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Summary of Findings from the Great Plains Tree and Forest Invasives Initiative

Dacia M. Meneguzzo, Andrew J. Lister, and Cody Sullivan

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Abstract

The Great Plains Tree and Forest Invasives Initiative (GPI) was a cooperative effort of the U.S. Forest Service and state forestry agencies in Kansas, Nebraska, North Dakota, and South Dakota, with a primary goal of evaluating the tree resources throughout the four-state region as a preparedness measure for the arrival of invasive pests, such as the emerald ash borer (*Agrilus planipennis* Fairmaire). The GPI assessed the characteristics of the resource known as trees outside forests (TOF), or trees that occur on lands that do not meet the Forest Inventory and Analysis (FIA) definition of forest land. Data, including tree number, species, diameter, height, canopy health, and windbreak function, were collected on 1/6 acre plots. Across the four-state region, TOF account for almost half of the total area of all tree resources. Forest land covers about 6.4 million acres, while land associated with TOF covers 5.1 million acres. Approximately 56 percent of the land use associated with TOF is agricultural. Over one-third (36 percent) of the acres and more than half (55 percent) of the trees identified as TOF function as windbreaks of some sort, with agricultural windbreaks being most common. Of the windbreaks, 72 percent are in poor to fair condition and 48 percent are between 25 and 50 years old. As the existing windbreaks continue to age, fewer young trees are filling the gap. Just over half of the trees (53 percent) on TOF lands occur naturally while the remainder have been planted, and 86 percent of TOF trees are located in rural areas. Many tree species are present in the four-state region, but ash trees (*Fraxinus* spp.), the emerald ash borer's target of choice, are the most prevalent. This information will help natural resource professionals plan conservation and restoration efforts.

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Cover Photo

Example of a field windbreak in eastern Nebraska. Photo by Dacia Meneguzzo, U.S. Forest Service.

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Figure 1.—The narrow linear shape of windbreaks often does not meet the requirements for FIA's definition of forest land. Photo by USDA National Agroforestry Center, via flickr.com.

INTRODUCTION

Tree resources in the Great Plains occupy only a small portion of the landscape but provide important ecological functions, such as stabilizing stream and river banks to hinder erosion, and protecting soil, crops, wildlife, livestock, and structures from wind and harsh weather. In urban and residential settings, trees improve air quality, provide shade, and have aesthetic value (Robertson and Mason 2016). Although these trees are a critical resource, data describing their extent, composition, structure, and function are lacking, making it difficult to plan on-the-ground conservation and restoration efforts.

In the Great Plains region, tree resources are primarily found in narrow strips that are part of agroforestry plantings, lining stream and river banks, or scattered across farmsteads and rangelands. The small size or narrow shape of these tree features precludes them from being included in national forest resource inventory programs, which often use a definition of forest land that has area and width requirements. For example, the Forest Inventory and Analysis (FIA) program of the U.S. Forest Service, which inventories all forest lands across all ownerships, defines forest land as land that currently has or previously had at least 10 percent live-tree canopy cover and is at least 1.0 acre in size and 120.0 feet wide. As a result, the FIA inventory of forested areas excludes much of the tree resources in the Great Plains region (e.g., Fig. 1). In this report, trees that grow on land that does not meet the requirements outlined in FIA's definition of forest land are referred to as "trees outside forests" (TOF).

In 2008-2009, state forestry agencies in Kansas, Nebraska, North Dakota, and South Dakota worked with the U.S. Forest Service to evaluate the TOF resource. This assessment was in part a preparedness measure for the arrival of the destructive, exotic wood-boring emerald ash borer (*Agrilus planipennis* Fairmaire; EAB) (Fig. 2), which is a threat to all species of ash. By knowing the species composition and, therefore, how much of the total tree resource is at risk, the potential impact of EAB can be quantified. This has allowed for the development of alternatives to planting more ash trees and has increased the understanding of the possible economic impacts of ash tree loss. In addition, data were collected to describe the area, condition, and ecosystem function of TOF serving as windbreaks. This multi-state and multi-agency effort is known as the Great Plains Tree and Forest Invasives Initiative, or GPI.

Figure 2.—Emerald ash borer. Photo by David Cappaert, Michigan State University, via Bugwood.org.

METHODS

The goal of the GPI was to characterize the TOF resource in the Great Plains states of Kansas, Nebraska, North Dakota, and South Dakota. GPI field plots (Table 1, codes 2-14 and code 1 urban plots) measured 1/6 acre in size (radius = 48.1 feet) and all trees that were 1.0 inch in diameter at breast height (d.b.h.) or larger were measured. Data collected on GPI plots are described in Table 2. Detailed information regarding GPI data collection procedures is available in Lister et al. (2012) or in the unpublished GPI inventory field guide (hereafter referred to as GPI field guide).[1]

GPI field data collection personnel assessed agroforestry trees and other nonforest trees (e.g., Perry et al. 2009) that compose the TOF resource. Primary and secondary ecological functions of interest for each rural TOF plot were recorded using the codes in Table 3. For example, as taken from the GPI field guide (section 2.1.7), "A tree planting in a field that parallels a county road would have the primary function as field windbreak and a second benefit as a living snow fence." When tree function codes 1-10 were identified, additional attributes for tree function condition (Table 4) and tree function age (Table 5) were also determined and recorded. The condition and age data were collected to estimate the amount of aging windbreaks that require renovation. (Tables begin on page 20.)

RESULTS

TOF Profile

TOF account for almost half of the total treed area in the four-state region. According to the FIA inventory, the 2009 estimate of forest land for the four-state region was slightly more than 6.4 million acres (Miles 2015), while the GPI estimate of area with TOF was nearly 5.1 million acres (Fig. 3). In each of the states, the area of land associated with TOF was at least half the amount of that in forest land. The area of TOF land in North Dakota was almost equivalent to forest land area in that state.

The GPI estimate of total number of TOF in 2009 was nearly 458 million, with a gross volume of more than 4.2 billion cubic feet. A list of tree species found on GPI plots is available in the appendix. Nearly half (49 percent) of all TOF were less than 5 inches in diameter, and three-fourths were less than 9 inches in diameter (Fig. 4). The height distribution (Fig. 5) showed a similar pattern, with the majority of the trees (70 percent) having a height of 25 feet or less. However, larger diameter TOF (i.e., 15 inches d.b.h. or larger) made up two-thirds of the total volume.

TOF and Land Use

Agriculture accounted for over half of TOF-associated land use, with nearly 2.9 million acres (56 percent) of total TOF area being associated with agriculture. Agriculture was followed by other rural nonforest uses with 1.0 million acres (20 percent), and residential and rural home sites combined accounted for almost 900,000 acres (18 percent) of the area associated with TOF (Fig. 6). The breakdown varied by state, and not all land uses were observed in all states (Fig. 7). Kansas had no recorded TOF area in the marsh-wetland land use category, and Kansas and South Dakota had no TOF associated with golf courses. In Nebraska and North Dakota, TOF were found in all 12 land use categories.

[1] U.S. Forest Service. 2009. Great Plains Initiative inventory project: data collection procedures. Ver. 2.0. Unpublished paper on file with Dacia M. Meneguzzo.

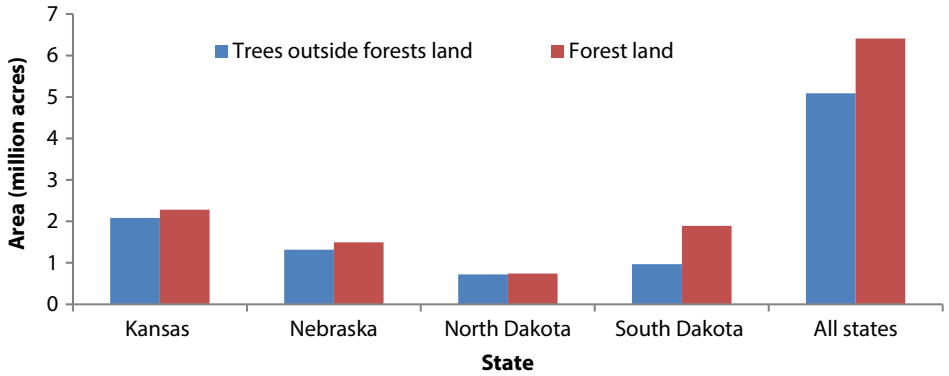

Figure 3.—Area estimates for FIA forest land and trees outside forests land by state and for Kansas, Nebraska, North Dakota, South Dakota combined, 2008-2009.

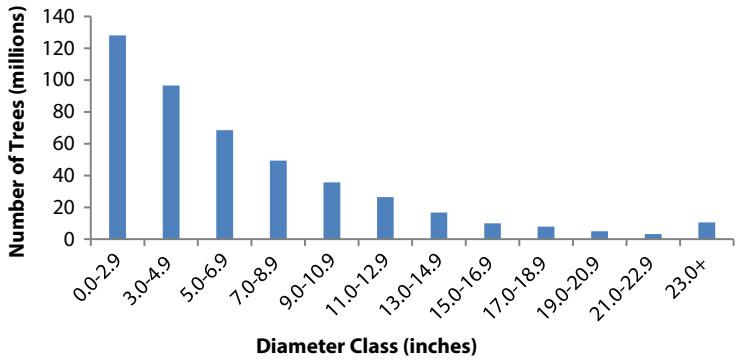

Figure 4.—Number of trees outside forests by diameter class, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

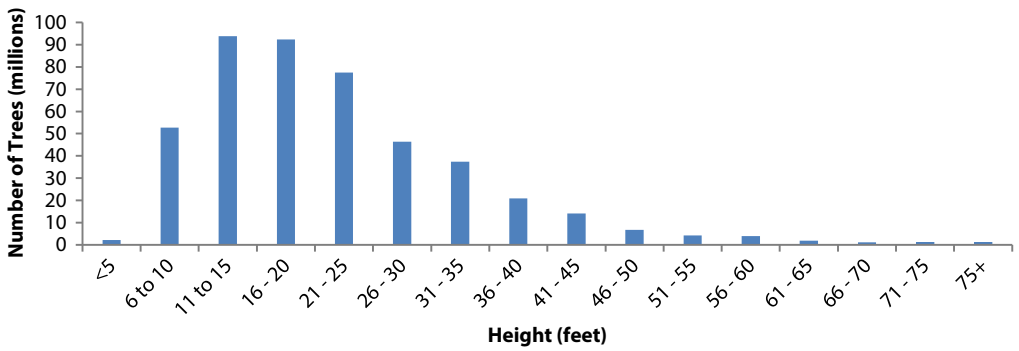

Figure 5.—Number of trees outside forests by height class, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

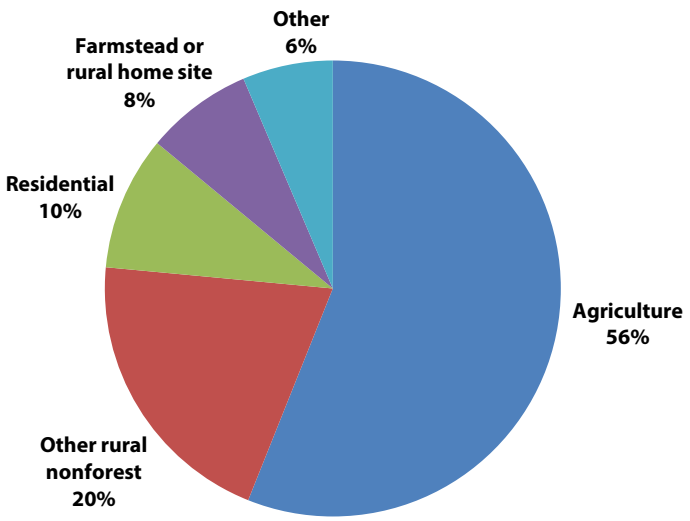

Figure 6.—Distribution of area of trees outside forests by most commonly associated GPI land use, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

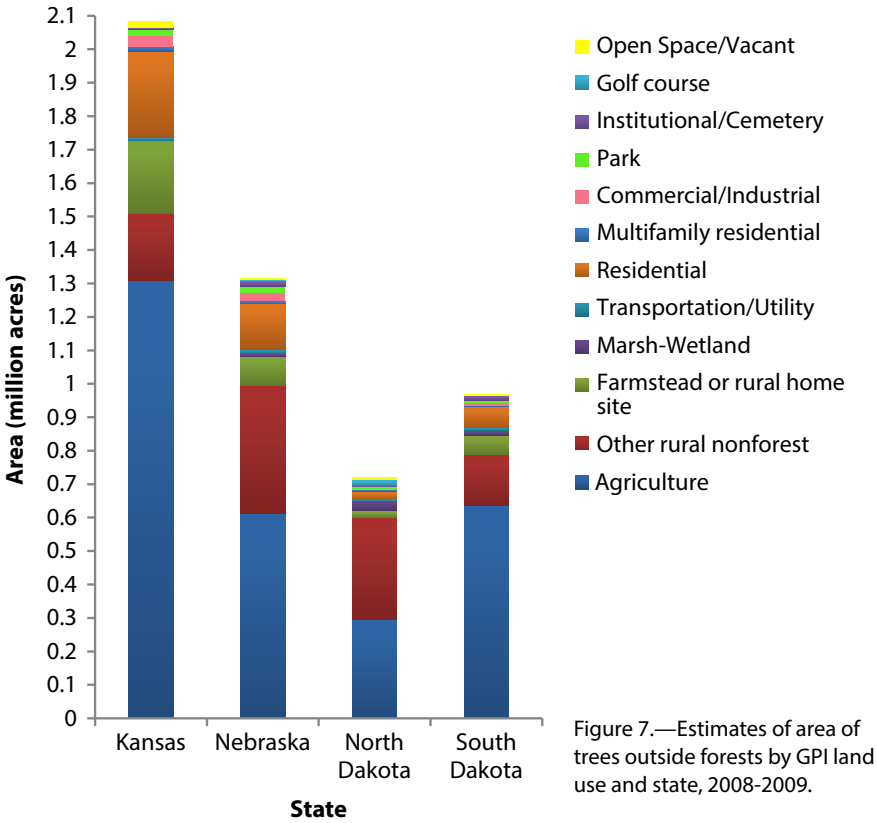

Figure 7.—Estimates of area of trees outside forests by GPI land use and state, 2008-2009.

TOF as Windbreaks

Often times TOF occur in distinct linear formations that serve some sort of windbreak function. Results showed that windbreaks made up over one-third of TOF-associated land area. TOF that were categorized as some type of windbreak (see Table 3) were also assigned condition and age variables. The remaining TOF that occur as individual trees or in loosely scattered formations were categorized as "windbreaks absent" and were not assigned function, condition, or age information. The distribution of these two TOF spatial pattern categories varied by state and for the region (Fig. 8). Overall, windbreaks occurred on more than 1.8 million acres (36 percent) of TOF lands in the region. The distribution ranged from 21 percent in Kansas to 62 percent in North Dakota.

Windbreak Functions

Agricultural windbreaks are the most common windbreak function, and TOF are often intentionally planted and arranged in patterns to perform various ecosystem functions. For example, a linear planting of trees along a field boundary to protect it from prevailing winds serves as a field windbreak. Ecosystem functions were recorded for TOF formations that met the windbreak criteria.

A detailed description of the distribution of TOF windbreak functions in the four-state region (Fig. 9) and in each state individually (Fig. 10) showed that not all functions were found in all states, and the area of TOF by function varied as well. Nebraska was the only state where planted riparian buffers were observed, while South Dakota was the only state with TOF recorded as serving primarily as living snow fences. Plots in Kansas did not include TOF windbreaks on abandoned farmsteads, while those in North Dakota had no TOF windbreaks whose primary function was wildlife habitat.

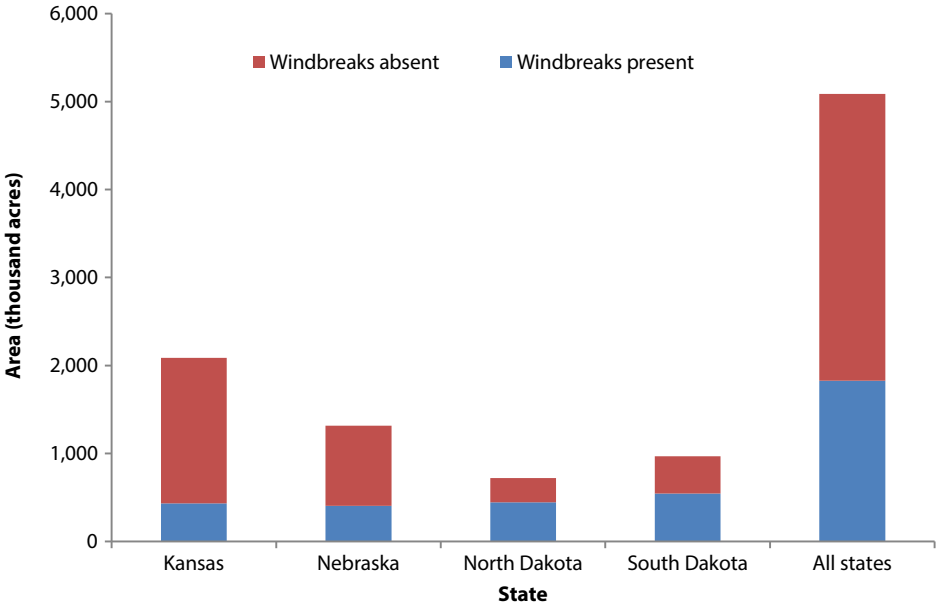

Figure 8.—Area of land associated with trees outside forests by windbreak presence/absence and state, 2008-2009.

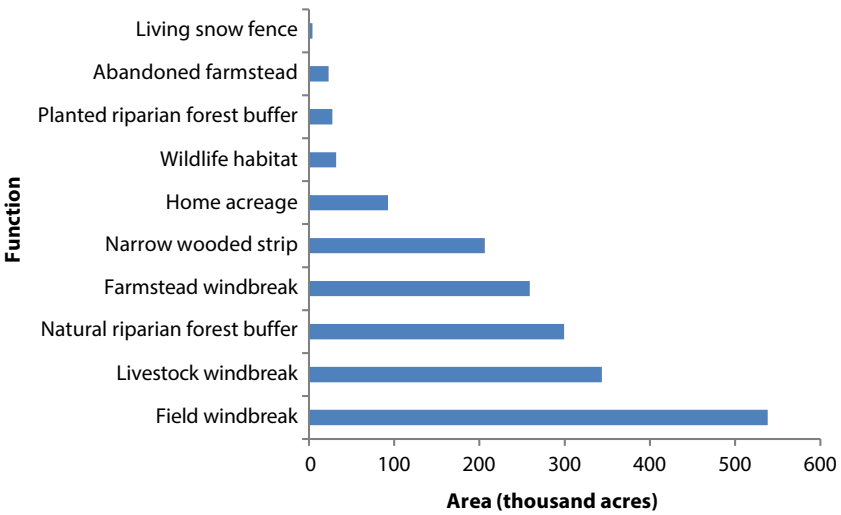

Figure 9.—Area of windbreaks by primary function, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

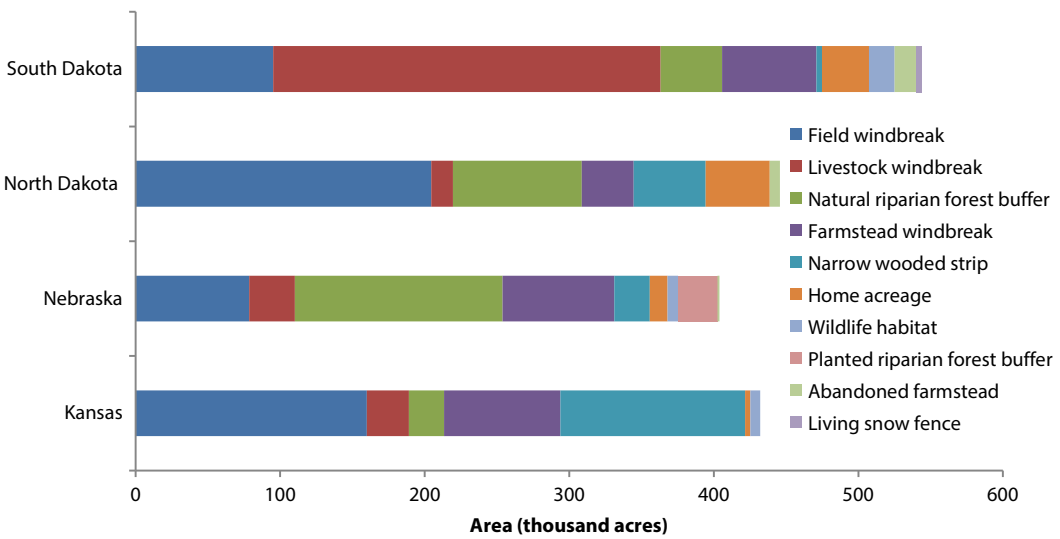

Figure 10.—Area of windbreaks by primary function and state, 2008-2009.

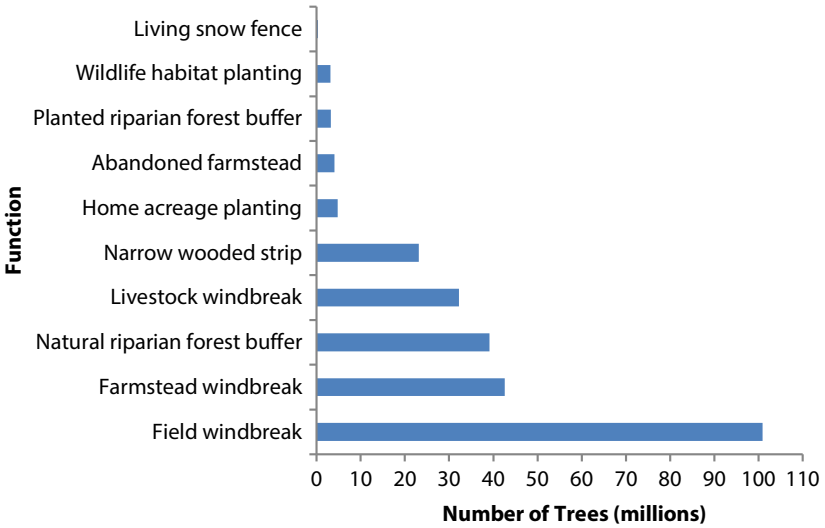

Figure 11.—Number of windbreak trees by function, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

The estimated total number of TOF for the four-state region was nearly 458 million, with more than half (55 percent) of the trees occurring in windbreaks (Fig. 11). While the actual land area of non-windbreak TOF may be larger than that of windbreak TOF formations, windbreak areas contain more trees due to their more dense and compact arrangements. The types of tree species planted in windbreaks can impact density as well.

Example of a field windbreak that also serves as a living snow fence. Photo by Dacia Meneguzzo, U.S. Forest Service.

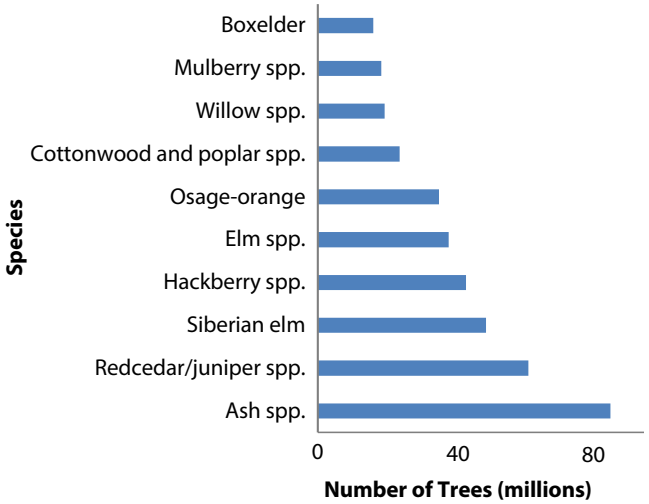

Figure 12.—Ten most prevalent species of trees outside forests by number, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

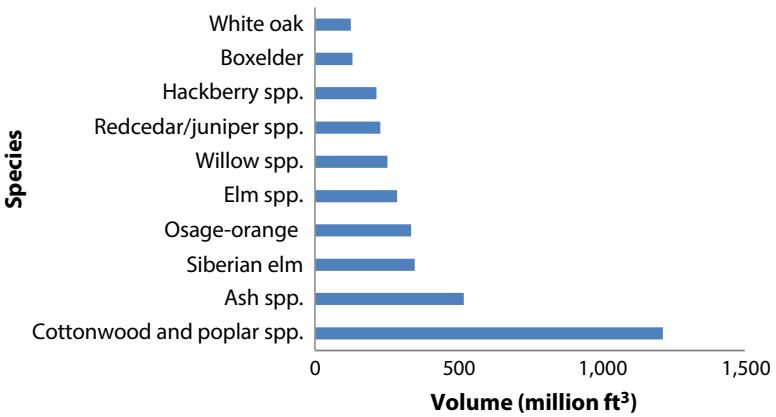

Figure 13.—Distribution of gross volume of trees outside forests by species in Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

Species Composition of TOF

Given the potential threat of invasive pests, it is important to know the species composition of TOF. Maintaining or increasing species diversity is essential for future plantings because it can help prevent decimation of a particular species due to insects or diseases. Figures 12 and 13 show the 10 most prevalent TOF species by number and by gross volume in the four-state region. Ash spp.[2] are the most numerous species in this region and rank second in gross volume.

The 10 most prevalent TOF species by number in Kansas, Nebraska, North Dakota, and South Dakota varied by state (Figs. 14-17). In North and South Dakota, the total number of ash trees represent a higher proportion of the 10 most prevalent species than they do in Kansas or Nebraska. The prevalence of ash in this region is a concern because EAB has already been discovered in Nebraska and Kansas and has the potential to become a serious threat in North Dakota and South Dakota since ash is the most numerous species in both states (Figs. 16 and 17).

[2] Scientific names of trees species are listed in the appendix.

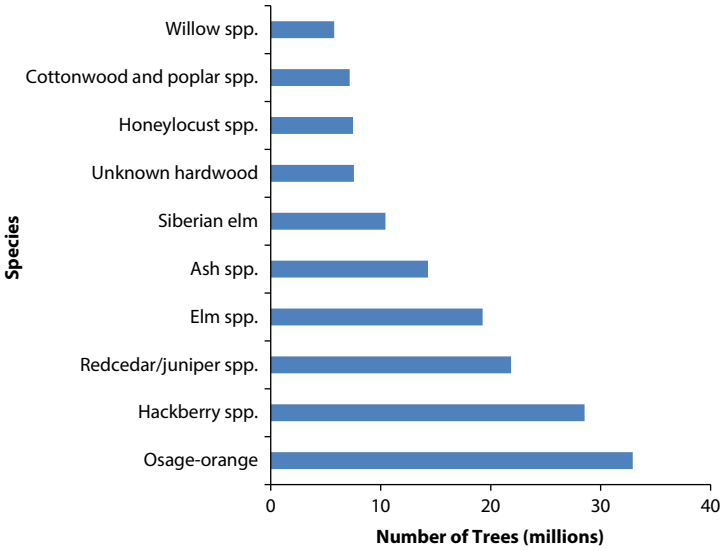

Figure 14.—Ten most prevalent species of trees outside forests by number, Kansas, 2008-2009.

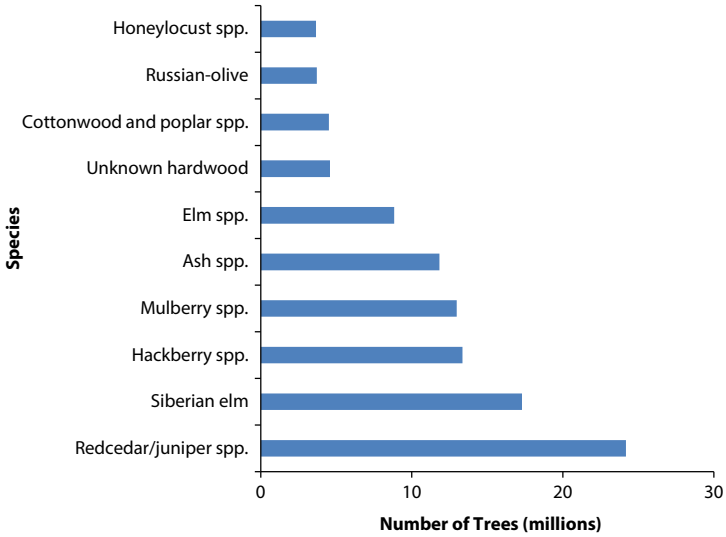

Figure 15.—Ten most prevalent species of trees outside forests by number, Nebraska, 2008-2009.

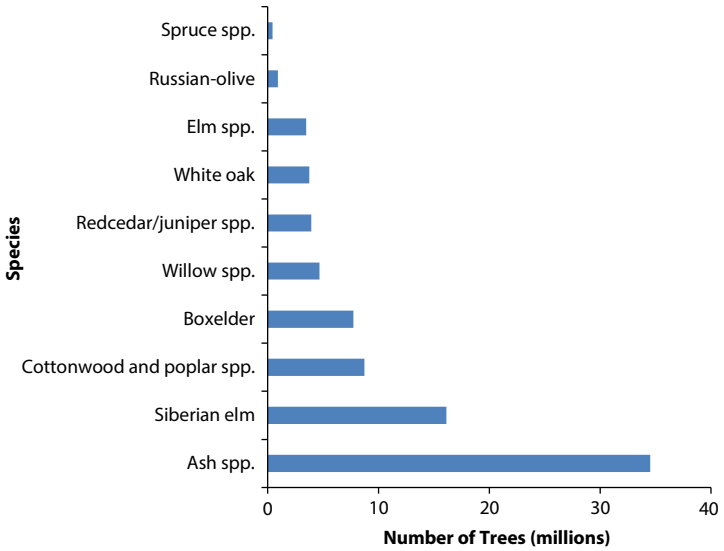

Figure 16.—Ten most prevalent species of trees outside forests by number, North Dakota, 2008-2009.

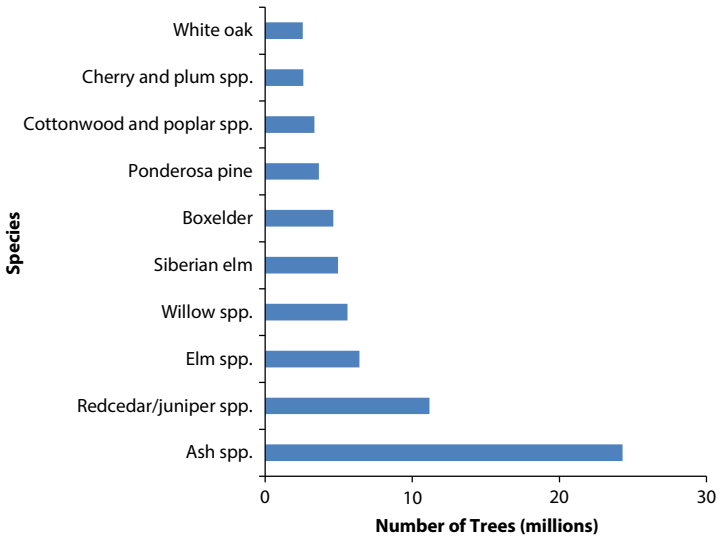

Figure 17.—Ten most prevalent species of trees outside forests by number, South Dakota, 2008-2009.

Particular tree species may be more commonly associated with certain TOF functions. The five most common tree species by number that occurred on TOF land with the most common windbreak functions were determined for the four-state region (Figs. 18-22). Ash spp. were among the top five species for all of the common windbreak functions but were most prevalent in natural riparian buffers (Fig. 20) followed by narrow wooded strips (Fig. 22). The living snow fence function was only recorded in South Dakota and was composed of 80 percent hackberry species and 20 percent green ash species. Planted riparian buffers were only recorded in Nebraska and were 100 percent eastern redcedar/juniper spp.

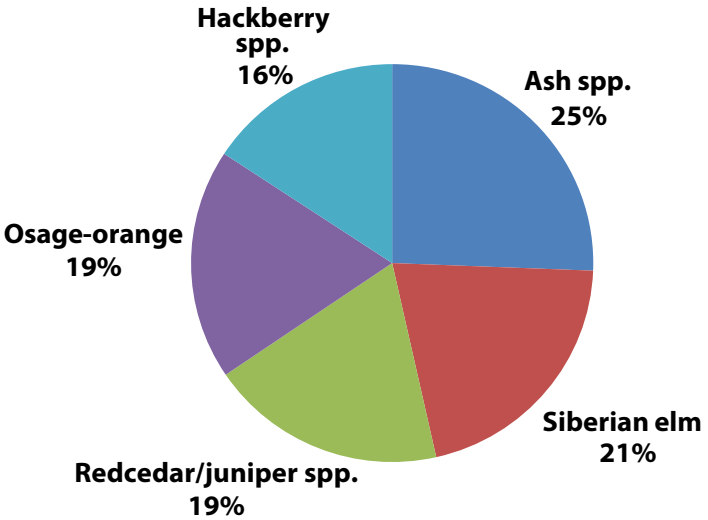

Figure 18.—Distribution of the five most common species of trees outside forests by number in field windbreaks, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

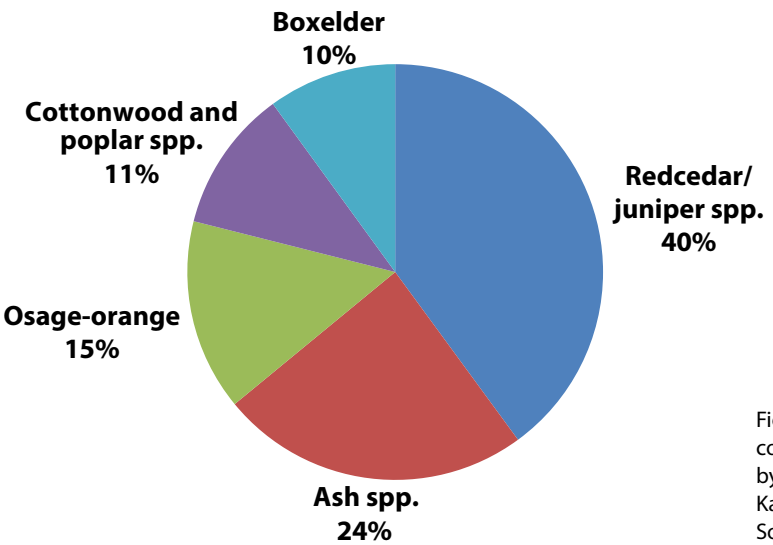

Figure 19.—Distribution of the five most common species of trees outside forests by number in livestock windbreaks, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

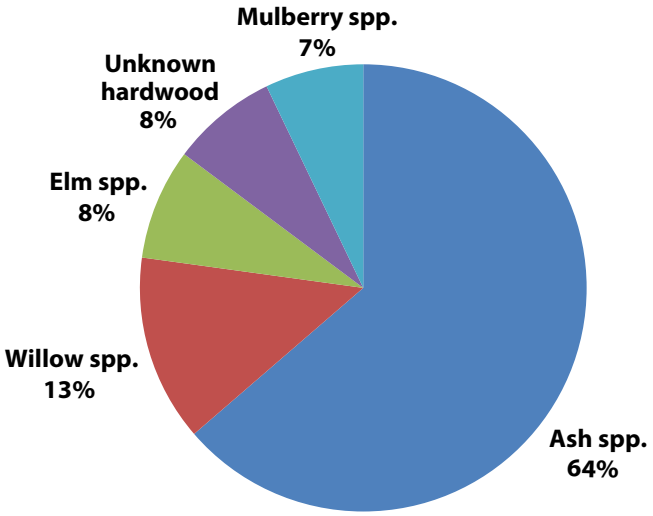

Figure 20.—Distribution of the five most common species of trees outside forests by number in natural riparian buffers, Kansas, Nebraska, North Dakota, and South Dakota, 2008-2009.

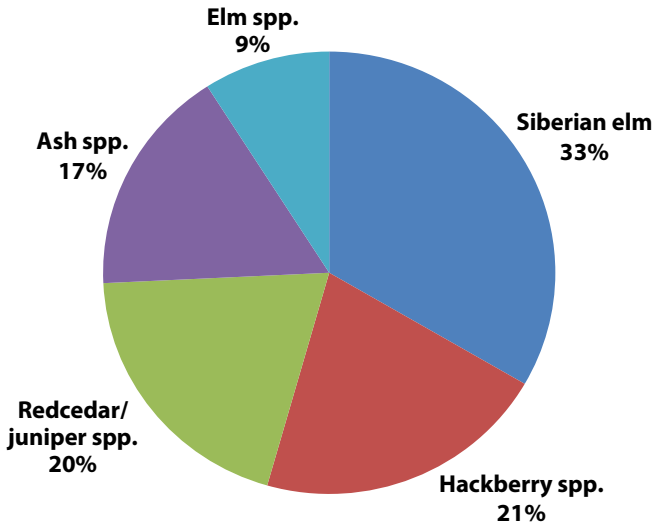

Figure 21.—Distribution of the five most common species of trees outside forests by number in farmstead windbreaks, Kansas, Nebraska, North Dakota, and South Dakota, 2008-2009.

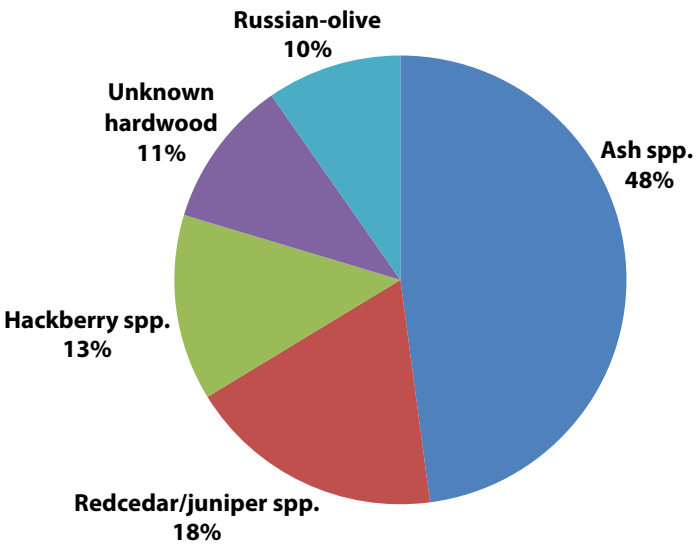

Figure 22.—Distribution of the five most common species of trees outside forests by number in narrow wooded strips, Kansas, Nebraska, North Dakota, and South Dakota, 2008-2009.

Windbreak Condition

Windbreak condition was recorded on an estimated 1.8 million acres of windbreaks in order to assess renovation needs. Of the total windbreak area in the region, nearly half was in fair condition and nearly three-fourths was in either fair or poor condition (Fig. 23). The proportion of windbreak area in good, fair, and poor condition varied depending on the windbreak function (Fig. 24). This information can help guide windbreak renovation efforts.

The proportion of windbreak area in good, fair, and poor condition also varied by state (Fig. 25). The majority of the windbreak TOF area was in fair condition in North Dakota and South Dakota. The distribution of windbreak condition varied by windbreak function within each of the four states (Fig. 26-29).

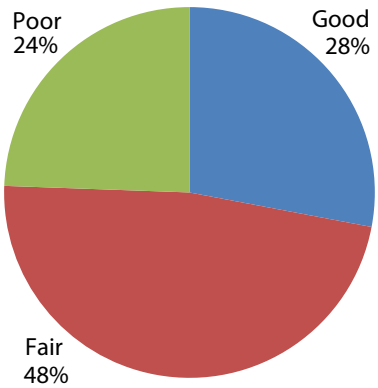

Figure 23.—Distribution of windbreak area by condition, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

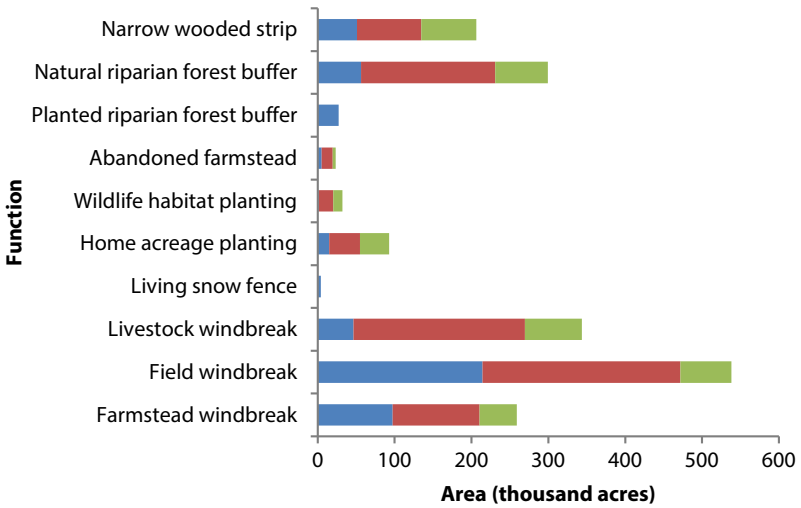

Figure 24.—Distribution of windbreak area by function and condition, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

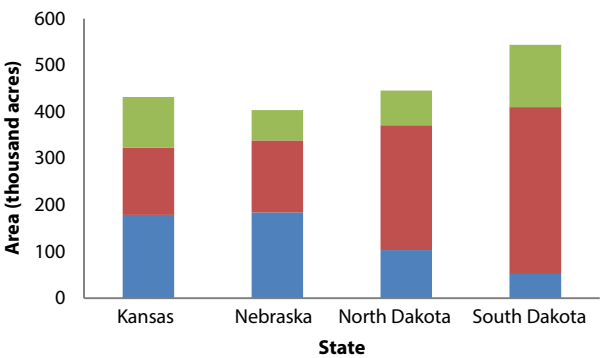

Figure 25.—Distribution of windbreak area by state and condition, 2008-2009.

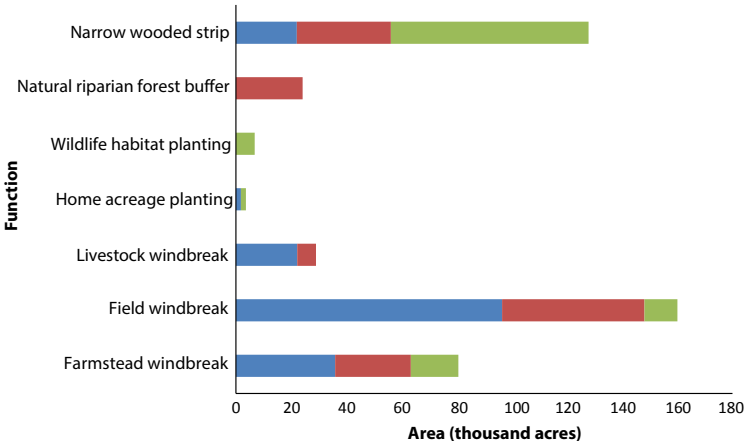

Figure 26.—Distribution of windbreak area by function and condition, Kansas, 2008-2009.

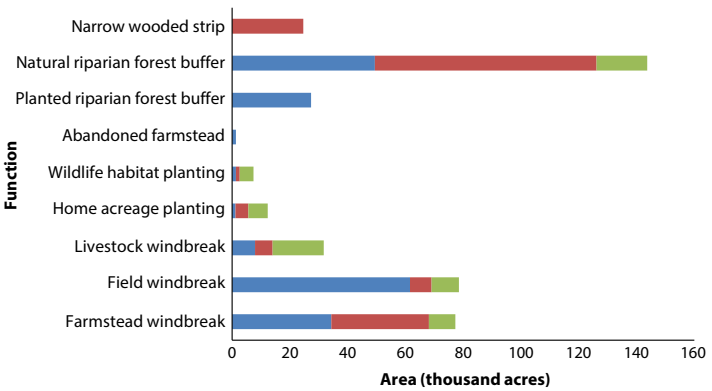

Figure 27.—Distribution of windbreak area by function and condition, Nebraska, 2008-2009.

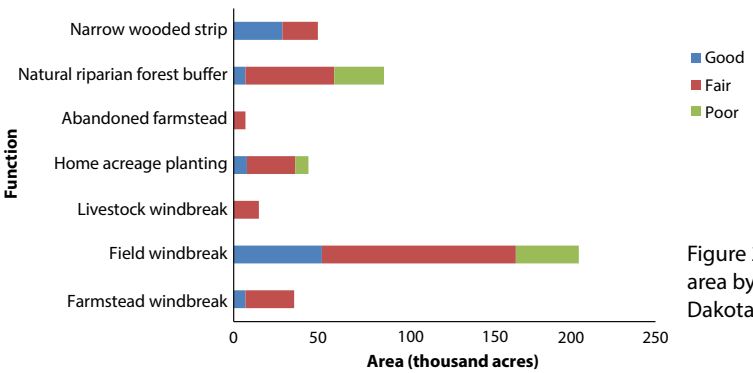

Figure 28.—Distribution of windbreak area by function and condition, North Dakota, 2008-2009.

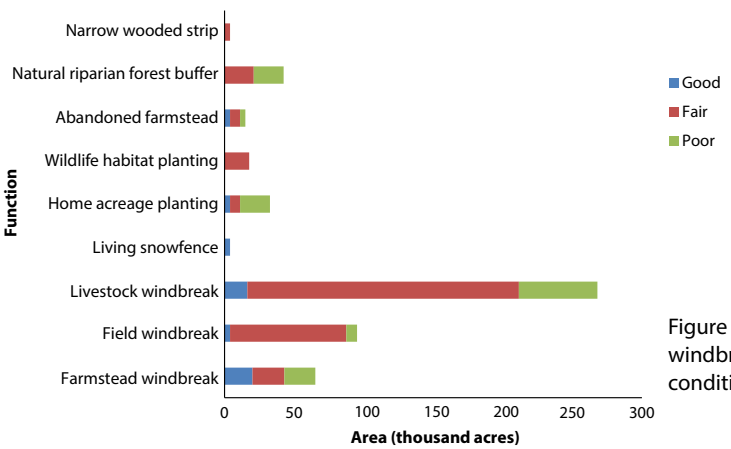

Figure 29.—Distribution of windbreak area by function and condition, South Dakota, 2008-2009.

Of the 457.7 million TOF across the four-state region, 253.6 million (55 percent) are part of windbreaks; approximately 90 percent those trees fall within windbreaks that are in fair or good condition (Fig. 30). The proportion of the total number of trees within each windbreak condition varies by state (Fig. 31) and by species (Fig. 32).

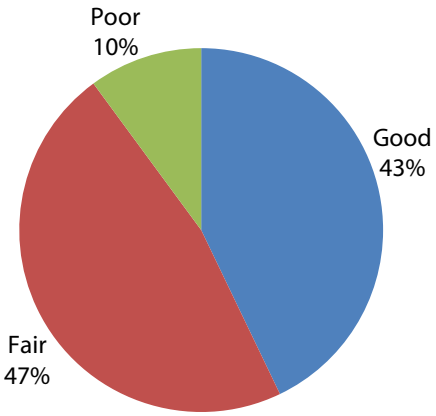

Figure 30.—Distribution of number of windbreak trees by condition, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

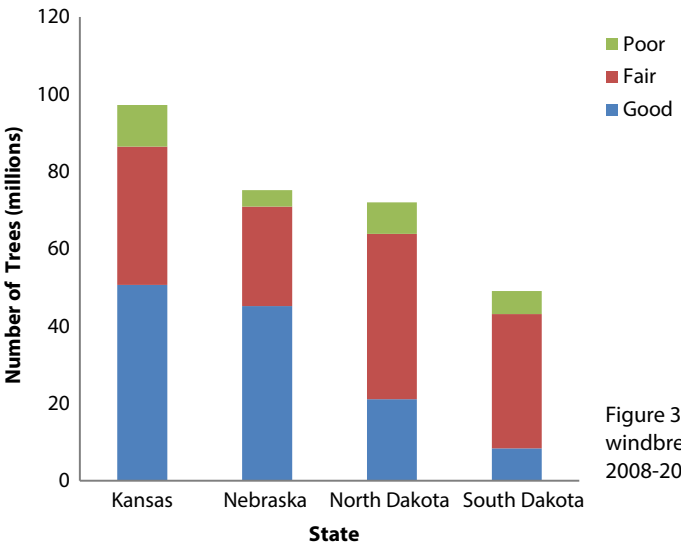

Figure 31.—Distribution of number of windbreak trees by state and condition, 2008-2009.

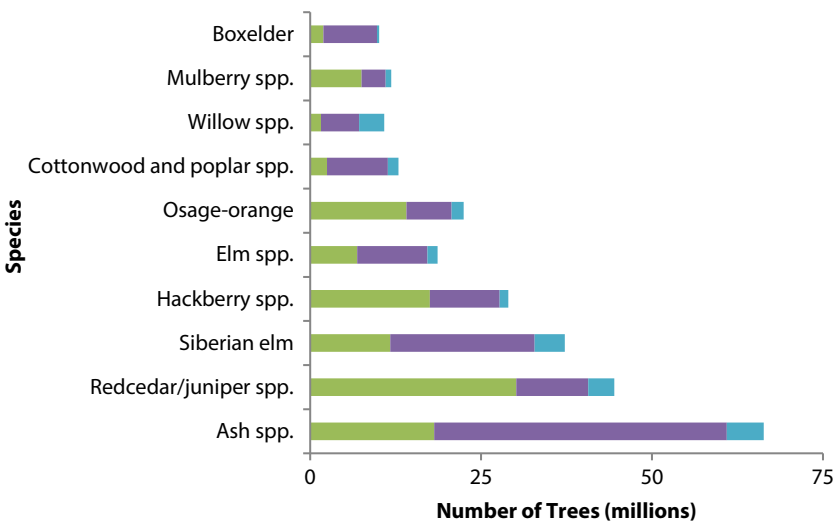

Figure 32.—Distribution by condition of the 10 most common species of trees outside forests by number in windbreaks in Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

Windbreak Age

Windbreak age refers to the average age of the tree function and is used to determine renovation needs. In the four-state region, most windbreaks were in the 25-50 year age group (Fig. 33) whether they occurred naturally or were planted (Fig. 34), but the distribution of windbreak age varied by state (Fig. 35). Overall, older trees occurred more frequently in artificially regenerated stands compared to those that occurred naturally (Fig. 34). The youngest grouping (<25 years old) also contained the fewest number of trees, indicating that windbreaks are aging and fewer young trees are serving windbreak functions. The majority of the youngest windbreaks were found in Kansas while most of the oldest windbreaks were found in South Dakota. Figures 36-40 break down the distribution of windbreak area by function and age for the region and each state.

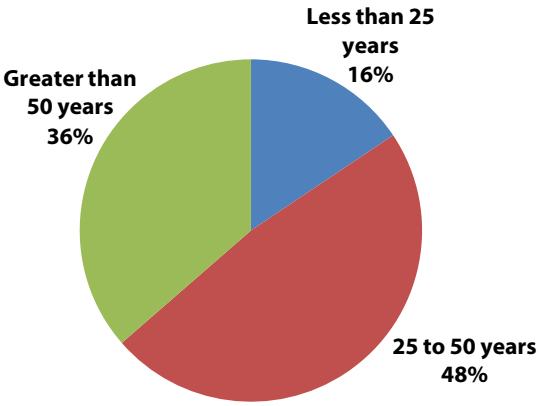

Figure 33.—Distribution of windbreak area by age, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

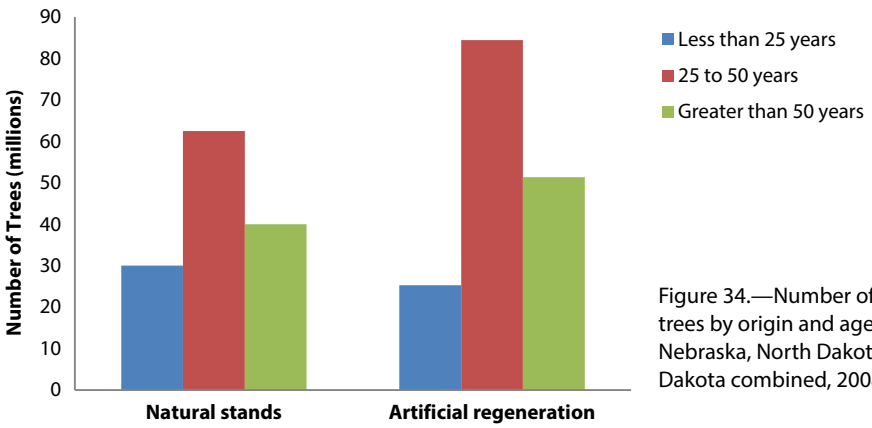

Figure 34.—Number of windbreak trees by origin and age in Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

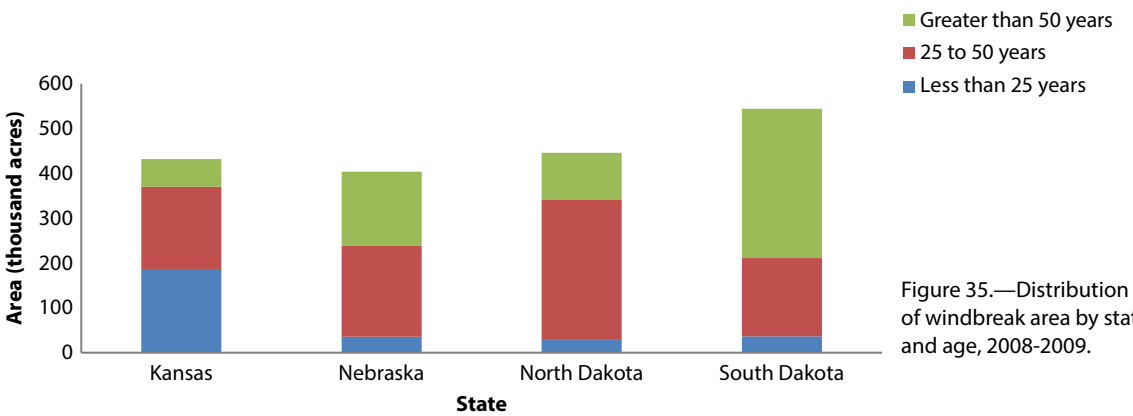

Figure 35.—Distribution of windbreak area by state and age, 2008-2009.

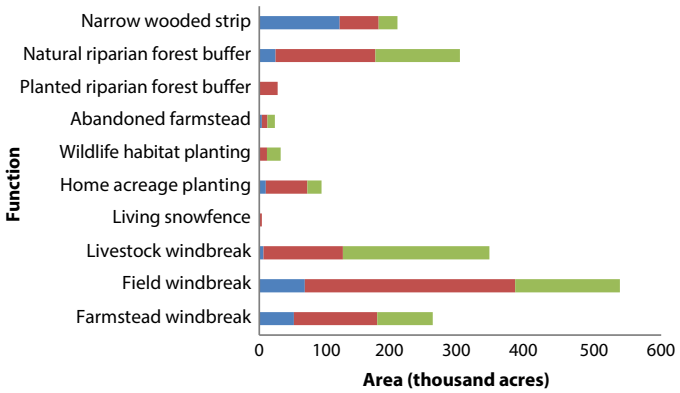

Figure 36.—Distribution of windbreak area by function and age, Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

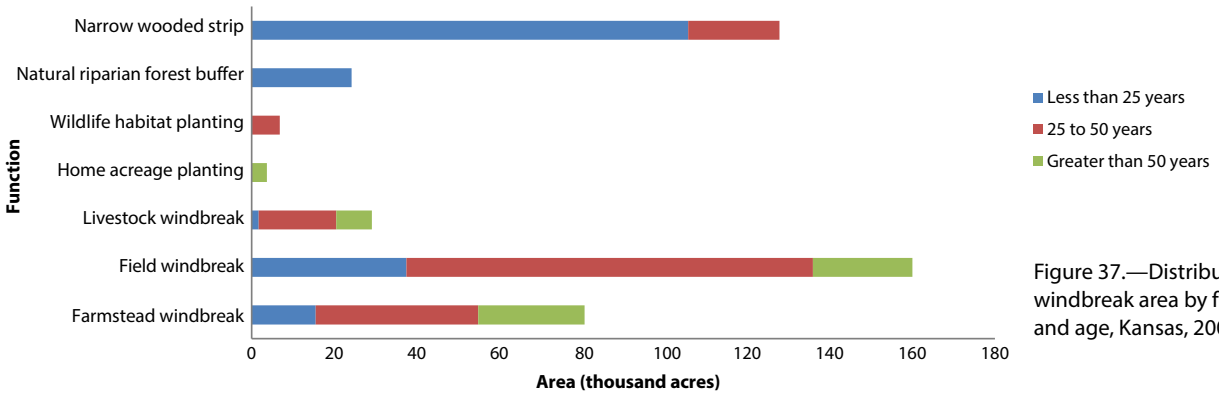

Figure 37.—Distribution of windbreak area by function and age, Kansas, 2008-2009.

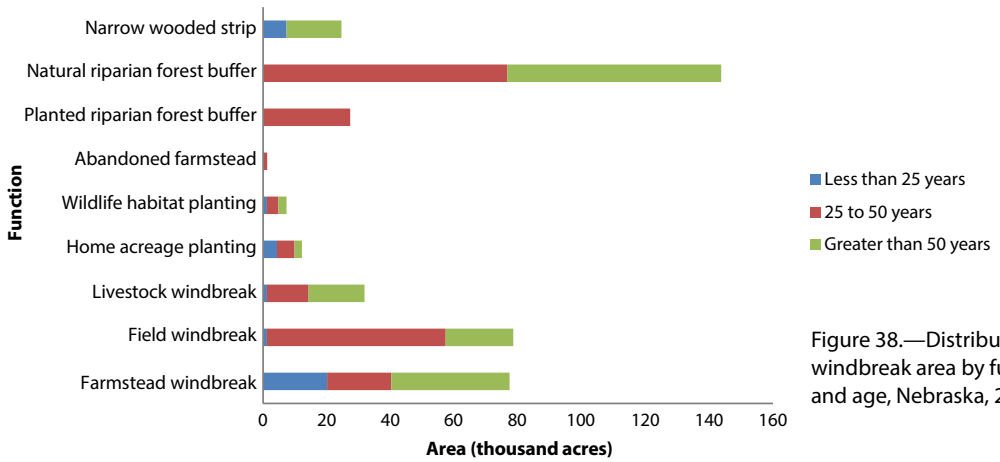

Figure 38.—Distribution of windbreak area by function and age, Nebraska, 2008-2009.

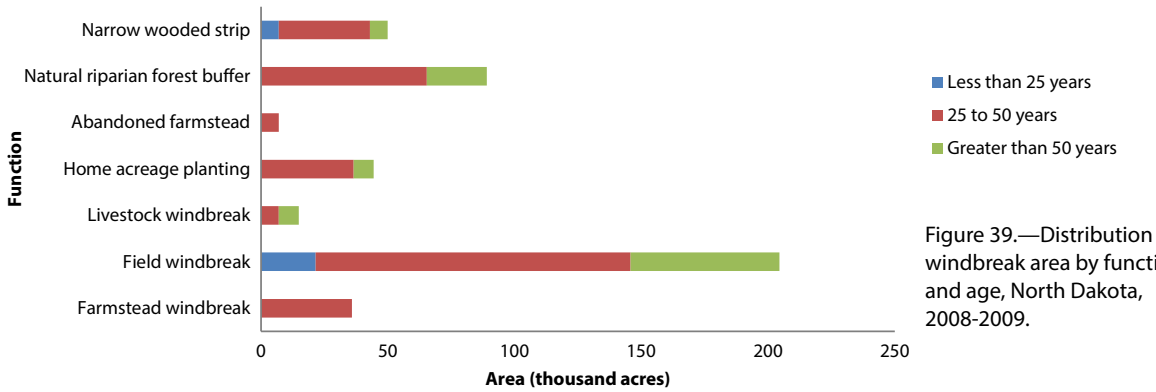

Figure 39.—Distribution of windbreak area by function and age, North Dakota, 2008-2009.

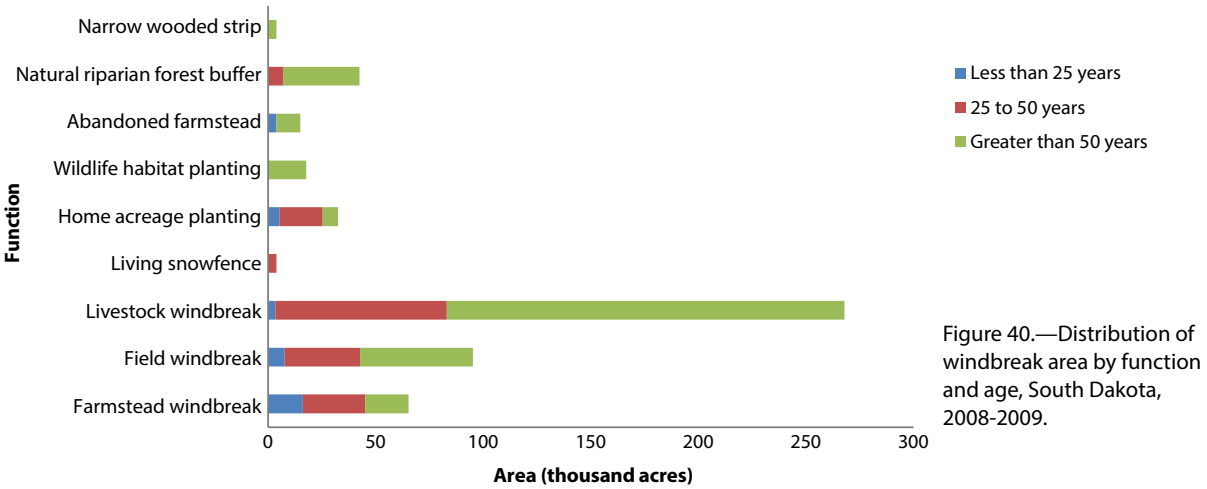

Figure 40.—Distribution of windbreak area by function and age, South Dakota, 2008-2009.

Natural vs. Artificial Stand Origin

In terms of origin, 57 percent of all TOF in the region grew naturally, while the remaining 43 percent were planted. The top five most commonly planted species by number were eastern redcedar/juniper spp., Siberian elm, ash spp., hackberry spp., and Osage-orange. These species accounted for 69 percent of all artificially regenerated trees. Ash spp. were the most numerous in naturally regenerated TOF lands, accounting for nearly one-fourth (23 percent) of the trees in such areas, followed by eastern redcedar/juniper spp., elm spp., hackberry spp., willow spp., and cottonwood and poplar spp. Selecting tree species for planting is an important consideration given threats such as EAB. Figures 41-44 show the top five most commonly planted tree species in each state. Interestingly, Ball et al. (2007) showed that green ash is the most commonly planted street tree in South Dakota, which is consistent with the GPI results.

Ownership of Lands with TOF

The overwhelming majority (92 percent) of TOF by number occurred on private land, and distributions were found to be similar in each of the individual states. Based on total number of TOF, ash spp. and eastern redcedar were the two most commonly occurring species by number overall on both public and private lands, but the most common species varied by state (Table 6). (Tables begin on page 20.)

Urban vs. Rural TOF

Given the predominance of rural lands in the states inventoried, it was not surprising that most TOF (86 percent) were found in rural settings. Species diversity varied in rural versus urban areas. Ash spp., redcedar/juniper spp., Siberian elm, hackberry spp., Osage-orange, and other elm spp. were the most commonly occurring species on rural land (Fig. 45). In urban settings, elm spp., hackberry spp., unknown hardwoods, ash spp., redcedar/juniper spp., and Siberian elm were the most common species (Fig. 46). Most of the area of TOF (87 percent) was associated with low population densities, with only 13 percent associated with population densities of 31 people or more per square mile (Fig. 47).

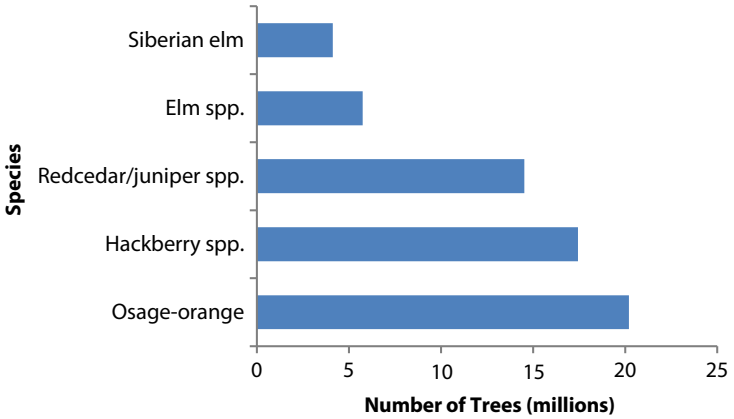

Figure 41.—The most common species of trees outside forests by number in stands that were planted, Kansas, 2008-2009.

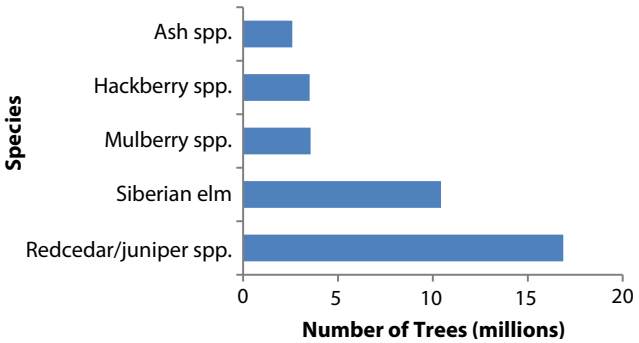

Figure 42.—The most common species of trees outside forests by number in stands that were planted, Nebraska, 2008-2009.

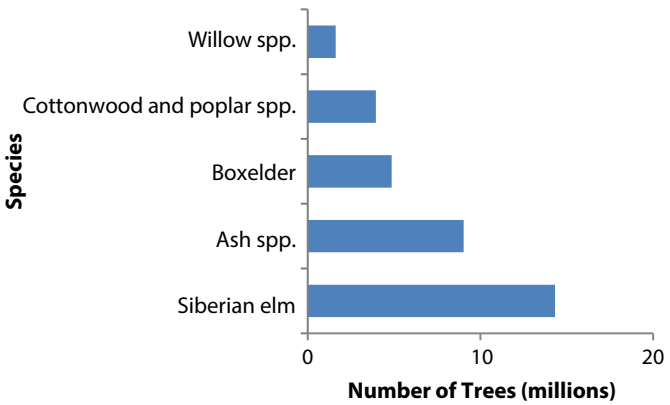

Figure 43.—The most common species of trees outside forests by number in stands that were planted, North Dakota, 2008-2009.

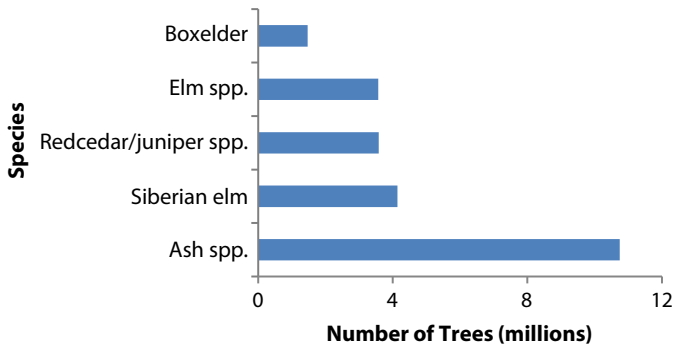

Figure 44.—The most common species of trees outside forests by number in stands that were planted, South Dakota, 2008-2009.

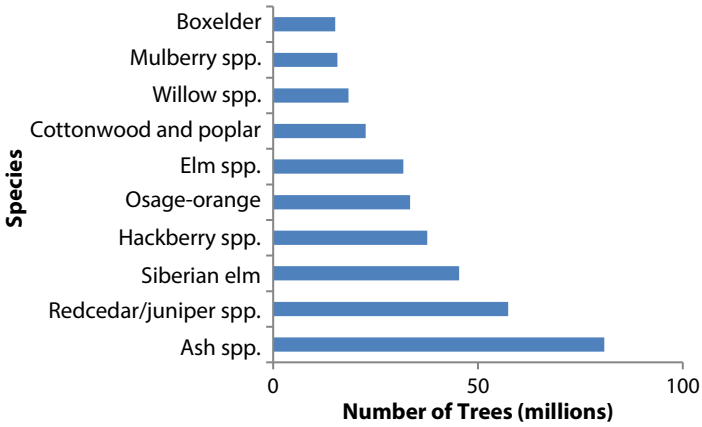

Figure 45.—Ten most common species of trees outside forests by number in rural areas in Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

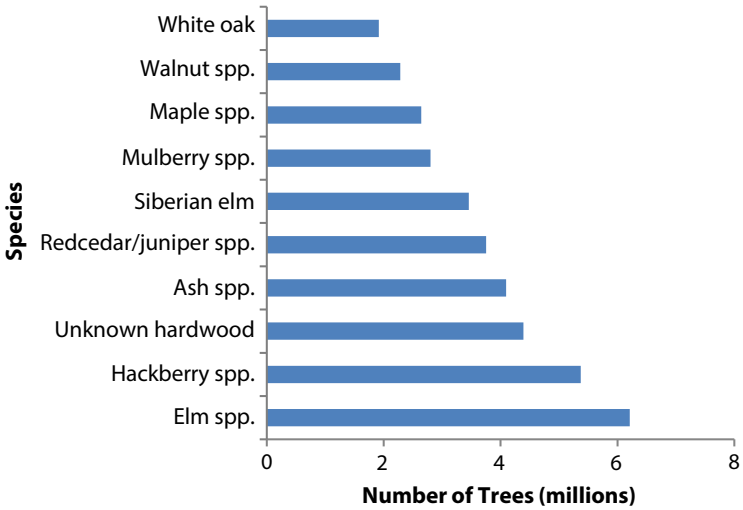

Figure 46.—Ten most common species of trees outside forests by number in urban areas in Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

Figure 47.—Area of land with trees outside forests by population density class in Kansas, Nebraska, North Dakota, and South Dakota combined, 2008-2009.

SUMMARY

The goal of the GPI was to inventory tree covered lands in rural and urban areas that do not qualify as forest land to obtain a more comprehensive assessment of the tree resource in the Great Plains region. Preparedness in terms of locating and quantifying the tree resources at risk of attack by invasive insects, primarily emerald ash borer, was the driving force behind this initiative. The GPI has provided valuable information regarding the vast tree resources that have not previously been inventoried across this four-state region. These data are essential for planning efforts to mitigate the potentially devastating effects of attacks by invasive pests. The primary outcomes were increased public awareness and the preparation of action plans pending the arrival of EAB, which was in fact discovered in Nebraska and Kansas after the GPI was completed. Trees play an important role in people's lives in both rural and urban settings. It is important that natural resource managers have the data they need to guide the planning and sustainability efforts necessary to maintain the tree resource in this region in the future.

ACKNOWLEDGMENTS

This project was funded, in part, by the natural resources agencies of the Great Plains region: Kansas Forest Service; Nebraska Forest Service; North Dakota Forest Service; and South Dakota Department of Agriculture, Division of Resource Conservation & Forestry. We thank our many partners from these agencies who were instrumental in helping lead, manage, and implement the project, including Steve Rasmussen, Bob Atchison, Coe Foss, Tim McDonnell, and Tom Claeys. We also thank James Blehm, Jay Solomakos, Katherine Johnson, Pat Miles, Steve Evans, Charles Scott, Doug Griffith, Dan Kaisershot, Cassandra Olson, and the many other FIA employees who helped with the design, implementation, and analysis of the GPI.

LITERATURE CITED

Ball, J.; Mason, S.; Kiesz, A.; McCormick, D.; Brown, C. 2007. **Assessing the hazard of emerald ash borer and other exotic stressors to community forests.** Arboriculture & Urban Forestry. 33(5): 350-359.

Lister, A.J.; Scott, C.T.; Rasmussen, S. 2012. **Inventory methods for trees in nonforest areas in the Great Plains states.** Environmental Monitoring and Assessment. 184(4): 2465-2474. https://doi.org/10.1007/s10661-011-2131-6.

Miles, P.D. 2015. **Forest Inventory EVALIDator Web-application, ver. 1.6.0.03**. [Online only]. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Northern Research Station. Available at http://apps.fs.fed.us/Evalidator/evalidator.jsp (accessed December 3, 2017).

Perry, C.H.; Woodall, C.W.; Liknes, G.C.; Schoeneberger, M.M. 2009. **Filling the gap: improving estimates of working tree resources in agricultural landscapes.** Agroforestry Systems. 75: 91-101. https://doi.org/10.1007/s10457-008-9125-6.

Robertson, G.; Mason, A., eds. 2016. **Assessing the sustainability of agricultural and urban forests in the United States.** FS-1067. Washington, DC: U.S. Department of Agriculture, Forest Service. 75 p.

Tiner, R.W. 1997. **Technical aspects of wetlands: wetland definitions and classifications in the United States.** In: U.S. Geological Survey. National Water Summary on Wetland Resources. WSP 2425. https://water.usgs.gov/nwsum/WSP2425/definitions.html (accessed December 3, 2017).

Table 1.—GPI land use categories and descriptions (adapted from GPI field guide)

Code	GPI Land Use
1	Accessible Forest Land—To qualify as forest land, the condition must be at least 1.0 acre in size and 120.0 feet wide (must maintain 120.0 feet by 363.0 feet wide measured stem-to-stem from the outer-most edge to equal an acre). Do not tally trees for GPI land use code 1 unless plot type is 2 (urban).
2	Agriculture—Cultivated cropland, grazed pasture (with livestock evidence), orchards, vineyards, nurseries, farmsteads and related buildings, feed lots, rangeland, timberland/plantations that show evidence of management activity for a specific crop or tree production. Mowed hayfields and fields with perennial plants like alfalfa quality.
3	Other Rural Nonforest—Idle farmland (not tended within last 2 years and stocking <10%); windbreaks (used for protection of building); shelterbelts (used for protection of soil and crop fields). Riparian buffers, wooded strips, unmanaged grounds (no grazing or other crops harvested) with isolated trees.
4	Farmstead or Rural Home Site—Farmsteads, ranch headquarters, yards and landscape trees close to lived-in buildings, and related buildings that utilize energy sources. Plot center is <100 feet from an inhabited home and related buildings.
5	Marsh/Wetland—Areas subjected to periodic tidal flooding or other areas where water is present for extended periods during the growing season and for longer periods during the nongrowing season. Water usually comes from rainfall, snowmelt, a rising water table, groundwater seepage, or incoming tides. Water may be present on the surface of wetlands for varying periods, as in flooded or ponded wetlands, or it may simply keep the underlying soils saturated near the surface with no surface water present. Wetlands include bogs, marshes, salt marshes, swamps, meadows, and fens (Tiner 1997). Bogs are not always nonforest. Some tree species such as black spruce can adapt to bog conditions. If the stocking requirement is met, the land is considered forest land. The decision as to whether the land is productive or unproductive will be made by the field crews. Swamps are not always nonforest. Some tree species readily adapt to the swamp conditions. If the stocking requirement is met, the land is considered forest land. The decision of whether the land is productive or unproductive will be made by the field crews.
6	Water—Wide streams, rivers, lakes, and other water bodies (both natural and man-made). Small pools and fountains would be classified as adjacent land use.
7	Transportation/Utility—State and federal roadways, usually paved, with highway signs and related greenspace (such as interstate highways with on and off ramps; sometimes fenced); railroad stations, tracks, and yards; shipyards; airports; etc.; power generating facilities, sewage treatment facilities, covered and uncovered reservoirs, empty stormwater runoff/flood control channels/conduits. If plot center falls on any other type of road or associated median strip, plot is classified according to nearest adjacent land use. Not private ownership. County roads and town streets are not included.
8	Residential—One to four-family freestanding structures. For urban plots only.
9	Multifamily Residential—Structures containing greater than four residential units. For urban plots only.
10	Commercial/Industrial—Includes outdoor storage/staging areas as well as parking lots in downtown areas that are not connected with any institutional or residential use. For urban plots only.
11	Park—Can contain undeveloped (unmaintained) as well as developed portions. Likely not private ownership.
12	Institutional, Cemetery—Schools, hospitals/medical complexes, colleges, religious buildings, government buildings, etc. May contain small undeveloped (unmaintained) areas. Likely not private ownership.
13	Golf Course—Likely not private ownership.
14	Open Space/Vacant—Land has no apparent use; boarded up buildings and vacant structures are classified as the original designated use of the structure. For urban plots only.
15	In another country (or state)
16	Inaccessible—Any plot area within the sampled area that cannot be accessed because of a hazard or danger; for example cliffs, quarries, strip mines, illegal substance plantations, temporary high water, etc.
17	Denied Access—Any plot area within the sampled area to which access is denied by the legal owner, or to which an owner of the only reasonable route to the plot denies access.

Table 2.—Attribute data collected by field crews on the GPI plots (modified from Lister et al. 2012)

Type[a]	Attribute	Plot type[b]
Plot	GPS coordinates	U, R
Plot	Rural or urban plot	U, R
Condition	Primary land use[c]	U, R
Condition	Windbreak width (10-foot increments)	R
Condition	Windbreak condition[d]	R
Condition	Windbreak age	R
Condition	Planted vs. natural	U, R
Condition	Function of trees[e]	R
Condition	NFT land use present/absent	R
Condition	Canopy cover class	U
Condition	Owner group (private or federal/state/local)	U, R
Tree	Species	U, R
Tree	Diameter (1-inch increments)	U, R
Tree	Height to location of diameter measurement	U, R
Tree	Height to base of the live crown (5-foot increments)	U
Tree	Height to top of tree (5-foot increments)	U, R
Tree	Crown dimensions – perpendicular axis lengths (5-foot increments)	U
Tree	Foliage present/absent	U
Tree	Crown light exposure class	U
Tree	Crown dieback class	U, R
Tree	Distance and azimuth to three nearest buildings	U, R

[a]On each plot, different types of data were collected. Plot data characterize the entire plot area. Condition data characterize contiguous areas that are formed using land use delineation rules. Tree level data are collected on trees not found in conditions that would be classified by FIA as forest.

[b]U=Urban, R=Rural

[c]This attribute consists of 17 anthropic and natural classes and includes inaccessible and denied access areas (see Table 1).

[d]Good, fair, or poor based on criteria including percent live trees, windbreak completeness, density of trees, presence of invasives, evidence of diseases, presence of regeneration, and expected longevity (see Table 4).

[e]Tree planting functions include farmstead, field or livestock windbreak, living snow fence, home acreage planting, wildlife habitat planting, abandoned farmstead, planted riparian buffer, natural riparian forest buffer, or narrow wooded strip (see Table 3).

Table 3.—Function of trees recorded on rural plots in the GPI inventory (adapted from GPI field guide)

Code	Function
1	Farmstead or ranch headquarters windbreak—Planted or naturally growing trees in an organized area within 300 feet of farm or ranch buildings that are providing wind or snow protection.
2	Field windbreak—Planted or naturally growing trees forming a uniform and dense continuous protection at least 100 feet long next to a cultivated or previously cultivated agricultural field. These windbreaks give wind protection for crops and reduce soil erosion and drift snow across the fields. Owner is expected to provide some type of management for establishment or cleanup/ replacement if the trees are damaged.
3	Livestock windbreak—Planted or naturally growing trees forming protection for livestock (pens or in a pasture areas). Owner is expected to provide some type of management for establishment or cleanup/replacement if the trees are damaged.
4	Living snow fence—Planted or naturally growing trees along and parallel to a road or transportation route on the north or west sides of the road within 300 feet from the edge of the road. Owner is expected to provide some type of management for establishment or cleanup/ replacement if the trees are damaged.
5	Rural home acreage protection—Planted or naturally growing trees within 300 feet of a home (not farm or ranch) for energy savings, privacy, and property identity, usually close to a community or urban area.
6	Wildlife habitat trees—Planted trees (may or may not be in rows) or naturally growing organized grouping of trees with a diversity of shrubs, deciduous, and evergreen trees planted for wildlife.
7	Abandoned farmstead—Planted or naturally growing trees that at one time gave protection to the farmstead that is no longer active.
8	Planted riparian forest buffer—Planted trees along a water or other riparian resource.
9	Natural riparian forest buffer—Naturally occurring trees along a water or other riparian resource.
10	Narrow wooded strip—Natural woodlands that do not meet FIA criteria of being at least 1 acre in size and 120 foot wide, or with a density of at least 10%, and is not along a water resource (riparian forest buffer). Usually extending out from forestland. Codes 1-9 take precedence over this code.
11	Isolated tree resource—Individual volunteer trees in fence lines, or out in pastures, road ditches, or other odd locations, and without identifying features of a planned tree planting. These trees do not compose a consistent, uniform, or dense form (at least 100 feet length) for a windbreak determination. Scattered trees out in open areas and without any oriented use. Codes 1-9 take precedence over this code.

Table 4.—Description of tree function condition codes in the GPI inventory (adapted from GPI field guide)

Code	Description
1	Good—Less than 25 percent of trees are dead and at least five additional attributes[a] apply
2	Fair—Less than 25 percent of trees are dead and three to four additional attributes[a] apply
3	Poor—Less than four of the attributes[a] apply and /or more than 25 percent of the trees are dead

[a]Additional attributes include:

Continuous barrier, no gaps (missing trees)
Density of 50 percent or greater
No smooth bromegrass or fescue sod present
Majority of the tree crowns are healthy with less than 25 percent of the trees showing insect, disease, or herbicide damage
None to very little livestock activity in the planting
Tree regeneration is present
Trees are expected to live another 20 years

Table 5.—Tree function age codes and descriptions in the GPI inventory (adapted from GPI field guide)

Code	Description
1	Less than 25 years
2	25 to 50 years
3	Greater than 50 years

Table 6.—Most common species of trees outside forests on public and private land by state, 2008-2009

State	Public land	Private land
Kansas	Unknown hardwood/Elm spp.[a]	Osage-orange
Nebraska	Elm spp.	Eastern redcedar/juniper spp.
North Dakota	Ash spp.	Ash spp.
South Dakota	Ponderosa pine/willow spp.	Ash spp.
Four-state region	Ash spp.	Ash spp.

[a] Unknown hardwoods are the most common, followed by elm species

APPENDIX

Tree species found on GPI inventory plots, Kansas, Nebraska, North Dakota, and South Dakota, 2008-2009

Common Name	Genus	Species
Maple spp.	*Acer*	spp.
Boxelder maple	*Acer*	*negundo*
Silver maple	*Acer*	*saccharinum*
Birch spp.	*Betula*	spp.
Hackberry spp.	*Celtis*	spp.
Russian-olive	*Elaeagnus*	*angustifolia*
Ash spp.	Fraxinus	spp.
Honeylocust spp.	*Gleditsia*	spp.
Walnut spp.	*Juglans*	spp.
Redcedar, juniper spp.	*Juniperus*	spp.
Osage-orange	*Maclura*	*pomifera*
Apple spp.	*Malus*	spp.
Mulberry spp.	*Morus*	spp.
Spruce spp.	*Picea*	spp.
Pine spp.	*Pinus*	spp.
Ponderosa pine	*Pinus*	*ponderosa*
Scotch pine	*Pinus*	*sylvestris*
Austrian pine	*Pinus*	*nigra*
Cottonwood and poplar spp.	*Populus*	spp.
Fruit tree other than apple spp.	*Prunus*	spp.
Oak spp.	*Quercus*	spp.
White oak	*Quercus*	*alba*
Northern Red oak	*Quercus*	*rubra*
Willow spp.	*Salix*	spp.
Mountain ash spp.	*Sorbus*	spp.
Saltcedar	*Tamarix*	spp.
Basswood spp.	*Tilia*	spp.
Other evergreen (evergreen not listed above)	Tree	evergreen
Other hardwood (hardwood not listed above)	Tree	broadleaf
Elm spp.	*Ulmus*	spp.
Siberian elm	*Ulmus*	*pumila*

Meneguzzo, Dacia M.; Lister, Andrew J.; Sullivan, Cody. 2018. **Summary of findings from the Great Plains Tree and Forest Invasives Initiative.** Gen. Tech. Rep. NRS-GTR-177. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 24 p. https://doi.org/10.2737/NRS-GTR-177.

The Great Plains Tree and Forest Invasives Initiative (GPI) was a cooperative effort of the U.S. Forest Service and state forestry agencies in Kansas, Nebraska, North Dakota, and South Dakota, with a primary goal of evaluating the tree resources throughout the four-state region as a preparedness measure for the arrival of invasive pests, such as the emerald ash borer (*Agrilus planipennis* Fairmaire). The GPI assessed the characteristics of the resource known as trees outside forests (TOF), or trees that occur on lands that do not meet the Forest Inventory and Analysis (FIA) definition of forest land. Data, including tree number, species, diameter, height, canopy health, and windbreak function, were collected on 1/6 acre plots. Across the four-state region, TOF account for almost half of the total area of all tree resources. Forest land covers about 6.4 million acres, while land associated with TOF covers 5.1 million acres. Approximately 56 percent of the land use associated with TOF is agricultural. Over one-third (36 percent) of the acres and more than half (55 percent) of the trees identified as TOF function as windbreaks of some sort, with agricultural windbreaks being most common. Of the windbreaks, 72 percent are in poor to fair condition and 48 percent are between 25 and 50 years old. As the existing windbreaks continue to age, fewer young trees are filling the gap. Just over half of the trees (53 percent) on TOF lands occur naturally while the remainder have been planted, and 86 percent of TOF trees are located in rural areas. Many tree species are present in the four-state region, but ash trees (*Fraxinus* spp.), the emerald ash borer's target of choice, are the most prevalent. This information will help natural resource professionals plan conservation and restoration efforts.

KEY WORDS: trees outside forests, invasive pest, Great Plains, windbreaks, inventory

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