for its beauty, conservation, and recreational value. They love nature and animals and appreciate ecological benefits of woods. They make up 29% of woodland owners in Kansas and own 32% of woodland. Best reached with low-cost actions to achieve objectives, by challenging the belief that woods are best left alone, promoting ecological values and appealing to their stewardship responsibility for their woods.
- **Working the Land Owners:** Pragmatic. They value the aesthetic and recreational benefits of woodland but also see woods as a financial asset. They make up 24% of woodland owners in Kansas and own 25% of woodland. Best reached by affirming their outdoorsy lifestyle and traditional values, by not telling them what to do, respecting independence and cautiousness, providing them good information.

Developing and Audience Profile

Our audience profile in Kansas is based upon research.[1] Our profile also includes the collective brainstorming at the TELE workshop about farmers and ranchers values or what's important to them, how they spend their time and money or what they do, what gets their attention and what they know and believe about the desired action. This is all visualized in the figure on the previous page.

Developing the Message

To identify the main reasons our target audience would take action and to create a convincing message, we've taken the audience attributes developed with the figure and created the pain/gain chart below. The pain column lists all the barriers that would keep a farmer or rancher from contacting a forester and the gain column shows all the benefits for taking that action.

Pain	Gain
• Lose Production	• Trustworthy partner (voice)
• Time and Effort	• Sell Healthy Riparian Buffer example
• Planting time is busy	• Reduce snow drift
• Contractors hard to get	• Nostalgia
• Perception of neighbors	• Pollinators (help)
• (Good Ground; weedy)	• Shade
• Delayed results	• Fruit/blooming shrubs
• (Short time horizon)	• Reduce Soil erosion
• Don't want to talk to government	• CRP
• Don't want to be told what to do	• Reducing pesticide drift
• Need to be careful with herbicide	• Right thing to do
• Wildlife damage to crops	• Support environment
	• Help change traditional farming
	• Improve landscape

1 *Nonagricultural Benefits of Windbreaks, Ted Cable, Great Plains Research: A Journal of Natural and Social Sciences, 1999; and Farmer's Attitudes and Behaviors Toward Shelterbelts in Kansas, Ted Cable, Research Gate 1993; The Use of windbreaks by Hunters in Kansas, Ted Cable, 1990*

Evaluating our pain versus gain lists helped us decide that the benefits were compelling enough to override the barriers and to pick the strongest theme to form the core of our message.

The Message Strategy

The Kansas Forest Service will target 12 counties in central and western Kansas (see table below). These counties were selected based upon input from the foresters, windbreak condition, planting opportunities, and NRCS and Conservation District staff. Targeted landowners will be identified with help from NRCS, County Conservation District staff, and use of any geospatial windbreak data. Soil health experts need to be on-board with this effort! Landowners will receive a letter from the forester inviting them to either establish a field windbreak or renovate an existing one. Landowners will also learn of windbreak benefits through demonstration sites, research, from neighbors and through field days. Two field days will be held in each district.

Foresters will provide 60 on–site assessments for windbreak establishment or 15 per district. Five windbreak establishment plans will be prepared per county.

		Windbreak	
Counties	**District**	**# WBs**	**Acres**
Cloud	5	2,083	2,971
Ottawa	5	1,393	2,476
Republic	5	2,134	3,240
Pratt	6	930	2,260
Rice	6	2,229	5,070
Stafford	6	1,612	6,410
Barton	7	1,135	2,713
Ellis	7	686	1,071
Ellsworth	7	735	1,391
Hamilton	8	99	212
Morton	8	104	60
Stanton	8	73	64

Sixty landowners with farms or ranches between 300 – 1,000 acres who are members of the Kansas Farmers Union or the Kansas Rural Center, will contact their district forester to request a site visit consultation about field windbreak establishment. They will take this action because they want to be good stewards of their natural resources. The financial incentives through CCRP, EQIP, and the Water Resources Cost-share Program make it more feasible to do so. Sixty new field windbreaks will be established by January 2022.

Choosing Channels and Materials

Delivery of our messages will be timed to coincide with 1) sign up periods for the targeted cost-share programs so that site assessment and planning can be accomplished prior to application deadlines and 2) with early spring dust storms when wind erosion is visible. The messages will be provided 4 – 6 times from critical partners including County Conservation Districts, K-State Research and Extension County offices, Kansas Rural Center, Kansas Farmer's Union and NRCS. Our main channel will include letters sent directly to landowners through Conservation Districts. These will be followed by a phone call a week later from County Conservation Districts and the foresters. Other channels will include workshops with K-State Research and Extension, radio messaging through K-State Radio Network, Tree Tales program, newsletters, news releases through local papers using all the partners outreach channels.

Implement, Evaluate and Adapt

Process measures for success will include the number of site visits and windbreak establishment plans developed. Outcome measures will be the number of contracts developed through each cost-share program and the number of acres of windbreaks planted including acres protected. Partners and participating landowners will be surveyed after the first year to measure success and identify needed adaptations. A more difficult impact to measure is

the reduction in tons per acre of soil erosion on cultivated cropland as a result of field windbreak establishment in the 12-county area. Baseline measurements are needed prior to establishment of field windbreaks followed by repeated measurements when windbreaks reach an adequate size to provide protection. Crop yield benefits should also be monitored.

Nebraska

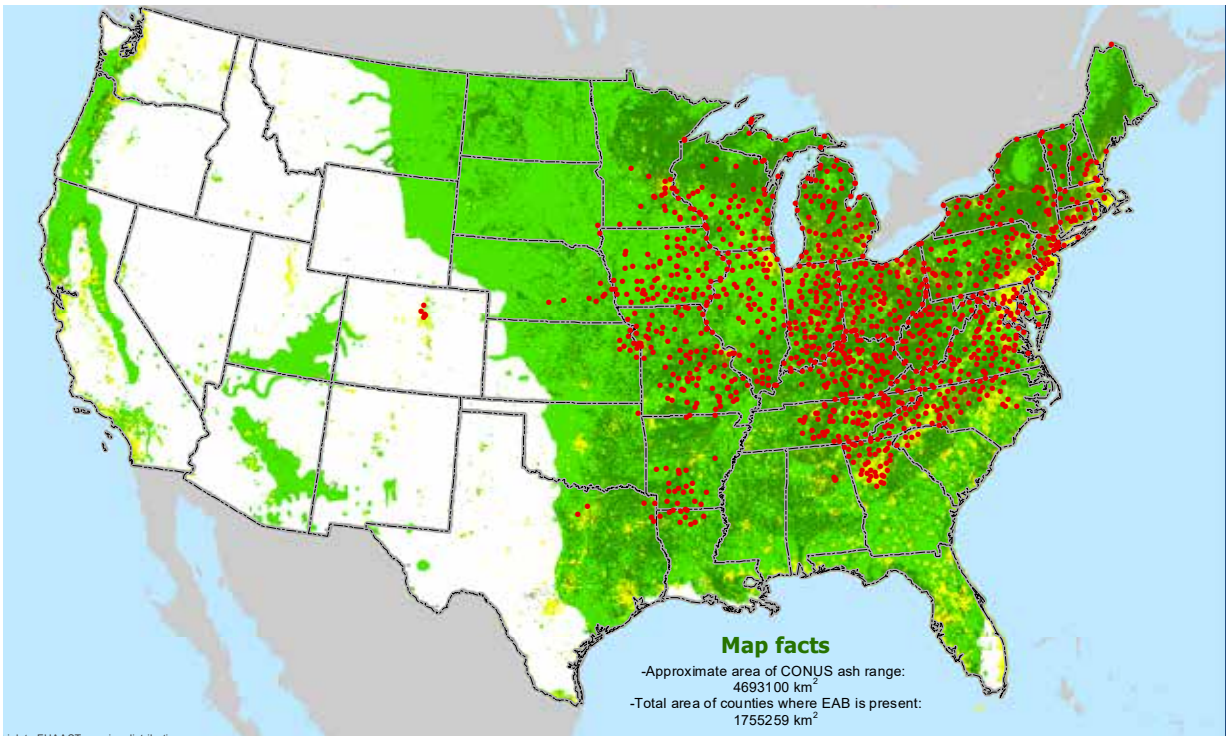
Engagement Objective

The goal of this project is to encourage agricultural producers with aging windbreaks, that no longer provide adequate protection, to renovate their windbreaks. This will be accomplished by reconnecting with landowners that previously expressed interest in windbreak renovation, have met with a Nebraska Forest Service (NFS) rural forestry staff and/or have a windbreak renovation plan for their property and project. These landowners will be provided with follow-up assistance to complete an application for windbreak renovation cost-share and then initiate on-the-ground project implementation.

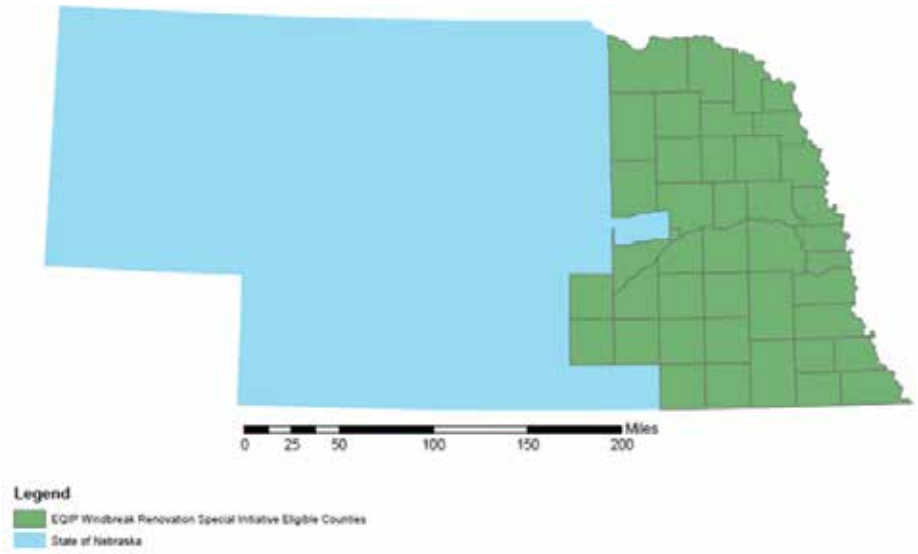
Due to the high reliance on green ash (*Fraxinus pennsylvanica*) in field windbreaks and the presence of emerald ash borer (EAB) in the Omaha/Lincoln corridor in Nebraska, as well as neighboring states of Kansas, Iowa, Missouri and South Dakota (**Approximate Range of Ash Species in the Contiguous U.S. with EAB Positives**), we have selected counties that are both 1) within 150 miles of current EAB detections and 2) are eligible for NRCS EQIP Windbreak Renovation Special Initiative cost-share as our project boundary, **Windbreak Renovation Priority Area in Nebraska**.

Additionally, counties in the Northeast and Southeast regions will receive greater attention due to increased windbreak density, higher population density, higher average cropland value, and increased likelihood of EAB infestation.

Approximate Range of Ash Species in the Contiguous U.S. with EAB Positives



Windbreak Renovation Priority Area in Nebraska



Landowner Identification:

The NFS will utilize a geospatial analysis for identifying landowners. Using ArcGIS, we will overlay our priority counties, statewide forest canopy cover map (produced during GPI 2, which is used to identify and classify windbreaks), landowner parcel data from county assessors, land use data and NRCS soil erodibility layers. With this method we will be able to identify specific landowners within our priority area who have degraded/incomplete windbreak systems (or lack windbreaks completely), have elevated land values due to agricultural land use and have an elevated risk of erosion (**Landowner Identification**). If possible, we will refine this list of identified landowners even further to identify those who have requested windbreak assistance in the past. These targeted landowners would be prime candidates for windbreak assistance as they would have the most to gain.

Communication Goal

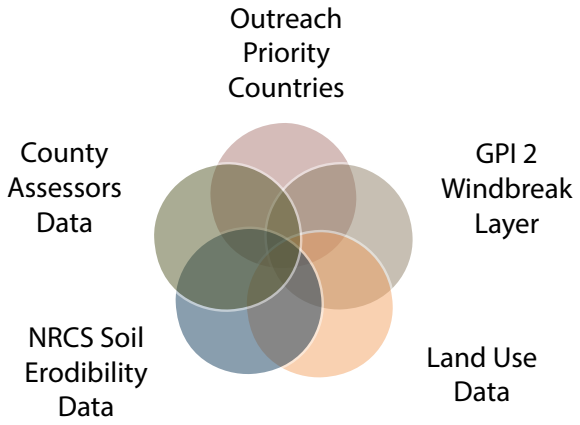
The goal of the project is to contact 500 landowners who currently have been identified as a prime candidate for windbreak renovation and recommend a course of action.

Success will be measured by the number of landowners contacted, the number of windbreak renovation practice plans written and, ultimately, by the number of windbreak renovation practices completed.

NFS staff will initiate a follow-up call with previous landowners who have requested windbreak assistance to determine if they have proceeded with their planned renovation. Staff will evaluate the landowner's current interest level and recommend a course

Pain	Gain
• It's a gamble	• Monetary
• Adding workload	• Sets a good example
• Instant gratification	• Point of Pride
• Programs	• Increase diversity
• Application process	• Non-timber products
• Time	• Energy Savings
• Everybody is in	• Micro environment
• Everybody business	• Snow harvesting
• Legacy	• Know we exist
• Equipment/ Contractors to do the work	• Non- recognition
• Compliance	• Technical Resource
• Follow through	• Legacy
• Loss of prairie land	• Postcards/ Gate signs
	• Follow through
	• Kids in the Windbreak

Landowner Identification



of action. A number of NFS rural forestry program staff attended the TELE Workshop in May 2018 in Nebraska City, NE, and will utilize concepts learned and developed as a part the workshop. While not all of the staff who will be involved in these outreach efforts were able to attend the TELE Workshop, all have significant experience with working with landowners to achieve their tree and forest management goals.

Step 1. The NFS foresters will work with agency communications staff and Natural Resource District (NRD) partners to produce and distribute a series of articles and direct mailings to educate our prime prospects as identified above, about emerald ash borer, its potential impact and consequences to their windbreaks and livelihoods. Forester provides information over the phone about services, cost-share and design and schedules a visit.

Step 2. We will work with partners, listed below, to host a series of "tailgates" workshops to be held on agricultural producers' lands who have recently completed a windbreak renovation or are in the process of renovating a windbreak. All prime prospects that live within a 25-mile radius of the "tailgate" location will be invited to participate.

Step 3. We will contact "tailgate" attendees by mail or email and ask whether they are interested in having a NFS forester visit their property and provide and evaluation of their windbreak and written recommendation.

Developing the Message

To identify the main reasons our target audience would take action and to create a convincing message, we've taken the audience attributes developed with the figure and created the pain/gain chart below. The pain column lists barriers that would keep a farmer or rancher from contacting a forester and the gain column shows all the benefits for taking that action. Evaluating our pain versus gain lists helped us decide that the benefits were compelling enough to override the barriers and to pick the strongest theme to form the core of our message.

The Message Strategy

There are a large number of landowners who requested technical assistance, but have not applied for financial assistance. This is commonly due to the high cost of renovation, changing levels of time/ interest in doing the work, or death/ injury that prevents action; however, most projects stall at this stage due to inactivity being the path of least resistance. It was determined that messaging should initially target landowners with plans already written or have previously expressed interest in windbreak improvement; however, new contacts would continue to be encouraged.

Channels and Materials

1. Landowners already with plans will be contacted directly by phone
2. Messages provided to NRD newsletters and County papers targeting conservation-focused
3. 5 X 7 inch info-cards distributed to NRD offices

This graphic represents the collective brainstorming at the TELE workshop where Great Plains foresters indicated how they thought farmers and ranchers would express what is important to them, how they spend their time and money, what gets their attention, and what they know and believe about the desired action.

Nebraska

Values

- Family
- Time Commitment
- Farm profitability
- Legacy
- Heritage
- Provide for their family
- Pride and Ownership
- Sustainability and Preservation of the Farm

Knowledge

- Crops
- Family/ inherited knowledge
- They knew to do something, but what?
- Location?
- Where?
- It's hard
- Time consuming
- Expensive
- Gratification
- Expansion into other trees
- Species selection
- Past Practices

Time / $

- Volunteer Fire Departments
- Auctions
- Farm
- Church
- Outdoors/Hunt
- Elected/ Volunteer
- Board memebers
- Coffee

Attention

- Free Stuff
- Innovation
- Money
- Changes in politics
- Taxes
- Innovation
- Hunting
- Examples
- Curiosity
- Commodity Prices
- Weather
- Local gossip
- Foreign Markets/ Imports
- Government

Phone call Talking Points

Call to Action - Let's finish this together

- You have a plan to care for your windbreak
- You started this, you want to take care of your windbreaks
- Take the next step to complete the job.
- We can help, but money will not be available in the future
- Act now…A tree planted last year is one year older than planted today

Call to Action - Protect the future, cherish the past

- Make grandpa's windbreak your own
- More trees mean more game animals, which means better hunting
- Make an investment for your family
- Testimonial from local completed project

Implement, Evaluate and Adapt

Monitoring and Evaluation will include the number of:

- funding applications submitted
- acres of windbreak restored
- farmsteads protected
- cropland/ rangeland acres protected
- miles of roads protected

5 X 7 Inch Info Card

FRONT

- Put your plan into action
- Restore your windbreak this year

Before *After*

Money available through EQIP windbreak renovation special initiative. Contact us to apply today for financial assistance.

BACK

Testimonial

- Ready for another generation

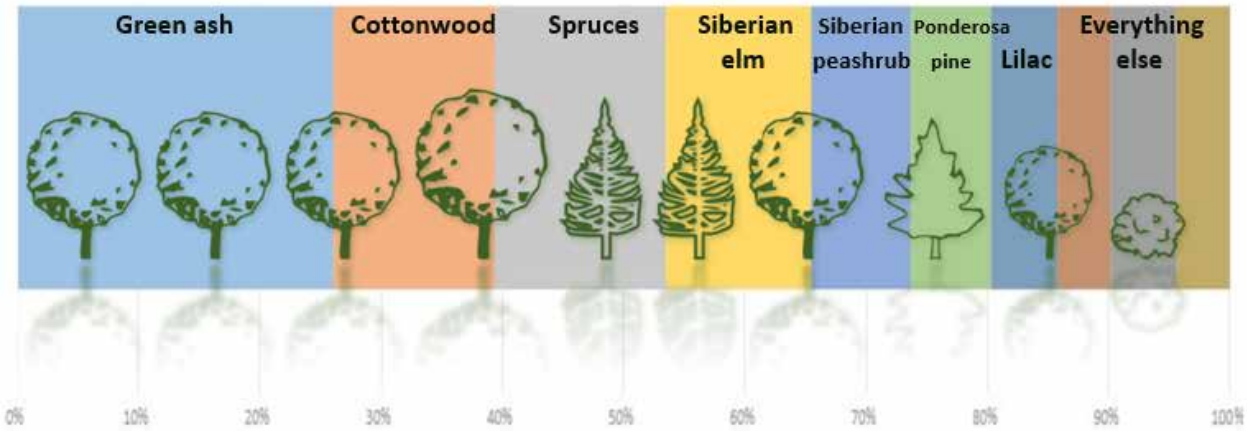
- Contact (City, Phone, Email) information for NFS rural forestry staff offices.

North Dakota

Engagement Objective

The North Dakota Forest Service (NDFS) Windbreak Renovation Initiative (WRI), which began in 2015, encourages agricultural producers with aging windbreaks that no longer provide adequate protection, to renovate their windbreaks. The initiative includes both technical and financial assistance. Since 2015 technical assistance has been provided to over 650 interested landowners and cost share assistance has been extended to 350 of them. This leaves nearly 300 landowners with plans to renovate their windbreak but who have not applied with NDFS for cost share.

The objective of this engagement effort is to reconnect with landowners that previously expressed interest in windbreak renovation, have met with North Dakota Forest Service (NDFS) Forest Stewardship staff and have a Forest Stewardship Management and/or Windbreak Renovation Practice Plan written for their property and project, but have not applied for financial assistance.



Nearly half of the windbreaks in North Dakota are in fair to poor condition and one in every four windbreak rows is green ash and therefore highly vulnerable to emerald ash borer (EAB). This provides additional urgency to this effort.

Landowner Identification:

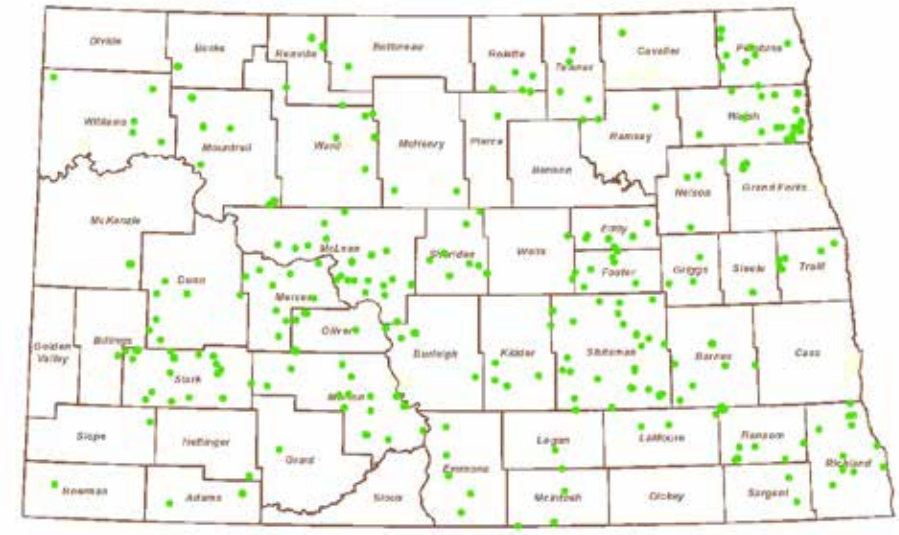
The NDFS will utilize the agency's Outdoor Heritage Fund (OHF) WRI landowner database to identify landowners who have not submitted applications for WRI funding after being provided a Forest Stewardship Plan and/or Windbreak Renovation Plan.

Communication Goal

The goal of the project is to contact 250 landowners who currently have Forest Stewardship and/or Windbreak Renovation Practice Plans but have not applied with NDFS for cost-share assistance to complete their windbreak renovation. This will determine what additional assistance NDFS can provide to help them meet their windbreak renovation goals.

Developing the Message

To guide the conversation with the landowner to identify the main reasons the landowners have not taken action and to create a convincing message, we've taken the audience attributes developed through the TELE workshop and created the pain/gain chart below. The pain column lists barriers that would keep a farmer or rancher from completing their windbreak renovation and the gain column lists potential messages they may find encouraging.



Landowners with renovation plans who have not applied with NDFS for cost-share

Pain	Gain
• Doing nothing is the path of least resistance • Limited contractor availability for removals • All work needs to be done before reimbursement • Landowner is responsible for paying for 50% of the project in cash or in-kind • Small window of time to do removals • Little marketable value for removed materials • Not enough time to do the in-kind work (2 yrs) • Difficult work needs to be performed: removal, coppicing, pruning	• 50% landowner's share can be in-kind (Zero $ cost) • Improved wildlife and hunting • Replanting cost assistance • Fewer snags/ branches falling on fields • More even snow deposition • Pride in well-kept windbreak • Reduce soil erosion • Non-Timber Forest Products (NTFP) • Work can be done in farming "off" season

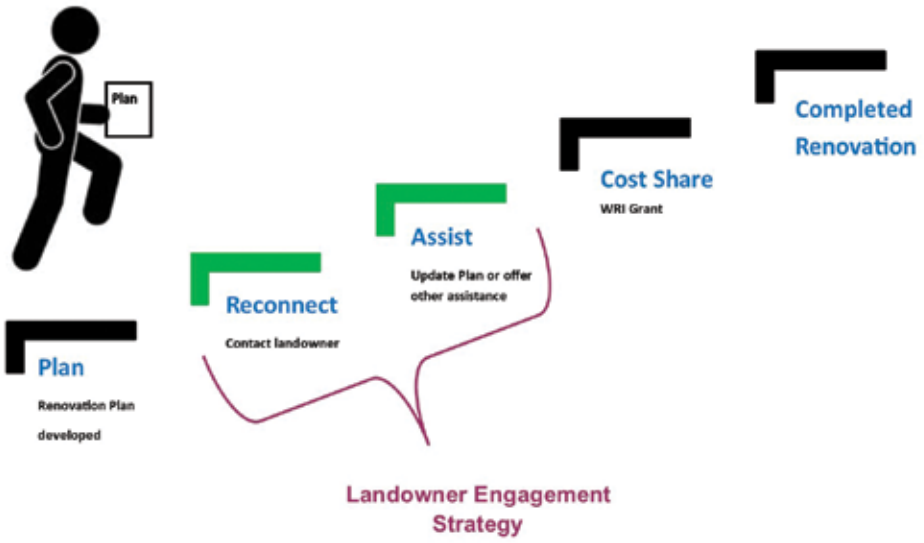
Landowner Engagement Strategy

Step 1. The NDFS FSP staff will assess the OHF WRI database and create a list of landowners that have not yet submitted an application for windbreak renovation cost-share.

Step 2. Based on criteria such as who was the original plan writer and geographic distribution of the landowners, each NDFS Forest Stewardship staff member will be assigned a group of landowners to contact.

Step 3. NDFS staff will contact landowners and use the Pain/Gain matrix to determine the reason that the windbreak renovation appears to have "stalled." At this point NDFS staff will offer the appropriate assistance, which may be:

- None. Conversation reveals the landowner completed the renovation on their own without utilizing NDFS cost-share assistance. NDFS Staff will:
  - ✓ Inquire if the NDFS renovation plan was followed
  - ✓ Provide current contact information and encourage the landowner to contact NDFS is they need any further assistance
  - ✓ Log the information into the NDFS FSP Landowner Assistance database
- Offer additional technical assistance with additional/alternative recommendations. NDFS Staff will:
  - ✓ Guide the landowner via phone/email or schedule a site visit



This graphic represents the collective brainstorming at the TELE workshop where Great Plains foresters indicated how they thought farmers and ranchers would express what is important to them, how they spend their time and money, what gets their attention, and what they know and believe about the desired action.

North Dakota

Values

- Ability to pay debts
- Faith
- Predictability
- Legacy/Family
- Community
- Aesthetic – uniformity

Knowledge

- Windbreaks are a nuisance– get in the way
- High cost to remove/ maintain trees
- Government regulations are bothersome
- Government assistance is expected
- Wildlife value – especially deer and moose
- Trees have value, but worth it?
- Trees reduce sand-blasting of crop seedlings

Time / $

- Farming is life/ identity
- Family-focused with kids/ grandkids continuing legacy
- Community events are entertainment -Pot luck, hunting, local sports
- Community service is expected– local boards, coops, church
- Unstructured time with other farmers is important— Coffee at C-store, beer in bar

Attention

- Grant Regulations
- Reduction in deer tag #
- Crop failure
- Commodity Prices
- Water/Flood Management
- Weather
- Ways to save $
- Farm and Ranch guide

- ✓ Update/Amend the landowner's Forest Stewardship and/or Windbreak Renovation Practice Plan
- ✓ Log the information into the NDFS FSP Landowner Assistance database

- Refer the landowner to the appropriate NDFS FSP staff person to continue with the cost-share application process.

Measuring Success

Success will be measured by logging the results of windbreak renovations completed with NDFS technical assistance only, acres and numbers of renovation plans amended or updated, and the number of previously stalled projects now applying for financial assistance.

Ultimately the results of this engagement strategy will be combined with the performance outcomes of the WRI program as a whole, which include:

- Acres of forest restored (windbreaks renovated)
- Number of rural residences, miles of roadway, and acres of cropland protected

South Dakota

Outreach Objective

Renovate 500 to 700 windbreaks in an eight-county area in South Dakota (Aurora, Davison, Douglas, Hanson, Sanborn, Jerauld, Yankton, and Hutchison counties)

- Only one forester, but Conservation Districts are able to design and implement. Needs 160 calls per year from 8,000 landowners/producers
- 20 – 25 plans per county per year
- 12 – 15 cost-share applications per county per year
- 170 – 200 calls/year

Process

- Landowners have windbreaks in disrepair
- Contact Nathan Kafer, SDDA agroforester, for a consultation to restore windbreak
- Evaluate and design windbreak
- Apply for cost-share conservation district
- Site preparation – conservation district
- Planting – conservation district
- Spot checks and maintenance

Audience Profile

- Have shelterbelt/windbreak
- Have land (cropland) in one of eight counties
- Need financial means to put in their share
- Orientation to hunting
- Crop farmers versus crop and livestock
- Conservation "leaders" Soil Conservation District Board
- Windbreaks in very poor condition
- New landowners
- Family versus corporate farms
- Open to cost share/government

Farmers with damaged windbreaks in one of our eight counties will call Nathan to get an expert opinion on how to restore their windbreaks because:

- They have lost value and function
- They can get cost share for something that needs to be done
- They'll get a good plan and government will pay for it
- They want the windbreaks to do the job they were planted for
- They will help ensure soil health and help productivity into the future.

Doing this will make them feel:

- Proud because added value to the land, being a good steward
- Getting something done – accomplishment
- Relieved – windbreaks are doing their job
- Got a good deal - smart

Because:

- They want to improve the quality of their life and farm for future generations
- (Difference will get attention)
- They want to optimize the value of all their farm assets.
- (too much competition)

Feeling:

- Responsible parent/patriarch Satisfied/ accomplished
- Contact Nathan your local agroforester for a free consultation on how to restore and improve your windbreaks.

Other things to include:

- There is cost share for this
- Contact area forester before cost share funds run out
- What Nathan will do: (In two hours.)
  - ✓ Evaluate your design and offer multiple benefits to your farm and quality of life

Evaluate your shelter belt and suggest improvements that will maximize its value for your farm and family.

Partners

- SCDs – all eight of them
  - ✓ Promote program via newsletter, tree sales
  - ✓ Plant the trees (and maybe prep work too)
  - ✓ Do commission grants
- District Conservationists need to be on board with NRCS
  - ✓ Know the program
  - ✓ Recognize the importance of the program
  - ✓ Approve the applications
  - ✓ Get an earmark or match
- Extension hubs

Channels

- Radio
- Soil Conservation District newsletters

Pain	Gain
• More on your to do list • Time – Call, evaluation (2-3 hours) • Working with government (Esp. cost share bureaucracy) • Cost share – has rules (loss of control) and accountability to government agency	• Restore/Improve functionality of Windbreaks (Provided they realize that they are damaged.) • Money helps to do something that will improve land. • Free knowledge from the experience of evaluation. • Improve the farm for generations • Create wildlife habitat • Forest products / fruit • Feeling like they are being good stewards • Improve crop yields • Amenities – scenic value make you feel good • Ownership of the belt • Improving drought resilience cookbook

- Direct Mail (915 trifold brochures for the list of target land owners.)
- Showing generations
- Images
- Doing an activity that speaks to quality of farm life
- Grandpa and grandkids (ask Robin)
- Fall colors flowering
- Tree Sales Fliers at NRCS bulletin
- Green sheet – Stories

Metrics

- # of calls/emails to area forester (200 per year)
- # of consultations
- # of plans written (160 per year)
- Cost share Applications (96 – 120)
- # Plantings by Conservation Districts
- Farms
- Miles
- # of trees

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South Dakota

Values

- Wildlife
- Family – Generational ties to Land
- Profit
- Time is very valuable
- Social Standing – Church, Community Org.
- Good Farmers
- Good Steward
- Land – Livelihood, heritage
- Off-farm employment

Knowledge

- Windbreaks multi-functional, good screens
- Many Windbreaks may now look bad
- Old ways vs New ways
- Meeting with gov. is hard – Local government is better
- Organic farming is the new trend?

Time / $

- Hunting – own and public birds
- Church
- Farming
- Coffee @ Coops, gas station
- 50s – 60s grandchildren, many live on farms
- Bird, deer, pheasant meetings

Attention

- Weather
- Land Value – debts to borrowers $
- Who buys land and how they look after it
- Crop prices – input prices effects decisions
- What other farmers are doing
- Other family members; Internet research; Extension

Summary

Thanks to this grant and the USFS Northern Research Station (USFS – NRS), northern Great Plains states now have GIS layers that identify the location of all tree resources. Before GPI 2, statewide tree canopy layers did not exist, preventing states from knowing the actual area of trees that did not meet the definition of a "forest." In the four-state region of this initiative, trees outside forests (TOF) account for almost half of the total treed area including windbreaks and riparian forests, which provide essential ecosystem services to the plains states. GPI 2 also lays the groundwork for similar high-resolution layers for urban and incorporated areas and to further define the function of trees in the rural landscape.

GPI 2 also provided an important update on decade-old information of the condition, function, age, and species composition of windbreaks in the Great Plains. Windbreaks in need of renovation to retain their intended function varied by state: 34% in Nebraska, 46% in North Dakota, 55% in Kansas, and 64% in South Dakota. Regarding windbreak function, most windbreaks inventoried in this study were designed to protect fields and cropland, with the exception of Kansas, where 61% protect farmsteads, the second most common function overall. Livestock windbreaks were the third most common function in Nebraska and Kansas with 20% and 11% respectively, while living snow fence windbreaks were more common in South Dakota at 11% and North Dakota at 8%. Almost half the windbreaks in the four-state area range between 25 – 50 years of age, with 24 – 27% older than 50 years. This supports the suggested need for renovation and ongoing maintenance of windbreaks. Kansas and Nebraska have significantly higher percentages of eastern redcedar in their windbreaks, 54% and 52%, respectively. This contributes to concerns of expansion of eastern redcedar into grasslands when not managed, and sometimes, the lack of partner support to promote windbreaks. Kansas also has 11% of windbreaks consisting of Austrian, Scotch, or ponderosa pine, all prone to various insect and disease problems. North and South Dakota have the highest green ash components, 26% and 21%, respectively, and therefore the greatest risk for emerald ash borer mortality.

Substantial research supports the ecosystem service values that windbreaks provide, and this report references many of those studies. Due to limited funding, time constraints, and inventory structure, this project did not have adequate models to provide estimated dollar values for ecosystem services. This is undoubtedly a need, especially as markets continue to grow in the private sector, and government policy encourages it. From a market standpoint, the challenge will always be the small size of the resource in the Great Plains and the need to bundle a variety of ecosystem service values and landowner collaboration.

A variety of health issues face Great Plains windbreaks, with abiotic and environmental stress often being prominent. Emerald ash borer is the concern in the Dakotas, while *Diplodia*, *Dothistroma*, pine wilt, and bagworms are more significant issues in Kansas and Nebraska. The condition, age, and species composition of these windbreaks also contribute overall decline in windbreak health.

This project used Tools for Engaging Landowners Effectively (TELE) to create outreach plans to engage farmers, ranchers, and other landowners in windbreak renovation and establishment. These plans explore why this initiative was needed, reasons for windbreak removal, barriers to renovation and establishment, communication objectives, and targeted geographic areas. The plans identify audience segments, profiles, values, knowledge, resources, and what gets their attention. Message strategies were also developed as

well as the channels and materials needed to deliver the message.

Future Needs

Consistent financial support is needed to periodically inventory trees outside of forests (TOF), focusing on windbreaks and riparian forests in the Great Plains. The research and analysis of trees outside of forests in the Great Plains must continue so that we have information on the size, condition, and sustainability of windbreaks and riparian forests. Models still need to be developed to place ecosystem service values on windbreaks and riparian forests. Policy and financial incentives are needed to protect existing windbreaks from removal and compensate producers adequately enough to adopt new windbreak plantings.

September 2021