Black Hills National Forest

Draft Forest Assessments:

Timber

Forest conditions west of Custer (junction of Ditch Creek and Six Mile roads), 1997 (top) and 2020 (bottom).

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Chapter 1. Introduction

There is a need to re-evaluate the timber program level authorized by the 1997 Forest Land and Resource Management Plan (forest plan) for the Black Hills National Forest, management practices, product mixes, and metrics that inform forest management. There have been major changes to the national forest since 1996 when an increase in mountain pine beetle (MPB) populations was first detected. These changes are related to the major ecosystem drivers and stressors for the national forest, timber production, MPB epidemics, and wildfire. This assessment highlights changes to key forest vegetation characteristics that determine sustainable timber program levels.

Federal Laws, Regulations, and Policy

Laws, regulations, and policy that provide direction for the sustainable production of timber on national forest lands are the Multiple-Use Sustained Yield Act (MUSYA) of 1960 and the National Forest Management Act (NFMA) of 1976. The MUSYA authorizes and directs national forests to be managed under principles of multiple use and to produce a sustained yield of products and services. The NFMA limits the sale of timber from each national forest to a quantity equal to or less than a quantity that can be removed in perpetuity on a sustained-yield basis.

The timber program for the 1997 forest plan (table 1) was developed per the 1982 Planning Rule. The sustainable timber program for the revised forest plan will be developed per direction from the 2012 Planning Rule. There are key differences between the 2012 and 1982 Planning Rules regarding timber production.

- The ***Sustained Yield Limit*** (SYL, 2012 Planning Rule) vs. the ***Long Term Sustained Yield Capacity*** (1982 Planning Rule, LTSYC)

  The SYL replaces the LTSYC and is the volume that may be produced in perpetuity on lands tentatively suitable for timber production (now called "may be suitable"). LTSYC was also an estimate for the volume that may be produced in perpetuity on may be suitable lands. Both estimates are hypothetical growth and yield thresholds that limit timber production on national forest lands. SYL, unlike LTSYC, is not limited by multiple-use objectives (forest plan resource desired conditions, goals, objectives, standards, and guidelines). In theory, the SYL may be higher than the LTSYC if similar variables such as the total area for may be suitable lands and net growth (gross growth minus mortality) are constant.

- The ***Allowable Sale Quantity*** (ASQ, 1982 Planning Rule).

  The ASQ is no longer applicable to timber program estimates per the 2012 Planning Rule. ASQ was an estimate of the sustainable yield of commercial material per utilization specifications for sawtimber[1] and products other than logs[2] (POL) from lands designated as suitable for timber production only. This material was included in the LTSYC but was less than or equal to the LTSYC. ASQ included constraints such as projected budget levels and organizational capacity to achieve forest plan desired conditions, goals, objectives, standards, and guidelines. ASQ was applied on a decadal basis and was a limit on timber production for volume produced from suitable lands.

[1] Sawtimber: trees ≥ 9.0 inches diameter at breast height (dbh). DBH is measured at 4.5 feet above ground level.

[2] Products other than logs (POL): posts, poles, and fiber from trees or parts of trees less than sawlog size. POL typically includes trees ≥ 5 inches dbh and < 8.9 inches dbh, with tops of trees > 4 to < 6 inches in diameter. The current forest utilization practice for pole material is trees ≥ 7.0 and < 9.0 inches dbh.

- The Projected Timer Sale Quantity/Projected Wood Sale Quantity (PTSQ/PWSQ[3] 2012 Planning Rule) vs. the Timber Sale Program Quantity (TSPQ, 1982 Planning Rule).

  These estimates are decadal timber program estimates. They are not limited to lands designated as suitable for timber production but will be based primarily on products from suitable lands. These estimates are based upon existing forest conditions and must be consistent with forest plan desired conditions, goals, objectives, standards, and guidelines. For the 1997 forest plan, TSPQ was based almost entirely on the ASQ (guideline 2402 in the amended forest plan (USDA Forest Service 2005) limited the program level to 202,000 CCF in the second decade without plan revision) but did include an incidental amount of volume produced from unsuitable lands.

The ASQ set the limit for timber production from suitable lands by decade for the 1997 forest plan timber program. The 2012 Planning Rule does not contain a metric that is equivalent to the ASQ. The SYL is now the long-term limit for timber production on national forest lands that applies to entire forest rotations and cycles. The estimates for PTSQ/PWSQ are produced for the duration of the new forest plan. Although PTSQ and PSWQ are not targets nor limitations on timber production, they are constrained by the SYL and existing forest conditions. They are also intended to be adjusted to changing organization and fiscal capacity and fluctuations with forest product markets.

The 1997 Forest Plan Timber Program Assumptions

In 1997 the standing inventory (sawtimber and POL) was predicted to increase over the next 50 years because net growth was expected to exceed timber production levels (ASQ) (table 1). The growth rates that were used to calculate ASQ were lower than actual growth at that time. Mortality rates incorporated into the 1997 ASQ were not representative of the actual MPB and wildfire mortality that would occur over the next 25 years.

Table 1. Estimated average annual sustainable harvest levels, 1997 forest plan, decades 1 through 5, Black Hills National Forest, 1982 Planning Rule

[Source: USDA Forest Service 1996. The 202,000 CCF ASQ for decades 1-3 = 181,000 CCF of sawtimber and 21,000 CCF of POL. CCF, 100 cubic feet.]

Estimate	Land Base	Constraints	Decade 1 (CCF)	Decade 2 (CCF)	Decade 3 (CCF)	Decade 4 (CCF)	Decade 5 (CCF)
Long Term Sustained Yield Limit	Tentatively suitable, now "may be suitable"	Multiple use objectives	242,000	242,000	242,000	242,000	242,000
Allowable Sale Quantity	Suitable	Forest plan direction, organizational capacity, fiscal capacity	202,000	202,000	202,000	220,000	221,000
Projected Timber Sale Quantity (calculated for the 1st decade only)	Tentatively suitable, now "may be suitable"	Forest plan direction, organizational capacity, fiscal capacity	204,000	n/a	n/a	n/a	n/a

[3] The PTSQ is the estimated amount of timber meeting utilization standards for the period covered by the forest plan (sawtimber and pole-sized material). PWSQ is the estimated amount of all other wood products such as fuelwood and biomass.

Sustainable timber program levels for the revised forest plan will be affected by changes to the following forest vegetation characteristics:

1. Net growth: Long-term gross growth and mortality rates that are representative of timber production and natural disturbance cycles (SYL)
2. The area of timberlands by forest type (SYL)
3. The existing standing inventory (PTSQ/PWSQ)
4. The existing forest structure (size class and density) (PTSQ/PWSQ)

Data Sources

A comparison was made between the 2001-2005 and 2017-2019 Forest Inventory and Analysis (FIA) inventories for available[4] timberlands in South Dakota. Data from the 2001-2005 inventory was derived from the FIA public website via the EVALIDator application (Version 1.8.0.01). The 2017-2019 data was assessed via a customized version of the EVALIDator data access tool that was distributed to the public in January 2020 by the FIA group of the Northern Research Station (NRS). These data support the most reliable comparison of changes to the forest standing inventory for the period assessed based on sampling error and the interval between measurements.

Sampling intensity was increased for the 2017-2019 inventory, so volume estimates include measurements from plots that have been sampled for the first time. Repeat measurements are ideal for assessing changed conditions over time. A more reliable Forestwide comparison of standing inventory for either timberlands or suitable lands that is representative of change during the implementation of the 1997 forest plan would be based on repeat measurements only since 2000 for the entire forest and stratified by both timberlands and suitable lands. A database consistent with this sampling design has been requested by the Forest.

Other data such as forest vegetation inventory databases (RIS, July 10, 1995, FSVeg, November 3, 2021), the forest activity tracking database (FACTS, December 10, 2021) and forest timber sale records (periodic timber sale accomplishment reports and cut and sold reports) were assessed to identify trends for forest types, forest structure and density, stocking, management practices, and cut and sold volume. Forest Health Protection Aerial Detection Survey data, 1996 to 2021, were used to assess the scale of the MPB epidemic on national forest lands. The large wildfire history inventory (April 5, 2022) was used to assess the scale of wildfire affected acres.

Limitations with the Standing Inventory Comparison

The purpose of the current standing inventory comparison in this report is to highlight trends by diameter classes. This comparison is not intended to identify the scale of change for volume on suitable lands or Forestwide since forest inventories were not stratified by suitable lands until the 2017-2019 FIA data collection effort and the most reliable data sets for Wyoming are not yet available.

This comparison is based on timberlands only. Timberlands are defined as forest lands that can grow a minimum of 20 cubic feet per acre per year (FIA definition). Lands designated as suitable for timber production are subsets of timberlands that incorporate management direction per the forest plan. Inventory changes on suitable lands where timber production has been concentrated are expected to be greater than the changes on timberlands. Per the 2021 FSVeg forest inventory, 80% of the total Black Hills National Forest timberland area in South Dakota, 723,000 acres, and 74% of the Black Hills

[4] Land that is not withdrawn by law(s) prohibiting the management of land for the production of wood products (USDA Forest Service 2019).

National Forest total timberland area in Wyoming, 117,000 acres, is designated as suitable for timber production.

Chapter 2. National Forest Land Classification for Timber Production

Changes to May be Suitable and Suitable Lands

May be suitable lands are timberlands designated as potentially suitable for timber production that are not withdrawn by statute, executive order, or regulations; not withdrawn by the Secretary of Agriculture or Chief of the Forest Service and excluding non-forest land and lands for which there is no reasonable assurance that these lands can be adequately restocked within 5 years following a regeneration harvest.

Land classifications are updated on an ongoing basis in the national forest FSVeg database per site-specific planning and implementation efforts. The classification of national forest acres for the suitability of timber production in 1997 are compared with the 2021 FSVeg classifications in table 2. These classifications are consistent with the 1982 Planning Rule to highlight key changes in land classes by planning factors but does not represent final classification per the 2012 Planning Rule that will support new forest plan direction.

Table 2. Timber suitability classification for the Black Hills National Forest, 1997 and 2021

[Source: 1995 RIS inventory and 2021 FSVeg inventory.]

Timber Suitability Classification Factors	1997 Forest Plan Alternative G (acres)	2021 (acres)
Net National Forest Acres	**1,242,713**	**1,253,002**
Less Non-forested Acres	117,988	117,521
Administratively Withdrawn, not technologically feasible, can't be restocked within 5 years	55,979	74,376
Tentatively Suitable (now “may be suitable”)	**1,068,746**	**1,061,105**
Less Areas Incapable of Producing Industrial Wood	60,271	63,618
Less Areas with Low Productivity	43,935	40,754
Less Experimental Forest and Research Watershed	4,254	6,058
Less Inyan Kara Mountain and Administrative Sites	1,171	1,170
Lee Administrative Sites and Campgrounds	1,252	7,639
Less Critical Game Habitat	0	437
Less Late Succession	38,931	45,014
Less Remaining Portions of Areas Managed for other Multiple Uses	41,116	39,908
Less Uneconomical for Timber Harvest	11,926	21,710
Less Other (superfund, land exchange)	0	1,648
Suitable and Available Acres (includes non-stocked areas)	**865,890**	**833,148**
Less non-stocked acres, ponderosa pine forest	13,022	66,898
	852,868	**766,250**

Key administrative, economic, and feasibility changes from 1997 to 2021 include:

- An increase to the Black Elk Wilderness, (administratively withdrawn) (3,337 acres)
- An increase in areas considered inaccessible (not technically feasible) (15,481 acres)
- The addition of research natural areas (research watershed) (1,806 acres)
- An increase in developed recreation sites (administrative sites and campground) (6,469 acres)
- An increase in areas classified as isolated patches (uneconomical for timber harvest) (6,504 acres)

These changes reduce the area designated as suitable for timber production. Changes to forest cover are discussed in Key Inventory Trends. See table 12 in the appendix for a complete balance sheet of changes to land classes.

Classification Direction for May be Suitable Lands

The classification of lands that may be suitable for timber production that will be updated per the 2012 Planning Rule will be different than classification under the 1982 Planning Rule. Current direction requires the following factors to be deducted from national forest lands to determine lands that are suitable for timber production:

i. Statute, Executive order, or regulation prohibits timber production on the land,

ii. The Secretary of Agriculture or the Chief of the Forest Service has withdrawn the land from timber production,

iii. Timber production would not be compatible with the achievement of desired conditions and objectives established by the plan for those lands,

iv. The technology is not currently available for conducting timber harvest without causing irreversible damage to soil, slope, or other watershed conditions,

v. There is no reasonable assurance that such lands can be adequately restocked within 5 years after final regeneration harvest, or

vi. The land is not forest land.

Factors i, ii, iv, v, and vi are deducted from national forest lands to determine the total may be suitable area. Factor iii is then deducted from may be suitable acres to derive the total area that is suitable for timber production. Factors that were applied to may be suitable lands in the 1997 forest plan (LTSYC) but would be deducted from may be suitable lands for the revised forest plan (SYL) are areas that are considered hardwood forest types.

Chapter 3. Key Ecosystem Drivers and Stressors

Ecosystem drivers are factors or processes that affect ecosystem characteristics and contribute to the natural range of variation. Stressors are defined as factors that may directly or indirectly degrade ecosystem composition, structure, or processes in a manner that may impair its ecological integrity (36 CFR 219.19). Many system drivers can be stressors if they are operating in atypical ways, outside of their natural range of variation. Management influences can be drivers or stressors.

The commercial timber production footprint from 1997 to 2021, MPB affected acres from 1996 to 2020, and wildfire affected acres from 1997 to 2021 are shown in figures 4-6 in the appendix. An estimated 200,000 acres of the commercial timber footprint does not overlap with the MPB affected areas and the wildfire affected areas. More than 60%, 750,000 acres, of all national forest lands on the Black Hills National Forest, 1,253,002 acres, have been affected by these drivers and stressors.

Timber Production and Management Practices

Since implementation of the 1997 forest plan, the Forest has sold 3,800,000 (93.5%) CCF of sawtimber, 263,000 CCF of POL (6.5%), implemented commercial treatments on approximately 550,000 acres (Tables 3, 4, and 5), pre-commercially thinned 250,000 acres, successfully regenerated 300,000 acres through natural seeding, and planted approximately 8,000 acres. The Hell Canyon and Northern Hills Ranger Districts have produced the highest level of commercial timber. The Bearlodge Ranger District has had the smallest program (table 3) but the highest average value for volume sold since 2013.

The average annual output of sawtimber and POL from 1997 to 2021, 162,409 CCF, represents 80% of the 1997 forest plan ASQ. Timber production increased in response to the MPB epidemic starting in 2004. Annual volume sold by product is listed in table 13 in the appendix, and annual volume cut by product, in table 14.

Table 3. Average annual volume sold by decade by product, Black Hills National Forest

[Source: Periodic timber sale accomplishment reports and cut and sold reports.]

Fiscal Year	Saw (CCF)	POL (CCF)	Firewood (CCF)	Add Volume (sawtimber) (CCF)	Total (CCF)
Decade 1: 1997-2006	117,388	3,194	5,522	0	126,104
Decade 2: 2007-2016	181,709	5,912	6,582	512	194,715
Decade 3: 2017 through 2021 only	152,015	2,684	7,450	8,258	170,407
Annual Average: 1997-2021	150,042	4,179	6,331	1,856	162,409

Average annual cut levels, total and by decade (table 4), exceed the amount of volume sold. Removals of sawtimber and POL increased during the MPB epidemic. Commercial timber production practices during this time emphasized the removal of live trees only. Recently killed trees or older mortality were infrequently salvaged. The combination of MPB mortality and timber production of primarily live trees intensified net growth trends.

Table 4. Average annual volume cut by decade by products, Black Hills National Forest

[Source: Periodic timber sale accomplishment reports and cut and sold reports.]

Fiscal Year	Sawtimber (CCF)	Poles (CCF)	Posts (CCF)	Fuelwood (CCF)	Non-saw Pine (CCF)	Misc.-Conv (CCF)	Green Bio Conv (CCF)	Annual Total (CCF)
Decade 1: 1997-2006	134,802	10	45	5,021	0	4,616	0	144,484
Decade 2: 2007-2016	197,584	3,083	108	6,803	1,471	3,478	0	211,318
Decade 3: 2017 through 2021 only	165,111	2,250	1,450	7,529	995	1,727	18	176,741
Annual Average: 1997-2021	165,977	1,687	304	6,235	1,185	3,583	18	177,669

The standard silvicultural practice at the beginning of the MPB epidemic, commercial thinning mature stands of ponderosa pine to a residual density of 80 square feet of basal area[5], was determined to be ineffective for mitigating MPB mortality. As a result, the primary practice became shelterwood establishment cutting, a regeneration method (appendix, silviculture terminology). These treatments reduced residual densities to 40 to 60 square feet of basal area, creating open conditions that are ideal for seed dissemination, seed germination, and early stand development. Regeneration treatments create new age classes. Thinning cuts, unlike regeneration treatments, alter existing stand densities and structure but are not intended to create new age classes.

Overstory removals have replaced shelterwood establishment cuts as the primary silvicultural practice starting with the implementation of the Black Hills Resilient Landscapes Project in 2018. These treatments remove the overstory that was retained via the shelterwood establishment cuts to release the new age class in the understory. This transition occurred following the end of the MPB epidemic in 2016 because the levels of dense or moderately dense, mature ponderosa pine stands were below desired levels per forest plan objectives or were reserved to meet other resource objectives. The total area of open stands exceeded desired levels (Section 4, Structural Stage (Size Class and Density)). Cut volume per acre has decreased from 8.0-10.0 CCF produced via shelterwood establishment cuts to an average of 6.0 CCF produced via overstory removals. The total commercial acreage treated is listed by district for 1997-2021 in table 5.

Table 5. Total commercial acreage treated by district, Black Hills National Forest, 1997-2021

[Includes overlapping acres for forest stands that have been treated multiple times during this period. See table 15 in the appendix for annual numbers by silvicultural method. Source: FACTS database.]

	Bearlodge (acres)	Hell Canyon (acres)	Mystic (acres)	Northern Hills (acres)	Total
Decade 1: 1997-2006	21,741	60,412	65,486	53,745	201,384
Decade 2: 2007-2016	29,758	81,554	53,878	68,664	233,854
Decade 3: 2017 through 2021 only	26,126	28,282	24,030	33,945	112,383
Annual Average: 1997-2021	3,105	6,810	5,736	6,254	21,905

Mountain Pine Beetles

The increase in MPB populations from endemic to epidemic levels was first recognized in 1996 (table 6). The highest level of MPB affected acres was detected in 2003 via Forest Health Protection Aerial Detection Surveys (appendix, table 16). MPB-related mortality peaked in 2013, and MPB populations returned to endemic levels in 2016. During the epidemic, MPB impacts occurred on an estimated 412,500 acres of national forest lands. MPB impacts were lower in Wyoming. Higher site productivity on the Bearlodge Ranger District may have been a factor for increased tree resistance to MPB attacks.

[5] The area of the cross section of a tree stem including the bark, generally at breast height (4.5 feet above the ground).

Table 6. Aggregate acreage (no overlap between survey years) affected by MPB mortality by district, Black Hills National Forest, 1996-2021

[Source: Forest Health Protection Aerial Detection Surveys.]

	Bearlodge	Hell Canyon	Mystic	Northern Hills	Totals
Area affected by MPB (acres)	28,167	100,927	131,620	151,785	412,500
Ponderosa pine forest type (acres)	135,843	367,122	266,384	259,731	1,029,079
Percentage of ponderosa pine forest affected	21%	27%	49%	58%	40%

Forest silvicultural practices have been primarily even-aged and two-aged from 1997 to 2021 (95%) (appendix, table 15). Uneven-aged silvicultural methods are intended to create forest stands with a minimum of three age classes and more complex structure. A high level of even-aged and two-aged management creates a landscape that is more susceptible and less resilient to MPB mortality when majority of the ponderosa pine forest is mature. This increased risk and reduced potential for recovery is due to the high level of forest stands with more susceptible trees (sawtimber sized trees), greater continuity of susceptible trees, an increased potential for hazardous fuels levels following MPB-related mortality, greater loss of seed sources, and lower potential for replacement trees following MPB events, in comparison with a landscape that contains a higher level of uneven-aged structure.

Wildfire

Since 1997, wildfires have burned approximately 172,000 acres of lands on the Black Hills National Forest. The total burn area that does not overlap with MPB affected acres or that burned multiple times is 152,356 acres (table 7). Majority of these wildfires occurred in South Dakota. Changes in the growing season and precipitation in the winter type due to warmer temperatures throughout the year may increase fire frequency, increase wildfire extents, and prolong the fire seasons (Graham et al. 2021). These changes may diminish the potential for forest regeneration and growing stock potential (Graham et al. 2021). Severe events such as the 2000 Jasper wildfire that burned 83,511 acres, primarily on the Hell Canyon Ranger District, have converted areas of high burn severity to grasslands for decades if not centuries and decreased the total area of ponderosa pine forest. This will have long-term impacts without management intervention on a scale comparable to the disturbance event. On the Black Hills National Forest, an average of 430 acres per year have been planted with ponderosa pine trees in the Jasper burn area since 2003.

Table 7. Aggregate wildfire acreage by district on national forest lands in the Black Hills National Forest, 1997 to 2021

[Includes overlapping acres for areas that burned more than once during this period. Source: Forest large fire history inventory.]

	Bearlodge	Hell Canyon	Mystic	Northern Hills	Total
Area affected by wildfire (acres)	1,478	108,286	34,218	8,374	152,356
National forest lands (acres)	169,865	459,471	309,879	313,787	1,253,002
Percentage of national forest lands affected	0.9%	23.6%	11.0%	2.7%	12.2%

Chapter 4. Key Inventory Trends

Net Growth

Net growth is defined as gross growth minus mortality (Graham et. al 2021). Net growth estimates for long-term forest cycles and rotations[6] per likely management scenarios determine sustainable timber program levels. Actual changes to net growth and the impacts on sustainable timber program estimates were unforeseen in 1997.

Negative net change (net growth minus removals) (Graham et. al 2021) was initially identified by forest staff in 2012 per a draft of NRS-81, South Dakota's Forests 2010 (Piva et al. 2013) and confirmed by the publication in 2013 of NRS-83 Forests of the Black Hills National Forest (Walters et al. 2013). NRS-81 reported that due to high mortality rates for ponderosa pine, the average annual removals of growing stock was greater than the average annual net growth of growing stock. NRS-83, which was specific to the Black Hills National Forest, indicated that the net growth to removals ratio of ponderosa pine growing stock on timberlands was 0.88. Discussions regarding the implications of these reports and the potential impacts to the timber program were initiated with key stakeholders at this time.

Ponderosa Pine

Total net growth shifted from positive to negative as a percentage of standing inventory (from + 2.20% or greater to - 0.75%, growing stock, various inventories (figure 1), from 1999 to 2019. This decline in net growth is primarily due to increased MPB-related mortality (from 0.27% to 3.07%); however, weather and fire-related mortality has also increased (from 0.21% to 0.40%) (figure 2).

This 20-year trend is important because this cycle of change from positive to negative net growth may repeat several times during a 120- to 150-year rotation or series of cutting cycles for ponderosa pine. Between 1896 and 2012 there have been six MPB epidemics of various severities despite the implementation of a variety of direct and indirect control methods and silvicultural practices. This is a frequency of an epidemic every 20 years (Graham et al. 2016). Inventory levels have also fluctuated during this period. These fluctuations highlight why sustainable timber harvest limits are based on representative rates for entire forest cycles and rotations. Rates from annual or periodic inventories are just snapshots and can be higher or lower than rates for entire rotations or cutting cycles.

Graham et al. (2021, p. 35) found that positive net growth and an increase in inventory would likely only occur over the next several decades at timber program levels of 90,500 and 72,400 CCF per year (ponderosa pine sawtimber):

> *"The 2019 forest conditions and probable growth and mortality estimates suggest that an average annual harvest for the timber program on the BHNF in the range of 72,400 to 90,500 CCF/yr appears to be the best option, in the short-term, for sustainable harvest levels (table 7). Over the next several decades (figs. 12 and 13), if mortality rates stay below 1.04%, both harvest levels of 72,400 and 90,500 CCF/yr appear to favor an increase in standing live sawtimber volume, allowing for some recovery regardless of the growth rate modeled. If mortality exceeds 1.04%, most of the harvest levels are unsustainable unless growth rates are 2.73% and mortality is ≤ 1.52%.[7]"*

[6] Cycle applies to both natural disturbance cycles and uneven-aged forest management. Rotation applies to even-aged forest management. See Silviculture Terminology in the appendix.

[7] The program levels discussed in Graham et al. 2021 are based upon net growth only. Actual sustainable timber program levels will be lower as a portion of this net growth is reserved from timber production to meet other resource objectives per the forest plan. These program levels apply to ponderosa pine sawtimber on suitable lands only.

Table 4—Merchantable volume of ponderosa pine trees (> 5 inches d.b.h.), in CCF, on suitable timberland of the Black Hills National Forest. See Box 1 for a description of gross growth as described by FIA.

Date	Average annual volume (CCF)					Standing live inventory (CCF)
	Gross growth	Mortality	Net growth	Harvest[a]	Net change	
1962[b]	213,010	12,180	200,830	109,780	91,050	7,810,000
1984[c]	339,540	34,910	301,660	199,540	102,120	13,449,000
1999[d]	380,000	42,120	337,880	204,628	133,252	15,353,000
2011[e]	358,170	140,460	217,710	246,630	-28,920	13,477,960
2017[f]	247,768	246,122	1,646	261,721	-260,075	9,050,031
2019[f]	185,049	244,703	-59,654	183,592	-244,804	7,958,314
	Average annual volume (% of inventory)					
1962[b]	2.73	0.16	2.57	1.41	1.17	—
1984[c]	2.52	0.26	2.24	1.48	0.78	—
1999[d]	2.48	0.27	2.20	1.33	0.87	—
2011[e]	2.66	1.04	1.62	1.83	-0.21	—
2017[f]	2.74	2.72	0.02	2.89	-2.87	—
2019[f]	2.33	3.07	-0.75	2.31	-3.08	—

Figure 1. Merchantable volume of ponderosa pine trees (>5 inches dbh) on suitable timberland of the Black Hills National Forest, republished from Graham et al. (2021)

Table 1—Volume mortality rates based on standing live volume of growing stock trees (> 5 inches d.b.h.), throughout the last several decades in the Black Hills region. Values of mortality category (rounded to 2 significant digits) are based on the proportion that each disturbance contributed to the overall total mortality rate. Values might not add up due to rounding.

Year	Mortality rate (%)	Insect (%)	Fire (%)	Disease (%)	Weather (%)	Other (%)	Mortality (%) without insect included
1962[a]	0.15	0.03	0.00	0.08	Not reported	0.03	0.12
1984[b]	0.26	0.03	0.03	0.00	0.17	0.03	0.23
1999[c]	0.27	0.03	0.03	0.03	0.19	0.00	0.24
2011[d]	1.24	0.80	0.13	0.00	0.27	0.04	0.44
2019[e]	3.07	2.60	0.20	0.05	0.20	0.02	0.47

[a]1962: Mortality and standing live volume based on softwoods across all land ownerships in South Dakota on suitable timberlands (data source: Choate and Spencer 1969).

[b]1984: Mortality and standing live volume based on ponderosa pine across all land ownerships in South Dakota on suitable timberlands (data source: Collins and Green 1988). Mortality by disease was 0.002).

[c]1999: Mortality and standing live volume based on ponderosa pine on the Black Hills National Forest (South Dakota and Wyoming) on suitable timberlands (data source: DeBlander 2002). Mortality by disease was 0.025 and fire was 0.025.

[d]2011: Mortality rate was based on ponderosa pine on the Black Hills National Forest in South Dakota on suitable timberlands. Walters et al. 2013 reported mortality of 1.04%, which included Wyoming and South Dakota; however, when FIA provided the values for 2011 by mortality category, it was only for South Dakota lands.

[e]2019: Mortality and standing live volume based on ponderosa pine on the Black Hills National Forest (South Dakota and Wyoming) on suitable timberlands (source: USDA FS 2021).

Figure 2. Volume mortality rates based on standing live volume of growing stock trees (>5 inches dbh) throughout the last several decades in the Black Hills Region, republished from Graham et al. (2021)

White Spruce

Net growth of white spruce on the Black Hills National Forest has remained positive, from 10,500 CCF per year (2006 to 2010) to 6,700 CCF per year (2017 to 2019)[8]. Despite conditions that favor positive net growth, the above levels represent a small proportion of the white spruce inventory, less than 2%. Overall changes to the white spruce inventory will continue to be gradual without a future increase in mortality and/or increased management of this forest type.

Forest Types

The total commercial forest area (ponderosa pine and white spruce forest types) is a key variable for sustainable timber program estimations, at both the SYL and PTSQ/PWSQ levels. Changes will affect the expansion of volume yield estimates. A comparison of the 1995 RIS and the 2021 FSVeg forest inventories (table 8) indicates that stocked ponderosa pine forest area has decreased by 78,500 acres. This decrease is due to an increase in non-commercial forest types and the conversion of forested areas to grasslands due to wildfire (a 66,000-acre increase).

Table 8. Forest land area by forest type, Black Hills National Forest, 1995 to 2021

[Source: 1995 RIS inventory and 2021 FSVeg inventory.]

Forest Type	1995 (acres)	2021 (acres)	Change (acres)
Non-commercial	NA	NA	NA
Aspen	48,225	42,250	-5,975
Bur Oak	9,190	14,154	4,963
Conifer/Hardwood Mix	0	7,532	7,532
Other Hardwoods	690	5,522	4,831
Other Softwoods	153	159	6
Paper Birch	2,623	1,757	-866
Rocky Mountain Juniper	494	1,109	615
Subtotal	*61,375*	*72,482*	*11,107*
Commercial	NA	NA	NA
Ponderosa Pine	1,018,819	940,318	-78,501
White Spruce	21,737	33,700	11,962
Subtotal	*1,040,556*	*974,018*	*-66,539*
Non-stocked ponderosa pine	22,793	88,982	66,189
Total	*1,124,725*	*1,135,481*	*10,757*

Changes to forest area are also discussed in the *Forested Ecosystems Assessment*. This comparison using FIA inventory data shows similar trends but at a greater magnitude. The FIA data indicate that the total non-commercial area is much larger than the area designated as non-commercial per the forest inventory data (151,000 acres was estimated by FIA, 2005-2011, and 167,000 acres was estimated by FIA, 2017-2019). This inconsistency is likely due to differences in forest type classification protocols and the high sampling errors (low plots counts) associated with hardwoods, mixed stands, and other softwoods for the FIA data or a combination of both factors. Non-stocked areas have increased; however, the inventory data

[8] Net growth estimates for white spruce were not available from the 2001-2005 FIA inventory.

used with the FIA comparison was collected after the Jasper wildfire in 2000, so the estimated increase is lower.

The increase in non-stocked commercial forest is significant because portions of forest area that have been converted from forest to grasslands by wildfire will not naturally regenerate for decades or centuries due to the loss of conifer seed sources and competition from non-forest vegetation. Planted areas may be included in SYL calculations but will not contribute to shorter-term timber program estimates.

Lands that were formerly occupied by tree cover, but do not presently have tree cover, should be identified as non-forest lands unless the land will be naturally or artificially regenerated into forest cover in the near future (example: clearcut lands) (USDA Forest Service 2015).

Standing Inventory

Inventory comparisons were produced for the forest standing inventory (live trees) for timberlands in South Dakota, commercial species only, for 2001 to 2019. These comparisons are for growing stock trees ≥ 5.0 inches diameter breast height (dbh). The unit of measure varies by size class; volume for the POL size classes (trees 5.0 to 8.9 inches dbh) is in merchantable bole volume by CCF only; volume for the sawtimber size class (trees ≥ 9.0 inches dbh) is in net sawlog volume by CCF.

Changes in standing inventory by diameter class are listed in tables 17 and 18 in the appendix. It is important to keep in mind that these estimates are for timberlands. Changes to the standing inventory on lands considered suitable for timber production will be greater because this is the area where commercial timber production is concentrated. Changes to standing inventory in Wyoming, although not assessed in this document (see introduction) will be more moderate than changes in South Dakota due to a smaller commercial timber program and fewer acres affected by bark beetles and wildfire.

Ponderosa Pine

The total sawtimber standing inventory on timberlands in South Dakota (figure 3) has decreased 27%[9]. The greatest decreases of sawtimber have occurred in the diameter classes ≤ 15.0 inches dbh. Removals of sawtimber from 1997 to 2021 have been concentrated in the 12.0- to 14.0-inch dbh diameter classes. Sawtimber volume in the 9.0- to 14.9-inch dbh diameter classes decreased by 32 to 42%[10]. Volume in the POL diameter classes has decreased by 40%[11]. All major forest ecosystem drivers and stressors, commercial timber production, pre-commercial thinning, MPB impacts, and wildfire, are factors.

[9]Sampling errors (68% CI) fall within a range of 5.81% to 6.36%.
[10]Sampling errors (68% CI) fall within a range of 7.71% to 9.82%.
[11]Sampling errors (68% CI) fall within a range of 7.9% to 11.56.

Source: Forest Inventory and Analysis inventory data, 2001 to 2005 and 2017 to 2019.

Figure 3. Ponderosa pine volume (CCF) by diameter class (inches dbh) on timberlands in South Dakota, Black Hills National Forest

White Spruce

The white spruce forest type occurs in South Dakota only. Timber production and mortality due to natural ecosystem stressors in the white spruce forest has been limited (USDA Service 2019). Since 1997, spruce has primarily been harvested from pine-dominated stands (improvement cutting), aspen stands (hardwood restoration cutting), and meadows (meadow restoration cutting) where sawtimber size spruce is present. As a result, the total white spruce standing inventory has changed little since 1997[12]. Shifts in volume have occurred between diameter classes due to stand growth; however, some of the growth into commercial diameter classes has likely been offset by the removal of spruce from other non-spruce forest/vegetation types.

Structural Stage (Size Class and Density)

The forest plan (as amended in 2006) directs the Black Hills National Forest to manage for a specific distribution of structural stages for the ponderosa pine forest across five management areas:

4.1: Limited Motorized Use and Forest Product Emphasis

5.1: Resource Production Emphasis

5.4: Big Game Winter Range Emphasis

[12] A minor decrease of white spruce volume occurred from 2001 to 2019 (appendix, table 18). This difference is well within the sampling errors for total sawtimber for each inventory. Spruce volume estimates are less reliable than estimates for ponderosa pine due to the low number of FIA plots located in the spruce forest.

5.43: Big Game and Resource Production

5.6: Forest Products, Recreation, and Big Game Emphasis

(Forest plan objectives 4.1-203, 5.1-204, 5.4-206, 5.43-204, 5.6-204).

Structural stages are defined in table 9. The change in structural stage for ponderosa pine forest type for 1995 and 2021 is shown in table 10.

The total area for these management areas is currently 876,500 acres. This includes 112,181 acres of lands that are designated as unsuitable for timber production. A lower level of forest management occurs on unsuitable lands; however, the structural stages in these areas do contribute to the desired distribution of acres. Managing for the desired distribution of structural stages is intended to ensure an even flow of age and size classes in perpetuity, which should maintain habitat for a range of wildlife species.

Table 9. Structural stage definitions

[In 1995, the threshold between structural stage classes 3 and 4 was 8.0 inches dbh. This change in protocol 1995 to 2021 will affect comparisons between areas by size class but not by density class. SS, structural stage.]

Structural Stage Definition	Size Class (inches dbh)	Density Class canopy cover (cc)	Other Criteria
SS1 – grass/forb stage	n/a	< 10% cc	
SS2 – shrub/seedling stage	trees < 1.0	≥ 10% cc	≥ 150 pine seedlings per acre
SS3 – sapling/pole stage	trees ≥ 1.0 and < 9.0	A = cc < 40%	
		B = cc ≥ 40 and < 70%	
		C = cc > 70%	
SS4 - mature stage	trees ≥ 9.0	A = cc < 40%	
		B = cc ≥ 40 and < 70%	
		C = cc > 70%	
SS5 – late successional	10 trees ≥ 16.0	≥ 10%	10 trees ≥ 160 years

There are several limitations to the current forest use of this metric. Structural stage can be calculated via different methods: by relative density or by percentage of area cover. There are also different interpretations across the national forest regarding how canopy cover is applied by canopy layer to determine density classes for structural stage classes 3 and 4.

Structural stage is a metric intended to identify changes to size class and density for even-aged and two-aged forest stands. Structural stage is not a descriptive metric for determining the scale of uneven-aged forest conditions regardless of the method utilized because the number of canopy layers is not included. Structural stage class 3 is also a wide-diameter class range that is not informative for identifying specific thinning needs for POL or smaller size class forest stands.

Table 10. Change in structural stage for ponderosa pine forest type in Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6), 1995 to 2021

[Source: 1995 RIS inventory and 2021 FSVeg inventory.]

Structural Stage	Percent of Total Area	1995 (acres)	2021 (acres)	Change in Acres	1995 (percent of total management area)	2021 (percent of total management area))
1	5%	13,050	71,463	58,413	1.5%	8.2%
2	5%	9,738	51,694	41,955	1.1%	5.9%
3A	10%	83,822	83,060	-762	9.4%	9.5%
3B	15%	120,899	42,875	-78,024	13.5%	4.9%
3C	5%	41,049	23,899	-17,150	4.6%	2.7%
4A	25%	301,701	350,537	48,836	33.8%	40.0%
4B	25%	220,812	162,260	-58,553	24.7%	18.5%
4C	5%	86,287	86,009	-278	9.7%	9.8%
5	5%	16,480	4,704	-11,776	1.8%	0.5%
Total	100%	893,839	876,500	-17,339	100.0%	100.0%

- The forest is now more open and younger (table 11).
- Non-stocked areas (SS1) and recently regenerated forest stands (SS2) have increased by 100,000 acres.
- Total forest areas designated as open density has increased by 148,500 acres.
- Moderately closed and closed structural stages (3B, 3C, 4B, 4C) are all below forest plan objectives except for SS4C. This surplus of SS4C, 5%, was reserved by the 2018 Black Hills Resilient Landscapes Project decision for growth into the SS5 class in the future. SS5 was below the forest plan objective in 1995 and has decreased by 12,000 acres due to MPB mortality.
- The biggest surplus occurs in SS4A, 15%. This surplus was created via shelterwood establishment cuts that were implemented to mitigate the impacts of the MPB epidemic.

Table 11. Change in structural stage by density class, ponderosa pine forest type, Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6), 1995 to 2021

Source: 1995 RIS inventory and 2021 FSVeg inventory.]

Structural Stage	1995	2021	Change in Acreage
Open density			
1 – Non-stocked areas, previously forest cover	13,050	71,463	58,413
2 – Recently regenerated, shrubs/seedlings	9,738	51,694	41,955
3A – Intermediate stands, saplings/poles	83,822	83,060	-762
4A – Mature stands	301,701	350,537	48,836
Subtotal	408,311	556,754	148,442
Moderate to closed density			
3B and 3C – Intermediate stands, saplings/poles	161,948	66,774	-95,174
4B and 4C – Mature stands	307,100	248,269	-58,831
Subtotal	469,048	315,043	-154,005
Variable density			
5 – Late successional stands	16,480	4,704	-11,776
Total	893,839	876,500	-17,339

Chapter 5. The Need for Change

Sustainable Timber Program Levels

The gross growth and mortality rates (net growth) applied to sustainable timber program calculations are averages for entire rotations or cutting cycles that account for multiple disturbance cycles. The 1997 forest plan timber program was based on ideal net growth that assumed in an increase of the standing inventory for the next five decades. The 1997 LTSYC, ASQ, TSPQ estimates were therefore not consistent with actual on-the-ground conditions from 1996 to 2021. The combination of the major ecosystem drivers and stressors, timber production, bark beetles, and wildfire during this time have caused long-term changes to the forest.

The standing inventory trends identified per the FIA data comparison indicate that volume in the 5.0 to 14.9-inch dbh diameter classes has decreased by an estimated 32-42%. This also indicates that actual average annual program levels of 162,500 CCF sold and 178,000 CCF cut, 1997 to 2021 were not sustainable. This conclusion is supported by the findings of Graham et al. 2021.

The timber production increases in response to the MPB epidemic in decade 2, 2007 to 2016, were necessary to mitigate the severity of the MPB epidemic but represented a short-term departure from sustainable levels only and not realistic long-term sustainable program levels.

Commercial Forest Area

The total area for lands designated as may be suitable and suitable for timber production has decreased due to an increase in the net area of non-commercial forest (hardwoods) and non-stocked areas, some of which have been converted to grasslands for decades or centuries. This decrease will reduce long-term volume yield estimates (SYL) and short-term program levels (PTSQ/PWSQ).

The total commercial forest area has also decreased due to administrative changes such as the expansion of the Black Elk Wilderness, an increase in developed recreation sites, an increase in inventoried roadless

areas and research natural areas, and an increase in areas designated as uneconomical or infeasible for timber production. This increase in areas designated as uneconomical or infeasible for timber production will impact timber program levels and is the result of more accurate mapping and the fact that more of the national forest has been surveyed due to the management response to the MPB epidemic.

Structural Stage

The ponderosa pine forest in the Forest Products Management Areas (4.1, 5.1, 5.4, 5.43, and 5.6) is now more open with a greater proportion of young forest. Older, denser forest structure has shifted by about 150,000 acres to non-stocked areas, recently regenerated forest stands (SS2), young, open stands (SS3A) or open, mature stands (SS4A). Following implementation of overstory removal treatments authorized by the 2018 Black Hills Resilient Landscapes Project decision, commercial timber production in these areas will be limited for the next two decades to primarily low yield thinning and uneven-aged practices that enhance late successional conditions in the mature, moderate closed (SS4B), and closed stands (SS4C). Much of the net growth in the mature ponderosa pine forest will occur on trees that are reserved to meet multiple use objectives.

Objectives

The forest plan structural stage objectives may limit adaptive management responses to unforeseen events if these objectives are interpreted as static targets that do not allow forest managers to adjust for changed conditions. Key stressors that cause large-scale disturbance events during forest cycles may require deviation from any desired size class and density distribution. Examples where deviation may be essential include the need to reserve surplus SS4B and SS4C stands to support promotion of late successional forest and meet changing wildlife habitat management strategies, the need to reserve additional SS4A to promote the development of uneven-aged conditions, or the need to manage for higher levels of open conditions (SS3A and SS4A) in areas adjacent to communities or containing water sources and infrastructure to reduce the risk of extreme wildfire behavior.

Forest Planning Metrics

The structural stage system that was incorporated into modeling for the development of the 1997 forest plan needs to be defined consistently across different resource areas to ensure that forest management planning and implementation aligns with stated forest plan objectives and desired conditions. There are inconsistent field interpretations and protocols for determining density classes. The current classification for sapling- and pole-size material (SS3 classes), 1.0 to 8.9 inches dbh, is too broad to adequately identify management needs in the younger ponderosa pine forest. Finally, the 1997 forest plan structural stage metric is not useful for monitoring levels of uneven-aged structure and therefore has limited value to assess consistency with desired conditions for wildlife habitat.

Silvicultural Practices

Uneven-aged Management

The current level of uneven-aged management Forestwide (5% of all commercial silvicultural treatments implemented from 1997 to 2021) needs to increase to enhance forest resiliency to large-scale MPB epidemics and better meet other resource needs such as enhancing wildlife habitat for species that rely on forest conditions with complex, heterogenous structure such as the northern goshawk (*Accipiter gentilis*).

Majority of the silvicultural practices on the Black Hills National Forest are considered even-aged or two-aged, which create conditions that are more conductive and less resilient to severe bark beetle events.

Potential effects include the greater loss of large-diameter forest structure, higher hazardous fuel loads, and longer intervals to re-stock stands due to lower numbers of replacement trees and fewer seed sources.

Pre-commercial Thinning

The total ponderosa pine area designated as a seedling structural stage (SS2) has increased by 42,000 acres, from 9,700 acres to 51,700 acres, per the 1995 RIS and 2021 FSVeg inventories. There are currently 67,000 acres of dense sapling- and pole-size stands (SS3B and SS3C) stands. Majority of the seedling/sapling/pole stands are considered overstocked and will benefit from pre-commercial thinning.

Pre-commercial thinning needs are projected to grow to approximately 260,000 acres by the next decade[13] Recent average annual treatments from 2017 to 2021 have occurred on 8,953 acres (FACTS database). Projected annual needs range from 13,000 to 15,000 acres per year. The Forest Service has recently requested additional funding to increase the level of pre-commercial thinning via service and stewardship contracting.

Reforestation

The planting program (430 acres per year since 2003) is inadequate to restock burn areas that have no or very limited potential for natural regeneration over the next two decades. Areas that will not be restocked within the next two decades should be deducted from sustainable timber program calculations (SYL and PTSQ/PWSQ) for the next forest plan. Opportunities for increasing the annual planting program, current forest capacity, and additional funding opportunities are currently being evaluated.

Late Successional Stands

The total area considered late successional ponderosa pine forest (SS5) was below the 1997 forest plan objective (5% of Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6) initially and has declined during the MPB epidemic. There is a need to inventory and monitor forest stands that currently contain late successional characteristics or forest stands that are progressing towards these conditions in the short-term (SS4B and SS4C) and would benefit from management designed to promote desired conditions.

In additional, the 1997 forest plan definition of SS5, derived from Mehl (Kaufman et al. 1992), is consistent with two-aged forests and is not adequate for defining late successional conditions. This definition should be reassessed in conjunction with a general assessment of structural stage metrics.

Product Mixes

Forest management needs on the Black Hills National Forest are shifting away from a program that emphasizes the management of mature ponderosa pine forest stands (SS4 classes) to the thinning of younger stands. The average cut tree diameter for commercial sales of sawtimber, typically in the 12- to 14-inch dbh range, is expected to decrease following implementation of overstory removal treatments per the 2018 Black Hills Resilient Landscapes Project. Program levels for pole-size material and biomass have been minor components of the overall forest program historically and since 1997. Increased commercial utilization of smaller diameter material will increase the cost effectiveness and capacity to promote the growth and resiliency of the young pine forest.

[13] 2020 Forest Stand Improvement Report to the Regional Office. These estimates fluctuate as they are updated annually.

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Appendix

Table 12. Suitability of national forest lands for timber production, Black Hills National Forest, 1997 and 2021

[Source: 1997 RIS inventory and 2021 FSVeg inventory.]

Timber Suitability Classification Category	ALTERNATIVE G (1995 Data)		FSVeg Nov 3, 2021	
	Acres Reduced	Running Total	Acres Reduced	Running Total
Black Hills National Forest Acres		1,531,715		1,532,864
a. Less Private Land, State, Other Federal	289,002		279,862	
Net National Forest Acres		1,242,713		1,253,002
b. Less Non-forested Acres				
Meadows, Rock				
Non-vegetated	8,717		3,916	
Grassland	104,174		105,271	
Shrubland	3,085		4,946	
Water	2,012		3,389	
TOTAL	117,988	1,124,725	117,521	1,135,481
c. Less Forested Portion of Areas				
Administratively Withdrawn				
Black Elk Wilderness	9,831	1,114,894	13,168	1,122,313
d. Less Areas Not Technologically Feasible Without Resource Damage				
Unstable Soils (Comp. 720 and 722)	9,101		8,869	
Not Accessible (Comp. 721)	35,354		50,835	
TOTAL	44,455	1,070,439	59,704	1,062,609
e. Less Areas That Cannot Be Restocked Within 5 Years (Comp. 710, 893)	1,693	1,068,746	1,504	1,061,105
TENTATIVELY SUITABLE (now “may be suitable” (See 36CFR219.14 (b))		1,068,746		1,061,105
f. Less Areas Incapable of Producing Industrial Wood				
Aspen (Comp. 822, 891)	48,062		44,957	
Oak (Comp. 826)	8,881		13,295	
Other Hardwoods (Comp. 831, 832, 895, 900)	3,328		4,910	
Converting conifers to meadows (892, 896)	0		456	
TOTAL	60,271	1,008,475	63,618	997,487
g. Less Areas with Low Productivity or With Inadequate Response Information (Comp. 740)	43,935	964,540	40,754	956,733
h. Less Experimental Forest and Research Watershed				

Timber Suitability Classification Category	ALTERNATIVE G (1995 Data)		FSVeg Nov 3, 2021	
	Acres Reduced	Running Total	Acres Reduced	Running Total
Experimental Forest (Comp. MA 5.3A)	3,368		3,371	
Research Watershed (Alkali) (Comp. MA 5.3B)	886		881	
Research Natural Area (RNA) (Comp. 811)			1,806	
TOTAL	4,254	960,286	6,058	950,675
i. Less Inyan Kara Mountain (MA 3.2A)	1,171	959,115	1,170	949,505
j. Less Administrative Sites and Campgrounds				
Administrative Sites (Comp. 850)	318		278	
Developed Recreation Sites (Comp. 825)	892		7,361	
Other (Seed Collection Sites, etc.) (Comp. 860)	42		0	
TOTAL	1,252	957,863	7,639	941,866
k. Less Critical Game Habitat				
Within Norbeck (Comp. 805)	0		415	
Other (Comp. 800)	0		22	
TOTAL	0	957,863	437	941,428
l. Less Late Succession (Comp. 701, 702, 801, 802) – Where Otherwise Unsuitable	38,931	918,932	45,014	896,415
m. Less Remaining Portions of Areas Managed for other Multiple Uses				
Botanical Areas (Comp. MA 3.1)	6,075		6,709	
Riparian Areas (Comp. 804)	4,407		273	
Backcountry Recreation Areas (MA 3.31 and 3.32)	12,710		14,919	
Spearfish Canyon (Comp. MA 4.2A)	6,391		4,109	
Southern Hills Comp. MA 5.1A)	11,533		13,899	
TOTAL	41,116	877,816	39,908	856,506
n. Less Uneconomical for Timber Harvest				
Steep Slopes (Comp. 820 and 821)	6,884		8,289	
Topography Prevents Harvest (723)	0		297	
Roading Problems (Comp. 823)	2,461		4,039	
Isolated Patches (Comp. 824)	2,581		9,085	
TOTAL	11,926	865,890	21,710	834,796
Other				
Superfund site (Comp. 806)	0		1,598	
Proposed Land Exchange (Comp. 873)	0		50	
SUITABLE AND AVAILABLE ACRES		865,890	1,648	833,148
Less non-stocked acres, ponderosa pine forest	13,022	852,868	66,898	766,250

Table 13. Annual total volume sold by product, Black Hills National Forest, 1997 to 2021

[Source: Periodic timber sale accomplishment reports and cut and sold reports.]

Year	Saw	POL	Firewood	Add Volume	Total
1997[1]	169,197	3,919	7,643	0	180,759
1998	151,765	2,385	6,927	0	161,077
1999	144,100	856	7,633	0	152,589
2000	74,613	1,695	4,764	0	81,071
2001	19,036	1,689	2,949	0	23,675
2002	89,853	1,359	3,151	0	94,364
2003	78,019	3,424	3,235	0	84,679
2004	160,046	10,987	4,982	0	176,015
2005	141,632	3,451	5,158	0	150,241
2006	145,614	2,176	8,779	0	156,569
2007	174,759	3,119	5,200	0	183,078
2008	238,793	6,416	7,491	0	252,700
2009[2]	194,680	3,523	9,042	0	207,245
2010	181,658	2,609	7,352	0	191,619
2011	161,934	8,072	7,320	0	177,326
2012	164,835	6,421	5,662	0	176,918
2013	161,116	5,997	5,221	0	172,334
2014	159,798	4,349	6,741	0	170,888
2015	183,819	11,125	5,762	0	200,706
2016[3]	195,698	7,492	6,025	5,118	214,334
2017	173,476	6,613	6,740	12,871	199,700
2018	181,053	2,038	7,694	21,251	212,037
2019	163,671	825	8,622	0	173,118
2020	114,306	707	7,451	2,952	125,416
2021	127,571	3,235	6,743	4,215	141,764
Totals	3,751,043	104,482	158,287	46,407	4,060,220

[1]All volume was converted from MBF. Volume started being reported in CCF in 1998.

[2]Previous volume was reported from the old Timber Sale Accounting system. In 2009 and forward, volume was pulled from PTSAR system.

[3]Add volume started being tracked through Modifications and Agreements.

Table 14. Annual volume cut by product, Black Hills National Forest,1997 to 2021

[Source: Cut and sold reports. Volume was converted from MBF to CCF from 1997 to 2007. Cut and sold reports were available in CCF starting in 2008.]

Fiscal Year	Sawtimber	Poles	Posts	Fuelwood	Non-saw Pine	Misc.- Conv	Green Bio Conv	Annual Total
1997	118,620		202	6912		4097		129,830
1998	130,393	27	3	8303		2033		140,759
1999	140,545	8	105	6892		1252		148,801
2000	127,846	25	46	6450		3541		137,907
2001	150,941	1	2	3202		4205		158,350
2002	118,989	9		2514		3228		124,740
2003	128,895	10	4	2822		3694		135,426
2004	139,983	8	1	3415		7122		150,529
2005	145,396	1		5514		14305		165,215
2006	146,412	4	1	4188		2682		153,286
2007	171,312	4	2	3836		5082		180,236
2008[1]	201,633	30	10	14,016		8,989		224,678
2009	212,532	4	177	6,397	2,906	6,881		228,897
2010	222,212	1,850	454	6,722		6,386		237,625
2011	221,545	4,878		7,120		1,948		235,491
2012	193,848	5,258		6,650		774		206,530
2013	208,936	8,172	1	5,093		1,030		223,233
2014	171,388	1,055		6,100		1,011		179,554
2015	193,427	3,362	1	6,168	36	1,508		204,502
2016	179,010	6,216	115	5,925		1,166		192,432
2017	175,441	3,745	749	6,502		400		186,836
2018	132,751	754		9,532		2,017		145,054
2019	181,623		2,907	8,314	308	1,428		194,579
2020	172,982		693	6,615	1,114	865	8	182,278
2021	162,757			6,684	1,562	3,925	27	174,956
Total	4,149,416	35,423	5,471	155,883	5,926	89,569	35	4,441,724

Table 15. Annual commercial timber acres by silvicultural method, Black Hills National Forest, 1997 to 2021

[Source: FACTS database, December 10, 2021. All regeneration methods are considered even-aged except for selection methods, which are considered uneven-aged.]

Fiscal Year	Thinning[1] (acres)	Shelterwood Cut[2] (acres)	Overstory Removal[3] (acres)	Clearcut (acres)	Patch Cut (acres)	Hardwood / Meadow Restoration (acres)	Seed Tree Cut (acres)	Selection (acres)	Improvement Cut (acres)	Sanitation / Salvage (acres)	Total (acres)
1997	4,034	7,403	1,820		414		351	811	470		15,303
1998	4,118	8,012	2,034		344		759	596	1,043	186	17,092
1999	7,216	6,076	2,341		324		682	544	526	112	17,821
2000	5,205	6,190	2,026		425		336	361	198	83	14,824
2001	3,234	3,393	3,647		129		587	323	225	1,583	13,121
2002	7,845	4,931	3,139		436		901	921	409	579	19,161
2003	6,357	3,565	3,283		364		117	684	732	1,460	16,562
2004	11,016	8,254	5,180		1,110		632	682	1,885	239	28,998
2005	12,984	4,864	4,343	16	364		818	471	391	563	24,814
2006	16,985	5,465	7,266	15	597		679	1,396	845	440	33,688
2007	10,306	3,231	3,185		16	13	577	529	448		18,305
2008	17,244	3,355	6,706		96	151	710	343	145	926	29,676
2009	16,987	1,854	3,529	20	27	56	85	803	168	1,053	24,582
2010	8,968	2,834	5,579			52	273	1,025	176	4,592	23,499
2011	8,152	2,115	4,479	10	6	219	331	2,425	7	2,060	19,804
2012	15,428	1,934	4,579			10		811	96	4,320	27,178
2013	11,702	4,272	3,641		64		12	2,297	8	1,573	23,569
2014	7,820	7,008	3,326					716	79	2,571	21,520
2015	9,765	7,378	2,143			2		1,456		419	21,163
2016	14,620	6,306	1,668		20			1,068		876	24,558
2017	9,213	3,397	2,046			23		1,031			15,710
2018	5,469	2,330	7,003		13			2,063		13,083	29,961
2019	4,653	3,354	13,211			547		2,906	381	28	25,080

Fiscal Year	Thinning[1] (acres)	Shelterwood Cut[2] (acres)	Overstory Removal[3] (acres)	Clearcut (acres)	Patch Cut (acres)	Hardwood / Meadow Restoration (acres)	Seed Tree Cut (acres)	Selection (acres)	Improvement Cut (acres)	Sanitation / Salvage (acres)	Total (acres)
2020	1,531	1,746	11,293			864		1,494	224	3,019	20,171
2021	4,966	906	8,191	2,227	10	256	213	2,999	154	1,539	21,461
Total	225,817	110,173	115,658	2,288	4,759	2,193	8,063	28,755	8,610	41,304	547,621

[1]Many commercial thinning treatments were regeneration treatments, shelterwood establishment cuts, but were coded as thinning per treatment descriptions in the 2012 Mountain Pine Beetle Response Project.

[2] Includes all entries associated with a shelterwood system except for overstory removals.

[3] Includes liberation cuts.

Table 16. Annual acres affected by MPB per aerial detection surveys by district on national forest lands, Black Hills National Forest, 1996 to 2021

[Source: Forest Health Protection, Aerial Detection Survey program. Reported acres include overlap between surveys years (ongoing mortality can be identified in the same area for multiple years).]

Survey Year	BL (acres)	HC (acres)	MY (acres)	NH (acres)	Total (acres)
1996	385	396	669	634	2,084
1997	658	249	708	5,383	6,999
1998	1,578	1,040	3,411	7,263	13,293
1999	857	4,770	3,973	8,584	18,184
2000	1,094	4,006	2,366	5,871	13,337
2001	4,144	17,609	32,247	43,661	97,662
2002	5,068	24,247	35,532	32,660	97,506
2003	3,974	45,755	52,556	71,400	173,685
2004	8,070	14,078	18,256	18,164	58,567
2005	879	5,830	7,373	4,049	18,130
2006	890	12,337	15,577	8,211	37,015
2007	775	5,708	13,535	4,599	24,617
2008	314	7,231	14,050	2,611	24,206
2009	208	4,806	11,657	4,965	21,635
2010	235	6,006	25,501	10,462	42,203
2011	1,204	8,675	32,602	22,101	64,583
2012	537	5,374	12,504	11,102	29,518
2013	509	7,174	16,611	8,112	32,406
2014	695	5,152	5,627	4,080	15,553
2015	1,154	4,925	4,428	4,788	15,295
2016	347	835	355	758	2,296
2017	1,729	1,967	62	789	4,547
2018	37	165	15	12	230
2019	9	2	2	2	15
2020	13	0	0	1	14
2021	0	0	0	0	0
Total	34,977	187,940	308,947	279,630	811,494

Table 17. Ponderosa pine volume (CCF) by size class (inches dbh), on timberlands in South Dakota, Black Hills National Forest

[Sampling error percentage at the 68% confidence interval level. The unit of measure varies by size class: POL size class volume (trees 5.0 to 8.9 inches dbh) is presented in merchantable bole volume; sawtimber size class volume (trees ≥ 9.0 inches dbh) is presented in net sawlog volume. Total sampling errors are not available for total volume or total POL because these values represent a sum of volume derived from the different units described above.]

Inventory	FIA 2001 to 2005	FIA 2017 to 2019	Percent Change
5.0-6.9	542,789 (11.56%)	330,232 (9.09%)	-39.20%
7.0-8.9	1,690,499 (9.53%)	992,056 (7.9%)	-41.30%
9.0-10.9	1,753,187 (7.88%)	1,012,661 (7.71%)	-42.20%
11.0-12.9	1,891,209 (8.83%)	1,259,662 (7.33%)	-33.40%
13.0-14.9	1,699,688 (9.82%)	1,158,629 (8.46%)	-31.80%
15.0-16.9	1,329,817 (11.8%)	1,133,588 (8.83%)	-14.80%
17.0-18.9	952,695 (14.35%)	813,501 (11.89%)	-14.60%
19.0-20.9	557,330 (21.65%)	680,568 (14.66%)	22.10%
21.0-22.9	141,182 (53.91%)	445,239 (23.63%)	215.40%
23.0-24.9	169,581 (52.2%)	136,028 (35.35%)	-19.80%
25.0-26.9	40,215 (99.8%)	54,268 (68.74%)	34.90%
27.0-28.9		50,824 (99.9%)	n/a
29.0-30.9		38,753 (99.9%)	n/a
31.0-32.9		45,046 (95.68%)	n/a
POL	2,233,288	1,362,044	-39.00%
Sawtimber	8,534,904 (6.36%)	6,510,552 (5.81%)	-23.70%
Total	10,768,192	7,872,596	-26.90%

Table 18. White spruce volume (CCF) by product classes on timberlands in South Dakota, Black Hills National Forest

[Change in white spruce total volume per size class. (Sampling error percentage at the 68% confidence interval level). The unit of measure varies by size class: POL size class volume (trees 5.0 to 8.9 inches dbh) is presented in merchantable bole volume; Sawtimber size class volume (trees ≥ 9.0 inches dbh) is presented in net sawlog volume. Total sampling errors are not available for total volume or total POL because these values represent a sum of volume derived from the different units described above.]

Inventory	Total POL	Total Sawtimber	Total
FIA 2001 to 2005	107,099	478,125 (30.78%)	585,224
FIA 2017 to 2019	127,240	426,653 (24.21%)	553,893
Percent change	18.8%	-10.8%	-5.4%

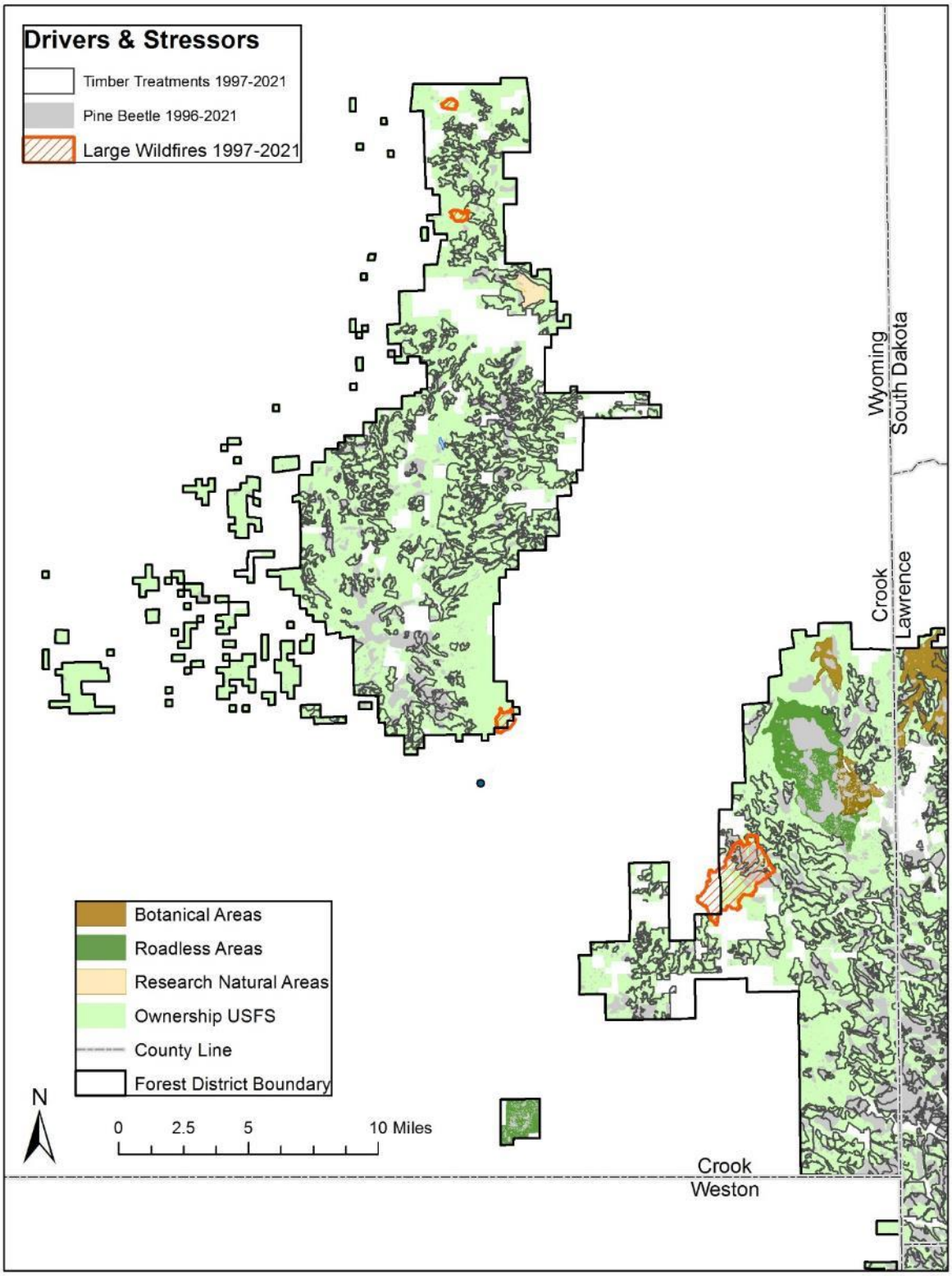

Figure 4. Major drivers and stressors for the Black Hills National Forest, Bearlodge Ranger District, Wyoming, 1996 to 2021

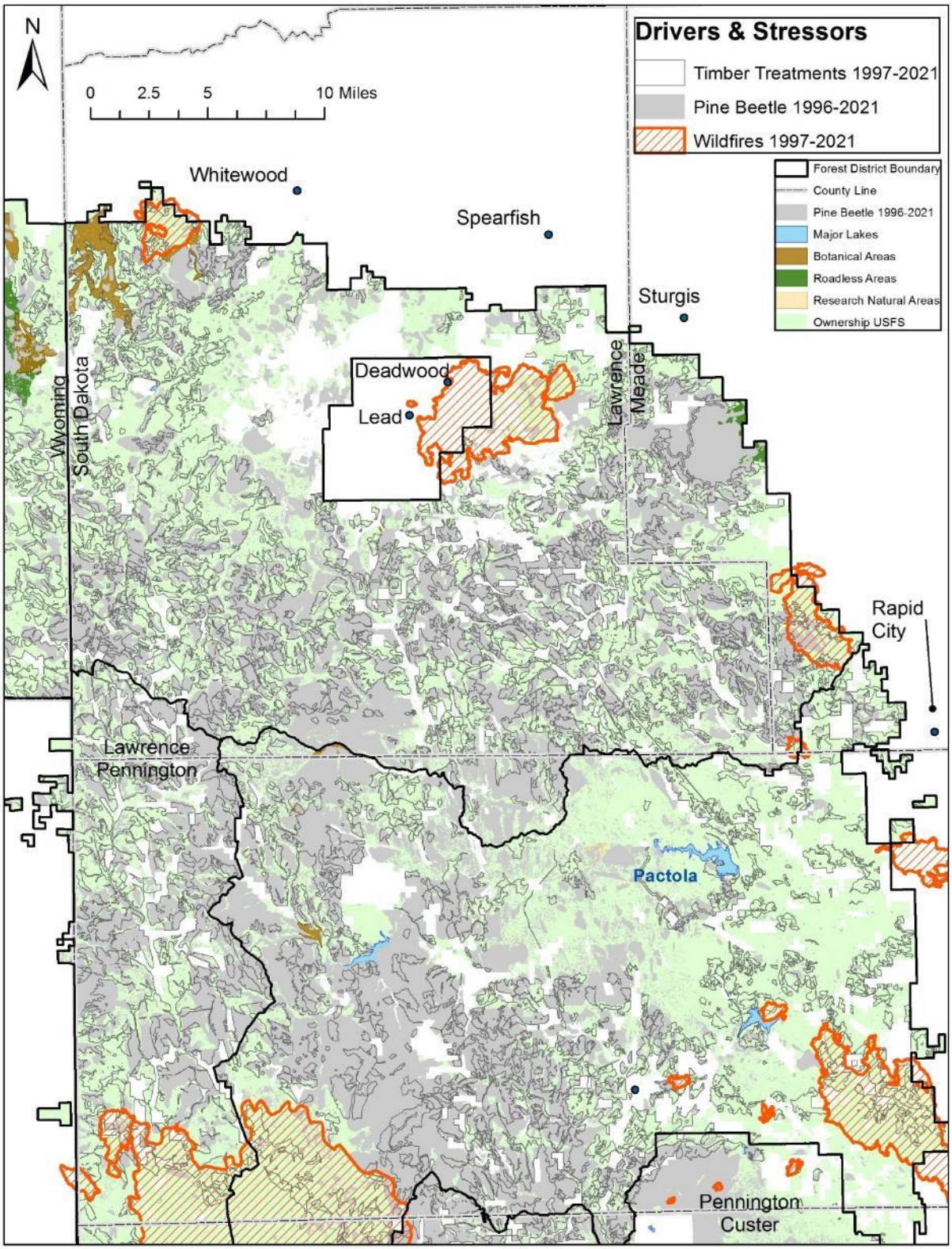

Figure 5. Major drivers and stressors for the Black Hills National Forest, Northern Hills and Mystic Rangers Districts, South Dakota, 1996 to 2021

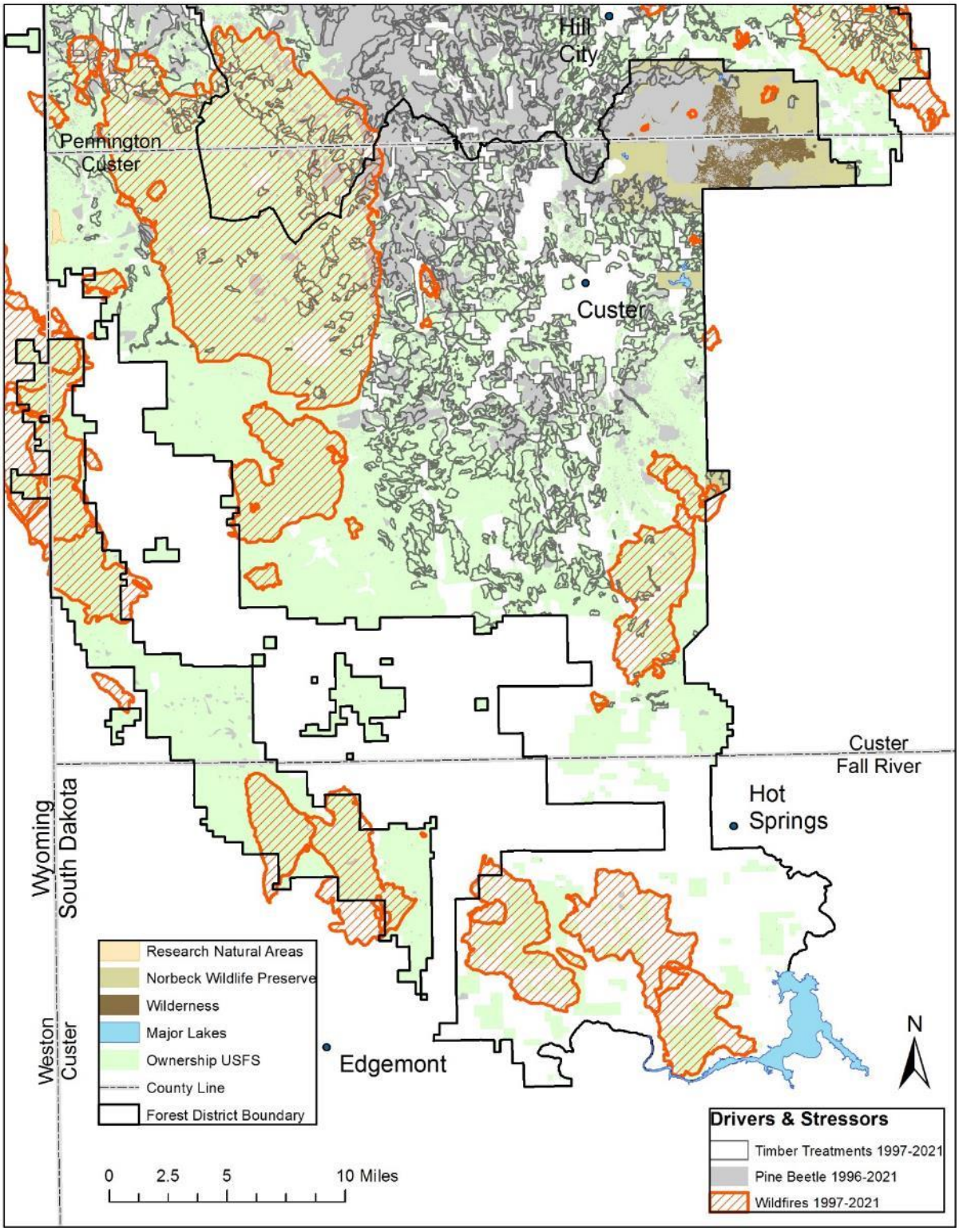

Figure 6. Major drivers and stressors for the Black Hills National Forest, Hell Canyon Ranger District, South Dakota, 1996 to 2021

Silviculture Terminology

The source for all definitions is Society of American Foresters (1994) unless noted otherwise.

Cutting Cycle: The planned interval between partial harvests in an uneven-aged stand.

Even-aged Methods: Methods to regenerate a stand with a single age class.

Even-aged Stand: A stand of trees containing a single age class in which the range of tree ages is usually less than 20 percent of rotation.

Hardwood Restoration Cut: The objective of these cuts is to increase the number of acres of hardwoods. This would be accomplished by patch cutting in pine stands with remnant hardwoods or expanding the edges of existing hardwood stands. As described earlier, hardwoods and the mix of tree species are key components of biological diversity (USDA Forest Service 1996).

Improvement Cut: A cutting made in a stand pole-sized or larger primarily to improve composition and quality by removing less-desirable trees of any species.

Intermediate Treatment: A collective term for any treatment designed to enhance growth, quality, vigor, and composition of the stand after establishment or regeneration and prior to final harvest.

Meadow Restoration Cut: This cut restores meadow acres encroached upon by conifers over the last century. This is accomplished through cutting pine or spruce adjacent to existing meadows. The location and extent of these cuts are determined by soil types and by the use of historic photographs. Meadow restoration is distinct from the removal of small pine trees that have encroached into meadows. Meadows are a key component of the biological diversity being lost as conifer cover expands. (USDA Forest Service 1996).

Overstory Removal: The cutting of trees comprising an upper canopy layer in order to release trees or other vegetation in an understory.

Pre-commercial Thinning: A thinning that does not yield trees of commercial value, usually designed to reduce stocking in order to concentrate growth on the more desirable trees.

Regeneration Method: A cutting method by which a new age class is created.

Rotation: In even-aged systems, the period between regeneration establishment and final cutting.

Shelterwood Establishment Cut: A method of regenerating an even-aged stand in which a new age class develops beneath the moderated micro-environment provided by the residual trees. The sequence of treatments can include tree distinct types of cuttings: 1) an optional preparatory cut to enhance conditions for seed production; 2) an establishment cut to prepare the seed bed and to create a new age class; and 3) a removal cut to release established regeneration from competition with overwood (overstory removal).

Thinning: A cultural treatment made to reduce stand density of trees primarily to improve growth, enhance forest health, or to recover potential mortality.

Two-Aged Stand: A stand composed of two distinct age classes that are separated in age by more than 20 percent of rotation.

Two-Aged Methods: A planned sequence of treatments designed to maintain and regenerate a stand with two age classes.

Uneven-aged Stand: A stand of trees of three or more distinct age classes, either intimately mixed or in small groups.

Uneven-Aged System: A planned sequence of treatments designed to maintain and regenerate a stand with three or more age classes.

Figure 7. Mature, open ponderosa pine forest (trees greater than 9 inches dbh, crown cover 11 to 40%) following a shelterwood establishment-cut (USDA Forest Service 2018)