South Dakota Forest Action Plan

Section I:

Forest Resource Assessment

INTRODUCTION:

Forested land makes up less than 4% (1.95 million acres) of South Dakota's total land (Walters, 2015). However, the forests are a vital part of the state's ecosystem and environment. This section is an assessment of the existing forest resource and summarizes the extent and condition, values, threats, ownership, needs, problems, and opportunities by five major forest types. For this assessment the major forest types are:

- Coniferous
- Upland hardwood
- Bottomland
- Shelterbelts and windbreaks
- Urban and community forests

Analysis was performed to obtain forest areas, extents, ownership, and composition in two different ways. The graphs and tables that summarize areas and quantities were derived using United State Department of Agriculture Forest Inventory and Analysis data (FIA). The maps were created by RCF using Geographic Information Systems (GIS) with LANDFIRE Dataset from 2012. Data sources and layer construction methods used for the GIS analyses are covered in Section II of this Forest Action Plan.

The FIA data were accessed using multiple FIA online tools. One-seventh of forest plots in the FIA are surveyed each year; after seven years of surveying, the cycle starts again. All acreages given in this report, unless cited otherwise, were retrieved from FIA data using the 2018 survey year. A 2018 query will return a summary of the data from the previous seven-year period (Years 2011–2018) of the FIA survey rotation.

Because it is not feasible to sample and evaluate all of South Dakota's 1.95 million acres of forest land, the FIA process is to sample many small, widely spaced plots of different types of forest across the state and apply the resulting information to the entire forest. This methodology results in coarse estimates which, in some cases, contain a high level of error, as indicated by color on some of the following tables (i.e., red values indicate that percent sampling error is greater than 50%). However, the FIA program works to achieve a national precision standard of 3% error per million acres of timberland (Bechtold and Patterson, 2005).

When examining FIA results, one must also bear in mind that the geographic area occupied by a forest-type group, although often named after one or more major tree species, may contain many different tree species. For example, those unfamiliar with forestry classification might assume that the "cottonwood/willow" forest-type group implies that these are the only species within the forest. However, the bottomland area occupied by this forest-type group also may contain elm, ash, Eastern redcedar, Rocky Mountain juniper, Russian olive, and other woody plants. The white spruce classification in the FIA data refers to the population of Black Hills spruce as a variety of white spruce unique to the Black Hills (*Picea glauca var. densata*); the Black Hills spruce is the state tree of South Dakota. Also, some of the FIA forest-type groups list species that do not occur in South Dakota. Beech, yellow birch, and sugarberry are not found in the state. These species will be deleted from further listings in this document.

Other information in this report regarding forest values, threats, problems, needs, and opportunities was obtained through review of multiple documents, including many forest resource plans, fire management plans, forest reports, environmental impact statements, internet Web sites, and other sources of information.

1.0 CONIFEROUS FOREST

Figure 1.1 Ponderosa pine forest type near Custer, SD in the Black Hills (South Dakota Department of Agriculture, 2016)

1.1 DEFINITION

Coniferous forests are dominated by conifers – vascular plants that bear naked seeds. The seeds are arranged in cones, a characteristic which separates them from other gymnosperms. All cone-bearing trees have needles or scale-like leaves and are usually evergreens. Wood from these trees is known as "softwood." Boreal coniferous forests, the world's largest terrestrial biome, are spread over massive areas and are found predominantly at high altitudes or cooler climates in the northern hemisphere. Coniferous forests in South Dakota are found mostly in the Black Hills as ponderosa pine (Figure 1.1), Rocky Mountain juniper, and Black Hills spruce. Small patches of ponderosa pine, white spruce, Rocky Mountain juniper, and eastern redcedar occur in other parts of the state.

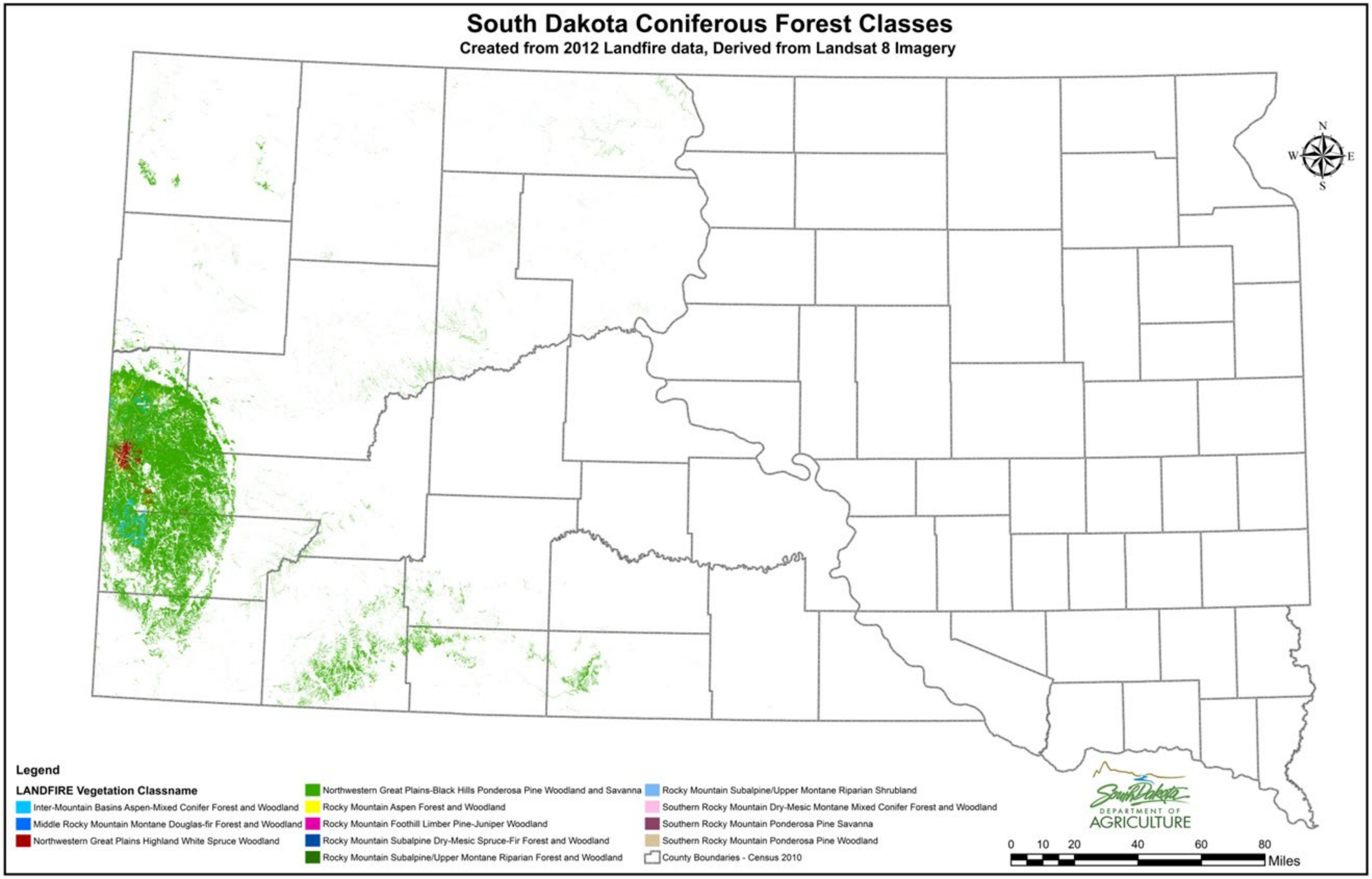


Figure 1.2 SD Coniferous Forest Lands (Map)

1.2 EXTENT AND CONDITION

Coniferous forests make up approximately 77%, or 1.49 million acres, of South Dakota's 1.95 million acres of forest land. Coniferous forest lands are shown in Figure 1.2.

Approximately 86% of South Dakota's coniferous forests are in the Black Hills, with 1.03 million acres of ponderosa pine, 77,000 acres of Black Hills spruce, and 133,000 acres of nonstocked forest land. The USDA's Forest Inventory Analysis (FIA) defines a nonstocked area as "… land that currently has less than 10 percent stocking but formerly met the definition of forest land. Forest conditions meeting this definition have few, if any, trees sampled (O'Connell et al, 2016).

Although the clear majority of South Dakota's nonstocked acres are within counties dominated by the ponderosa pine forest type, FIA has separated out nonstocked acres as a forest type on its own. For this assessment, nonstocked acreages are reported in with the coniferous forest types, although many acres of nonstocked could be associated with other forest types in the state. Nonstocked acres in the Black Hills are largely attributed to large-scale disturbance events such as the Jasper Fire that burned over 83,000 acres west of Custer in 2000, and the mountain pine beetle epidemic that has affected over 447,000 acres to varying degrees since 1996 (Allen, 2016). The Black Hills also contains small stands of lodgepole pine and limber pine.

According to the Landfire dataset from 2012, the coniferous forests in South Dakota are composed of 11 different ecological vegetation systems as listed in Table 1.1.

LANDFIRE Vegetation Classification System	**Acres**
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	24829.90
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	9.75
Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna	1373058.14
Northwestern Great Plains Highland White Spruce Woodland	27092.77
Rocky Mountain Foothill Limber Pine-Juniper Woodland	183.13
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	2.79
Rocky Mountain Subalpine/Upper Montane Riparian Forest and Woodland	344.69
Rocky Mountain Subalpine/Upper Montane Riparian Shrubland	71.25
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	19.48
Southern Rocky Mountain Ponderosa Pine Savanna	7.39
Southern Rocky Mountain Ponderosa Pine Woodland	979.27
TOTAL	1426598.56

Table 1.1 Coniferous Forest Vegetation Systems in SD (LANDFIRE, 2012)

The acreages listed are mapped using Landsat 8 imagery, and do not reflect the acreages reported in the FIA dataset. The "Rocky Mountain Aspen Forest and Woodland" vegetation system is not listed in the table but is found widely throughout the Black Hills. Due to it being dominated by species that are not coniferous it is included in the Upland Hardwoods section later in this assessment.

Outside of the Black Hills, other areas of mixed forest types (coniferous and deciduous) are present in Oglala Lakota, Butte, Jackson, Bennett, and Todd Counties. Ponderosa pine, Rocky Mountain juniper, and eastern redcedar are found on the Pine Ridge and Rosebud Indian Reservations as well as in Bennett and Jackson Counties. Harding County also has ponderosa stands in the Custer Gallatin National Forest and adjacent areas. Draws along the Cheyenne and Missouri Rivers are populated with Rocky Mountain juniper and eastern redcedar. Abandoned fields and pastures support eastern redcedar and Rocky Mountain juniper, with eastern redcedar dominating in eastern South Dakota and Rocky Mountain juniper dominating in the west. Both species are expanding their range, especially in the uplands along the Missouri River in south-central South Dakota (Piva et al. 2009). According to the USDA, FIA data, eastern redcedar has expanded by over 16,000 acres (30% of current acreage), and Rocky Mountain juniper as expanded by over 7,500 acres (11% of current acreage) since the previous forest action plan was published. These forest types are not identified in the Landfire maps depicted in Figure 1.2, as the eastern redcedar is considered a component of an upland hardwood forest type dominated by bur oak (*Quercus macrocarpa*), although in most of this vegetative classes range, eastern redcedar is the dominant tree. FIA data depicted in Table 1.2 shows nearly 57,000 acres of eastern redcedar forest type in South Dakota.

Forest type	Tree Age Classification (Acres)									
	Total	0-20 years	21-40 years	41-60 years	61-80 years	81-100 years	100-120 years	121-160 years	161-200 years	200+ years
White spruce	87,590	2,686	3,380	5,670	27,633	26,943	5,670	11,833	3,774	-
Eastern redcedar	56,859	-	8,693	26,366	15,371	6,429	-	-	-	-
Rocky Mountain juniper	73,914	5,963	5,706	17,857	27,871	10,889	2,815	2,815	-	-
Ponderosa pine	1,063,602	60,059	69,854	112,153	201,441	273,428	204,274	123,772	9,177	9,444
Total	1,281,965	68,708	87,633	162,046	272,316	317,689	212,759	138,420	12,951	9,444
Percent of Total	100%	5%	7%	13%	21%	25%	17%	11%	1%	1%

Table 1.2 Area of Coniferous Forest Type by Tree Age Class (Acres) (U.S. Department of Agriculture FIA, [2018a])

Individual tree size (Figure 1.5) is largely affected by site and other environmental factors, however, the stand-size class is closely correlated to age-class distribution, or stand age, as smaller trees tend to be younger with larger trees older (Piva et al. 2009). The age of a forest is important in determining regeneration, economic potential, suitability for a particular wildlife species, insect and disease susceptibility, and past disturbances such as fire (Piva et al. 2009). Coniferous forest age class in South Dakota is well distributed throughout the early mature and mature range with over 75% older than 60 years (Table 1.2 and Figure 1.4 [USDA 2018a)). Although ponderosa pines older than 700 years have been found in the Black Hills, very few specimens over 200 years of age exist. Nonstocked acreage is not represented in the table, but all the approximately 172,000 acres of nonstocked forestland statewide is under the 0-20-year age class.

Figure 1.3 Ponderosa Pine Regeneration in the Black Hills (SD Department of Agriculture, 2016)

The ponderosa pine in the Black Hills is known for its prolific regeneration (Figure 1.3). The species generate a large seed crop every three years. Germination of seed and establishment of seedlings occurs in the spring, which is the wettest time of year. The combination of approximate seed source, abundant seed production, and timely rainfall results in regeneration rates of several thousand seedlings per acre (Boldt and Van Deusen, 1974).

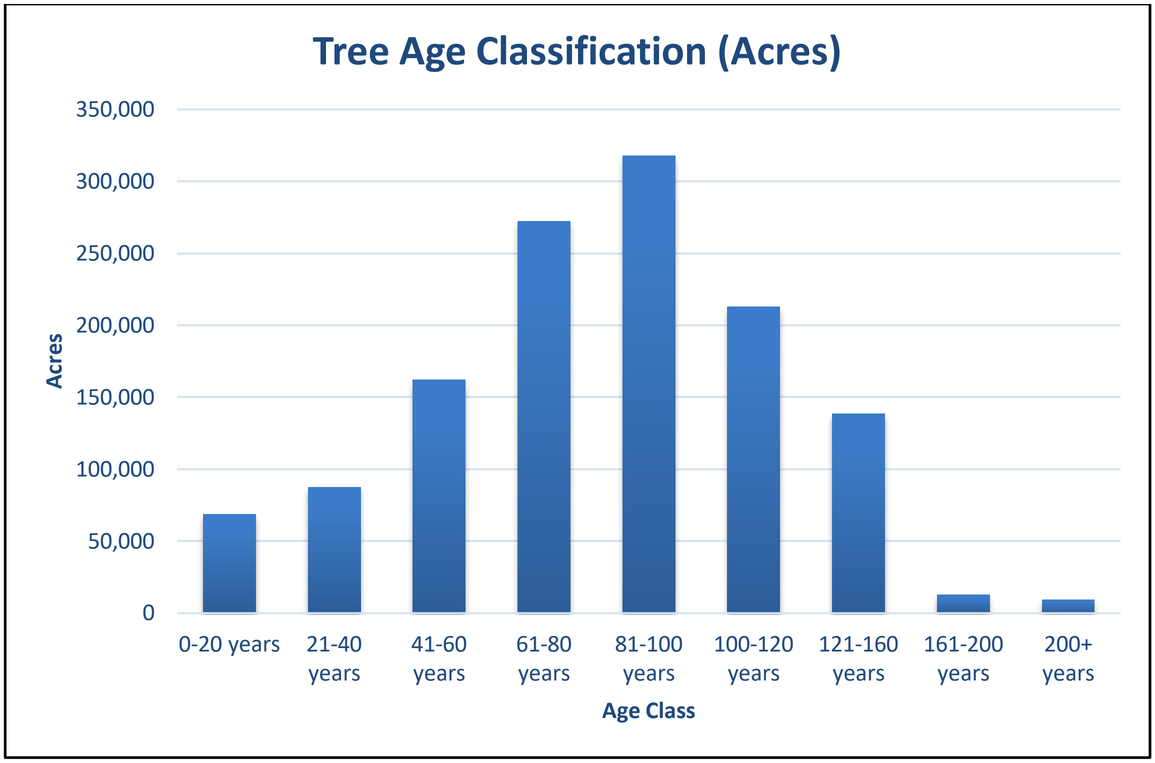


Figure 1.4 Coniferous Tree Age Classification (U.S. Department of Agriculture FIA, [2018a])

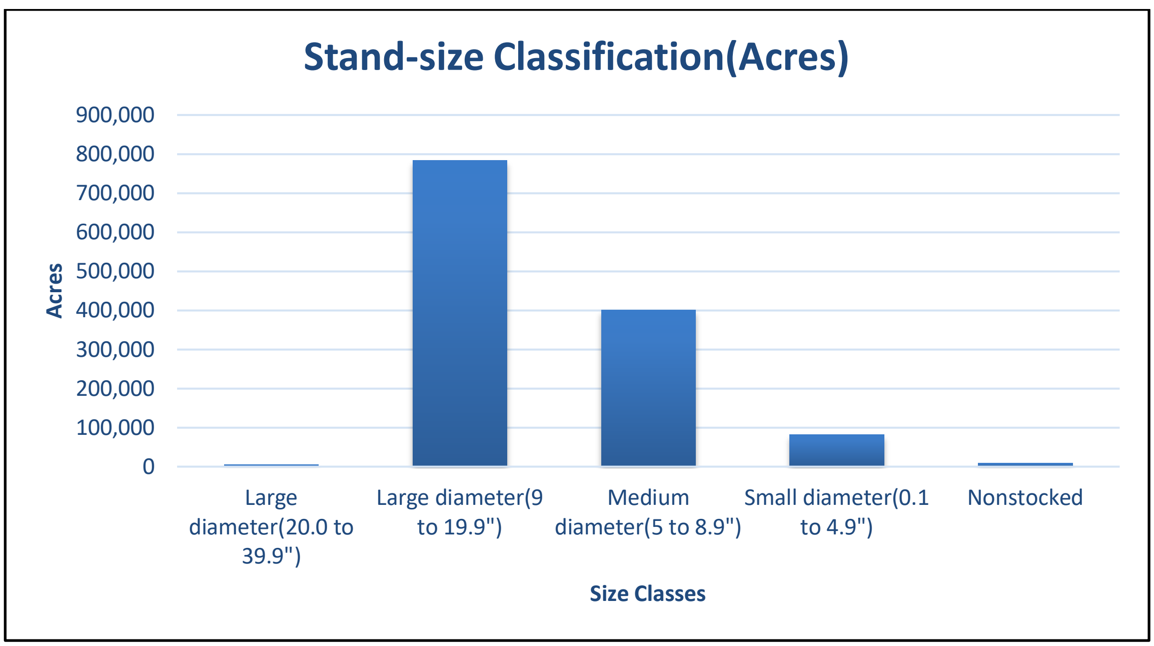


Figure 1.5 Tree Size Classification (U.S. Department of Agriculture FIA, [2018a])

Figure 1.6 shows the comparison between the size class distribution of ponderosa pine at the onset of the MPB epidemic in 2003 and after the end of the epidemic in 2018 (USDA 2018a). This data shows that the size class most impacted by mountain pine beetle during this epidemic was the large diameter trees, greater than 9” DBH.

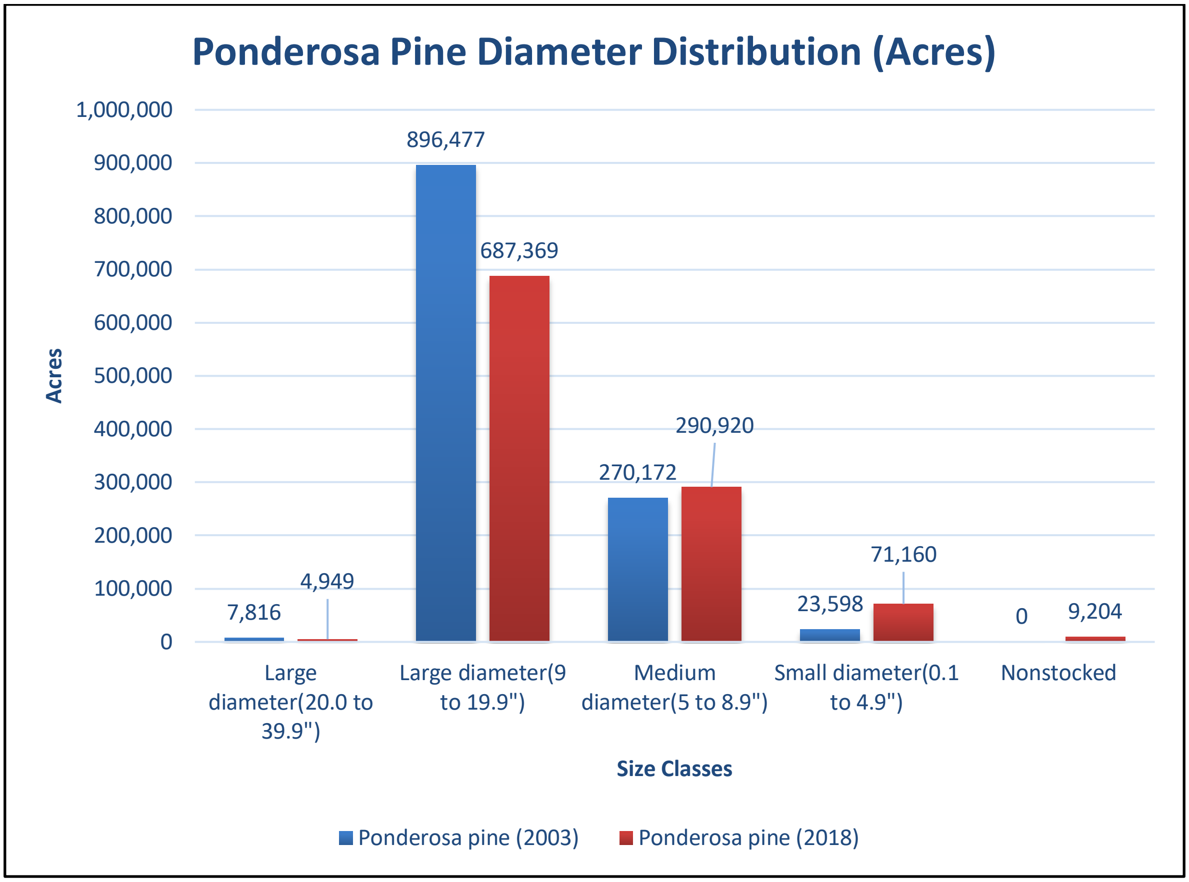


Figure 1.6 Ponderosa Pine Diameter Distribution, in Acres (U.S. Department of Agriculture FIA, [2018a])

Also shown in Figure 1.6 is the increase of medium diameter stocked acres of ponderosa pine (+8%), and small diameter stocked acres nearly tripled since 2003. These stands of smaller diameter trees create the greatest challenge to forest management as there are limited markets for growing stock trees less than 9” in diameter, and almost no market for trees less than 5” in diameter. Without management these stands become overstocked, growth stagnates with little or no diameter growth, the risk for catastrophic wildfire increases, and results in greater risk of future insect and disease outbreaks.

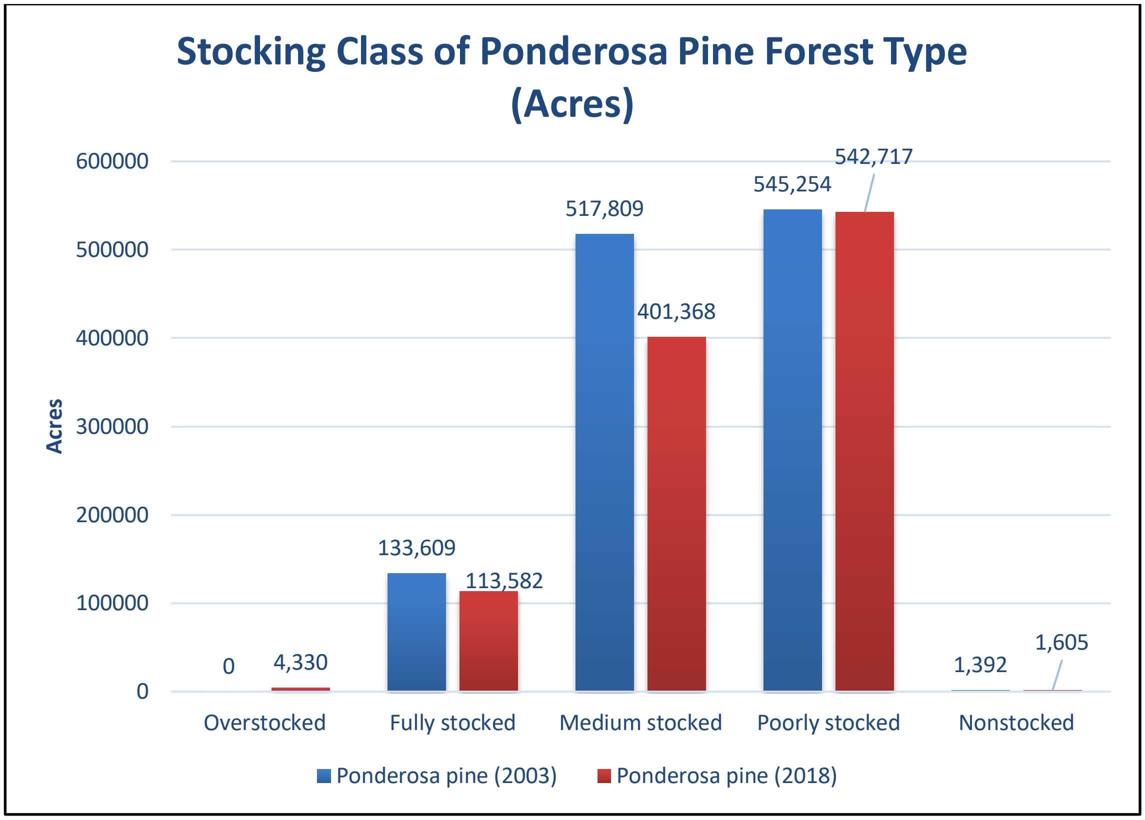


Figure 1.7 Stocking Class of Ponderosa Pine Forest Type (U.S. Department of Agriculture FIA, [2018a])

Figure 1.7 shows the comparison of ponderosa pine stocking class in 2003 when the current MPB epidemic was beginning and in 2018, two years after the epidemic had ended (USDA 2018a). The full effects of the MPB epidemic will continue to be measured until 2023, due to the seven-year rotation of FIA plot measurements. Stocking is defined as the relative degree of land occupied by trees, measured as basal area, or the number of trees in a stand by size or age and spacing, compared to the basal area or number of trees required to fully use the growth potential of the land (O'Connell et al, 2016). Stocking refers to trees of all sizes, from 0.1" diameter and up. Growing stock is a different metric that refers to trees at least 5" in diameter. South Dakota contains over 1.1 million acres of ponderosa pine timberland, with approximately 1 million acres in the Black Hills. Approximately 51% of ponderosa forest is poorly stocked, 38% is medium stocked, and only 11% is fully stocked. Stocking class and productivity class are important measures of economic condition of the Black Hills ponderosa pine forest type because logs from these forests are used to supply local sawmills.

Figures 1.6 and 1.7 both show a reduction in the total stocked acreage of ponderosa pine forest from 2003 to 2018. This reduction is likely attributed to forest conversion from large-scale disturbances such as wildfire and smaller, more localized disturbances, such as development. Once the land-use or dominant cover type of these areas is changed, they are no longer classified as forestland.

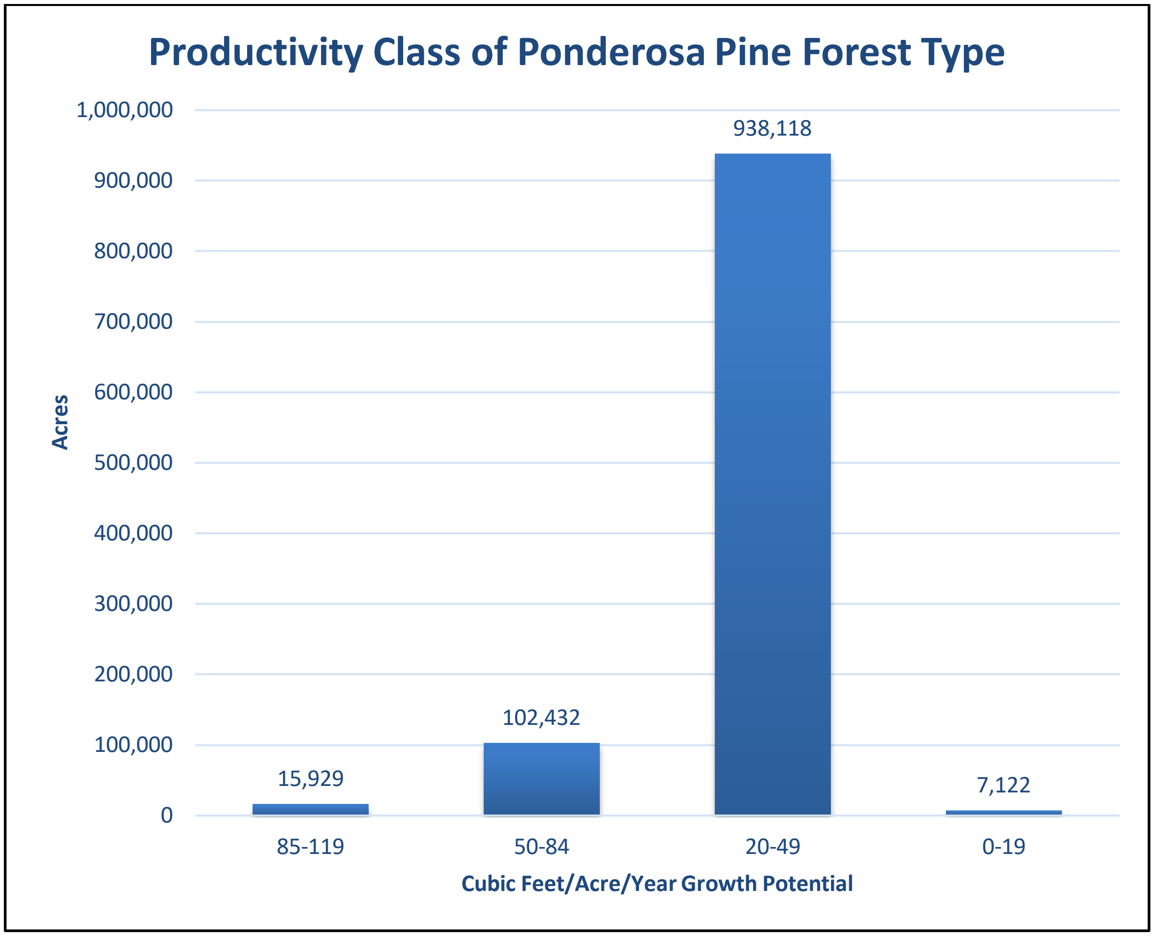


Figure 1.8 Productivity Class of Ponderosa Pine (U.S. Department of Agriculture FIA, [2018a])

Figure 1.8 shows the site productivity of the ponderosa pine forest-type group, defined as the potential annual cubic volume growth per unit land area in fully stocked natural stands (USDA 2018a). Approximately 88% of ponderosa pine forest has the potential to produce between 20 and 50 cubic feet of wood per acre per year, and nearly 10% has the potential to produce between 50 and 85 cubic feet of timber per acre per year.

In 2018-2019 the US Forest service completed a double intensification of FIA plots on national forest system lands within the Black Hills and on what is considered the suitable base (lands suitable for timber production and harvest). Many of these plots were new, and therefore could not measure growth, mortality, or any changes that must be re-measured through time to calculate. The intent of the double-intensification was for planning sustainable harvest volumes into the future.

1.3 VALUES

Tourism brings about 2 billion dollars to the South Dakota economy each year (South Dakota Department of Tourism, 2016). Many of these tourists come to recreate in the scenic coniferous forests of the Black Hills. Recreational opportunities in the forests of the Black Hills include hunting, fishing, bird-watching, hiking, camping, mountain biking, gold panning, skiing, all-terrain vehicle riding, off-road vehicle use, snowmobiling, and horseback riding.

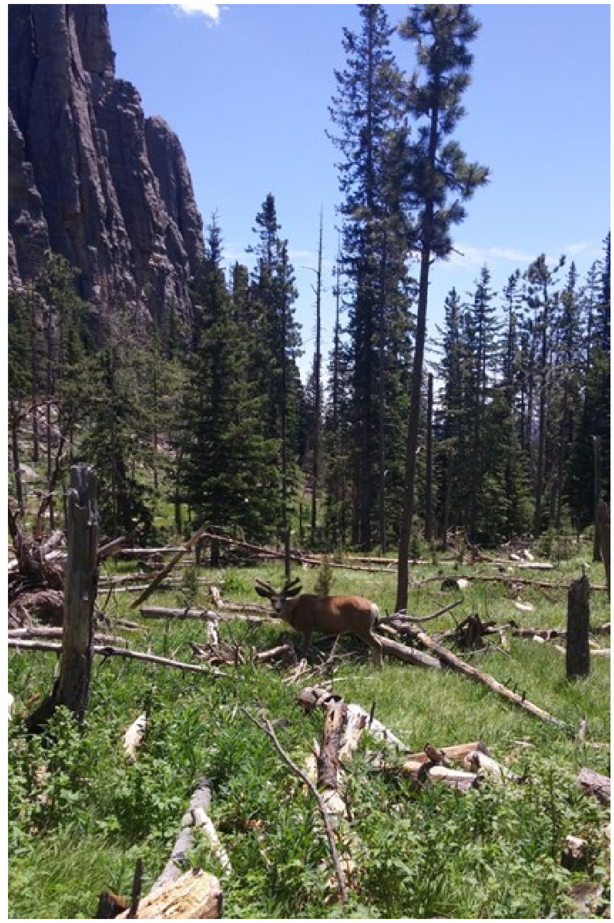


Figure 1.9: Mule Deer in Custer State Park (SD Department of Agriculture, 2016)

Coniferous forests provide valuable wildlife forage and cover. Evergreen forests in South Dakota are a haven for deer (Figure 1.9), elk, turkeys, mountain lions, coyotes, bighorn sheep, mountain goats and numerous smaller animals such as, squirrels, porcupines, raccoons, rabbits, skunks, mice, bats, and birds. In the recent past, the Black Hills forests supported wolves and bears, but these species were eradicated with the arrival of Euro-Americans and have never been reintroduced. Conifers provide food for squirrels, birds, and porcupines, although porcupines are known to kill trees by chewing off bark. Coniferous forests host a variety of insects which are an important part of the forest food web. Several mammal species and many bird species make their homes in conifers, including the Osprey, which is a state-listed threatened species. The northern long-eared bat, which was listed as threatened in 2015, uses the coniferous forests of the Black Hills to roost (USFW, 2015). These are referenced in the Threatened and Endangered species matrix in Appendix H. The South Dakota Game Fish & Parks State Wildlife Action Plan (SDGFP SWAP) identifies key wildlife species and their habitat requirements within coniferous forests of South Dakota.

According to Mark Vedder, United States Forest Service (USFS) Rangeland Management specialist for the Black Hills National Forest (BHNF), "the Black Hills National Forest has 133 active livestock grazing allotments where permitted cattle are grazed each season, in a mix of coniferous, hardwoods, meadows, and grassland vegetation. A total of 1,201,749 acres (National Forest Land acres and Waived Private Land Acres) may be grazed under permit, by a total of 24,151 head of cattle. A total of 335 permits (term, private land, on/off, and crossing) are issued to 144 permittees. Term Grazing Permits are issued for a 10-year period for grazing privileges covered by terms and conditions for use of pastures, maintenance of range improvements, specified numbers of head per allotment, and stated period of use." Vedder explains that private landowners who want to graze private livestock on their land in conjunction with national forest land must be "willing to sign a Term Private Land Permit, which effectively waives management of their lands to the Forest Service, for the term of the private land permit (10-year term but they may cancel at any time)." This permit authorizes the Forest Service to manage the waived lands adjacent to national forest land for various soil, water, and vegetation management objectives, while considering the intentions of the landowner. In Harding County, approximately 74,000 acres of Custer National Forest are permitted for grazing. Grazing also occurs on many of the 440,000 acres of private coniferous forest land. South Dakota counties that host grazed conifer forests include Custer, Fall River, Harding, Lawrence, Meade, and Pennington. Grazing also reduces fire danger by removing fuels and maintains the ecology of the pine savannah which developed under grazing pressure. The practice of livestock grazing in combination with timber production is termed silvopasture. Studies have shown that moderate grazing has no effect on timber production and can positively affect native plant diversity (Chowanski, 2016).

Conifer forests are important to water quality protection. Tree canopies and forest litter protect soils from erosion by dispersing rain and slowing runoff. Conifer forest litter has a high capacity to absorb water. Roots protect soils from erosion by providing a matrix for soil cohesion and stability. All these factors play a role in reducing erosion and the amount of sediments that enter waterways. This is particularly important in areas such as the Black Hills that have salmonid and other fish species that need clean, silt-free gravel beds for spawning and reproduction. Considerable investments have been made to create habitat for trout which are an introduced species in the Black Hills. The South Dakota Coordinated Plan for Natural Resources Conservation also ties in with coniferous forests in its Water Resources goal that 50% of South Dakota waters will meet their beneficial uses. Objective 1.4 is to install 128,000 acres of non-forested riparian buffers and 30,000 acres of forested riparian buffers by 2019. Objective 1.6 is to reduce sediment delivery to waterbodies by 70,000 tons/year through 2019.

Forest industry is a major economic contributor to the state's economy generating over $243 million of wood products each year (BHFRA, 2016). Ponderosa pine is extensively used in the Black Hills for boards, tongue and groove paneling, poles, posts, log homes, and other products such as firewood. Mill residue created through the industrial processing of timber is used in particle board, fuel wood pellets, industrial fuel, domestic fuel, livestock bedding, decorative bark for landscaping, pulp, and mulch. Conifers are also used for Christmas trees. Most of the sawmills in South Dakota and several forest products businesses exist in and around the Black Hills, including in the towns of Custer, Hill City, Newell, Pringle, Rapid City, Spearfish, Sturgis, and Whitewood. There are nine primary wood processors and five secondary processors in the Black Hills. There is an inter-dependency among these processors. Without sawmill residues many secondary processors wouldn't exist. Without the secondary processors the sawmills would have to dispose of residues at great expense. The forest products industry directly employs over a thousand people and contracts with over 400 more (BHFRA, 2016). The industry provides revenue for private landowners that wish to generate income from treed land. In addition to the economic benefits provided by forest products, the industrial infrastructure provides opportunities to conduct vegetative management treatments on all ownerships that would otherwise not be possible, except at great expense.

There is market potential for biomass in the Black Hills because of conifers. These products can be used in heating systems using biomass boilers, as well as particle board production for cabinet-making. In 2006, woody biomass boiler feasibility studies were undertaken at seven schools and four other public facilities in the Black Hills area. Biomass Energy Resource Center (BERC) of Montpelier, VT was hired to complete the feasibility studies. Cost analysis revealed that conversion of eight of the facilities would yield a positive net present value over 30 years without significant changes to existing facilities. (South Dakota Department of Agriculture, 2006). Since the results of the study were published, two state facilities, The State Veteran's Home in Hot Springs, and Evergreen Star Academy in Custer, have converted to woody-biomass boiler systems. Even with the industrial infrastructure that exists, woody biomass is still underused. In 2004, harvesting of industrial roundwood products left over 8.8 million cubic feet of residues on the ground (Piva et al, 2004). Skog et al, (2008) estimates there are over 112,000 oven-dry tons per year of biomass available in South Dakota.

The Black Hills National Forest estimates 93,512 bone-dry tones of wood residues are created each year from whole tree harvesting in the BHNF (Cook, 2009). These residues form 1,600 slash piles each year, and there is an estimated 2-year backlog of piles on the forest. Custer State Park estimates they create 4,733 bone dry tones of recoverable wood biomass residues following timber harvest each year [Hill, 2006]. In the absence of an industry to use these residues, they are burned as weather allows reducing the fire hazard. The Black Hills are a valuable cultural resource. The name "Black Hills" is a translation of the Lakota "Paha Sapa," referencing the black appearance from the surrounding plains because of the conifer forest. Today, Paha Sapa remains a sacred place in Lakota and Cheyenne culture where it is considered the center of the world. Lakota and previous indigenous tribes left petroglyphs, pictographs, fire rings, burial mounds, and other artifacts. The Black Hills is also home to more recent cultural resources, including evidence of the Custer expedition, flume trails from mining, and ghost towns.

1.4 THREATS

Based on the documents reviewed, the largest threats to South Dakota's coniferous forests are insect infestation, disease, and fires. Other threats, direct and indirect, include fragmentation, extreme weather events (drought, hail, wind, ice, etc.), forest stagnation, weeds and invasive species, climate change, natural lack of tree species diversity, lack of wood products industry, unpredictable budgets, high cost of managing non-commercial stands, a lack of public knowledge related to forest management, and loss or degradation of wildlife habitat. These can also combine to increase the relative threat from each individual threat. For example, fires that occur in areas of heavy tree mortality because of pine beetle infestations can burn hotter because of the high concentration of dry, dead timber. Fires that burn through beetle caused tree mortality can destroy any natural regeneration that may have become established, increasing the time required for the forest to recover to full stocking. Also, beetles may be attracted to trees that are weakened by fire damage (Sieg et al, 2006).

Mountain Pine Beetle

The mountain pine beetle *(Dendroctonus ponderosae)* is a native species across much of the western United States, Canada, and Mexico. The beetles are small, about the size of a grain of rice, yet they target large trees in densely stocked stands, and can cause widespread mortality in most pine species, including all three species native to South Dakota. Although it is not clear what triggers the beginning of an outbreak, large stands of over-stocked mature pine trees allow epidemics to thrive due to the microclimate created by lack of air-movement within the stand and an abundant food source for the beetles to reproduce. The beetles successfully kill trees by boring into the host, in South Dakota usually ponderosa pine in the Black Hills, and producing a pheromone to attract other beetles to mass attack and overcome a pine tree's natural defenses. The beetles and their larvae feed on the inner bark, or phloem layer, which transports nutrients produced from the needles through photosynthesis. They also introduce blue-stain fungi which restricts the trees ability to transport water from the roots to the rest of the tree. Analyses of high-resolution aerial photography taken between 2010- 2016 found 130,705 acres of MPB mortality, not counting infested acreage that was treated through removals or other methods. When combined with less precise maps sketched by observers in aircraft from 1996 – 2011, it is estimated that over the last 20 years about 450,000 acres have been affected to varying degrees by mountain pine beetle in the Black Hills (Allen, 2016). Results of brood studies show that the epidemic peaked in 2011 when brood populations were static (no longer increasing) and have been declining rapidly since (Schotzko and Allen, 2016). In 2015, approximately 2,100 acres of MPB infested trees were detected in the imagery analysis completed using aerial photography acquired in 2016. Although the epidemic has ended, there are still small localized areas of pine mortality from MPB and areas of overstocked pine stands in the Black Hills susceptible to attack. The mountain pine beetle is considered the most serious insect threat to pines throughout the Black Hills (Figure 1.10).

Figure 1.10: A patchwork of mountain pine beetle infested ponderosa pine on Custer Peak in the northern Black Hills (SD Department of Agriculture, 2011)

Pine Engraver Beetle

The pine engraver beetle *(Ips pini)* is another bark beetle in South Dakota capable of killing ponderosa and lodgepole pine trees. These beetles typically infest green slash, tops and limbs of pine trees damaged or broken off during weather events or created during forest management activities, or in developed areas where heavy equipment has damaged tree root systems. During times of severe drought, they are also commonly found infesting stressed pine saplings, and the tops of larger trees. If drought conditions persist, or a large quantity of green slash is created in a localized area allowing the pine engraver populations to increase, the beetles can infest and kill groups of mature trees in one season.

Other insects that pose problems in conifer forests of South Dakota include the cedar bark beetle, pine needle scale, pine sawfly, pine tip moth, spruce needleminer, spruce spider mite, and the Zimmerman pine moth.

Coniferous Tree Diseases

Diplodia tip blight is a disease caused by the fungus *Sphaeropsis sapinea* that affects ponderosa pine statewide. This disease is common in pine windbreaks through the state and is usually found in older stressed trees. Although typically not a tree-killer, repeated infections of stressed trees can cause mortality. Other stressors, such as drought or hail, can cause symptoms of this disease to become more apparent. Other types of blight are present in South Dakota and are caused by fungi that kill the foliage on conifers. Examples include kabatina, phomopsis, brown felt, and dothistroma needle blight. These blights primarily affect juniper, spruce, and occasionally ponderosa pine. Other diseases that can cause minor problems in coniferous forests in South Dakota include Armillaria root rot, cedar-apple rust, cytospora canker, elytroderma needle cast, stigmina needle cast, and western gall rust.

Noxious Weeds

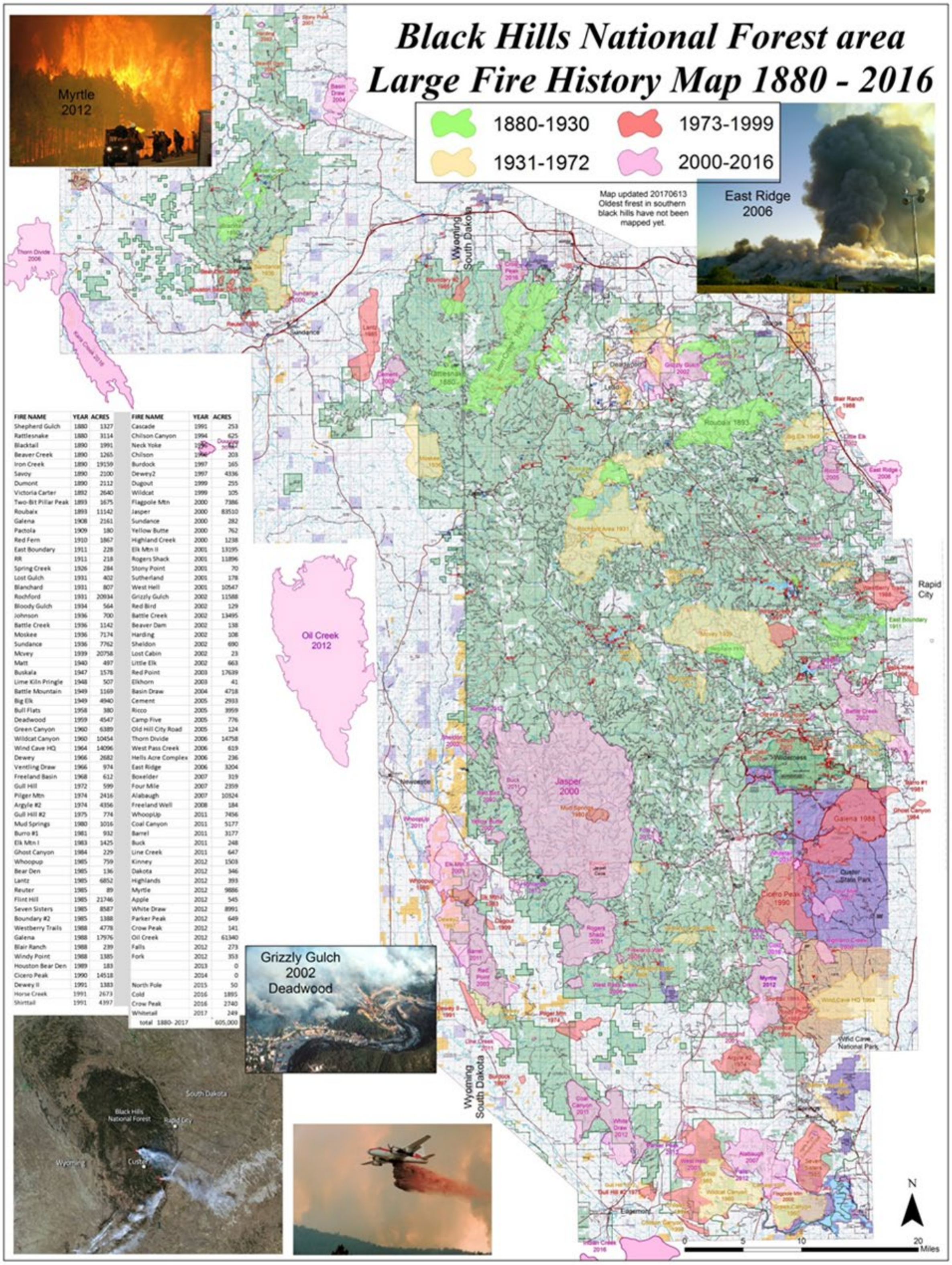
Disturbance in the coniferous forest type often leads to increased occurrence of noxious weeds. In the Black Hills and surrounding counties Canada thistle *(Cirsium arvense)* and leafy spurge *(Euphorbia esula)* are reported in large numbers. These weeds are often found in the forest following ground disturbance such as timber harvest, wildfire, and recreation.

The negative impacts from these weeds can include out-competing native vegetation, reducing land values, poisoning livestock, and increasing the cost of managing the land through eradication and control efforts (SDSU, 2010).

Forest Fire

Forest fires pose a large threat to the conifer forest type in South Dakota. Widespread housing developments within and near the conifer forests of the Black Hills have created new firefighting challenges within the wildland urban interface (WUI). Fire history in the Black Hills included both natural and anthropogenic (human influenced) fires which thinned the trees and created a mosaic of stand structures across the landscape. The fire return interval, or the frequency in which fires occur, is variable across the Black Hills, occurring more frequently in the southern, dryer portions of the hills, and less frequently in the wetter portions, generally found in the northern hills and higher elevations. Figure 1.11 shows the areas where major fires have occurred from 1910 to 2016. Additional information about wildfires in the Black Hills is presented in Appendix A.

The arrival of settlers in western South Dakota in the late 1800s brought the beginning of fire suppression. The use of anthropogenic fire was replaced by mechanical efforts to thin trees, leaving some to grow to maturity. This mechanical thinning was originally accomplished with axes and hand saws but has since evolved to a combination of techniques including chainsaws, shearers, and mulchers/masticators. In the absence of fire, fuel buildup within coniferous forests can create a multitude of problems (Arno and Brown, 1991), including high severity fires. In the Black Hills, Mitchel and Yuan (2010) conducted research within the 84,000-acre Jasper Fire footprint where they failed to record a single seedling in areas of the fire that burned at high severity. Keyser et al. (2008) and Wudtke (2011) concluded the lack of regeneration following stand replacing fire in the Black Hills would remain a management concern into the future as these areas are expected to persist as grass and shrub dominated communities. The BHNF has been working to restock this area by planting nearly 150,000 ponderosa pine seedlings across 400 acres annually since 2002 (Daily, 2019). Although mechanical thinning is still the most commonly used method to thin over-stocked forests, prescribed fire has been gradually reintroduced to the Black Hills landscape as a management tool since the 1970s. Fire is also used in combination with mechanical treatments to eliminate residues from thinning and to accomplish other management objectives such as wildlife habitat improvement. Even with active fire suppression and mechanical thinning, fire continues to be part of the landscape at a lower burn severity and a decreased extent.



FIRE NAME	YEAR	ACRES	FIRE NAME	YEAR	ACRES
Shepherd Gulch	1880	1327	Cascade	1991	253
Rattlesnake	1880	3114	Chilson Canyon	1994	625
Blacktail	1890	1991	Neck Yoke	[illegible]	[illegible]
Beaver Creek	1890	1265	Chilson	[illegible]	203
Iron Creek	1890	19159	Burdock	1997	165
Savoy	1890	2100	Dewey2	1997	4336
Dumont	1890	2112	Dugout	1999	255
Victoria Carter	1892	2640	Wildcat	1999	105
Two-Bit Pillar Peak	1893	1675	Flagpole Mtn	2000	7386
Roubaix	1893	11142	Jasper	2000	83510
Galena	1908	2161	Sundance	2000	282
Pactola	1909	180	Yellow Butte	2000	762
Red Fern	1910	1867	Highland Creek	2000	1238
East Boundary	1911	228	Elk Mtn II	2001	13195
RR	1911	218	Rogers Shack	2001	11896
Spring Creek	1926	284	Stony Point	2001	70
Lost Gulch	1931	402	Sutherland	2001	178
Blanchard	1931	807	West Hell	2001	10547
Rochford	1931	20934	Grizzly Gulch	2002	11588
Bloody Gulch	1934	564	Red Bird	2002	129
Johnson	1936	700	Battle Creek	2002	13495
Battle Creek	1936	1142	Beaver Dam	2002	138
Moskee	1936	7174	Harding	2002	108
Sundance	1936	7762	Sheldon	2002	690
Mcvey	1939	20758	Lost Cabin	2002	23
Matt	1940	497	Little Elk	2002	663
Buskala	1947	1578	Red Point	2003	17639
Lime Kiln Pringle	1948	507	Elkhorn	2003	41
Battle Mountain	1949	1169	Basin Draw	2004	4718
Big Elk	1949	4940	Cement	2005	2933
Bull Flats	1958	380	Ricco	2005	3959
Deadwood	1959	4547	Camp Five	2005	776
Green Canyon	1960	6389	Old Hill City Road	2005	124
Wildcat Canyon	1960	10454	Thorn Divide	2006	14758
Wind Cave HQ	1964	14096	West Pass Creek	2006	619
Dewey	1966	2682	Hells Acre Complex	2006	236
Ventling Draw	1966	974	East Ridge	2006	3204
Freeland Basin	1968	612	Boxelder	2007	319
Gull Hill	1972	599	Four Mile	2007	2359
Pilger Mtn	1974	2416	Alabaugh	2007	10324
Argyle #2	1974	4356	Freeland Well	2008	184
Gull Hill #2	1975	774	WhoopUp	2011	7456
Mud Springs	1980	1016	Coal Canyon	2011	5177
Burro #1	1981	932	Barrel	2011	3177
Elk Mtn I	1983	1425	Buck	2011	248
Ghost Canyon	1984	229	Line Creek	2011	647
Whoopup	1985	759	Kinney	2012	1503
Bear Den	1985	136	Dakota	2012	346
Lantz	1985	6852	Highlands	2012	393
Reuter	1985	89	Myrtle	2012	9886
Flint Hill	1985	21746	Apple	2012	545
Seven Sisters	1985	8587	White Draw	2012	8991
Boundary #2	1985	1388	Parker Peak	2012	649
Westberry Trails	1988	4778	Crow Peak	2012	141
Galena	1988	17976	Oil Creek	2012	61340
Blair Ranch	1988	239	Falls	2012	273
Windy Point	1988	1385	Fork	2012	353
Houston Bear Den	1989	183		2013	0
Cicero Peak	1990	14518		2014	0
Dewey II	1991	1383	North Pole	2015	50
Horse Creek	1991	2673	Cold	2016	1895
Shirttail	1991	4397	Crow Peak	2016	2740
			Whitetail	2017	249
			total 1880- 2017		605,000

Figure 1.11: Black Hills Fire History Map (Marchand, 2017)

County	1/2- Mile Buffer	1 1/2-Mile Buffer	3-Mile Buffer
Fall River	20-foot-crown spacing, eliminate ladder fuels, treat surface fuels	10-foot crown spacing	Treat to reduce probability of high-intensity wildfire (crownfire)
Lawrence	20- foot- crown spacing, eliminate ladder fuels, treat surface fuels	10-foot crown spacing	Treat to reduce probability of high-intensity wildfire (crownfire)
Meade	60- foot burn area, all slash removed	80-foot burn area, remove ladder fuels close to private property	Treat to reduce probability of high-intensity wildfire (crownfire)
Pennington	20-foot- crown spacing, eliminate ladder fuels, treat surface fuels	10-foot-crown spacing	Treat to reduce probability of high-intensity wildfire (crownfire)
Custer	Encourage subdivision associations to adopt covenants, provide direction to property owners on an individual basis, encourage adoption of Firewise principles		
Perkins	Establish firegaurds, maintain road ditches, maintain windbreaks, create fuel breaks, establish survivable space around homes		
Butte	Establish fireguards, planned grazing, mowing ditches and driveways, maintain windbreaks, plant windbreaks with fire- resistant species, thin pine trees		

Table 1.3 Community Wildfire Protection Plan Vegetative Treatment Recommendations

Because of land fragmentation, fire not only threatens forest and trees, it also threatens forest land interlaced with a patchwork of private land where development is continuing to take place. Fire suppression is necessary to protect homeowners because the Black Hills are highly developed. Any wildfire in South Dakota, if allowed to burn, will eventually threaten homes or towns.

All counties in the Black Hills have prepared Community Wildfire Protection Plans (CWPP), including Butte, Custer, Fall River, Lawrence, Meade, and Pennington. Perkins and Harding Counties, although outside of the Black Hills, have also prepared a CWPP. These plans all have the same general objectives and goals, including fire management and suppression by reduction of litter, slash, and ladder fuels, and managing forests in such a way as to create open spaces and reduce tree densities. Areas of WUI within the Black Hills National Forest based on CWPPs are presented in Figure 1.11. Virtually all the Black Hills in South Dakota fall within a 3-mile radius of a WUI. Vegetative treatment recommendations for these interface areas are presented in Table 1.3.

All goals and objectives in the CWPPs are designed to reduce risk. CWPPs need to be considered when forest management agencies are developing forest planning documents, writing environmental impact statements, consulting landowners for input on management plans, and planning logging activities.

Aurora, Brown, Charles Mix, Day, and McPherson Counties have Comprehensive Fire Management Plans that were prepared in 2004 and 2005. Except for Charles Mix County, these counties have little or no forest land. Charles Mix County has deciduous forest along the Missouri River and some eastern redcedar encroachment on the upper slopes and rangelands along the

Missouri River. The primary threat of wildland fire is from agricultural burning and range fires. Mitigation measures include prescribed burning, grazing, creating fire breaks by disking and harrowing, mowing, and cultivation of shelterbelts.

1.5 OWNERSHIP

According to USDA, FIA 2018a data, nearly two-thirds of the coniferous forests in South Dakota are on national forest land, most of which is in the Black Hills, but includes some land in Harding County in Custer Gallatin National Forest (Table 1.4). The second largest ownership class of coniferous forests in South Dakota is private landowners, which makes up over 30% of this forest type in the state. Although most of this private forest land is located within the Black Hills, there is a significant amount of Rocky Mountain juniper and eastern redcedar in breaks and draws, mostly along the Cheyenne River, White River, and the lower Missouri River. The remaining 7% is split between National Park Service (Wind Cave, Jewel Cave, and Mount Rushmore), Bureau of Land Management, and state land, located primarily in Custer State Park.

The coniferous forests on National Forest land are managed under Land and Resource Management Plans (LRMPs) as required by the National Forest Management Act (NFMA) of 1976. These plans are developed and revised on a periodic basis and are required to address the principals laid out in the Multiple-Use Sustained-Yield Act of 1960. The Black Hills LRMP was last updated in 2005 and sets forest management goals based on percentages of various stand structures throughout the forest to achieve multiple resource objectives. The Custer-Gallatin LRMP was published in 1986 but was undergoing revision at the time of this writing. It breaks the forest into management zones and identifies goals within each zone based on the resource objectives specific to that zone.

In the Black Hills, private lands form a lattice network throughout the National Forest System lands. Many of these private lands are being subdivided and developed, which continually increases the threat of wildfire to homes. This in turn precludes "let burn" policies that have been adopted on the more remote national forests in the west.

Forest type	National Forest	National Park Service	Bureau of Land Mgmt	Other federal	State	County and Municipal	Private	Total
White spruce	64,028	-	11,341	-	-	-	12,221	87,590
Eastern redcedar	-	-	5,670	-	-	-	51,189	56,859
Rocky Mountain juniper	13,850	-	4,253	-	-	-	55,812	73,914
Ponderosa pine	719,884	9,923	-	-	44,431	-	289,364	1,063,602
Nonstocked	92,497	5,670	4,330	-	8,212	-	64,299	175,009
Total	890,259	15,593	25,594	0	52,643	0	472,885	1,456,974
Percent of Total	61%	1%	2%	0%	4%	0%	32%	100%

Table 1.4 Coniferous Forest ownership by Forest-Type, in Acres (U.S. Department of Agriculture FIA, [2018a])

1.6 NEEDS, PROBLEMS, AND OPPORTUNITIES

Coniferous forests are the predominant forest type in South Dakota. Despite the abundance of data available, additional needs, problems, and opportunities are described further.

Data

There is a need for more thorough data and the ability to query this data both geospatially and temporally. Although there is an abundance of data, these data from different sources often produce different results due to different means of acquisition. The LANDFIRE data, for example, is out of date, and contains tree species in its forest cover type descriptions that are not found in South Dakota. The FIA data used in this assessment to report on acreage is derived from permanent sample plots taken by contractors on the ground, and then extrapolated to the State. Plots meant to get an accurate sample of the forested resources in the State are visited over the course of seven years with an equal number of plots visited each year. The most recent dataset includes the data acquired over the entire data collection cycle. As depicted in the tables, the error rates on these acreage estimates are often large. This is currently the best data we have available, and it is useful for drawing conclusions about the forested resources of South Dakota, however, there is opportunity for improvement in data accuracy. In 2017, the BHNF doubled the number of FIA sample plots and revisited all regular permanent plots in the annualized cycle within areas classified as suitable for timber harvesting. All plots were visited within three years. The sample was expanded to improve accuracy and evaluate the impact of the recent mountain pine beetle epidemic. The maps showing the coniferous forests of South Dakota, and other forest types in the state were created using LANDFIRE, which is derived from Landsat 8 imagery taken from a satellite. The acreages from these two datasets are not reconcilable.

Fragmentation

The forested land across South Dakota, as it is across the entire United States, is made up of a patchwork of various ownerships. Increases in housing density and development are creating greater fragmentation and strain on wildlife habitats and general forest health (Stein et al, 2005). Within South Dakota, and especially in the Black Hills, development is ongoing on private forest lands and immediately adjacent to national forests. As housing density increases and lands become fragmented, negative impacts may result, including reduction in wildlife habitat and browse, increases in human/wildlife conflicts, reduction in habitat connectivity, poorer water quality, and reduced outdoor recreational opportunities (Stein et al, 2007). Forest management also becomes more difficult on smaller acreages due to inefficiencies and challenges of coordinating activities among multiple owners.

The patchwork of land holdings in the Black Hills provides an opportunity to develop a model for shared cross-boundary management on a landscape scale between private landowners, the state, and the federal government. Laws and regulations to manage federal public lands should be flexible enough to allow for local collaborations that provide for cultural resource and environmental protection, sustainable timber harvest, livestock grazing, mining, wildlife habitat, and recreation. One such opportunity currently being explored is the Cohesive Strategy project, which is bringing together all relevant land-management and emergency response agencies to work together to achieve landscape scale work to create resilient landscapes, fire-adapted communities and a safe & effective wildfire response. One way to achieve this collaborative effort is the Good Neighbor Authority agreement between the State of South Dakota and the USDA Forest Service.

The Conservation Leaders Group is another good example of how shared land management on a landscape scale is already in effect. This group is a collaboration of land management agencies in the Black Hills of South Dakota and Wyoming, private landowners, and industry working together to create and implement objectives and strategies to promote proactive forest management in the Black Hills. Similar working groups have been created as sub-groups of the Conservation Leaders Group including the Black Hills Resilient Forest Working Group and the Black Hills Invasive Plant Partnership.

Forest Management

Because of mountain pine beetle, drought conditions, and fire, there is an abundance of coniferous forest land in the Black hills that needs increased forest management. Many dead trees remain standing with additional unburned slash and increasing litter density. Many ponderosa pine stands are also overcrowded and in poor general health. This issue crosses county, state, and federal agency jurisdictions, but there is a need to take action and an opportunity for collaboration. Funding must be acquired, and action taken to limit the spread of insect infestations, increase forest thinning in the densest stands, and remove dead trees and forest litter. Prescribed fire is an effective tool to accomplish this work, and there is a lot of potential for increased fire use across South Dakota. The availability of wood biomass residues remaining in the forest following timber harvest and other silvicultural operations provides an opportunity for product development or energy production.

Following the MPB epidemic of the early 2000's there is a need to develop a forest management approach that will avoid the scale of this recent epidemic. As long as pine is a component of the Black Hills forest ecosystem MPB will be present, and MPB epidemics will occur at periodic intervals. History shows us that the largest epidemics occurred on approximately 100-year intervals – about the time it takes for ponderosa pine trees to reach maturity. This suggests that the management that takes place over the next 100 years can influence the size and scope of the next large epidemic. A diversity of tree size and density classes across the landscape can help lower the risk of large-scale epidemics. Prescribed fire must play a larger role for reducing fuel hazards and risk of large catastrophic fires. The forest products industry is critical to the on-going management of the forest. The forest – private, state, and federal lands - must continue to produce enough marketable timber to sustain the forest products industry. A vibrant and dynamic forest products industry that recognizes and pursues new product and market opportunities that can utilize smaller size classes will be critical to implementing diverse management across the forest.

Encroachment

Rocky Mountain juniper and Eastern redcedar are currently expanding in much of their range in the southern/central parts of the State. Landowners are actively trying to combat this expansion through mechanical and chemical methods. Prescribed fire is an effective tool at reducing these tree species on rangeland, and some counties are looking for opportunities to increase this practice, as it is also beneficial to the native vegetation that livestock feeds on. These species are also considered a "low-value" forest product for a few reasons. A big constraint to utilizing the wood from the juniper encroachment in the state is its proximity to any timber market. These trees are expanding their range on the prairie, where the nearest forest industry is hundreds of miles away. Many of the juniper and redcedar are also somewhat open-grown on the prairie, so have a very bushy appearance, creating a lot of knots and what is typically considered defect in wood. The wood from these trees does have value however, as the aesthetic quality, and scent of the wood make it sought after for items such as cedar chests, saunas, animal bedding and other craft and wood-working projects. These species are also highly rot-resistant and make excellent fence posts. There is an opportunity for expanding the market for these trees, as landowners are eager to get rid of them.

Market Development

Although generally more valuable than the juniper and redcedar, ponderosa pine is still not considered to be a high value timber product. In the Black Hills, logs from ponderosa are harvested and milled into boards, paneling, particle board, and other secondary products. Smaller operations harvest smaller diameter timber to produce treated posts for fencing. By-products of milling operations include wood pellets, particle board, decorative landscape bark, mulch, and wood chips for heating plants. There continues to be a significant amount of underutilized wood waste that results from management activities in the ponderosa pine forests of the Black Hills. Product and market development that utilizes the full spectrum of tree size classes is necessary to economically manage the forest.

Prescribed Fire

There is an opportunity for an expansion of the prescribed burning program, particularly for fuels reduction and habitat modification. There is also a need for an improved wildfire assessment map that more accurately reflects the effects of fire, weather, and topography. Additionally, most counties within the Black Hills have CWPPs, but there is an opportunity for each county to reduce the likelihood and severity of fires while working with other county, state, and federal agencies.

Research

Across the state, there is still a need for additional research and information relating to forest health, such as the effect that climate change will have on the coniferous forest types of South Dakota. Similarly, there is opportunity for studying the ability of the juniper and redcedar forests to sequester carbon, compared to the rangelands in which they are expanding. There is opportunity in determining the ideal harvest rates and stocking levels to optimize carbon sequestration in the ponderosa pine forests of the Black Hills, while weighing these values alongside the need to maintain a viable forest industry and protect the forest from fire and MPB.

2.0 UPLAND HARDWOOD FOREST

Figure 2.1 Upland Hardwood Forest in the Coteau Area (South Dakota Department of Agriculture, 2016)

2.1 DEFINITION

Upland hardwood forests occur outside of floodplains where drainage is sufficient so that soils are not exposed to long periods of saturation. Tree canopy in upland forests is usually dense which allows shade tolerant species to persist. Upland hardwood forests in South Dakota range from dry to mesic and are comprised of tree species such as bur oak, quaking aspen, paper birch, green ash, boxelder, black walnut, basswood, and maple. (Figure 2.1)

2.2 EXTENT AND CONDITION

Upland hardwood forests make up approximately 20%, or 392,000 acres of South Dakota's 1.95 million acres of forest land (Walters, 2015). The range and extent of upland hardwood forests is shown in Figure 2.2. The map in Figure 2.2 was generated using Landfire dataset and Landsat 8 aerial imagery.

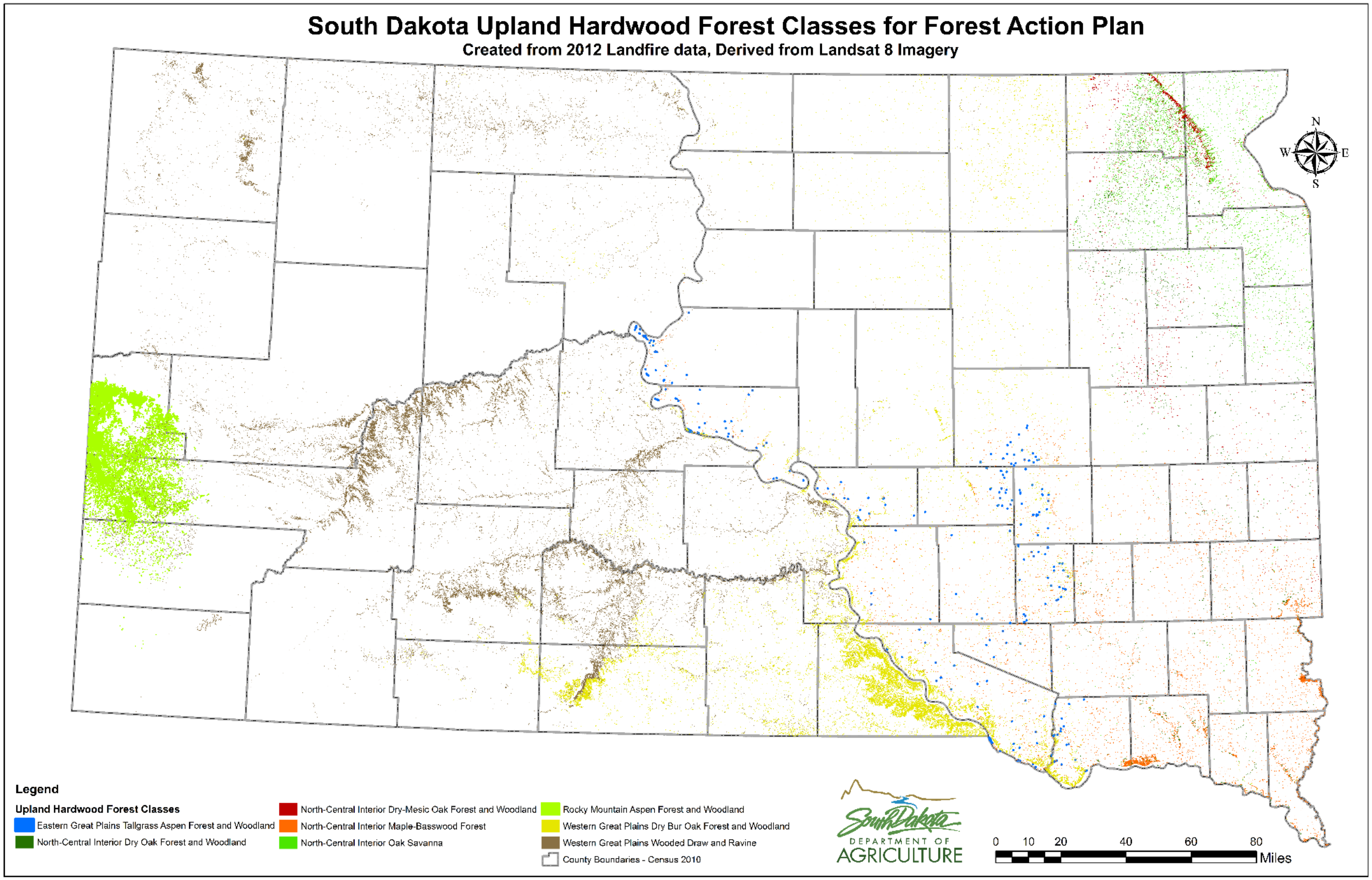


Figure 2.2 Distributions of Upland Hardwood Forest in South Dakota (Landfire 2012)

LANDFIRE VEG_Classification System	Acres
Eastern Great Plains Tallgrass Aspen Forest and Woodland	198.05
North-Central Interior Dry-Mesic Oak Forest and Woodland	18902.92
North-Central Interior Dry Oak Forest and Woodland	11011.00
North-Central Interior Maple-Basswood Forest	49649.13
North-Central Interior Oak Savanna	22317.37
Rocky Mountain Aspen Forest and Woodland	17029.18
Western Great Plains Dry Bur Oak Forest and Woodland	164529.00
Western Great Plains Wooded Draw and Ravine	173253.37
TOTAL	**456890.03**

Table 2.1 Upland Hardwood Forest Vegetation Systems in SD (LANDFIRE, 2012)

According to the Landfire dataset from 2012, the upland hardwood forest type in South Dakota is comprised of eight different ecological vegetation systems as listed in Table 2.1. The acreages accounted for in the Landfire dataset do not necessarily reflect those reported in USFS FIA data, simply due to different methods of data collection. FIA data is collected based on forest area which is defined as an area with at least 10% stocking, 120 feet width, and at least one acre in size, and Landfire is an aerial imagery and mapping tool. Areas in South Dakota with concentrated upland forests include western Harding County, the Black Hills, central Pennington County, portions of Bennett and Todd counties, and eastern and northeastern South Dakota. There are also forested areas all over the state, outside of the floodplains along reaches of the Cheyenne, Big Sioux, Belle Fourche, James, White, and Missouri Rivers, where upland hardwood species are dominant. FIA forest types that make up most upland hardwood forests of South Dakota include bur oak, hackberry-elm-green ash, and aspen.

Forest type	Tree Age Class						
	Total	0-20 years	21-40 years	41-60 years	61-80 years	81-100 years	100+ years
Eastern redcedar/ hardwood	16,591	-	16,591	-	-	-	-
Bur oak	113,278	4,926	-	21,346	36,943	27,490	22,573
Elm/ash/black locust	35,333	6,429	1,607	12,266	7,758	7,272	-
Mixed upland hardwoods	18,341	5,782	-	3,826	8,733	-	-
Sugarberry/ hackberry / elm / green ash	91,959	-	12,042	29,268	28,880	21,769	-
Sugar maple/ beech/yellow birch	2,900	-	-	2,900	-	-	-
Aspen	52,410	1,407	4,926	11,468	9,403	9,966	15,241
Paper birch	8,752	-	-	-	3,774	3,713	1,265
Other hardwoods	57,928	18,485	672	16,302	4,926	2,517	15,026
Other exotic hardwoods	36,428	-	3,214	30,232	2,981	-	-
Total	433,920	37,029	39,052	127,608	103,398	72,727	54,105
Percent of Total	100%	9%	9%	29%	24%	17%	12%

Table 2.2 Area of Upland Hardwood Forest by Age Class, in Acres (U.S. Department of Agriculture FIA, [2018a])

Age class analysis shows that approximately 71% of the upland hardwood forest in South Dakota falls into the 40-100 year range (Table 2.2, Figure 2.3). The age-class value used by FIA is the midpoint of the age class based on the dominant and co-dominant trees or the ages of the trees within the recorded stand size class. Therefore, trees of a wide variety of ages may be present in any given stand; only one age class is recorded.

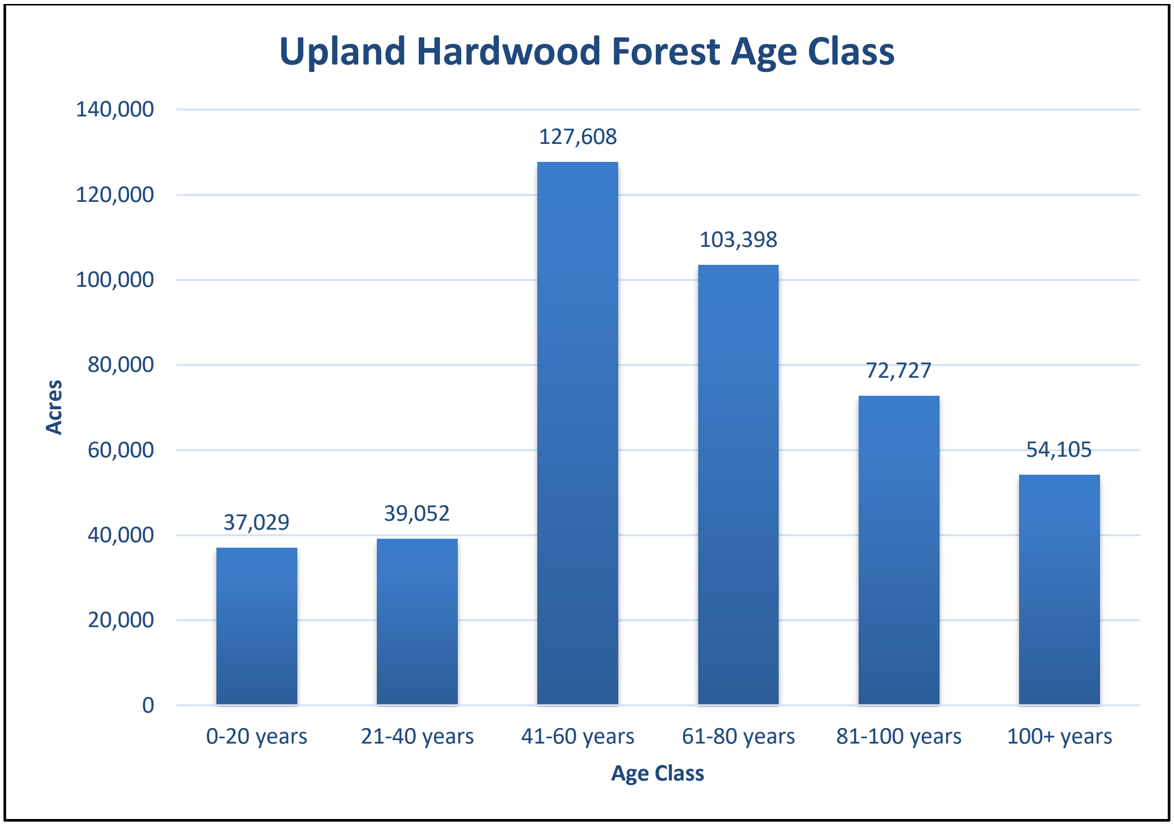


Figure 2.3 Area of Upland Hardwood Forest Age Class by Total Acres (U.S. Department of Agriculture FIA, [2018a])

Bur oak, with over 113,000 acres, is widely distributed in South Dakota and is the only native oak found throughout most of the state. Bur oak is found in eastern South Dakota along stream bottomlands, draws, and upper slopes; in dry prairie uplands in central South Dakota; and in the foothills and hogback draws of the Black Hills (Leatherberry et. al. 2000). Age class analysis of bur oak suggests that sapling size trees are not dominant anywhere, and 80 years of age is an approximate median age for the forest type with 56% of acreage younger than 80 and 44% of acreage being older (Figure 2.4). In a 2000 study, Leatherberry, et. al, stated that over 75% of the area of bur oak types supported stands that were at least 40 years old, but 54% of the area also supported seedling to sapling size trees. The more recent data appears to partially support this conclusion as 96% of bur oak recorded was over 40 years old.

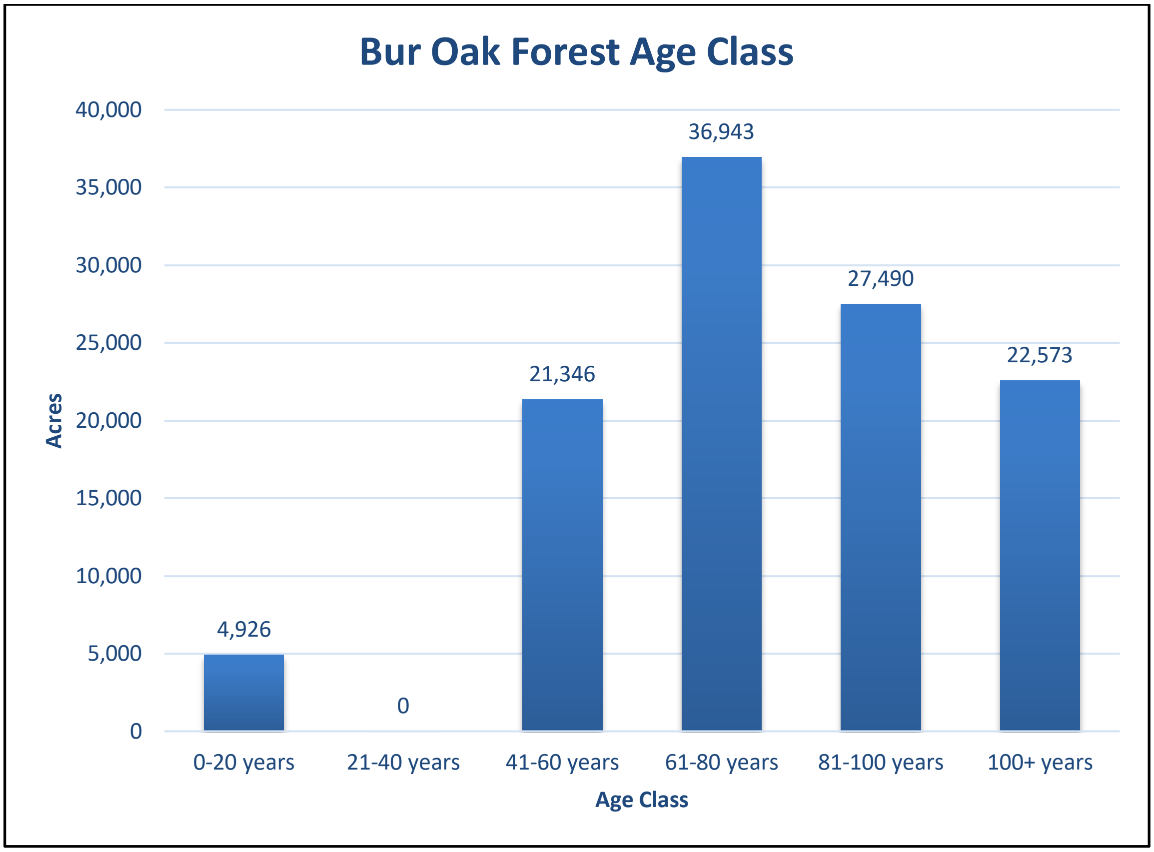


Figure 2.4 Bur Oak Forest Type Age Class by Total Acres (U.S. Department of Agriculture FIA, [2018a])

The aspen forest type is found mostly in the Black Hills with some occurrence in the northeast corner of South Dakota. Some aspen areas also contain paper birch (*betula papyrifera)* as a codominant species. The aspen forest type accounts for approximately 51,000 acres across the state. Age class analysis shows that nearly 70% of aspen forest stands are 60 years are older (Figure 2.5). Aspen is aided in regeneration by disturbance (chiefly fire) for regeneration by reducing conifer competition and encouraging root suckering. These disturbances have declined over the last century, which could be a factor in the age class distribution of aspen stands (Piva 2009).

The hackberry-elm-green ash forest type is the most abundant hardwood forest type in South Dakota covering more than 95,000 acres. This forest stand type can be found throughout the state in areas outside of the floodplains and riparian areas below the upland prairie grasslands. Age class analysis shows a fairly even distribution with approximately 70% of forest stands being between 40 and 80 years old (Figure 2.6). Again, due to the methodology of the data collection and reporting, zero acres in the 0-20 year age class does not necessarily indicate the absence of regeneration in these forest types.

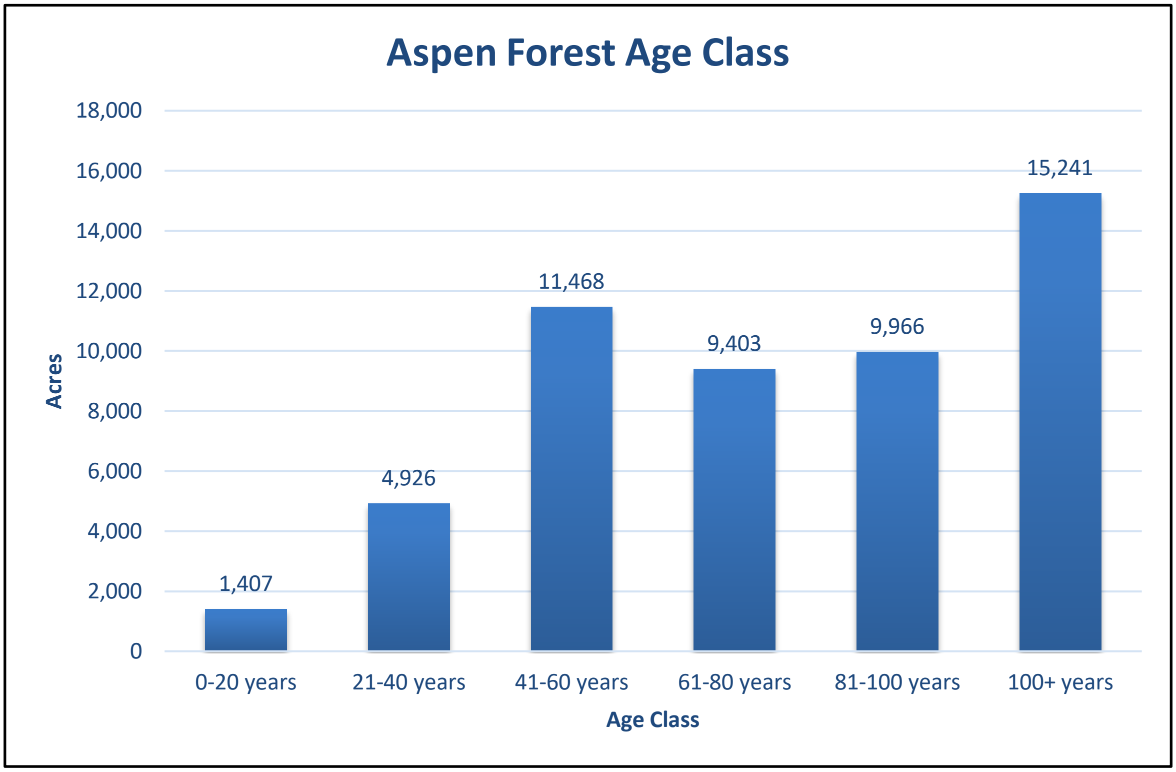


Figure 2.5 Aspen Forest Type Age Class by Total Acres (U.S. Department of Agriculture FIA, [2018a])

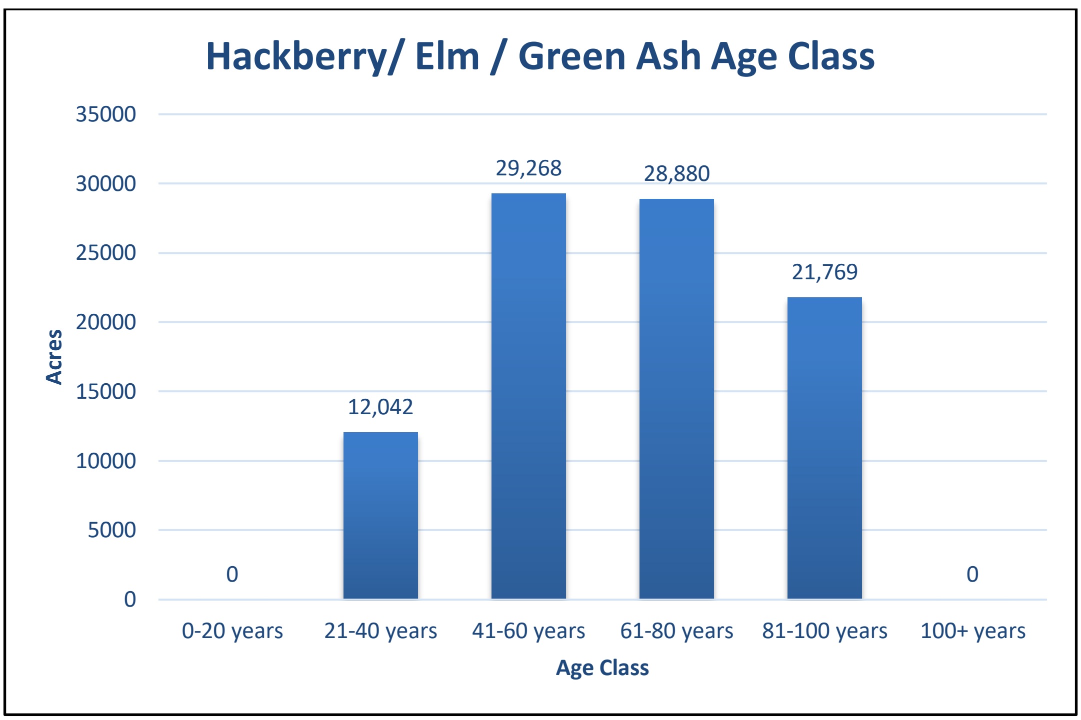


Figure 2.6 Hackberry-Elm-Green Ash Forest Type Age Class by Total Acres (U.S. Department of Agriculture FIA, [2018a])

2.3 VALUES

The geography and distribution (Figure 2.2) of upland hardwood forests will likely limit the long term sustained yield of traditional wood products such lumber and boards from this forest type. The greatest values of upland hardwood forests may be in other functions and benefits they provide to the landscape, and to the people that inhabit those landscapes. These benefits are known as 'ecosystem services' (Deal, et. Al. USFS 2017). Some of these ecosystem services are discussed below.

Upland hardwood forests are a critical factor in protecting the quality of both water and soil. Tree canopies and forest litter protect soils from erosion by slowing rainfall and dispersing runoff. Roots provide a matrix for soil cohesion and stability which reduces soil erosion. Live root systems act as a filtration buffer to absorb fertilizers that may be applied to nearby cropland before they enter streams.

Opportunities for large scale market development will likely be limited for the upland hardwood forest type. However, the tree species that make up the upland hardwood forest type allow for the production of high value products. Species like black walnut and bur oak are highly valuable when they are utilized in small scale or niche craftsman type markets. RCF maintains a 'log finder' website to assist both buyers and sellers of wood products in their utilization efforts. It provides a network to connect those seeking to have trees removed with those seeking to create a value added product. Users are not limited solely to upland hardwood species; a goal of the site is to aid in utilization of products that would otherwise go unrealized.

Upland hardwood forests in South Dakota provide critical habitat needs for wildlife across the state. Bur oak trees produce acorns that serve as a food source for deer, elk, and turkeys, for example. Northern Long Eared Bat, a federally threatened species, may utilize upland hardwood forests as roosting sites (Appendix H). The South Dakota Game Fish & Parks State Wildlife Action Plan (SDGFP SWAP) identifies key wildlife species and their habitat requirements within the upland hardwood forests of South Dakota.

There is a substantial cultural benefit to South Dakota provided by upland forests in the form of recreation and aesthetics. South Dakotans usually place high value on upland trees and forests because of their limited number and distribution. Recreation opportunities include hiking, camping, hunting, and photography (Figure 2.7). Upland hardwood tree species provide opportunities for tourism benefits with the color change associated with fall foliage and spring flowering seasons. For example, The Black Hills Shootout, an annual photography competition is held in the Black Hills in the fall showcasing the color change of aspen and birch trees in the region.

Figure 2.7 Aspen Stand in the Black Hills (SD Department of Agriculture, 2011)

Upland hardwood forests add diversity to the Great Plains landscape in South Dakota. Agriculture and grasslands dominate the landscape across nearly all the state. Areas of upland hardwood forests offer a visual break as well as a different ecosystem than their surroundings. In the Black Hills of western South Dakota, aspen, birch, and oak forests provide breaks in the coniferous forest type. These breaks are can be crucial to slowing the spread or reducing the negative impact of disturbances such as insect infestation or wildfire.

The wide distribution of the upland forest type may also be a benefit. Small areas, or pockets of the forest type may be affected by several factors, but the spread or impact would be slow or non-existent across this forest type. The fact that the upland forest type is somewhat of a mosaic across the state could slow the spread of an insect or disease issue simply due to the lack of continuity across the landscape and the isolation of some areas of the forest type.

2.4 THREATS

There are numerous threats facing the upland hardwood forests of South Dakota. There are insect and disease issues, indirect environmental concerns, as well as a variety of anthropogenic factors posing a threat to the forest type. There are a significant number of insects and diseases that affect upland hardwood tree species in the state, but those that constitute a major threat are discussed in more detail below.

Emerald Ash Borer

In May of 2018, emerald ash borer *(Agrilus planipennis)* (EAB) was discovered in the northern part of Sioux Falls. This was the first confirmed infestation in South Dakota and consisted of approximately 250 trees. The community of Sioux Falls has since been proactive in the implementation of an EAB response plan, and RCF has assisted in surveying the infested area, helping with a street tree inventory, and providing technical assistance through public outreach and education efforts.

EAB was first found in 2002 in Michigan and has since been found in 33 states and three Canadian provinces. South Dakota has a higher percentage of ash trees than any other state in the country. Data from the Great Plains Initiative (GPI) in 2008-2009 indicates that over 36% of the rural (upland, bottomland, and windbreaks) trees in South Dakota are ash trees (Sowers, 2014). Sowers' GPI report shows that 22% of all woodland trees are ash trees.

Dutch Elm Disease

Dutch elm disease (DED) infects American elm *(Ulmus Americana)* trees and is caused by a fungus (*Ophiostomas ulmi*) that is predominantly spread by bark beetles. Once the fungus is established in an elm tree, it rapidly spreads causing the tree to wilt and eventually die. DED was first detected in South Dakota in 1967 in Minnehaha County and has since spread to every county in the state (SDDA 2008). Although a significant number of elm trees have been killed, the rate of tree loss due to DED is decreasing due to programs focusing on prompt removal of infected trees and the limited number of widely disbursed American elms left in South Dakota (SDDA 2008).

Bur Oak Blight

Bur Oak Blight (BOB) (*Tubakia* iowensis) is a disease that was first noticed in the neighboring states of Minnestoa, Nebraska, and Iowa in the 1990s. The leaf disease is common in years with a wet spring when leaves are expanding and can intensify and eventually cover the entire canopy over successive years. Individual infected trees may recover following initial infection provided favorable weather conditions in subsequent years; however, they are more susceptible to secondary stress agents and may die if the disease and secondary stresses are left unmanaged. The disease has become more prevalent in wooded draws in Eastern South Dakota and is more common in a subspecies of bur oak (*oliviformis*) that is common on the drier upland sites (Ball, RCF 2016).

Two Lined Chestnut Borer

Two lined chestnut borer (*Agrilus bilineatus*) attacks distressed bur oak trees. Oaks that become infested often die within 1-3 years. Large infestations have been found in the south-central portion of the state and in Brookings, Lawrence, Lincoln, Mellette, Pennington, and Todd counties.

Common Buckthorn

Common buckthorn (*Rhamnus cathartica*) is an invasive plant species that is native to Europe but has spread across South Dakota. Buckthorn can out-compete native forest plants, degrade wildlife habitat, and form impenetrable layers that shade out understory vegetation. Buckthorn lacks natural controls such as insects or disease and is tolerant of many different soil types which have allowed it to proliferate across a variety of landscapes in South Dakota.

Native Conifer Encroachment

Upland hardwood forests are also being threatened by encroachment from native conifers. Eastern redcedar and rocky mountain juniper are slowly encroaching and overtaking areas that historically were upland hardwood forest types. In the Black Hills area, lack of disturbance, chiefly fire, has led to the decline of aspen and birch forest stands over time. The lack of fire has allowed conifer species such as Ponderosa pine and Black Hills spruce to encroach on and overtake stands of aspen and birch.

Land Use Change

Forest fragmentation and land use change can also pose a threat to upland hardwood forests in South Dakota. As ownerships and forestlands become smaller and more spread out, management can become less practical. Without proper management, the forest types will continue to degrade over time. Grazing of domestic livestock also poses a significant threat to upland hardwood forests. Grazing can hamper natural regeneration as well as degrade soil quality through compaction and increasing erosion (Stein, et al 2007).

Other environmental factors that can be a threat to upland forests include drought and climate change that may result in trees being stressed and therefore more susceptible to insect and disease issues.

Wood Products Market

The lack of viable markets and demand for products from upland hardwood forests could also contribute to the degradation of the forest type over time. In this instance, the geographic distribution of the forest type works to its detriment. Without a consistent supply, any market development would not be cost effective. Without viable markets for products, the cost of management can become an obstacle for forest managers.

2.5 OWNERSHIP

Approximately 67% of the upland hardwood forest land in South Dakota is privately owned (Table 2.3). Of the remaining acreage, approximately 27% is on federal land, and approximately 6% is owned by state and local entities. 'Other federal' ownership includes agencies such as Bureau of Indian Affairs (BIA), National Park Service (NPS), and Bureau of Land Management (BLM).

State and local ownership includes South Dakota Department of Game Fish and Parks (GF&P) and municipalities. State Parks with significant upland hardwood forest components include Custer State Park, Newton Hills State Park, and Sica Hollow State Park. In 2014, the Forest Legacy Program (FLP) was used to establish Good Earth State Park in the Blood Run National Historic Landmark (Figure 2.8). Establishing the state park as part of the FLP will protect the forest lands from conversion to non-forest use.

Forest type	Ownership group				
	Total	National Forest	Other federal	State and local	Private
Eastern redcedar / hardwood	16,591	-	-	4,340	12,251
Bur oak	113,278	19,586	-	-	93,692
Elm / ash / black locust	35,333	-	6,429	9,107	19,797
Mixed upland hardwoods	18,341	5,782	-	-	12,560
Sugarberry / hackberry / elm / green ash	91,959	-	-	5,285	86,674
Sugar maple / beech / yellow birch	2,900	-	-	-	2,900
Aspen	52,410	48,074	-	-	4,336
Paper birch	8,752	8,752	-	-	-
Other hardwoods	57,928	28,527	-	5,670	23,732
Other exotic hardwoods	36,428	-	-	-	36,428
Total	433,920	110,721	6,429	24,402	292,370
Percent of Total	100%	26%	1%	6%	67%

Table 2.3 Area of Upland Hardwood Ownership (U.S. Department of Agriculture FIA, [2018a])

2.6 NEEDS, PROBLEMS, AND OPPORTUNITIES

Upland hardwood forest stands in South Dakota are usually small, of poor quality, with large distances between them. These factors present obstacles for forest management. Additional needs, problems, and opportunities are discussed further below. These needs may not necessarily be limited to the upland hardwood forests.

Figure 2.8 Upland Hardwood Forest in Good Earth State Park (SD Department of Agriculture, 2015)

Data

There is a need for more thorough data, and the ability to query this data both geospatially and temporally. The FIA data used in this assessment to report on acreage is derived from permanent sample plots visited by contractors on the ground, and then extrapolated to the State. Plots meant to get an accurate sample of the forested resources in the State are visited over the course of seven years, with an equal number of plots visited annually. The map (Figure 2.2) showing the upland hardwood forests of South Dakota were created using LANDFIRE, which is derived from Landsat 8 imagery taken from a satellite. The acreages and classifications from these two datasets, while similar, cannot be equated with any degree of confidence. FIA data provides an accurate overview, or baseline of the state's forest resources. However, this data becomes less reliable as the information is stratified by species, or even more so, within species, due to the limited sample size. Increasing sample size of FIA would be impractical due to the costs and only marginal improvements in the data. Any opportunities to supplement FIA data with forest type specific inventory data should be explored. For example, the GPI project provided additional insight into forest resources that may not have been captured in the FIA sample.

Research

Additional research is needed in emerging fields as they may relate to upland hardwood forest ecosystems in South Dakota including, but not limited to:

- Climate change
- Carbon sequestration
- Nontraditional/secondary forest products (ginseng, honey, mushrooms, etc.)
- Pollinator habitat expansion
- Prescribed fire

Education and Outreach

There is a constant need for education and outreach as it relates to achieving desirable outcomes. Since most upland hardwood forests are privately owned, those landowners need to have access to sound advice.

Fragmentation

Forest fragmentation and patchwork ownership across the landscape also presents obvious challenges. As housing density increases and lands become fragmented, several negative impacts may result, including reduction in wildlife habitat and browse, increases in human/wildlife conflicts, reduction in habitat connectivity, poorer water quality, and reduced outdoor recreational opportunities (Stein et al, 2007). This presents an opportunity to work across boundaries and agencies on collaborative projects to achieve landscape scale objectives.

Grazing

The negative impacts of grazing on forest health have been well documented. Developing livestock management and grazing specific BMPs will benefit the health and potential productivity of upland hardwood forests.

Market Development

There is significant opportunity for market entry and development, especially in central and eastern South Dakota. A 2015 South Dakota Department of Agriculture, Resource Conservation and Forestry survey shows that only four facilities are active in areas east of the Missouri River. The challenges of market entry and sustainability in this sector have been discussed, but as technology and research evolve, so will the opportunities to develop a viable market strategy.

3.0 BOTTOMLAND FOREST

3.1 DEFINITION

Figure 3.1 Bottomland Hardwood Forest in Sica Hollow State Park (SDDA, 2016)

Bottomland, or riparian, forests occur inside floodplains where soils can be exposed to long term saturation. Bottomland forests are defined as trees in the cottonwood and willow forest type in the riparian zone with 200 feet of a stream. Bottomland forests (Figure 3.1) contain hydric to mesic soils and are comprised mainly of cottonwood and willow tree species. Other tree species that may be found in bottomland forests include elm, ash, eastern redcedar, Russian olive, and boxelder.

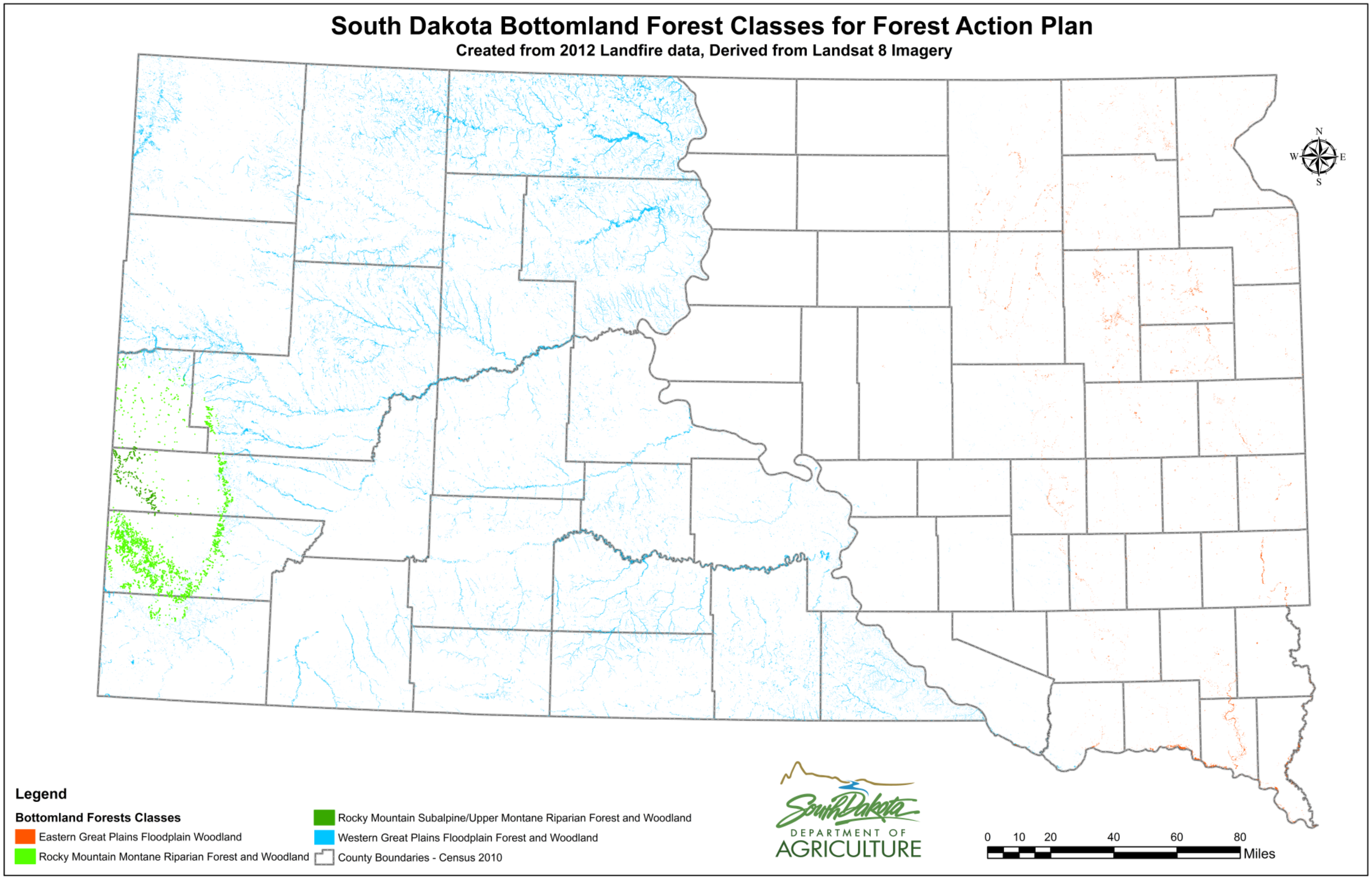


Figure 3.2 Distributions of Bottomland Hardwood Forests in SD (Landfire 2012)

3.2 EXTENT AND CONDITION

Bottomland forests make up approximately 3%, or 56,000 acres of South Dakota's 1.95 million acres of forest land (Walters, 2015). Although only a small percentage of total forest land is bottomland, most of the forest land in South Dakota outside of the Black Hills is found within a few miles of rivers and streams (Piva et al. 2009). In South Dakota, many river basins, lakes, ponds, and streams have adjacent areas of concentrated bottomland forest. The range and extent of bottomland forests is shown in Figure 3.2. The map in Figure 3.2 was generated using Landfire dataset and Landsat aerial imagery. According to the Landfire dataset from 2012, the bottomland forest type in South Dakota is made up of four different ecological vegetation classification systems listed in Table 3.1. The acreages accounted for in the Landfire dataset do not necessarily reflect those reported in the FIA data due to different sampling methods. FIA data uses a definition of forest land that may exclude a significant amount of bottomland acreage. FIA forest types included in South Dakota's bottomland forest include cottonwood and cottonwood-willow.

LANDFIRE_VEG CLASS SYSTEM	ACRES
Eastern Great Plains Floodplain Woodland	14796.25
Rocky Mountain Montane Riparian Forest and Woodland	3836.11
Rocky Mountain Subalpine/Upper Montane Riparian Forest and Woodland	344.69
Western Great Plains Floodplain Forest and Woodland	419056.11
TOTAL	**438033.16**

Table 3.1 Bottomland Forest Vegetation Systems in SD (LANDFIRE, 2012)

Cottonwoods are majestic and magnificent trees. They are typically found near streams, drainages, and ponds as they survive best around a source of shallow water. In general, cottonwood trees can quickly grow large, although as a result they are weak wooded and have a safe lifespan of roughly 70 years. Most (80%) of the cottonwoods in South Dakota are at least 60 years old with very few stands of young cottonwoods and virtually no saplings (Table 3.2 and Figure 3.3). Only 3% of cottonwoods in South Dakota are less than 40 years old.

Forest type	Tree Age Class (Years)						
	Total	0-20 years	21-40 years	41-60 years	61-80 years	81-100 years	100+ years
Cottonwood	56,117	-	1,679	9,387	27,776	11,129	6,146
Percent	100%	0%	3%	17%	49%	20%	11%

Table 3.2 Area of Bottomland Forest by Age Class, in Acres (U.S. Department of Agriculture FIA, [2018a])

Figure 3.3 Area of Cottonwoods by Age Class (U.S. Department of Agriculture FIA, [2018a])

A study by Dixon, et al, in 2010 studied cottonwoods along 390 miles of the Missouri River in an area ranging from Montana to Missouri. One stretch along the river from Oahe Dam to Big Bend Dam in South Dakota has seen significant decreases in cottonwood and bottomland forest in general. Findings along this stretch of the river align with the FIA data as about 91% of the existing stands are greater than 50 years old (Dixon, et al 2010). According to Dixon, the stand condition of this stretch of the Missouri River "has the poorest condition of all sampled study segments."

Cottonwood regeneration in South Dakota has drastically declined primarily due to alteration of natural flood events caused by the construction of dams. Cottonwood regeneration is highly dependent on flood events which facilitate the meandering of stream channels and the creation of new sandbar areas which enhance seedling growth. Dam releases in the spring which are designed to mimic natural spring snow melt have the potential to improve cottonwood age class distribution by increasing regeneration along certain riparian corridors. (Dixon, et al 2012)

Willow trees (*salix spp.*) grow in similar environments as cottonwoods but there is less concern about their condition and regeneration. Total acreage of cottonwoods is approximately 51,500 acres with an additional 4,500 acres of willows (Table 3.2). Secondary species within bottomland forests include elm, ash, Rocky Mountain juniper, and Russian olive.

3.3 VALUES

Bottomland, or riparian, forests (Figure 3.4) provide many benefits to South Dakota. They provide improved flood control and water quality, areas of wildlife habitat, aesthetic and cultural appeal, and provide recreation opportunities (Piva, et al 2009).

Eastern hognose snake, Northern long-eared bat, Northern river otter, and osprey are all federally threatened species that may be found within bottomland forests, or in the water bodies bordered by bottomland forests. These species either use the forest for habitat or are reliant on clean water that bottomland forests can help provide (Appendix H). Improved flood control and water quality are important benefits of bottomland forests. These areas act as water storage areas which can reduce downstream flood height. Vegetation, especially trees and their root systems, help to decrease flood water velocities and stabilize streambanks which reduce sediment runoff. They also improve water quality by reducing nonpoint sources of pollution including animal waste, nutrients, pesticides, and sediment. The forests act as a buffer and filtration system allowing sediment and organics to settle out from surface runoff or flood waters before entering the stream. (Poff, et al 1997)

Figure 3.4 Bottomland Hardwood Forest Type (SDDA, 2016)

Bottomland forests provide vital habitat for numerous species of wildlife across the state. These forests provide shade to streams which enhances fish habitat by maintaining water temperature and increasing levels of dissolved oxygen. The forests also provide shelter and food for various other reptiles, mammals, and birds. Because of their height and bulk, mature cottonwoods are important roosting and nesting sites for many species, including bald eagles. In fact, there have been efforts undertaken to restore cottonwood in its historical range with the specific objective of improving bald eagle habitat. (SD GF&P 2005) The South Dakota Game Fish & Parks State Wildlife Action Plan (SDGFP SWAP) identifies key wildlife species and their habitat requirements within the bottomland hardwood forests of South Dakota.

Bottomland forests also provide aesthetic and cultural benefits in addition to recreation opportunities (Figure 3.5). These forests have been a source of exploration and settlement over much of human history with many of the early settlements in South Dakota being along stream valleys. Recreation benefits in bottomland forests include hunting, fishing, trapping, hiking, and boating.

Figure 3.5 Bottomland Hardwood Forest in Good Earth State Park (SDDA, 2017)

3.4 THREATS

The long term health and viability of bottomland forests in South Dakota is dependent on a constant supply of water or regularly saturated soils. Any factor that may pose a threat to future water quality or water supply is a significant, albeit indirect threat to bottomland forests (Dixon, et al 2012). The biggest threats to bottomland forests in South Dakota include continued stream alteration, land use change, insects and disease, invasive species, and over grazing. Other threats to bottomland forests include, forest fragmentation, lack of species diversity, lack of available markets and the associated high costs of forest management.

Water Flow Alterations

Natural or anthropogenic alterations of water flow are a major threat (Poff, et al 1997) to bottomland forests. Potential sources of the changes could include climate change, agricultural irrigation needs, or dam construction. Riparian forests, especially cottonwood and willow, need periodic flooding to replenish rich soils and create new habitat for seedlings.

Invasive Species

Invasive species such as buckthorn, Russian olive, and salt cedar pose a threat as they expand their range into the bottomland forests. Salt cedar (*tamrarix spp.*) is a flowering tree/shrub that is considered a noxious weed. It absorbs a large amount of water, leaves behind large deposits of salt, aggressively replaces native riparian vegetation, and is difficult to eradicate. Invasive buckthorn is also a threat to bottomland forests as it becomes established in those areas.

Livestock Grazing

Grazing from domestic livestock also pose a significant threat. Livestock often prefer the edges of waterways and will often spend much of their time in and around the wet shady areas that bottomland forests provide. Unmitigated livestock and over grazing can lead to a loss of vegetation and regeneration, soil erosion, decreased water quality, and weed invasion (Zaimes 2006).

Insects and Diseases

Green ash and American elm are also becoming established in areas where cottonwoods have been declining (Johnson, et al 2012). Emerald ash borer (EAB) and Dutch elm disease (DED) are two threats that could also decimate these tree populations. Creek bottoms of continuous ash and elm become corridors for the spread of EAB and DED. EAB and DED are discussed in more detail in section 2.4.

3.5 OWNERSHIP

Approximately 86% of bottomland forests in South Dakota are privately owned. The remaining 14% is owned by either the state or local municipalities (Table 3.3). This is a significant change from previous data, which recorded approximately 10,000 acres of cottonwood forest under federal ownership. However, cottonwood forests classified as privately owned also increased by approximately 8,000 acres.

Forest type	Ownership group				
	Total	National Forest	Other federal	State and local	Private
Cottonwood	56,117	-	-	7,636	48,481
Percent of Total	100%			14%	86%

Table 3.3 Area of Bottomland Forest Ownership, by Acres (U.S. Department of Agriculture FIA, [2018a])

3.6 NEEDS, PROBLEMS, AND OPPORTUNITIES

Although most bottomland forests are privately owned, these forests provide important public benefits to the people of South Dakota (Piva, et al 2009). Because of the number and significance of the threats to bottomland forests, public outreach and education will be vital in all efforts to preserve and restore bottomland forests and riparian areas. Common themes are data needs, research expansion, and collaboration. Some areas for potential improvement include:

- A unified classification system and datasets would serve interagency collaboration. There are multiple agencies using multiple classification methods of bottomland or riparian forests that can result in drastically different data. A prime example is the difference between FIA and LANDFIRE data in this report.
- There are several parties interested in cottonwood restoration. Interagency collaboration would have a larger impact on the landscape and allow efforts to cross agency boundaries. Agencies that could play a role in research and project implementation include South Dakota Department of Agriculture, US Army Corps of Engineers, Bureau of Indian Affairs, USFS, and SD Game, Fish, and Parks among others. Despite recent interest "regeneration is not keeping pace with losses of cottonwood" (Dixon, et al 2010, 2012).
- Additional research is needed to determine the role prescribed fire could serve in managing bottomland forests.
- Developing grazing management Best Management Practices (BMPs).
- A more inclusive, specific, and robust forest inventory is necessary for planning and management of bottomland forests. Any opportunities to supplement FIA data with forest type specific inventory data should be explored. For example, the GPI project provided additional insight into forest resources that may not have been captured in the FIA sample.

4.0 WINDBREAKS AND WOODED STRIPS

4.1 DEFINITION

Trees-outside-of-forests are random trees or planted rows of trees and shrubs used to meet a wide range of resource objectives. They are composed of a variety of shrubs and trees, including eastern redcedar, Rocky Mountain juniper, elm, honeylocust, caragana, lilac, and plum. They occur in discontinuous patches across South Dakota (Figure 4.1). The term "windbreak" shall be used and taken to mean any row or belt of working trees. Trees-outside-of-forests are lands that have never supported forests, and lands formerly forested where use for timber growth is precluded by development for other use; lands that never have had, or that are incapable of having 10% or more of the area occupied by forest trees; or lands previously having such cover and currently developed for trees-outside-of-forests use.

Figure 4.1 Windbreaks protecting houses, buildings, gardens, and fields. (National Agroforestry Center, 2016)

There are different types of windbreaks that can be planted in South Dakota each windbreak has its own value, function and benefits. Living snow fences protect roadways from wind and snow and reduce snow plow costs. Livestock windbreaks provide benefits to feedlots, livestock pastures, and calving areas by reducing wind speeds. This will lower animal stress, improve health, and increase feeding efficiency. Farmstead windbreaks protect out-buildings and homes. Field windbreaks reduce wind erosion and crop damage from wind-blown soil. They improve water use efficiency reduce risks associated with drought and manage blowing snow. Riparian windbreaks are used to stabilize stream banks and reduce downstream sediment and nutrient delivery. Wildlife windbreaks provide nesting habitat and shelter from predation as well as food for local wildlife and protective cover when foraging in adjacent areas.

4.2 EXTENT AND CONDITION

The Great Plains Initiative (GPI) showed that there are 968,174 acres of non-forested land with trees in South Dakota with 543,755 of those as windbreak acres**.** Out of the total windbreak acres, 38% are for livestock, 18% are for field windbreaks, 9% are riparian wooded strips, and 13% are for farmsteads (Sowers, 2015). The remaining 22% is split between abandoned farmsteads, wildlife, rural home, residential, isolated trees, narrow wooded strips, and living snow fences. Most of the windbreaks are in the Bad-Missouri-Coteau-James and Minnesota-Big Sioux-Coteau river basins within the eastern half of the state (Piva etal 2009).

Minimal data exist regarding the extent, condition, and ownership of windbreaks within the state. 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 (Table 4.1). During this period of record nearly 384,000 acres of windbreaks including over 190,324,018 trees have been planted. Since 2006 there have been an average of 3,041 acres, or 1,161,198 trees planted each year. Typically, the number of acres planted in a year depends upon the availability of funds from cost-share programs with more trees planted in times of greater funding. Most of these trees were planted as field, farmstead, and feedlot windbreaks and a smaller percentage were planted for wildlife or to renovate existing windbreaks (Table 4.1). The GPI revealed that approximately 80% of planted trees were deciduous trees and only 20% were coniferous (Sowers, 2015).

Year	Total (acres)	Field Windbreaks (miles)	Field Windbreaks (acres)	Farmstead and Feedlot Windbreaks (acres)	Other Windbreaks (acres)	Renovation Plantings (acres)	Wildlife Plantings CRP (acres)	Conifer Trees Planted	Deciduous Trees Planted	Total Trees Planted	Average Trees per Acre
1940-1949	30,827	286	1,818							25,826,225	796
1950-1959	55,486	1,517	12,758	6,831	1,819					30,652,980	554
1960-1969	64,621	4,045	17,884	16,553	3,001					31,880,369	493
1970-1979	59,731	3,664	13,729	31,672	7,793	1,431				27,426,385	458
1980-1989	44,380	2,200	7,583	23,227	7,366	4,576	1,630	6,842,718	14,507,126	21,349,844	484
1990-1999	43,293	2,594	7,642	17,821	6,883	4,017	6,931	8,559,391	13,381,690	21,941,081	508
2000-2009	65,156	6,021	24,864	28,201	4,985	5,318	7,887	10,537,378	15,941,235	26,475,613	401
2010-2019	20,472	1,477	5,386	7,419	1,313	1,570	3,754	3,087,133	3,762,195	6,889,371	337
Total	383,966	21,804	91,664	131,724	33,160	16,912	20,202	29,026,620	47,592,246	192,441,868	4,031

Table 4.1 Conservation tree and Shrub Plantings in South Dakota (NRCS 2019)

The GPI for South Dakota was conducted during the summer months of calendar years 2008 and 2009 under the guidance of the FIA program. This was done in conjunction with similar efforts in Kansas, Nebraska, and North Dakota. This inventory focused on tree species on trees-outside-of-forests. The completed South Dakota data shows that ash is the predominate species in windbreaks; followed by redcedar/juniper. The GPI inventory shows that 63% of the woodlands and trees-outside-of-forests are in fair condition with the age group mainly being over 50 years of age.

A study in 1977 showed that mortality in windbreaks increased until they reach the 31-40-year age group, after which mortality seems to stabilize (Walker and Suedkamp 1977). This study also revealed that the condition of windbreaks improves in relation to the number of rows, with a nine-row belt most likely to be in good to excellent condition.

A study in 1987 covering 27 counties revealed that 61% of South Dakota's windbreaks were missing 30% or more of their canopy and needed renovation (Shaefer et al. 1987). Another study conducted in 1997 across the northern two-third of the state found that 87% of windbreaks needed renovation (Josten and Rasmuson, 1997). Both studies show that most of the windbreaks or trees-outside-of-forests need renovation because they were no longer functioning as designed. Sowers concluded from the 2008-2009 GPI data that overall the conditions of South Dakota's windbreaks show 63% are in fair condition and 8% are in poor condition, suggesting that renovations of older windbreaks are being completed (Sowers, 2015). Renovations differ however, depending on the goals and can include thinning, row removal, pruning, supplemental planting, sod release, coppicing, root pruning, and complete removal and replanting.

The Windbreak Condition Project was a result of a 2014 $150,000 USFS Competitive Grant (now Landscape Scale Restoration Grants) award to assess the condition of windbreaks in high priority areas in eight counties in South Dakota. The project utilized Geographic Information System (GIS) and remote sensing techniques and field survey methods to identify windbreak locations and assess the primary function and condition of the windbreaks in an eight county area of South Dakota: Aurora, Davison, Douglas, Hanson, Hutchinson, Jerauld, Sanborn, and Yankton counties. Sites that are small blocks of trees within maintained lawns, naturally forested riparian areas, ditch/road banks and fence lines were excluded from this project.

In Phase one, a total of 16,535 individual windbreaks were identified using the windbreak intercept tool developed by USFS Northern Research Station and the total acres of windbreaks were calculated at 42,512. In 2016, the ground truthing was completed for each of the eight counties. There was a total of 231 windbreaks measured, 10,694 trees and 3,227 shrubs logged between the eight counties. The field data collected in Phase one indicates that 49% of the windbreaks in this project area were in poor condition. The aerial photo analysis indicated that 45% of windbreaks were in poor condition. Aerial photo analysis also classified 16% more windbreaks as fair and 13% more as good when compared to field data collection.

In Phase two, the number of individual windbreaks was not totaled since the windbreak intercept tool was not available for use. In 2018 field measurements were completed on 225 windbreaks. A total of 7,447 tree and 1,687 shrubs recorded in the eight counties. The field data collected for Phase two indicates that 74% of the windbreaks in this project area were in poor and fair condition. This represents the same percentage that was in Phase one field checks.

With the data collected in the Windbreak Condition project RCF was able to obtain a Conservation Collaboration Grants or Agreements (CCGA) grant from the NRCS to hire a forester to broaden technical assistance and implement an education and outreach campaign to increase participation in renovating windbreaks in the eight county area of Phase one.

4.3 VALUES

Approximately 90% of South Dakota land-use classification is for agricultural use (Cropland or Rangeland). Windbreaks and trees-outside-of-forests provide many values to much of the land, especially to farms, fields, and ranches across the state. The values of windbreaks and trees-outside-of-forests are measured by snow control along roads, in farmsteads, and around livestock, as well as, increasing wildlife habitat, aesthetics, and recreation improvement.

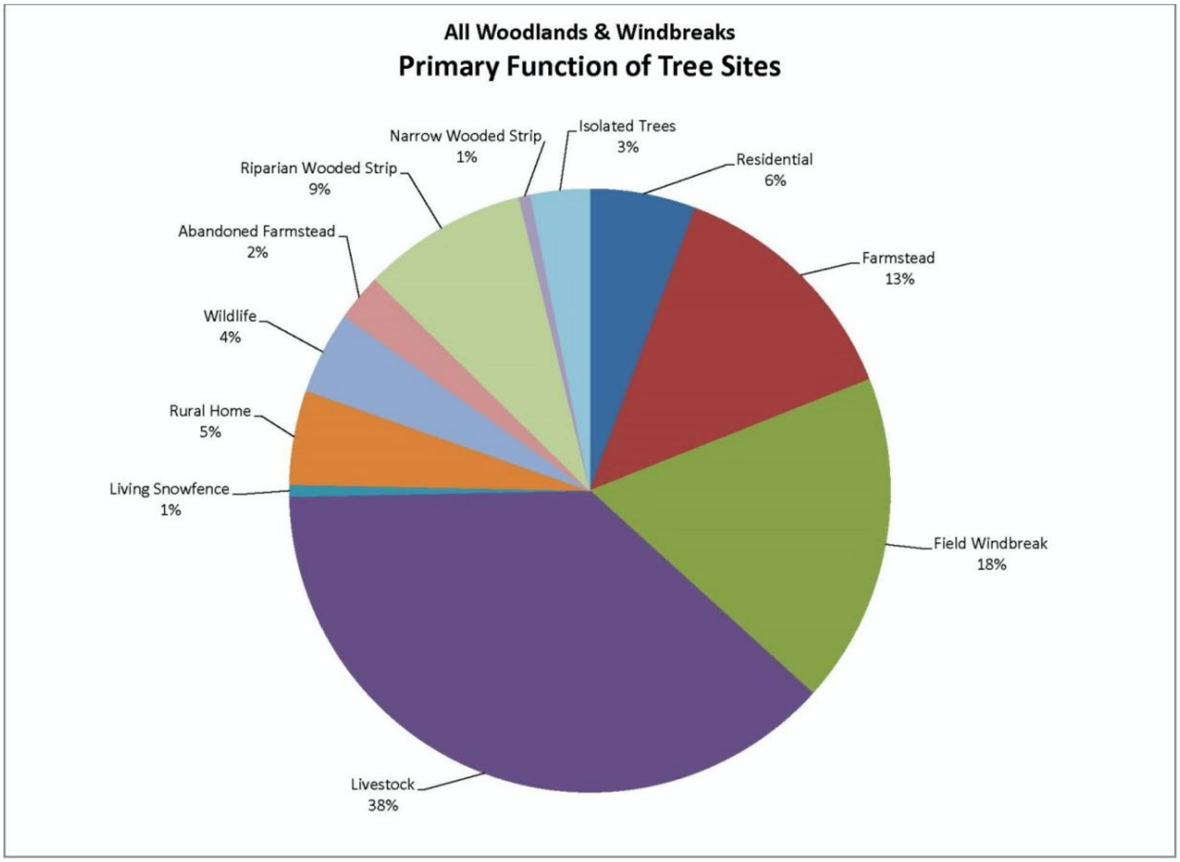


Figure 4.2 Primary function of tree sites (Sowers, 2015)

Windbreaks are economically and ecologically friendly practices for improving sustainability. Windbreaks protect farmsteads and crops from winds by reducing soil erosion on fields and reducing heating and cooling cost in residences and outbuildings. For homeowners in rural areas, well-designed windbreaks can cut home heating costs by 10 to 25% (NRCS 2006). A windbreak reduces heating costs by lowering the wind chill near your home. Wind chill is the temperature it "feels like" outside and is based on the rate of heat loss from exposed skin caused by wind and cold (U.S. Department of Energy 2016). Windbreaks also provide privacy to farmsteads by reducing visibility, controlling dust, and limiting traffic noise from roadways.

Windbreaks provide shelter to livestock during hot summer days and cold winters. The amount of feed required to maintain body temperature in cattle is reduced when they are protected by windbreaks. Canadian researchers found that cattle on winter range, in unprotected sites, required a 50% increase in feed for normal activities. 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 (University of Nebraska 1994).

Studies in Montana indicated that during mild winters, beef cattle sheltered by windbreaks gained an average of 34 to 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. Other types of livestock also benefit from shelter. Milk production in Holstein and Jersey dairy cattle declines at air temperatures below 35 degrees Fahrenheit. The amount of decline is dependent on animal health, coat condition, and feed intake. Under windy conditions further declines in production or increased feed requirements can be expected, due to lower wind-chill temperatures (Quam et al 1994).

Windbreaks alone, however, will not prevent odor problems but can provide farmers and ranchers with a "fresh" environmental tool to help reduce negative visual perceptions and the detection of smell by neighbors and surrounding communities. The potential of windbreaks to mitigate livestock odor arises from the tree/shrub impacts on the fundamental characteristics and physical behavior of the livestock odor plumes. Odor plumes are typically at ground level, often have limited upward movement, are variable, and may be very extensive covering large land areas. Odors generated in animal facilities are intense and detectable at appreciable distances. Windbreaks reduce odor around livestock facility for areas further downwind by redirecting airflow (NAC USDA, 2011).

Windbreaks across the state fill an important ecological niche and are beneficial to some wildlife species but can be unfavorable to some grassland species (Figure 4.3). There can be unfavorable outcomes when natural encroachment occurs, or establishment does not use a design appropriate for the area. When it comes to wildlife, windbreaks provide habitat for many different birds, but usually support fewer species than other forest types. Emmerich and Vohs (1982) found that windbreaks have the highest density of birds during the reproduction season. These windbreaks also can provide critical winter survival habitat for ring necked pheasant which provide economic benefits as well as recreational opportunities for all citizens, residents and nonresidents alike. During a typical South Dakota winter, cattail wetlands, tall grass, and food plots ranked highest in hen use, although tree cover was used at the end of a severe winter (a 1 in 10-year event) and may have prevented total mortality of hens that year. (Bakker, K 2006). The South Dakota Game Fish & Parks State Wildlife Action Plan (SDGFP SWAP) identifies key wildlife species and their habitat requirements within windbreak forests of South Dakota.

Figure 4.3 Windbreak for wildlife habitat (SDDA, 2017).

Living snow fences are windbreaks planted along travel ways to improve snow management (Figure 4.4). Living snow fences are more cost-effective than structural barriers, can meet many additional objectives, and provide a wide array of benefits beyond snow control. To achieve maximum snow accumulation, the windbreak density should range from 60% to 80% (University of Missouri Center for Agroforestry, 2015).

Figure 4.4 Living snow fence in Hanson County, SD (SDDA, 2017)

Benefits of living snow fences: (South Dakota Department of Agriculture 2004)

- Improved snow control due to greater snow storage capacity
- Longer life span than slatted snow fences
- Can be designed to provide winter livestock protection
- Provide and enhance wildlife habitat
- Aid in soil erosion control
- More aesthetically pleasing than slatted snow fence
- Relatively maintenance free once established
- Approximately ten times cheaper to install and maintain than slatted snow fence, based on cost comparisons over the expected life of a living snow fence
- Reduced snow removal cost

Properly maintained windbreaks can create a buffer in grass fires and may help to reduce fire intensity and provide suppression opportunities during a wildfire event [Mattox, 2009a]. Windbreaks also provide additional value to South Dakota because of increased scenic beauty of the landscape, they provide for recreational opportunities such as hunting and trapping, and they can provide fruit for use in the production of jams and wine.

Disadvantages of living snow fences: (South Dakota Department of Agriculture 2004)

- They require more space than slatted fences
- They take three to five years after planting to be effective
- They must be protected from livestock

Endangered species are not as abundant in windbreaks as they are in coniferous forest or upland and bottomland forest. However, there are a few that benefit from these windbreaks. The list of endangered species can be found in Appendix H.

Some grassland obligate species can be negatively impacted by trees planted in the prairies by habitat displacement or providing perches for predatory raptors (Kelsey et al, 2006).

4.4 THREATS

Windbreaks face threats from drought, disease and insects, change in land use, weeds and invasive species, herbicide drift, old age, lack of species diversity within the belt and within the rows, lack of data about South Dakota windbreaks, improper planting and maintenance, climate change, and intense weather such as tornadoes, blizzards, and heavy ice/snow events.

Maintenance

Weed barrier or fabric has become an issue over the last five years throughout South Dakota. The weed barrier does not seem to be deteriorating as fast around the trees and shrubs and is girdling trees within windbreaks. The biggest threat still throughout the state of South Dakota is simple deterioration because of lack of upkeep.

Insect and Disease

Insect and diseases are a threat to windbreaks, especially those that are single species. A dense, single-specie windbreak can be decimated by a single insect species or disease. An example of this would be if a four-row windbreak where all four rows were planted with green ash. Eventually, EAB will kill every tree in the windbreak. Windbreaks with diversified tree species are under less of a threat but can still be damaged by insects and diseases. Windbreaks that are also stressed from drought or overcrowding are at a higher risk of insect or disease issues. The two dominant species in shelterbelts, green ash and Siberian elm, are under the greatest threat of mortality and deterioration over eastern South Dakota (Walker and Suedkap, 1977). All native ash trees are susceptible to EAB. The 2008-2009 GPI data showed that 37% of the trees measured were green ash. With the discovery of EAB in South Dakota in 2018 many windbreaks are now at risk of losing one or more rows as EAB moves across the state. Honeylocust may become infested with the honeylocust borer (*Agrilus difficilis*)**.** Rocky Mt. Juniper and eastern redcedar may become infected with Cedar-Apple Rust fungus (*Gymnosporangium juniper-virginianae*) (Figure 4.5) or juniper twig blight (*Phomopsis juniperovora*) (Ball and Foss, 2009). Caragana may be threatened by blister beetles, stem decay, branch cankers, and septotoria leaf spot. Other concerns are pine wilt, pinewood nematode, pine tip moth, and Zimmerman pine moth (Piva et al., 2009).

Figure 4.5 Crabapple with cedar apple rust fungus (Dr. John Ball, 2017)

Animal Damage

Damage from deer, livestock, and other animals pose a threat to newly planted windbreaks or other trees-outside-of-forests. Several tree species are either eaten or rubbed on by these animals. A fence or tree tubes around sapling or newly planted windbreaks are important.

In 2003, the Lower Brule Sioux Tribe completed their Community Wildlife Protection Plan (CWPP) for 258,560 acres of reservation lands. The objective of the Lower Brule Wildfire Protection Plan is to reduce the risk of wildfire to life, property, critical infrastructure, and natural resources on Lower Brule Reservation. This plan also provides information regarding windbreaks being used as fire breaks. Windbreaks provide fire breaks where wildland fires can be stopped if fire resistant species and proper maintenance is used. Proper maintenance would be to disk or mow between rows to reduce low ground cover and grasses and remove dead trees and shrubs along with fallen branches to reduce ladder and ground fuels.

4.5 OWNERSHIP

Because windbreaks usually do not fall under the FIA definition of forest, there is no data regarding ownership in the FIA database. Most windbreaks are less than one acre in size and less than 120 feet wide and do not meet the FIA classification of forested land; therefore, these treed lands are not thoroughly inventoried. However, GPI was done with guidance from and coordination with FIA. The GPI was concluded in 2009 and showed that 8% of wooded lands are publicly owned and 92% of wooded lands are privately owned (Sowers, 2015).

4.6 NEEDS, PROBLEMS, AND OPPORTUNITIES

- Currently the GPI data is the only information about the extent, species, and condition of windbreaks and trees-outside-of-forests across the state. The Windbreak Condition Project currently in progress will help with determining average species and condition of windbreaks and trees-outside-of-forests in the current project area of southeastern South Dakota. In addition, the Trees-Outside-of-Forests Inventory (TOFI) uses remote sensing technology and, also under the guidance of FIA, will provide the first statewide inventory of TOFI extent. Results from this inventory were not available at this writing.
- Most windbreaks do not fall under the FIA definition of forest, and therefore no data is collected. FIA is the most extensive and ubiquitous compilation of forest data, it would be logical to expand it to windbreaks. The data collection under GPI and Windbreak Condition Study was designed to follow FIA protocols. An expansion of FIA is needed to include land with trees-outside-of-forests so that information can be collected about this important resource.
- Future inventories throughout the state of South Dakota like the Windbreak Condition Project or the GPI will help determine the health of South Dakota's windbreaks and trees-outside-of-forests. These inventories will help with future pest issues by determining the common tree or shrub species within a windbreak or wooded strip. Knowing that information will help with determining, where to focus our priorities.
- There is a great need to renovate existing windbreaks that are aging and becoming ineffective. The lack of public education and funding for windbreak renovation remains a key problem. Conservation districts have been successfully using the EQIP program and SD Conservation Commission Grants to address windbreak deterioration. A more robust forest products industry is needed to use wood from windbreak renovation activities.
- One future opportunity is to design windbreaks to provide habitat and flower plants that provide food for pollinators. Using plants that support pollinators within windbreaks can not only increase pollinators but also increase aesthetics. There are opportunities to use demonstration plots throughout

South Dakota to determine if it would be possible to use pollinator supporting plants in South Dakota’s windbreaks.

- Another opportunity is to set up demonstration sites for innovative renovation practices such as using a seed drill for planting trees and shrubs. Both Iowa and Nebraska have used this method to establish windbreaks throughout their states.
- A need is for education about weed barrier or fabric. Most producers believe that once the fabric is applied the windbreak is maintenance free. Many windbreaks throughout South Dakota are showing signs of fabric damage by girdling of trees. Workshops or short videos demonstrating how to remove the fabric and the tools that can be used, or just to show general care for the fabric may be needed.

5.0 URBAN AND COMMUNITY FORESTRY

5.1 DEFINITION

Urban and community forests are the accumulation of trees and other woody plants within cities and towns. This includes trees on both public and private land such as community parks, boulevards, community right-of-ways, business lots, and private yards.

Figure 5.1 View of the South Dakota Capitol from Capitol Lake (South Dakota Department of Tourism, 2016)

5.2 EXTENT AND CONDITION

South Dakota is home to 1.95 million acres of forest land (Walters 2015). In addition, there are 3.8 million urban and community trees (Nowak et al. 2012). According to the South Dakota tree inventory reports, the most common trees found in South Dakota's community forests are green ash, Siberian elm, silver maple, and common hackberry (CTAP & UFIA). Data from tree inventories indicate that the condition of a community forest can be characterized by four separate ranking conditions.

Community Tree Inventories

The RCF has been collecting community tree data for approximately 16 years. These inventories include trees along streets, on boulevards, and in community parks. This data provides a broad picture of the diversity, age, and condition of the community trees in South Dakota. To do this, communities are randomly selected for tree inventories or communities may request an inventory be conducted. After conducting an inventory, the results are added to our state data base and the community is provided with a working inventory of their community forest. This allows communities to spot trends in their forest, create long- and short-term plans to manage their community trees, and formulate a realistic budget for maintenance and new plantings. RCF has utilized a few different inventory systems including Davey Tree Keeper, Urban Forest Inventory and Analysis (UFIA), the Community Threat Assessment Protocol (CTAP), and most recently all of the inventories have been entered into TreePlotter.

In total, RCF has inventoried 77 communities throughout the state, with 68 of them being CTAP reports. Within a community, service foresters lead an inventory team to capture data representative of all public trees in that community. After acquiring this data, RCF then combines the data they have into a CTAP report. A list of the communities inventoried has been provided in Appendix C. These documents are kept on file as well as distributed to the community to help them better understand their urban forests and the management it requires. The most recent CTAP and UFIA data has been combined to provide an accurate perspective on South Dakota's community forests. Data from these combined inventories will be further explained in this section.

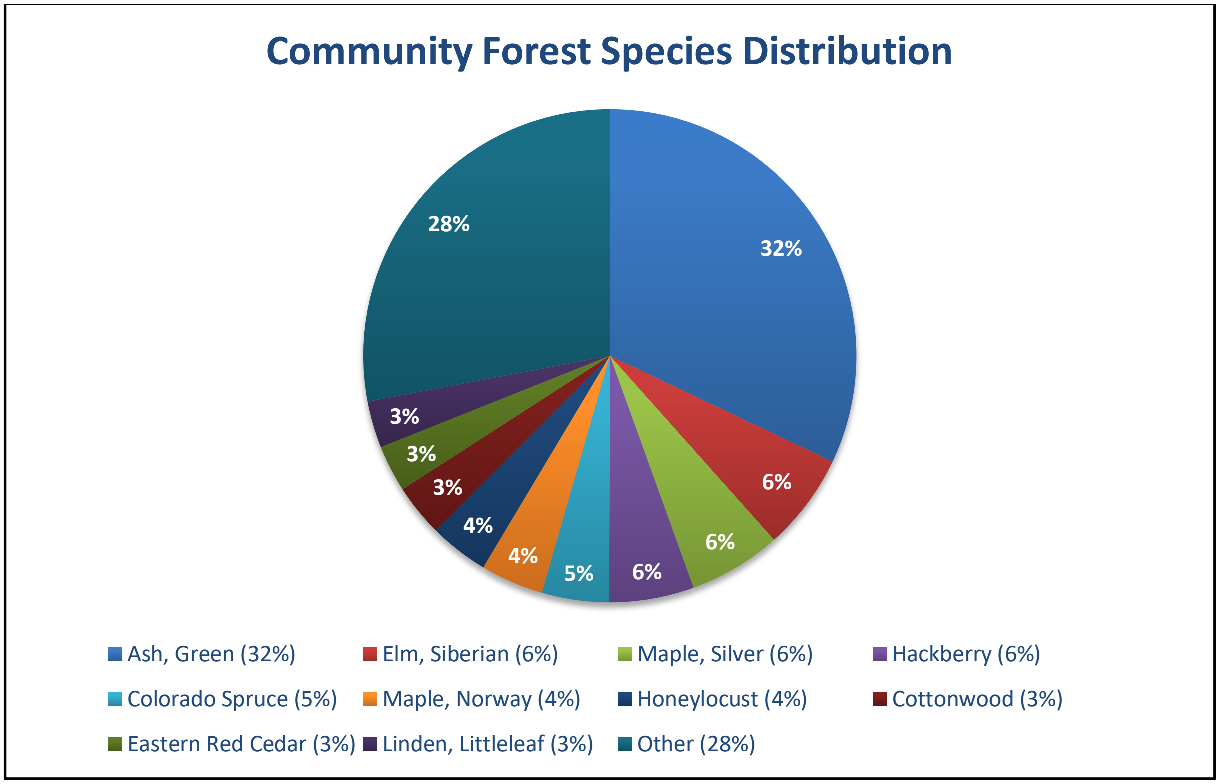


Figure 5.2 UCF Inventoried Species

Species diversity plays a large role in the health of urban forests. A lack of diversity leaves forests vulnerable to pests and diseases (Raupp et al. 2006). EAB is a substantial threat to South Dakota's ash trees. Figure 5.2 shows that 32% of trees in the inventoried communities are ash and this is representative of the entire state (CTAP & UFIA). Therefore, with the recent arrival of EAB in South Dakota we stand to lose 32% of the trees in South Dakota communities. The presented risk of EAB highlights how important genera diversity will be while working with South Dakota's community forests.

The diameter of a tree is related to site conditions such as moisture, nutrient availability, and competition (Bigler 2016). However, it is also a significant indication of the age of a tree without removing it to examine the tree rings. Taking measure of this information allows us to determine the overall age of a forest and roughly the remaining lifespan of the trees. Age diversity is another important factor of the health of a forest. If an urban forest has similar aged trees, those trees will fail roughly around the same time resulting in a loss of canopy cover in that forest. The urban trees in South Dakota are measured by their diameter at breast height (DBH) as shown in Figure 5.3. DBH is a standard unit of measure in forestry and arboriculture when explaining the size of a tree.

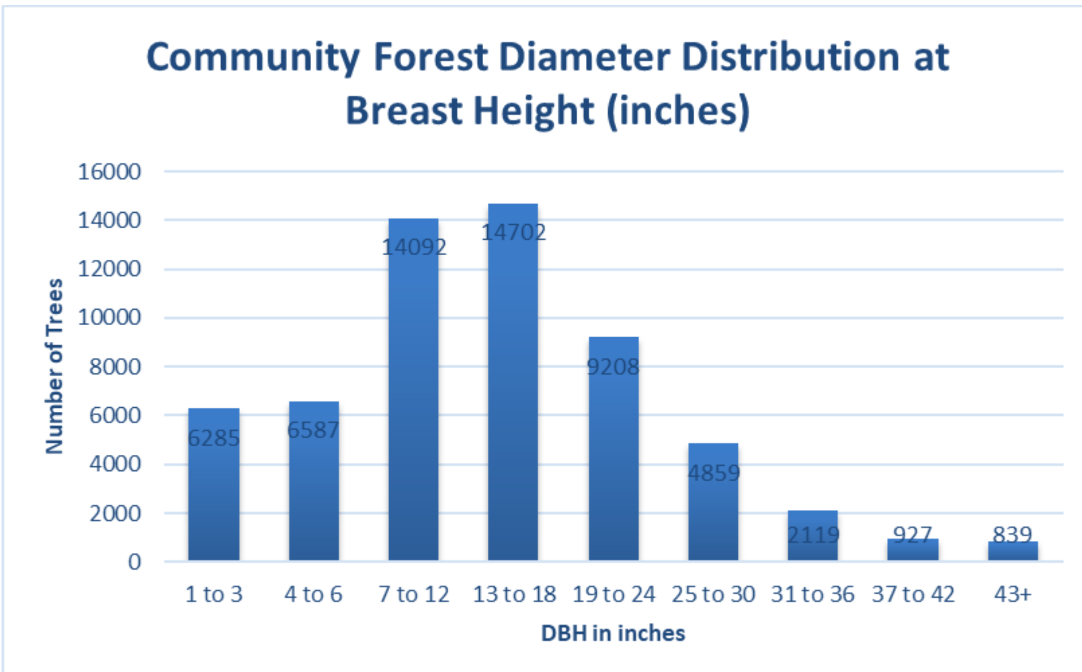


Figure 5.3 UCF Inventoried Tree Diameter

The four ranking conditions used in the South Dakota inventories are excellent, good, fair, and poor. Most of the trees within the urban forests of South Dakota are in excellent or good condition (81%); however, there are a sizable portion that are ranked as fair (13%) and poor (6%) (CTAP & UFIA) (Figure 5.4). Tree condition implies the general health of a tree which is predominantly determined by the percent dieback of the tree canopy. A tree with no die back receives an excellent rating. A tree with little dieback receives a good rating, moderate dieback provides a fair rating, and more than 50% dieback is rated as poor. These ratings provide an indication of the general health and risk of the community forests as well as help to determine what maintenance or replacement may be necessary in the future. As indicated in the graph, most of the South Dakota inventoried community forests are in good condition.

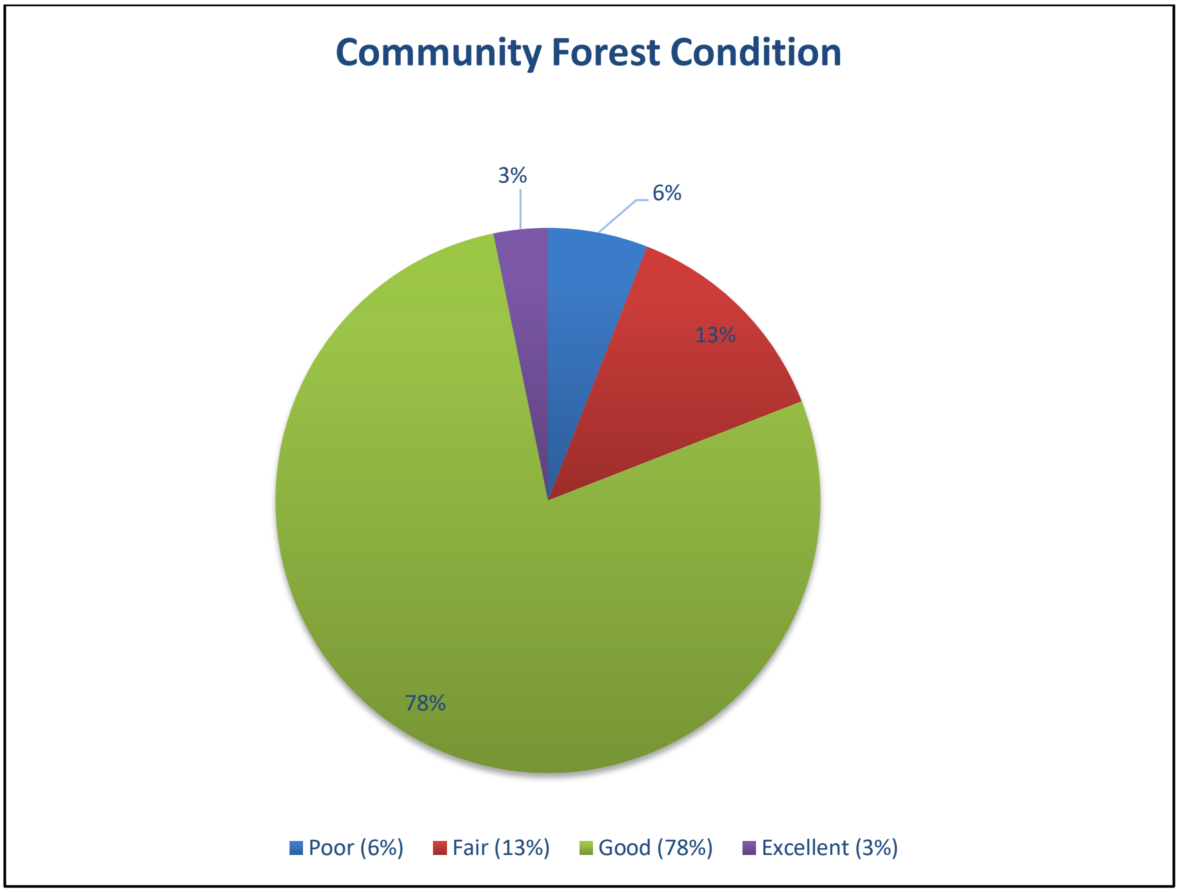


Figure 5.4 UCF Inventoried Tree Condition

Tree City USA Communities

Tree City USA is an Arbor Day Foundation Program that honors communities with good community forest practices and appreciation. In 2019, South Dakota had 32 Tree City USA's (TCUSA's) with more expected to enroll in the coming years (Figure 5.5). To be recognized as a TCUSA, a community must meet four qualifying standards:

1. A Tree Board or Department
2. A Tree Care Ordinance
3. A Community Forestry Budget of at Least $2.00 per Capita
4. An Arbor Day Observance or Proclamation

These four qualifying standards provide a base from which communities can grow and evolve. These standards are the basic qualities that a community should possess to manage its urban forests properly. Other benefits of being a TCUSA include more educational opportunities, increased public image, higher citizen pride, and better chances of being awarded forestry and community beautification grants compared to a non-TCUSA. For a full description of each of the qualifying standards visit the Arbor Day Foundation at www.arborday.org.

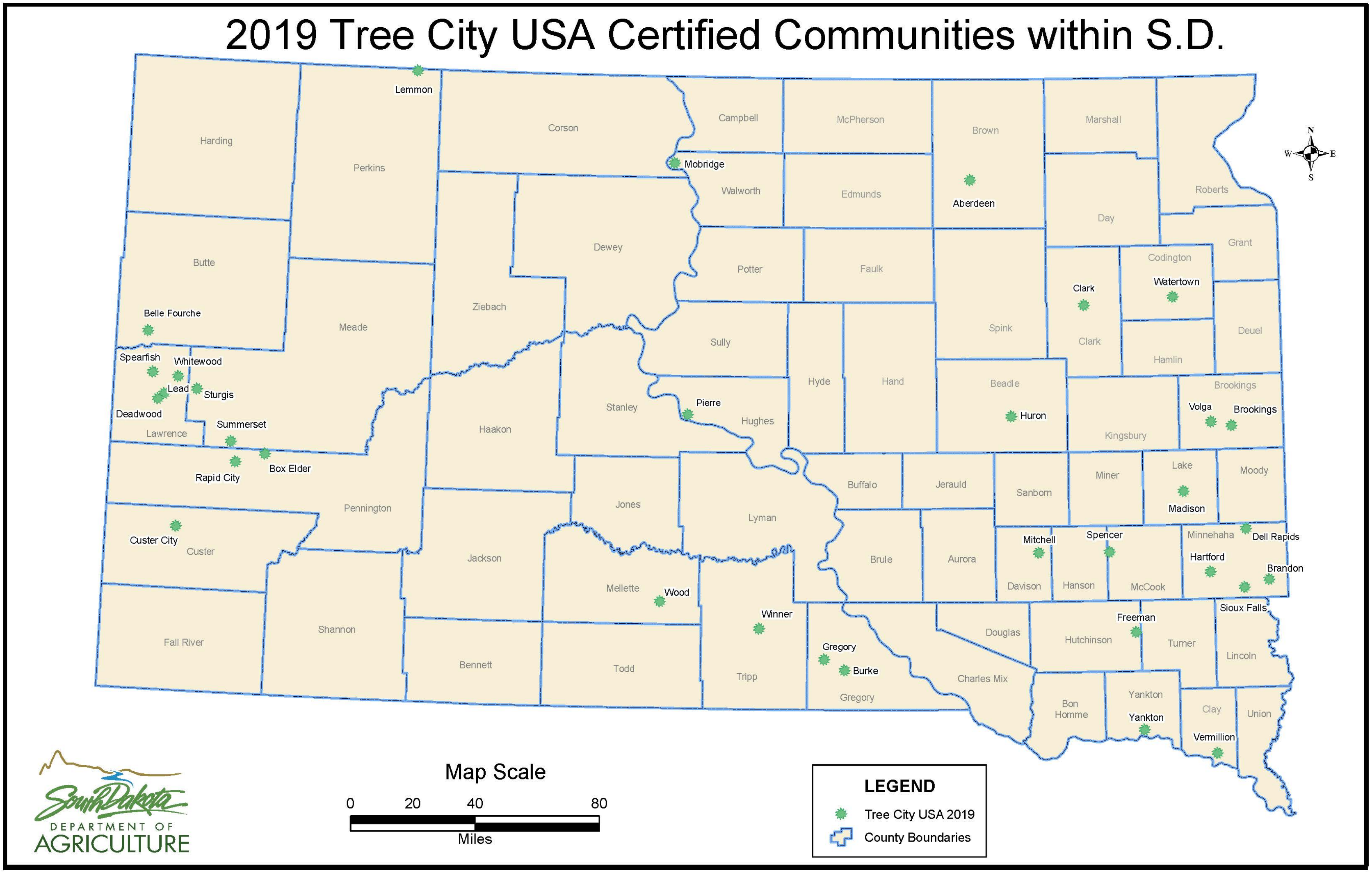


Figure 5.5 UCF Map of All South Dakota Tree City USA's (TCUSA)

5.3 VALUES

An urban forest provides similar benefits to other types of forests in many regards. The trees filter out pollutants from water before it reaches underground water systems, create oxygen and sequester carbon, and provide a source of biomass that can be used for many products that we use daily. In a 2014 research study titled Trees Improve Human Health and Save Lives, David Nowak gathered information on the health benefits of trees with the help of the USFS and Davey Institute scientists. Modeling of local environmental data revealed that trees removed 17.4 million metric tons of air pollution across the conterminous United States in 2010, with human health effects valued at $6.8 billion. The human health effects included the avoidance of more than 850 incidences of human mortality and 670,000 incidences of acute respiratory symptoms (Nowak et al. 2014).

Urban forests are experienced everyday by all members of the community. The benefits they provide are experienced more often by a higher number of people on a regular basis (Figure 5.6).

In an urban setting trees not only provide the benefits listed previously, they also provide many municipal benefits as well. On average, the higher percent of tree canopy a community has the more benefits the community is receiving from their trees. Slowed or collected storm water runoff, wind protection, shade, reduction in air pollutants, improved water quality, reduced energy needs, improved community aesthetics, and recreation opportunities are just some of the benefits a community receives from its urban forest (Maco & McPherson 2002).

Properly placed trees near buildings and homes provide the most beneficial municipal impacts by shading homes during hot summer months and blocking cold north east winds during the winter, thereby reducing energy costs and consumption. Trees also create effective sound buffers from nearby streets and visual fences for privacy and blocking out unwanted views. According to Dr. E. Greg McPherson of the Center of Urban Forest Research, "If you plant a tree today on the west side of your home, in 5 years your energy bills should be 3% less. In 15 years, the savings will be nearly 12%". And if property value is a concern, well-placed trees and other landscaping in a yard can increase the property value of a home by as much as 20% (Arbor Day Foundation 2016). City parks also provide a popular setting for events and festivals which provide a community with an alternative income source and its citizens a source of entertainment. Marketing biomass from trees can provide not only a sustainable energy source but also extra income for a community.

When considering environmental factors over a long period of time, old tree roots decompose improving soil aeration and increasing soil organic matter. Trees also improve water quality in urban areas near streams and waterways by reducing impervious areas and reducing water runoff. Trees slow rain to reduce ground impact, lower erosion rates, and increase soil stability (Center for Watershed Protection and USFS 2017).

Figure 5.6 Falls Park in Sioux Falls, South Dakota (South Dakota Department of Tourism, 2016).

5.4 THREATS

In South Dakota, the urban forests can face many threats, both natural and man-made. Natural threats include severe weather, climate change, water availability, lack of species diversity, old age, fire, disease, native invasive species, and insect infestations. Man-made threats our urban forests face include chemical sprays, improper pruning, neglected maintenance, improper planting, vandalism, lack of planting diversity, introduction of exotic pests and plants, lack of urban forest regulation for new developments, and lack of knowledge about the urban forest.

Because many urban forests are predominately planted as opposed to naturally occurring, there are numerous varieties of trees that can be found in these systems. While this can help species diversity, it can also lead to many of the same species and cultivars being planted in a localized area in a monoculture. Because of such monocultures, there are a variety of insects and diseases that the urban forest is highly susceptible to (Raupp et al. 2006). The main threats in South Dakota include canker disease, Dutch elm disease, emerald ash borer, Asian longhorn beetle, gypsy moth, and oak wilt.

Emerald Ash Borer

EAB is a major threat for South Dakota due to ash species accounting for about a third of publicly owned community trees statewide (Figure 5.7). This figure comes from a combination of results from the 2013 CTAP in 41 South Dakota Communities and the 2013 UFIA which expanded on the inventory work of the 2007 GPI where the ash population in the state was found to be 37%. It was estimated that the ash inventoried provide almost $1.7 million annually in benefits to communities. Therefore, EAB will cause South Dakota communities some financial pressure and create hazards by causing these trees to become brittle and unpredictable with a few years of infestation. EAB was discovered in Sioux Falls, South Dakota's largest community, in 2018.

Figure 5.7 Adult Emerald Ash Borer (United States Department of Agriculture)

Severe Weather

Severe weather poses a significant threat to urban forests as well. Because the urban forests are typically less dense than other types of forests, they are highly susceptible to strong winds, heavy snow, and ice storms. Lightning, flooding, fire, and drought can also cause real harm to the forest. Once damaged by weather events such as these, trees in urban areas are at high risk of causing other issues such as injury to people, damage to vehicles and homes, and damage to municipal utilities such as power and phone lines. Though fire may be less likely in an urban area, there are many locations in South Dakota where urban areas are near or adjacent to forests or grass lands. In South Dakota there are a total of 347,157 acres of WUI area (Martinuzzi et al. 2010). These areas are susceptible to wildfire jumping from wild areas to urban.

Land Use Change

One of the largest risks urban forests face are those we as humans pose upon them. Often when new developments are constructed, most of the trees in that area are removed. In these cases, ordinances for new developments can regulate the number of existing trees to be removed from a construction site and the actions required to care for the remaining trees during construction to ensure their health and vitality. Lack of knowledge about urban forests and trees in general also leads to many issues such as improper care or planting, neglect of trees, herbicide application too close to trees, and the introduction of invasive species. Education through public workshops and informative meetings with town officials is important to combat the risks humans pose to urban forests.

5.5 OWNERSHIP

Urban forests can be under the ownership of many different entities. In South Dakota there is a total of about 49,358,000 acres (Statemaster.com 2017). Of this total, 44,965,138 acres are privately owned while 4,392,862 acres are publicly owned (Statemaster.com 2017). Overall, around 90% of the South Dakota is privately owned (freestateproject.org 2017). This includes residential lots as well as most commercial lots. A small portion of public areas such as city parks are under the jurisdiction of local governments and conservation groups while trees in public right of ways and boulevards are owned and under the jurisdiction of community and city governments. Questions about ownership of a piece of land can be resolved by a record search at the applicable county auditor’s office.

5.6 NEEDS, PROBLEMS, AND OPPORTUNITIES

As South Dakota’s population continues to grow, its communities will do so as well. According to the United States Census Bureau, South Dakota has seen an increase in population by 70,461 people between April 1, 2010 and July 1, 2019 (U.S. Census Bureau 2020). This population growth is occurring most commonly along the I-29 corridor and in the counties of Minnehaha and Lincoln (Brooks et al. 2009). Urban forests will be impacted by this growth and will continue to play an important role in the quality of life in these communities and local ecosystems. Management for these forests will become increasingly important in the years to come and this will require landowner and community education, environmental awareness, and investment of resources from state government, local government, community organizations, and private landowners.

RCF has a strong history of providing funds to communities for their urban forests through the Urban and Community Forestry (UCF) program Challenge

Grant. This has been a great opportunity for communities to strengthen their urban forests and better educate the community.

The following points indicate the needs, problems, and opportunities for the future of South Dakota's urban forests.

- TCUSA is a program that recognizes communities with outstanding care and management of their urban forests. In the last decade, this program has seen a rise in participation in South Dakota which has led some communities to establishing tree boards and adopting tree ordinances. However, there are still several communities without proper programs in place. Many communities lack the professional staff, tree ordinances, and urban forestry care plans required to keep this asset healthy and safe.
- Though most of the populous areas in South Dakota are managing their urban forests, many smaller or more remote communities lack the knowledge and tools needed to properly care for their trees. RCF provides workshops to reach communities such as these but more outreach would benefit all those who need it.
- Larger communities in South Dakota offer tree related technical assistance to their residents. However, most communities still lack the resources to provide this assistance and many of the residents do not know where they can get this help. It will take a wide variety of outreach programs on many levels for all South Dakota residents to fully understand who can help regarding their trees and how to obtain the help.
- The division regularly holds educational workshops for landowners and interested people on forestry related topics from pest identification to proper pruning techniques. These workshops have proven beneficial to those who attend, however, they typically attract small groups of people and many South Dakota residents either don't hear about them or are too far away to attend. It would be beneficial to host these workshops in more communities throughout the state to maximize outreach. More press coverage of the workshops would help to reach a broader audience. Social media postings or broadcasted video would also be beneficial.
- The Urban and Community Forestry team is staffed by motivated foresters. This should lend itself well in the coming years to ensure progression of programs and new involvement opportunities.
- CTAP reports of many communities have been produced by RCF after conducting urban tree inventories in those towns. Having such an inventory benefits the community by allowing them to understand their forests and what management will be required to preserve those forests. These inventories are also beneficial in recognizing trends of forest health, age, diversity, and density across the state. While inventories have occurred in some communities, more inventories from around the state are required to

paint a more accurate picture of the true state of South Dakota's urban forests.

- South Dakota has many community forests with even aged stands that will near the end of their life cycle within the same time frame. As can be seen on in Figure 5.4, around 24% of the inventoried trees in the state are within the 7 to 12-inch category and 25% are within the 13 to 18-inch diameter category. As a result, communities will be faced with replacing many trees at once. Having over mature, even aged stands poses danger to residents, municipalities, and the overall health of South Dakota's urban forest system. Most communities do not have the funds or resources to replace many trees simultaneously and will inevitably lose canopy cover. Communities with maturing, even aged forests need to continue to plant trees when possible to help diversify the age of their forest to promote sustainable forests.
- The South Dakota urban forests have a concerning lack of diversity throughout the state. Though many communities are realizing how detrimental this can be due to the impending threat of EAB, the urban forests have yet to be adequately diversified. There are numerous opinions on what percent of tree cover from a specific genus represents adequate diversity. However, there is consensus that diversity needs go beyond the species level to achieve resiliency objectives.
- EAB causes concerns not only for tree loss, but for tree hazards. Ash trees killed by EAB are known to become very brittle and unpredictable, which can make removal costlier and more hazardous. Removal of ash trees before the tree dies will help to decrease removal costs and potential hazards to the environment around the tree.
- To help slow the spread of EAB, a few precautions can be taken by the public. By taking care to not move wood from infected areas, EAB can be more effectively quarantined. The transportation of firewood can play a major role in spreading EAB across South Dakota.
- Currently, social media sites are a core part of our daily lives. These sites provide RCF with an influential tool to spread the word about our work and services to a broad range of people. That being the case, we are only starting to create a social media platform for RCF. More work needs to be done in creating a web presence that is interactive, interesting, and current.
- South Dakota's youth are a resource in which to instill good conservation practices from an early age. Programs such as "adopt a tree", mentorships, community service clubs, and teen-led advocacy groups would not only benefit the future of our program but would also provide a source of exposure to our work.
- Some states are reaching out to the public via large scale public events. These often revolve around Arbor Day and bring attention to forestry and conservation while offering fun attractions such as local musicians and

vendors. South Dakota could benefit from RCF-led events in populous areas featuring wood working, recycled products, local produce, and other eco-friendly products. This would introduce the work that RCF does to the public in an interesting and fun way.

- South Dakota's urban population is growing. The expansion of residential areas typically leads to trees being removed to make way for new developments. These trees are seldom replaced and are faced with poor soil conditions when they are. A lack of planning and zoning ordinances in communities may exacerbate the lack of preservation of the existing natural resources. Effective ordinances will require public and private entities and the public-at-large to interact and work together to craft workable ordinances.
- South Dakota climate can be harsh, with extremely cold winters, hot summers, and late spring and early fall killing frosts. Trees must be well adapted to this area to survive. There are currently limited selections of trees that will thrive in this environment, however, new cultivars, such as the Northern Empress Japanese elm from North Dakota State University, are being developed in the northern plains that show promise for survival in South Dakota. While these trees are being studied elsewhere, there is little in the way of development specifically for South Dakota. It would be highly beneficial to conduct studies of new cultivars within the state to test their resiliency in the South Dakota climate.
- The WUI may present significant problems to our urban forests. Wildfire on any land is a threat; however, the most danger occurs when the fire is adjacent to population centers and homes. Communities that have WUI's need to acknowledge the threats and ensure emergency procedures are in place to protect public safety. FIREWISE USA™ programs can inform homeowners about ways to create fire defensible space on their properties.
- Throughout the state, urban and community forests also provide homes for wildlife. Conservation efforts and community forestry plans provide an opportunity to bring awareness to wildlife species within South Dakota.

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