

# ASSESSMENT OF THE NATIONAL FOREST ADVISORY BOARD TIMBER PROGRAM RECOMMENDATION Black Hills National Forest

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## INTRODUCTION

This report provides an assessment of the timber program recommendation approved by the Black Hills National Forest Advisory Board (NFAB) on October 21, 2020. My analysis of the latest sustainability research and inventory data has been ongoing since the January 27, 2020 release of the Forest Service Northern Research Station's Forest Inventory and Analysis (FIA) augmented 2017-2019 inventory and the March 2020 release of the Forest Service Rocky Mountain Research Station's General Technical Report Timber Draft 1 Growth and Yield in the Black Hills National Forest: A Changing Forest (Graham et al.). Most of the supporting analysis work was completed in response to stakeholder questions following the April 3, 2020 public Timber Stakeholder Meeting hosted by the Forest and throughout my advisory role to the NFAB timber sustainability working group, May 7 through October 21, 2020.

This report contains an Executive Summary that highlights key findings. Supporting rationale and supplemental information follows the executive summary.

## SUMMARY

The NFAB working group on timber sustainability was tasked on April 15, 2020 by Deputy Forest Supervisor Jerry Kruger to provide recommendations to the Forest Supervisor regarding a sustainable commercial timber program and the need to revise or amend the forest plan (Supplemental Information Document 1, p. 14). The findings below pertain to Task 1, develop and recommend a *no more than five-year pathway to meet sustainability* requirements based on constraints for Forest Service law, regulations, policy, Forest Plan structural stage (SS) objectives, and the assumptions that the scenarios presented Graham et al. Draft 1 and the augmented 2017-2019 FIA inventory represent sound science.

### Findings

The recommendation from NFAB was to produce an annual program level of 175,000 CCF of ponderosa pine (*Pinus ponderosa*) sawtimber and 6,000 CCF of white spruce sawtimber (*Picea glauca*). However existing data and supporting analysis clearly shows that this is not sustainable. Furthermore, this recommendation is not compliant with the National Forest Management Act of 1976, federal regulations, and agency policy concerning sustainable timber production. Implementation of this recommendation will result in the rapid decline of the forest standing inventory and the availability of sawtimber in the Black Hills operating area. This finding is consistent with the determinations in Graham et al. 2020 that the current ponderosa pine sawtimber standing inventory on lands classified as suitable for timber production is inadequate to maintain the 1997 Forest Plan Allowable Sale Quantity of 181,000 CCF per year and is also inadequate to maintain the Fiscal Year 2019 final program output of 163,682 CCF of ponderosa pine sawtimber (the estimated output of 153,534 CCF was applied to the GTR scenarios).

Analysis and existing data indicate that a realistic range for a sustainable timber program level (ponderosa pine sawtimber from lands classified as suitable for timber production, adjusted for management direction and ingrowth, without additional volume) is 65,000-93,500 CCF per year. In comparison, the October 21, 2020 NFAB program recommendation, adjusted for management direction and ingrowth, without any change to the short-term gross growth and mortality rates applied, is 102,500 CCF per year.

1. The NFAB recommendation to sustainably produce 175,000 CCF of ponderosa pine sawtimber per year is based on an incorrectly inflated starting standing inventory of 6,737,390 CCF.
  - a. This estimate was derived by expanding volume from the suitable timberlands to 106,089 acres of national forest lands classified as unsuitable for timber production. The standing volume on unsuitable lands should not be included in sustainable program level calculations.
  - b. The suitable timberland area estimation of 765,733 acres (2017-2019 FIA augmented inventory) is consistent with 865,890 acres designated as lands suitable for timber production by the 1997 Forest Plan. The variance can easily be explained by differences in classification methods for non-stocked areas. No adjustments to expansion factors are justified. Differences in FIA and Forest classification protocols do not apply to stocked areas and will not affect standing inventory estimates.
2. The Gross Growth Rate utilized, 3.06%, represents an upper limit of growth for short-term conditions only and should not be applied to long-term sustainable program calculations.
3. The Mortality Rate utilized, 0.40%, represents a lower limit of mortality for short-term conditions only and is not consistent with long-term trends for increasing fire and weather-related mortality.
4. No adjustments were applied to Net Annual Growth calculations to account for management direction, specifically growth that is not available for timber production per Forest Plan objectives for species viability (structural stages). This is an essential step in sustainable timber program level development. The application of management direction to sustainable level calculations will result in a significant amount of reserved standing inventory.
5. No adjustments were applied to Net Annual Growth to account for ingrowth from the SS 3 classes into the SS 4 classes. Ingrowth will increase the sustainable program level slightly during the next twenty years.
6. Additional volume within the Black Hills operating area was not fully evaluated. Increased forest management and timber harvest on non-federal lands including state, county and local government, private, and other non-federal public ownerships could help supplement or offset any decrease of forest timber program outputs.
7. Timber harvest from unsuitable lands would be insufficient to compensate for the gap between a true sustainable program level and the NFAB recommended annual program level of 181,000 CCF.

Concerns with the supporting rationale used to develop the NFAB working recommendation were summarized in a written report submitted to the NFAB working group on September 9, 2020 and were not considered in the final recommendation submitted to the Forest.

## SUPPORTING RATIONALE

Keys steps and considerations for producing a sustainable timber program estimate include:

1. Selecting an appropriate standing Inventory to calculate Net Annual Growth (NAG) in the suitable base (for the task assigned to the NFAB working group this applies to ponderosa pine sawtimber in the suitable timber base).
2. Identifying an appropriate time period for evaluating gross growth rates (GGR) and mortality rates (MR).
3. Selecting a realistic GGR that is representative of likely disturbance cycles and stages of forest stand development.
4. Selecting a realistic MR that is representative of likely disturbance cycles.
5. Incorporating adjustments to the initial sustainable program level calculations (NAG results) for:
  - a. Unavailable volume per management direction and
  - b. Ingrowth from the structural stage (SS) 3 class to the SS 4 classes (pole size trees to sawtimber size trees).
6. Identifying alternate sources of volume to supplement or offset any decrease in forest timber program outputs.

This process is illustrated by the formula below:

**Figure 1.** Steps (1-5) for calculating a sustainable timber program, lands classified as suitable for timber production.

$\text{Inventory} + \text{Gross Growth} - \text{Mortality} = \text{Net Annual Growth}$ $\text{Net Annual Growth} - \text{Unavailable Volume} + \text{Ingrowth} = \text{Sustainable Timber Harvest}$
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### 1. Standing Inventory

***Finding: An incorrect standing inventory estimate for ponderosa pine sawtimber was utilized as a starting point for sustainable program calculations.***

The most recent inventory estimation available for ponderosa pine sawtimber in the suitable base is 5,995,428 CCF per the 2017-2019 FIA augmented inventory. The NFAB working group was directed to use this estimate for development of a sustainable timber program level. This estimate is extrapolated from an area that is consistent with forest land classification records (Supplemental Information Document 2, pp. 15-17) and modification of the FIA results are not justified except for an adjustment to account for the final amount of ponderosa pine sawtimber sold in Fiscal Year 2019, from 153,534 CCF estimated to 163,682 CCF actual.

Calculating the standing inventory for ponderosa pine sawtimber by applying FIA CCF/acre factors by structural stage to the total area in Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6 (from the forest vegetation spatial data - FSVeg) is not valid. The total area (870,829 acres) for these Management Areas includes 106,089 acres classified as unsuitable for timber harvest. The standing inventory on unsuitable acres should not be included in sustained yield calculations for timber production. By doing this, the standing inventory volume is inflated by 742,000 CCF which produces an inflated NAG result and thus an inflated sustainable program level.

## 2. Sustainable Time Period

***Finding: Gross growth and mortality rates were selected for short time periods that did not fully consider disturbance cycles and utilize available inventory data.***

The National Forest Management Act (NFMA) of 1976 limits the sale of timber from national forest lands to a quantity equal to or less than a quantity which can be removed in perpetuity on a sustained-yield basis (Supplemental Information Document 3, pp. 18-19).

Sustainable program calculations incorporate GGRs and MRs that are realistic for entire rotations (the period between regeneration establishment and final removal). The intent of these calculations is to estimate the sustainable volume that could be removed in perpetuity. Appropriate rates should account for disturbance cycles such as bark beetle endemic and epidemic stages, trends for other causes of mortality such as fire and weather, and other factors such as timber harvest levels which alter forest density and structure at the landscape scale. A recommendation based on long term cycles and trends will avoid harvesting a disproportionate amount of the volume at the beginning of any planning period, certainly prior to or during the initial years of management per the next Forest Plan, i.e. “front loading”.

Forest management on the BKNF is implemented primarily through even-aged silvicultural systems. Applicable rotation lengths for these methods typically exceed 100 years. A 150-year rotation time period was applied to the sustainable program calculations for the 1997 Forest Plan. Other even-aged rotation examples include a 120-year rotation for aspen and a 140-year rotation for lodgepole pine for the sustainable program calculations for the current Forest Plan revision effort for the Grand Mesa–Uncompahgre-Gunnison NF (GMUG NF).

Should the BKNF prescribe management via predominantly uneven-aged management in the future, the applicable time frames for modeling are comparable. To continue with the GMUG NF Forest Plan revision example, ponderosa pine and Engelmann spruce are being modeled using uneven-aged management. This modeling incorporates 40 year cutting cycles. These are partial but more frequent entries in comparison in with even-aged management (i.e. 3-4 entries for the time between regeneration establishment and final removal vs. 1 entry. For example 3 partial entries every 40 years = 1 entry of 120 years).

The NFAB recommendation utilizes a high GGR and a low MR that are based on the current short-term condition of the forest, specifically the recent transition from epidemic to endemic mountain pine beetle population levels in 2016. A 5-year program recommendation for a path to sustainability must be based on a sustainable program level that is derived from longer term variables to comply with federal laws, regulations, and agency policy (i.e. calculate the long-term sustainable level, adjust for management direction, then recommend a 5 year program to achieve that level). The NFAB timber program recommendation does not accomplish this.

### 3. Gross Growth Rate (GGR)

**Recommendation: The gross growth rate of 3.06% is not representative of long-term forest conditions and trends and is an outlier.**

A realistic GGR is within a range of 2.51% - 2.88% per a review of available inventories. This range is consistent with the recommendation by Graham et al. and other inventories from which GGRs for ponderosa pine sawtimber can be derived. Graham et al. recommended a 2.51% GGR (from the 2017-2019 FIA augmented inventory):

“we found no mathematical way to justify a gross growth rate to use in our scenarios. Therefore, we felt an annual growth rate of 2.5% would readily reflect what may occur in the future and is well exemplified in the FIA data.”

GGRs are generally higher for sawtimber size trees than trees in the pole and sapling size classes. In order to evaluate GGRs for sawtimber from available, comprehensive inventories (not periodic cycles) 1960-2019, rates must be derived from comparable areas, size classes, and species. The best available comparison for applicable inventories is for ponderosa pine sawtimber, or sawtimber in the softwood species group (which will be predominantly ponderosa pine), on timberlands on national forest, in South Dakota (Supplemental Information, Document 4, Table 1a, p. 20). Comparisons of recent inventory and historical inventory results for lands classified as suitable for timber production are not possible since stratification of inventory data by suitable lands applies to the 2017-2019 augmented FIA inventory only. Table 3a presents GGRs available for comparison using equal parameters.

**Table 3a.** Gross growth rates for ponderosa pine or softwood species group, timberlands in South Dakota, on national forest lands.

Inventory Years	Gross Growth Rate	Source
1960	2.70%	Choate and Spencer, Jr.
1979 – 1983	3.19%	Collins and Green
2002 – 2011	2.88%	NRS FIA
2013 – 2019	2.87%	FIA public EVALIDator
2017 – 2019	2.33%	FIA augmented inventory

The 2.51% GGR recommended by Graham et al. includes ponderosa pine sawtimber in Wyoming, BKNF, so it is not included in the comparison above. A GGR higher than 2.51% may be warranted due to the predominantly open condition of the forest which will persist for decades. The low GGR of 2.33% and the high GGR of 3.19% should be considered outliers that are not representative of disturbance cycles throughout a rotation.

Regarding the recent FIA inventories, public and augmented, the 3.06% GGR utilized to calculate the NFAB recommendation should also be considered an outlier that may be representative of growth for a portion of a rotation only. This rate was derived from an average of periodic inventories for South Dakota from the public FIA EVALIDator application, 2010-2016. Use of this rate disregards any lower results from the more recent inventory such as 2.51% from the augmented 2017-2019, BKNF, suitable lands, Wyoming and South Dakota, and 2.33% for the BKNF, timberlands, South Dakota only.

FIA responses to “Review of the Black Hills National Forest 2017-2019 Augmented FIA Inventory Results” Report<sup>1</sup>, September 2, 2020, Concerns 13 and 14, page 9) advise caution with disregarding GGRs that are lower than estimates from the public database as estimates from the public database are based on older observations, use a different stratification, and thus different expansion factors. FIA considers the lower rates derived from the augmented inventory unbiased and representative.

#### **4. Mortality Rate (MR)**

***Finding: The mortality rate of 0.40% is not representative of long-term forest conditions and trends.***

A realistic MR is within a range of 0.5% - 1.0% per an evaluation of existing inventories (Supplemental Information, Document 5, pp. 22-25). A MR of 0.4% does not account for the trend of increasing weather and wildfire related mortality rates suggested by available inventory data and should be considered a starting point for the modeling of future mortality only. Graham et al. considered an MR estimate of 1.04% conservative and representative of a long-term trend for trees killed in the Black Hills.

Inventory data from which mortality by cause can be derived indicates the fire and weather related mortality is doubling (0.20 % - 1988, 0.20% - 1999, 0.40% - 2011, and 0.40% - 2019) and that future mortality will be greater than 0.40%. van Mantgem et. al. estimated that MR doubling periods for pinus species in the interior west are 29 years. Future increases in insect related mortality should also be considered.

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<sup>1</sup> “The Review of the Black Hills National Forest 2017-2019 Augmented FIA Inventory” is a consultant report produced by the Black Hills Forest Resource Association. Information in this report was utilized by members of the NFAB to develop the NFAB recommendation. This report is not published nor peer reviewed.

## 5. Net Annual Growth Adjustments

**Findings:** *The working group calculations did not adjust the sustainable program level based on net annual growth for management direction (ponderosa pine sawtimber in the suitable base).*

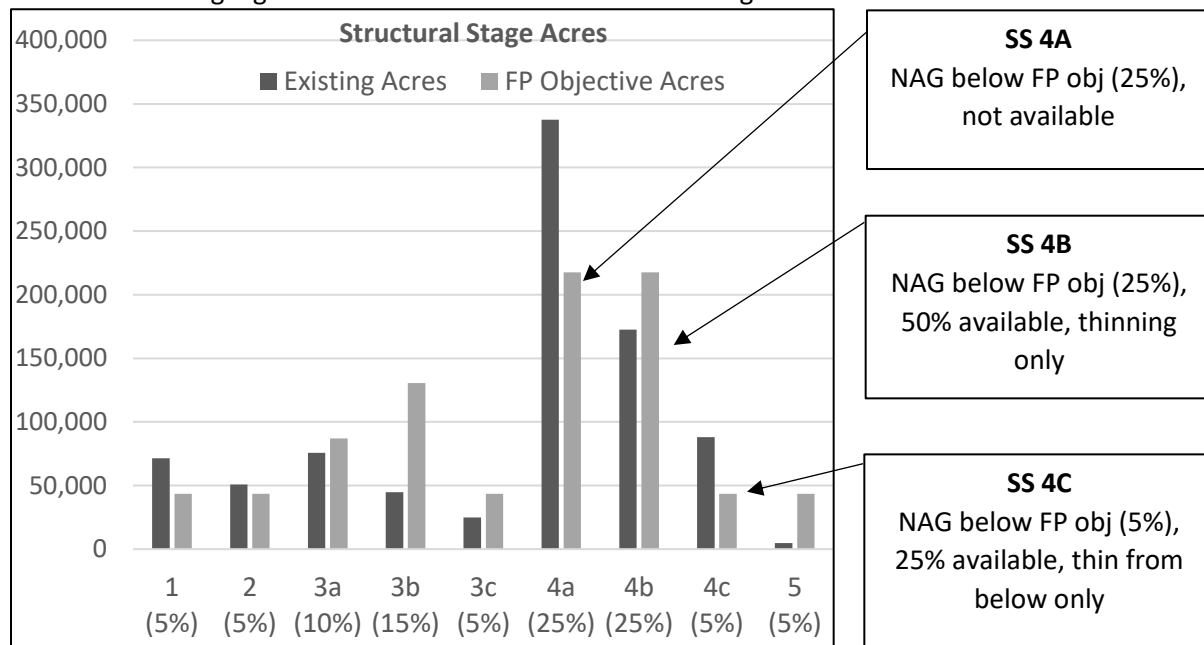
The current land management and resource direction for the BKNF, the 1997 Forest Plan and Phase Revision Phase II Amendment (USDA Forest Service 2006), was completed under the 1982 Planning Rule. The next Forest Plan revision effort will be guided by the 2012 planning rule. Both planning rules require that considerations such as management direction, desired future conditions, and fiscal capacity be considered during the development of sustainable timber programs but at different stages in the process. The NAG scenarios presented in Graham et al. represent sustained yield calculations for ponderosa pine sawtimber in the suitable timber base that do not incorporate management direction and desired conditions. Additional steps are required to determine sustainable program levels that do factor in Forest Plan desired conditions and management direction.

The prescribed structural stage distribution for Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6 (Supplemental Information, Document 6, pp. 26-27), is the most prevalent direction that determines available and unavailable volume for timber production. There are also project design criteria based on Forest Plan direction that also reserve volume. Such design criteria, intended to protect specific areas including nest sites, riparian areas, and wildlife habitat for sensitive species, were not modeled for the comparison scenarios presented in Section 7.

### Available - Unavailable Volume

NAG (inventory + gross growth – mortality) in structural stages (SS) that are not available for harvest per Forest Plan direction must be subtracted from projected timber sale program quantities. Figure 5a illustrates this concept.

**Figure 5a.** A comparison of the existing structural stage distribution to the Forest Plan target distribution to highlight available and unavailable net annual growth.



- SS 4A - NAG of the standing inventory in the total area that meets the 25% Forest Plan objective is reserved and not available for inclusion in annual timber program level calculations.
- SS 4B - the total area equal to or less than the 25% Forest Plan objective may be treated but only through silvicultural methods that maintain the existing SS (minimum canopy closure of 40%). The total area classified as SS 4B is currently below the Forest Plan objective at 19.8%.  
Treatments that maintain a canopy closure of 40% would be thinning throughout size classes and may remove up to 50% of standing inventory.
- Stands classified as SS 4C may be treated but only through silvicultural methods that maintain the existing SS. Treatments that maintain a canopy closure of 70% would be thinning from below and would remove a limited amount of standing inventory (up to 25%).
- SS 4C - the current surplus of 5% may be considered for harvest via treatments that modify the existing SS but would require direction that supersedes the Black Hills Resilient Landscapes (BHRL) Record of Decision, July 20, 2018. This surplus has been reserved for growth into SS 5 - Old Growth.
- SS 4B & SS 4C - Fuels reduction treatments authorized by the BHRL decision would not occur on a substantial footprint and would not alter timber program calculations at a meaningful scale.

An estimated **40-50% of the NAG is not available** for harvest per the Forest Plan structural stage distribution objectives for the suitable base in Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6. The adjustments to NAG were estimated as follows:

- SS 4A - Above objective. Only volume exceeding the 25% objective is available.  
**Adjustment = - 23%**
- SS 4B - Below objective. Only volume removed from thinning that does not modify the SS is available.  
**Adjustment = - 16%**
- SS 4C - Above objective. Volume on acres above objective is available. Only volume removed via thinning on acres that meet objective is available.  
**Adjustment = - 7%**

(Supplemental Information, Document 8, Net Annual Growth Adjustments for Management Direction calculations, p. 31).

The NFAB Recommendation does not adjust net annual growth per the Forest Plan SS objectives. The working recommendation discussed by the group on September 3, 2020, included the following breakdown of estimated volume by SS class (Table 5a). Following attainment of Forest Plan SS objectives in classes 3 and 4, available NAG would be significantly less than the proposed program level. The NFAB recommendation also does not reserve 5% for growth into SS 5 (old growth) in any SS class.

Failure to estimate available/unavailable volume per management direction will result in harvesting a disproportionate amount of the total volume during the next several years, i.e. “front loading”, and result in a rapid decline in the forest timber program level. Table 5a provides an example from the NFAB working group draft recommendation, years 8-10, with volume adjusted for management direction, post implementation of the Black Hills Resilient Landscape Project (BHRL).



**Table 5a.** Estimated available sawtimber volume by structural stage class, years 8-10, NFAB working group proposal, September 9, 2020, adjusted for management direction.

SS	Forest Plan Obj. %	Acres after Time	%	Proposed CCF/year, Years 8-10	Comments	Available CCF/Year
1	5%	71,563	8%	4,000	Uneconomical for commercial timber sales	0
2	5%	50,785	6%	5,500	Uneconomical for commercial timber sales	0
3A	10%	87,083	10%	10,000	Limited sawtimber, marginal for commercial timber sales	10,000
3B	15%	130,624	15%	5,500	Limited sawtimber, marginal for commercial timber sales	5,500
3C	5%	43,541	5%	6,000	Limited sawtimber, marginal for commercial timber sales	6,000
4A	25%	217,707	25%	48000	Growth is on reserved trees, total SS 4A area meets the Forest Plan objective	0
4B	25%	217,016	25%	67,000	Treatments can't modify structure stage. Only 50% of annual net growth is available for harvest	33,500
4C	5%	43,541	5%	29,000	Treatments can't modify structure stage. Only 25% of annual net growth is available for harvest	7,250
5	5%	4,804	1%	<b>175,000</b>		0
		866,664	100%			<b>62,250</b>

#### Ingrowth

***Finding: Estimated growth into the SS 4 classes was not incorporated into the proposal.***

Estimated ingrowth is additive to the sustainable calculations and will increase available NAG. Ingrowth will increase the total SS 4 class area in Management Areas 4.1, 5.1, 5.4, 5.43, and 5.6 and result in area and standing volume that exceeds Forest Plan objectives. Ingrowth was evaluated for a 20-year period to be consistent with land and resource management planning. Growth into SS 4 classes should be calculated separately from sustained yield calculations. Modeling results indicate:

- Ingrowth = approximately 16,500 CCF/year.
- This result is comparable with the gross growth estimate of 15,280 CCF/year for the same size classes (2017-2019 FIA augmented inventory, trees in the 5.0-8.9 inch dbh classes).
- During a 20-year period only trees in the 6.0-8.9 inch dbh classes will grow into the sawtimber size class regardless of density.
- Available volume in stands that have recently grown into the SS 4A class will predominantly contain sawtimber in the smaller diameter classes.  
(Supplement Information, Document 8, Adjustments to Net Annual Growth (Ingrowth), pp. 32-33)

## 6. Additional Volume

### White Spruce (Picea glauca)

**Finding: Harvest of white spruce may supplement a ponderosa pine sawtimber program by a minor amount of 6,000 – 7,500 CCF/year for a 20-year period.**

Preliminary forest pre-NEPA planning estimates indicate that harvest of a total 150,000 CCF of white spruce may be possible forest-wide (7,500 CCF/year for 20 years). The NFAB recommendation includes a comparable estimate of 6,000 CCF/year.

Since the assessment for the 1997 Forest Plan Revision, the amount of forestland typed as white spruce (existing vegetation) has increased from 22,000 acres to 34,000 acres. Landscape Vegetation Diversity (LVD) objective 239 directs the forest to manage for 20,000 acres of white spruce forest. The 150,000 CCF estimate includes management in both the suitable and unsuitable base. Silvicultural options in white spruce stands include partial treatments such as group selection and patch clearcutting.

### Off Forest Sources

**Findings: Off forest sources were not incorporated into the NFAB recommendation and further evaluation is advised. There is opportunity to increase forest management on non-federal lands in both South Dakota and Wyoming.**

Off forest sources of volume include material removed from forest management activities on state, county and local government, private, and other non-federal public ownerships. Tables 6a-6c present FIA inventory results for Wyoming and South Dakota Counties within the Black Hills operating area (Supplemental Information Document 7, Off Forest Sources, p. 28). The estimated standing volume for these ownerships is comparable to the estimated standing volume for ponderosa pine sawtimber in the suitable base of the BKNF. Discussion regarding the potential to increase forest management on these ownerships by the NFAB working group was limited.

FIA public data indicates that:

- The total standing inventory, non-federal ownerships, is comparable to the standing inventory, Black Hills NF, ponderosa pine suitable timber base (6,200,846 CCF vs. 5,995,428 CCF from the 2017-2019 FIA augmented inventory). **Table 6a**
- Since 2006, inventory in SD only has increased slightly, from 2.6 to 2.9 million CCF. **Table 6b**
- Average annual removals of ponderosa pine sawtimber in SD since 2003 from non-federal ownerships has declined, from 51,000 to 21,000 CCF. **Table 6c**

**Table 6a.** Standing inventory, ponderosa pine sawtimber (CCF), non-federal lands, South Dakota and Wyoming, Black Hills NF operating area counties.

Inv Years	State	State	County & Municipal	Private	Other (Non-Federal Public)	Total
2013 – 2019	SD	909,844	6,521	1,994,344	0	2,910,710
2011 – 2020	WY	669,242	0	2,620,894	0	3,290,136
						6,200,846

**Table 6b.** Standing inventory trends, ponderosa pine sawtimber (CCF) 2006-2019, non-federal lands, South Dakota. No data is available for Wyoming.

Inv Years	State	County & Municipal	Private	Other (Non-Federal Public)	Total
2013- 2019	909,844	6,521	1,994,344	0	2,910,710
2008 - 2012	573,334	7,014	2,026,140	0	2,606,488
2003 - 2007	522,894	6,176	2,080,302	0	2,609,372

**Table 6c.** Average annual timber removals from non-federal lands, ponderosa pine sawtimber (CCF) South Dakota, 2003-2019. No data is available for Wyoming.

Inv Years	State	County & Municipal	Private	Other (Non-Federal Public)	Total
2013 - 2019	0	0	10,823	10,780	21,603
2008 - 2012	606	0	42,611	0	43,217
2006 - 2007	15,585	0	35,622	0	51,207

Lands Unsuitable for Timber Production

***Findings: Projects may be implemented on lands classified as unsuitable for timber production however timber harvest will be limited. It is likely that less than 15% of the total area will be available. Projects implemented on unsuitable lands will not produce a sustainable flow of forest products. Estimates for volume removal will not be reliable unless informed by future project work.***

- The NFAB working group requested standing inventory estimates for the unsuitable base by suitability code and prioritized areas for the forest to evaluate for project work. (The forest estimate for ponderosa pine sawtimber, excluding wilderness = 2,425,661 CCF)
- Volume estimates for inclusion in the NFAB working group recommendation were not requested by the forest due to the substantial effort this type of work would entail and the low accuracy likely with spatial and tabular analysis.
- Timber may be harvested to meet other resource objectives however no timber harvest for the purpose of timber production may occur on lands not suited for timber production. (USDA 2015, (Title 36 CFR 219.11(d))).
- There are numerous limitations to forest management on unsuitable lands. In addition to congressionally withdrawn areas such as wilderness, key reasons for an unsuitable designation include:
  - Resource damage is likely or the potential for restocking is marginal.
  - The topography prevents harvesting by tractor or cable logging systems.
  - Sites are inaccessible and road construction would cause resource damage or is uneconomical.
  - Stands are considered non-commercial (aspen, bur oak, birch, and other hardwoods).
  - Sites are being converted to non-commercial stands such as meadows and aspen and hardwood sites.

Supplemental Information Document 7, Lands Unsuitable for Timber Production, p. 29-30)

- A quick review of unsuitable acres by suitability code and Forest Plan direction indicates that less than 15% of the total unsuitable lands may be available for mechanized treatment. Two thirds of the potentially available area is either designated old growth or areas that lacks adequate information to ensure that prompt reforestation is likely.

## 7. Sustainable Program Calculation Scenarios

### Findings:

- *A realistic sustainable timber program level falls within a range of 65,000 - 93,500 CCF/year (not including additional volume sources).*
- *The NFAB recommendation of 175,000 ponderosa pine sawtimber CCF/year = 102,500 CCF/year when adjusted for the correct starting inventory, management direction, and ingrowth, but no change to the short-term gross growth and mortality rates.*

Four scenarios were produced for comparison. The forest scenarios used the correct standing inventory, applied realistic, long term GGRs and MRs, incorporated adjustments to the NAG for management direction and ingrowth, and added volume per available forest estimates for white spruce. The NFAB scenario utilized the unrealistic short-term GGR and MR from the October 21, 2020 recommendation for comparison, applied adjustments to NAG for management direction and ingrowth, and added volume per the available forest estimate for white spruce. No volume estimates are provided for off forest sources of volume from lands classified as unsuitable for timber production.

### National Forest Advisory Board (NFAB) Recommendation:

- The short-term GGR and MR from the recommendation were applied to highlight the effects on a sustainable program level of other calculations that were omitted.
- The standing inventory of 5,995,428 CCF for ponderosa pine sawtimber, suitable lands, from the 2017-2019 augmented FIA inventory for the suitable base was used as a starting point.
- Net annual growth was adjusted by Forest Plan objectives for structural stages and ingrowth.

### Black Hills NF scenarios (scenarios 1-3):

- GGR and MRs were selected within the ranges recommended above for long term sustainable program calculations.
- The standing inventory of 5,995,428 CCF for ponderosa pine sawtimber, suitable lands was used as a starting point.
- NAG was adjusted for the Forest Plan structural stage objectives and ingrowth.

BKNF 1: High GGR, Low MR - "Optimistic" scenario with high growth and low mortality.

BKNF 2: Midpoint - "Average" scenario with mid-point growth and mortality.

BKNF 3: Low GGR, High MR - "Conservative" scenario with low growth and high mortality.

**Table 7a.** Results for a comparison of sustainable timber program calculations, NFAB recommendation and Black Hills NF scenarios.

Scenarios	Sustainable Program Levels- Ponderosa Pine Sawtimber						Additional Volume			Total Annual Sawtimber Volume - BH Operating Area CCF
	GGR	MR	Annual Sustainable Level CCF	Unavailable Net Annual Growth	Annual Ingrowth - SS 4 Class	Total Sustainable level CCF	White Spruce	Non-Federal Owner-ships	Un-suitable Lands	
NFAB Adjusted	3.06%	0.40%	<b>159,000</b>	73,000	16,500	<b>102,500</b>	6,000	TBD	TBD	<b>108,500</b>
BKNF 1: High GGR, Low MR	2.88%	0.50%	<b>142,000</b>	65,000	16,500	<b>93,500</b>	7,500	TBD	TBD	<b>101,000</b>
BKNF 2: Midpoint	2.70%	0.75%	<b>116,000</b>	53,000	16,500	<b>79,500</b>	7,500	TBD	TBD	<b>87,000</b>
BKNF 3: Low GGR, High MR	2.51%	1.00%	<b>89,500</b>	41,000	16,500	<b>65,000</b>	7,500	TBD	TBD	<b>72,500</b>

## SUPPLEMENTAL INFORMATION

1. **NFAB Tasking for the Timber Sustainability Working Group.** Direction provided to the National Forest Advisory Board timber sustainability working group by the forest on April 15, 2020.
2. **Starting Inventory (Inventory Area Comparison).** A comparison document jointly produced by the BKNF and Northern Research Station FIA to reconcile different suitable timberland estimates and demonstrate how the differences in land classification between forest and FIA protocol do not affect standing inventory estimates. This document was requested by the Black Hills Forest Resource Association following the April 3, 2020, public stakeholder meeting hosted by the BKNF, distributed to stakeholders, and posted on the forest public website, timber sustainability page.
3. **Forest Service Law, Policy, and Regulation Constraints Concerning Sustainable Timber Production.** A summary produced in response to the NFAB working group request to concisely summarize federal law, regulation, and agency policy regarding sustainable timber production.
4. **Gross Growth Rates.** A comparison of GGRs for ponderosa pine sawtimber or the softwood species group for timberlands, BKNF, South Dakota. This information was provided to the NFAB working group in the September 9 forest recommendation document to advise working group proposal development.
5. **Mortality Rates.** An assessment of MRs by cause 1960-2019. This document was provided to the NFAB working group in June 2020 per request. An updated version was forwarded to the working group in August to incorporate new FIA inventory data for the 2011 inventory, South Dakota only.
6. **Structural Stages.** Forest Plan definitions, management direction, and the current distribution.
7. **Additional Volume.**

### Off Forest Sources

A list of counties in South Dakota and Wyoming within the Black Hills operating area used to calculate the standing inventory for ponderosa pine sawtimber and timber harvest for non-federal ownerships such as private, state, local and municipal, and other non-federal public lands. The information (Additional Volume, Off Forest Sources) in Tables 6a, 6b, and 6c was derived from the FIA public data, EVALIDator application. Query parameters are provided.

### Unsuitable Lands

A rudimentary estimate of the potential to harvest timber from unsuitable lands based on timber suitability designations with adjustments for access, and partial harvest levels.

## 8. Scenarios.

### Net Annual Growth Adjustments for Management Direction

An example is provided for calculations to determine available and unavailable volume - net annual growth) by structural stage per management direction.

### Adjustments to Net Annual Growth (Ingrowth)

An example is provided for calculations to determine additional available volume per ingrowth from the SS 3 Classes into the SS 4 Classes.

## Supplemental Information Document 1: NFAB Tasking for the Timber Sustainability Working Group

### Black Hills National Forest Advisory Board Timber Sustainability Working Group Tasking

15 April 2020

The Black Hills National Forest Advisory Board (Board) working group on Timber Sustainability is tasked to provide advice to the Forest Supervisor through the Board on the following two issues based upon the stated assumptions and constraints. Present your recommendations to the full Board by the June meeting for consideration and recommendation to the Forest Supervisor.

1. For the Black Hills NF commercial timber program develop and recommend a *no more than five-year pathway to meet sustainability* requirements based on the following constraints and assumptions. A five-year pathway will allow time for the forest to plan for longer term solutions, for example Forest Plan revision.
  - a. Constraints
    - i. Forest Service Law, policy, and regulation 1. National Forest Management Act requirement to manage the forest in a sustainable manner.
    - ii. Existing structural stage objectives found in the Forest Plan as amended in 2005.
    - iii. Estimates of current distribution of structural stage conditions within the suitable base.
  - b. Assumptions
    - i. The Forest Inventory and Analysis data set released in January 2020 represents sound, statistically supportable science with which to make informed forest management decisions about our commercial timber program.
    - ii. The conclusions represented in the DRAFT General Technical Report (Graham, Battaglia, and Jain) are valid based on the FIA data, stated variable values for growth, mortality (removals), and standing volume. Additional scenarios can be run upon request.
    - iii. White spruce, unsuitable base ground pine, and off-forest timber represent viable alternate sources of commercial wood fiber.
2. Present a recommendation to the Forest Supervisor on:
  - a. The need to enter Forest Plan revision (or amendment).
  - b. If recommended, the timing on revision/amendment.

## Supplemental Information Document 2: Starting Inventory (Inventory Area Comparison)

### COMPARISON OF FOREST INVENTORY ANALYSIS AND FSVEG AREA ESTIMATES SUITABLE AND ACCESSIBLE TIMBERLAND

Black Hills National Forest & Northern Research Station, Forest Inventory & Analysis  
March 25, 2020

#### Background

Since the release of the online FIA data several questions have come up regarding the acreages that were reported. A comparison between the Forest Inventory Analysis (FIA) 2017–2019 inventory on the Black Hills National Forest (BHNF) land class area estimates and the 2015 forest Field Sampled Vegetation (FSVeg) Spatial layer was conducted to ensure consistency between inventories with an emphasis on suitable and accessible timberlands.

FSVeg Spatial is a geodatabase platform that combines vegetation stand data with survey information from various sources including common stand exam surveys (CSE), photo interpretation, quick plot surveys, and post-harvest updates. CSE data is collected following rigorous national protocols. Data is used to develop site-specific resource estimates to assess vegetation and site attributes, determine stand treatment needs, and develop detailed silvicultural prescriptions. Since 2015 we have collected CSE data on 20,000 plots geographically dispersed across the forest. Details on CSE data collection are [available online](#).

Forest Inventory Analysis data are collected by professional field crews implementing national protocols and subject to quality assurance/quality control procedures. Details on field data collection are [available online](#). The [peer-reviewed statistical foundations](#) of the FIA sample ensure that reliable, unbiased estimates are generated along with associated values of uncertainty.

A comparison between these inventory datasets is imprecise due to the differences in how area is calculated, the timing of exams, sampling intensity, and classification protocols. CSE has been collected over a longer time period in comparison with the FIA inventory. These exams are designed to sample forest stands in comparison with the landscape scale sampling intensity of FIA inventories.

The 2015 FSVeg layer was selected for comparison since this layer was provided to FIA to determine the land class of plot locations during inventory design.

The 2015 FSVeg layer was compared to the timber suitability calculations in Appendix G of the 2006 BHNF Land and Resource Management Plan Phase II Amendment to assess land class area changes during this time period.

We have concluded the following:

- The net suitable and accessible timberland total area estimates for each inventory are comparable (see Table 1). The FSVeg total (731,283 acres) falls within the 95% confidence interval for the FIA estimate ( $704,860 \pm 30,808$  acres).
- Differences in FIA and forest land classification are apparent regarding classification of currently non-forest areas or regenerating areas with low stocking. FIA data indicates that 44,000 acres is non-forest, presumably through a type conversion from forest to grasslands. The majority of these acres are still designated as part of the suitable and accessible timber base by the BHNF as non-stocked or marginally stocked areas (84,244 acres).

- Differences in classification of non-forest or regenerating areas with low stocking will not affect volume estimates.
- The BHNF suitable timber base decreased 2006-2015 by approximately 42,000 acres from 865,890 to 824,240 acres (see Table 2). Major changes to area estimates occurred for uneconomical areas and reserved areas such as wilderness, research natural areas, late successional reserves, and backcountry recreation areas.

**Table 1.** Comparison of FIA and FSveg inventory estimates of suitable and accessible timberland.

Land class or condition	FIA Inventory 2017 - 2019	FSVeg Dec 2015 Suitable Base	Comments
	acres		
<b>Total Acres - BHNF Suitable Base</b>	<b>828,925</b>	<b>824,240</b>	For FIA data, plot locations were derived from the forest suitable base layer
Private and other ownership	-5,456	-4,194	Includes state lands for FSveg
Reserved productive	-2,740	0	Wilderness, already filtered from FSveg spatial layer
<b>Net USFS Acres</b>	<b>820,729</b>	<b>820,046</b>	
Other forestland	-10,995	-2,471	Non-commercial stands
Non-forest	-44,000	-1,904	Other land use or vegetation type conversion
Not classified	0	-144	
<b>Net USFS suitable timberlands</b>	<b>765,734</b>	<b>815,527</b>	
Non-stocked	-60,873	-84,244	Canopy closure < 10% on site that is capable of growing commercial timber.
<b>Net stocked, suitable timberland</b>	<b>704,861</b>	<b>731,283</b>	

**Table 2.** Net major changes to suitable and accessible timberlands by land class category, BHNF, 2006 - 2015.\*

Description	Change (acres)
Increase in net NF acres	10,700
Increase in non-forest areas	-8,400
Increase in administratively withdrawn areas + Wilderness, + Research Natural Areas	-5,200
Increase in not technically feasible areas + Unstable soils, + Inaccessible, + Can't be restocked in 5 years	-19,000
Increase in non-commercial forests	-1,500



Description	Change (acres)
Decrease in areas removed to meet other multiple use objectives + Late Successional Reserves, - Riparian Reserves, + Developed Recreation Sites, - Backcountry Recreation areas, - Spearfish Canyon, - Southern Hills unsuitable	5,350
Increase in uneconomical areas + Steep slopes, + Road construction problems, + Isolated patches	-20,000
Forest type conversion	-3,500
Net Change to suitable and accessible timberland	-41,550

\*Comparison between land class area in 2006 BHN Land and Resource Management Plan Phase II Amendment and the February 5, 2015 FSveg Spatial layer. This table does not include all land class changes.

## Supplemental Information Document 3: Forest Service Law, Policy, and Regulation Constraints Concerning Sustainable Timber Production

Black Hills National Forest Advisory Board  
Timber Sustainability Working Group

**3. Regarding the FS law, policy, and regulation constraint. We need help understanding these constraints. Please provide summary briefs or documents in lay terms that can guide us with these. I know there are volumes of law, policy, and regulations. Providing these in full text would not be helpful because none of us have time to read or interpret them. Request from NFAB working group facilitator Greg Josten, May 1, 2020**

- The Multiple-Use Sustained Yield Act (MUSYA) of 1960 authorizes and directs national forests to be managed under principles of multiple use and to produce a sustained yield of products and services.
- The National Forest Management Act (NFMA) of 1976 limits the sale of timber from each national forest lands to a quantity equal to or less than a quantity which can be removed in perpetuity on a sustained-yield basis.
- The Code of Federal Regulations directs the Forest Service to implement NFMA by:
  - Calculating the Long-Term Sustained Yield Capacity (LTSYC) which is the sustainable amount that can be produced on suitable lands per site productivity and desired resource goals and objectives.
  - Calculating the Allowable Sale Quantity (ASQ) which considers commercial material per utilization specifications (sawtimber and POL) from the suitable base. This material is included in the LTSYC but is less than LTSYC.
    - ASC includes limitations and constraints such as budget levels and market conditions.
    - ASC is applied on a decadal basis.
  - Calculating a Timber Sale Program Quantity (TSPQ) that includes ASC volume plus any additional volume not included in ASQ such as fuelwood or biomass.
- The LTSYC may not be exceeded during the period covered by the Forest Plan (this applies to chargeable volume which is volume used in yield calculations).
- In order to meet multiple use objectives ASC may be exceeded for any decade covered by the Forest Plan.
- Plans to deviate from ASC must go through a public partition process as outlined in NFMA.
- Significant changes or prolonged changes to the ASC should trigger a Forest Plan amendment or revision.
- Salvage and sanitation of damaged material may or may not be included in LTSYC or ASC calculations and volume may be substituted for or sold in addition to ASC. Salvage and sanitation volume that was included in the LTSYC and ASC calculations (chargeable) counts towards ASC.
- The 2012 Planning rule changed the terminology for sustained yield calculations. Calculation of ASC is no longer required. New terms are:
  - Sustained Yield Limit (SYL): The volume that may be produced in perpetuity on lands that may be suitable for timber production. Calculation of SYL is not limited to the suitable timber base or by land management desired conditions, goals, and objectives. The SYL is not a target but is a limitation on harvest, except when the plan allows for departure.

- Projected Timber Sale Quantity (PTSQ): The estimated amount of timber meeting utilization standards for the period covered by the Forest Plan. This amount must be consistent with desired conditions, goals, and objectives but is not limited to the suitable timber base. PTSQ is not a target nor a limitation on timber harvest.
- Projected Wood Sale Quantity (PWSQ): Includes products in the PTSQ and all other wood products. PWSQ is not a target nor a limitation on timber harvest.

### Sources

The Multiple-Use Sustained Yield Act of 1960 (16 U.S. C. 528).

The National Forest Management Act Of 1976.

Title 36, Code of Federal Regulations, Part 219—Planning, Subpart A—National Forest System Land Management Planning (36 CFR part 219), published in the Federal Register on April 9, 2012 (77 FR 21162).

USDA Forest Service. 2006. FSH 1909.12 – Land Management Planning Handbook Chapter 60 – Forest Vegetation Resource Management WO Amendment 1909.12-2006-7, Effective Date: 01/31/2006.

USDA Forest Service. 2015. FSH 1909.12 – Land Management Planning Handbook Chapter 60 – forest vegetation resource management WO Amendment 1909.12-2015-1, Effective Date: 01/30/2015.

## Supplemental Information Document 4: Gross Growth Rates

Recent and historical inventories were assessed by timberland and not the forest suitable base for consistency. GRRs vary by size class so comparison of ponderosa pine sawtimber for the same land classification, where possible, will provide the most realistic growth rates for sustainable program development evaluation. A comparison of GRRs for ponderosa pine sawtimber, BKNF, for lands classified as suitable for timber production is not possible. Standing inventory for the forest suitable base is only available for the 2017-2019 augmented FIA Inventory.

Table 1a. Gross growth rates for timberlands on national forest lands in South Dakota.

Report / Inventory Publication Year	Inv. Year	Area	Size Class	Species	Unit	Gross Growth	Net Growth	Mortality	Inventory	Gross Growth Rate	Sources
1 - Choate & Spencer Jr., 1969	1960	Timber - land	Saw	Soft-woods	MBF	72,460	67,986	4,474	2,687,000	<b>2.70%</b>	Tables 11, 19, 21
2 - Collins and Green, 1988	1979-1983	Timber - land	Saw	Soft-woods	MBF	149,796	134,378	15,418	4,690,700	<b>3.19%</b>	Tables 10, 14, 15
3 – DeBlander, 2002	1999 Periodic Only	n/a									
4 - Walters et al. 2011	2002 – 2011	n/a									
USDA FIA 2011	2002 - 2011	Timber - land	Saw	Ponderosa Pine	CCF	247,903			8,599,015	<b>2.88%</b>	EVALIDator output - NRS
USDA FIA 2019	2013 - 2019	Timber - land	Saw	Ponderosa Pine	CCF	195,822			6,828,769	<b>2.87%</b>	EVALIDator output – Public
USDA FIA 2019	2017 - 2019	Timber - land	Saw	Ponderosa Pine	CCF	151,479			6,510,552	<b>2.33%</b>	EVALIDator - custom, BKNF

Table 1b. Available sampling intensity and sampling errors related to gross growth rates for timberlands on national forest lands in South Dakota.

Report / Inventory	# Plots - Inventory	Sampling Error - Inventory, 68% Confidence Interval	# Plots – Growth	Sampling Error - Growth, 68% Confidence Interval
1 - Choate & Spencer Jr., 1969	Unavailable			
2 - Collins and Green, 1988	Unavailable			
3 – DeBlander, 2002	Unavailable			
4 - Walters et al. 2011	Unavailable			
USDA Forest Inventory and Analysis 2011	153	6.37%	155	7.46%
USDA Forest Inventory and Analysis 2019	287	5.33%	152	7.72%
USDA Forest Inventory and Analysis 2019	290	5.81%	152	9.42%

## Supplemental Information Document 5: Mortality Rates

### MORTALITY RATE BY CAUSE SUMMARY

#### Review of Mortality Rates Discussed in Draft GTR Timber Growth and Yield in the Black Hills Nation Forest: A Changing Forest

August 3, 2020

#### RESULTS

- The mortality rate for the 2019 inventory, excluding insect related mortality, is 0.47%.
- The mortality rate for the 2011 inventory, excluding insect related mortality, is 0.44%.
- Weather related mortality increased from 1962 through 2011 then slightly decreased in 2019: 0 reported in 1969, 0.17% in 1988<sup>2</sup>, 0.18% in 1999, 0.27% in 2011, 0.20% in 2019.
- Fire related mortality has also increased since 1962: 0 reported in 1962, 0.2% in 1999<sup>3</sup>, 0.13% in 2011, and 0.20% in 2019.
- The increase in weather related mortality is consistent with the findings in van Mantgem et al. that regional warming and drought stress may be the dominant contributors to increased mortality rates for all major western tree genera. Mortality rate doubling periods for pinus species in the interior west were estimated to be 29 years. Endogenous causes of increasing tree mortality such as changes in forest structure, density, fire exclusion, life history traits, and successional dynamics were considered unlikely to be major contributors to the observed trends. Increasing mortality rates were due to both direct and indirect (insects and pathogens) causes associated with regional warming trends and drought stress.

**Table 1.** Annual mortality (CCF) by cause of death. UKN = unknown, unable to derive from available data.

Report #	Annual Mortality, CCF, Trees ≥ 5"DBH						
	Total	Insect	Disease	Fire	Weather	Vegetation	Unknown/ other
1 - Choate & Spencer Jr., 1969	Softwoods, National Forest 12,810 CCF <b>(0.16%)</b>	UKN	UKN – (0.09% for western SD inventory)	<b>0</b>	<b>0</b>	<b>0</b>	UNK
	Softwood, all commercial timberland 14,650 CCF <b>(0.15%)</b>	343 <b>(0.04%)</b>	827 <b>(.08%)</b>	UKN	UKN	UKN	295 <b>(0.03%)</b>
2 - Collins and Green, 1988	Pine, National Forest 34,910 CCF <b>(0.26%)</b>	UKN	<b>0</b>	UKN	UKN	<b>0</b>	UKN
	Pine, all commercial timberland 45,020 CCF <b>(0.26%)</b>	5,690 <b>(0.03%)</b>	<b>0</b>	5,150 <b>(0.03%)</b>	2,350 <b>(0.17%)</b>	<b>0</b>	4,830 <b>(0.03%)</b>

<sup>2</sup> The weather related mortality reported in 1988 was for ponderosa pine on all commercial timber ownerships but may have been underreported for the Black Hill NF (see discussion under Report 2 – Inventory Considerations).

<sup>3</sup> Collins and Green, 1988, reported that 9% of the overall mortality rate was caused by fire. This is for all timberlands and is not specific to the national forestlands.

Report #	Annual Mortality, CCF, Trees ≥ 5"DBH						
	Total	Insect	Disease	Fire	Weather	Vegetation	Unknown/ other
3 – Delander, 1999	Pine, National Forest 40,000 CCF <b>(0.26%)</b>	4,000 <b>(0.03%)</b>	3,600 <b>(0.02%)</b>	3,600 <b>(.02%)</b>	27,600 <b>(0.18%)</b>	0	1,200 <b>(0.01%)</b>
4 - Walters et al.	Pine, National Forest 140,460 CCF <b>(1.04%)</b>	UKN	UKN	UKN	UKN	UKN	UKN
FIA 2011	Pine, National Forest, SD only 148,017 CCF <b>(1.24%)</b>	95,380 <b>(0.80%)</b>	248 <b>(0%)</b>	15,842 <b>(0.13%)</b>	31,870 <b>(0.27%)</b>	0	4,678 <b>(0.04%)</b>
5 - Graham et al. Draft, 2020	Pine, National Forest 244,703 CCF <b>(3.07%)</b>	207,308 <b>(2.60%)</b>	4,268 <b>(0.05%)</b>	15,651 <b>(0.20%)</b>	15,510 <b>(0.20%)</b>	962 <b>(0.01%)</b>	1,003 <b>(0.01%)</b>

## INVENTORY CONSIDERATIONS

### Reports 1 & 2 (1 - Choates and Spencer, Jr. 1969) (2 - Collins and Green 1988)

- Report 1 provides total mortality estimates for national forestlands by species group (softwoods and hardwoods). Estimates by cause of death are provided for all ownerships only.
- Report 2 provides total mortality estimates for national forestlands. Estimates by cause of death are provided by species for all ownerships only.
- Report comments are specific to mortality rates in South Dakota:

#### Report 1 (p. 6)

- Estimates of annual net growth of growing stock indicated above are about 2.9% greater than the average for the 10 years preceding the survey. Mortality estimates are 28% less. These differences arise in large measure from the fact that estimated mortality for 1962 in the eastern part of the State is the average of only 3 years – years during which rainfall was greater and growing conditions better than the 10-year average. Differences are less for sawtimber.
- Another reason for low normal mortality is that forest fires are not as extensive as in many other areas.

(Tables 11, 21, & 22, p. 11, 34, & 35)

- 1962 mortality = 12,180 CCF/7,810,000 CCF (softwood, national forest) = 0.16%.
- Mortality rates for the previous decade: 30,360 CCF per year/1,085,000 CCF (all species group, all ownerships) = 0.28%

#### Report 2 (p. 7)

- Annual mortality of growing stock on timberland resulted in a loss of 5.9 million cubic feet of volume, which is 14 percent of the net annual growth. Weather caused over 65 percent of the total mortality (fig. 11 and table 16). In 1982, a wet snowfall in the Black Hills caused extensive mortality to ponderosa pine trees (fig. 12). Mortality on the Black Hills National Forest accounted for most of the weather-caused mortality. However, table 15 (Table 15

reports 34,910 CCF annual mortality, softwoods, national forest) does not reflect this loss, which has been estimated to be 50 million board feet (100,000 CCF) (Fowler 1986).

**Report 4** (Walters et al.)

- Mortality estimates by cause of death are not provided in report number 4.
- Mortality by cause data was obtained from the Northern Research Station, FIA (July 2020), for survey years 2002-2006 and 2007-2011 for the Black Hills National Forest, South Dakota, ponderosa pine growing stock on timberlands. This data will vary slightly from the data used in the 2011 report by Walters et al. A special study database was created to support the preparation of the 2011 report. This database is no longer available. Reasons for slightly different results include:
  - 1) use of a different set of plots which may result in different strata, different estimation unit assignments, and different expansion factors, and
  - 2) any updates or changes made to the database over time.

**Report 5** (Graham et al.)

- Rates by cause of death were derived from EVALIDator, inventory years 2017 - 2019.



**Table 2.** Forest Inventory summary for reports cited in Graham et. al. 2020.

Inventory Report #	Report Year	Author	Source	Inventory Year	Area Description	Acres	Growing Stock, Trees ≥ 5" DBH	
							Volume, CCF	Species/Material
1	1969	Choate and Spencer, Jr.	Western SD - Rocky Mountain & Intermountain Forest & Range Experiment Station (1960), Eastern SD - North Central Forest Experiment Station (1964-1965)	1960 - 1965	Commercial Forestland in SD only, National Forest only	957,000	7,810,000	Values are for softwoods, pine and spruce
2	1988	Collins & Green	East SD - Forest Survey, North Central Research Station (1979) & West SD- 1983, Forest Survey, Intermountain Research Station	1979 & 1983	Timberlands in SD (not reserved?), National Forest only	952,500	13,449,000	Values are for softwoods, pine, spruce, and eastern redcedar
3	2002	DeBlander	FIA	1999	Forestland including reserved land, National Forest only	1,150,627	15,353,000	ponderosa pine
4	2011	Walters et. al.	FIA	2002 - 2006, 2007 - 2011 SD, end of cycles 2002, 2005 WY	Timberlands (not reserved), National Forest only	1,135,200	13,477,960	ponderosa pine
FIA South Dakota inventory 2011	n/a	n/a	FIA	2002-2006 & 2007-2011 surveys, SD	Timberlands, National Forest only		11,932,981	ponderosa pine
5	2020	Graham et. al. Draft	FIA	2017 - 2019	Suitable Timberlands (not reserved)	765,733	7,958,314	ponderosa pine

## Supplemental Information Document 6: Structural Stages

Land and Resource Management Plan for the Black Hills National Forest, Rocky Mountain Region, Phase II Amendment, March 2006.

### Definitions

#### **Structural Stages (Vegetation)**

Any of several developmental stages of tree stands described in terms of tree size and the extent of canopy closure they create. They include:

**Structural Stage 1 (Grass/Forb):** The grass/forb stage was historically a product of fires, windthrow or similar disturbances. Under forest management, this stage can be created through harvesting. This stage is dominated by grasses and forbs lasting until tree seedlings become established.

**Structural Stage 2 (Shrub/Seedling):** The shrub/seedling stage consists of shrubs such as chokecherry, rose and serviceberry along with tree seedlings. A stand remains in Stage 2 until the tree seedlings reach one inch diameter at breast height (DBH), which should take less than a decade.

**Structural Stage 3 (Sapling/Pole):** The sapling/pole stage consists of trees with stems one to nine inches DBH. This stage typically persists up to 30 years to age 70. Less than 40 percent canopy closure is 3A; 40 to less than 70 percent canopy closures is 3B; and greater than 70 percent canopy closure is 3C. Understory production is inversely related to overstory pine canopy cover.

**Structural Stage 4 (Mature):** The mature stage begins when trees reach the 9-inch DBH class. Trees remain in this stage until they are about 160 years old. As with Structural Stage 3, understory productivity depends upon the overstory canopy cover. Less than 40 percent canopy closure is 4A; 40 to less than 70 percent canopy closures is 4B; and greater than 70 percent canopy closure is 4C. The sizes of trees in this stage will vary depending upon growing-site potential and the density of the stand.

**Structural Stage 5 (Late Succession):** This structural stage is characterized by very large trees (16+ inches DBH). Trees are at least 160 years in age; ponderosa pine that reach this age are commonly referred to as “yellow barks.” Late succession ponderosa pine may occur in dense stands, but may also grow in the open or in “parklike” stands (Mehl 1992).

### Forest Plan Direction

The prescribed structural stage distribution below is an objective that applies to the following Management Areas:

- 4.1 - Limited Motorized Use and Forest Product Emphasis
- 5.1 - Resource Production Emphasis
- 5.4 - Big Game Winter Range Emphasis
- 5.43 - Big Game and Resource Production
- 5.6 - Forest Products, Recreation and Big Game Emphasis

Chapter 1: Goals and Objectives. This is the overall direction for the Forest.

Goals describe desired end results and are normally expressed in broad general terms. Forest Plan goals link broad agency goals as set forth in law, executive order, regulation, agency directives and the Resource Planning Act program. These goals also closely reflect the Regional goals described in the Rocky Mountain Regional Guide (1992).

Objectives are concise statements of measurable desired results intended to promote achievement of Forest Plan goals. Objectives describe (1) desired resource conditions in the area covered by the plan, either in the next decade or longer and (2) desired levels of goods and services that the plan area is capable of producing in the next decade.

Objective - Forested Communities: Manage for the following percentages of structural stages in ponderosa pine across the management area in a variety of sizes and shapes.

SS1	5%	SS4A	25%*
SS2	5%	SS4B	25%*
SS3A	10%	SS4C	5%*
SS3B	15%	SS5	5%**
SS3C	5%		

\*10% of the structural stage 4 ponderosa pine acreage in the management area will have an average tree size of "very large". Seek opportunities to increase understory shrubs in open-canopy structural stages.

\*\*Active management is allowed, and may be necessary, to provide desired late-successional characteristics.

### Current Distribution

Based on the January 2020 Field Sampled Vegetation (FSVeg) Spatial layer.

SS	FP Obj.	Acres	Existing
1	5%	71,563	8.2%
2	5%	50,785	5.8%
3a	10%	75,831	8.7%
3b	15%	44,761	5.1%
3c	5%	24,921	2.9%
4a	25%	337,607	38.8%
4b	25%	172,448	19.8%
4c	5%	88,109	10.1%
5	5%	4,804	0.6%
		870,829	1.00

## Supplemental Information Document 7: Additional Volume

### Off Forest Sources

The following counties in the Black Hills National Forest operating area that were queried to produce standing inventory and harvest removal estimates from public FIA data:

#### South Dakota

County Code and Name
46019 SD Butte
46033 SD Custer
46047 SD Fall River
46063 SD Harding
46081 SD Lawrence
46093 SD Meade
46103 SD Pennington
46105 SD Perkins
46102 SD Oglala Lakota
46121 SD Todd

#### Wyoming

County Code and Name
56005 WY Campbell
56011 WY Crook
56045 WY Weston

### FIA Public data (Validator) parameters

Standing inventory and timber removals were queried for timberland for the inventory years specified in Tables 3, 4, and 5, Section 6, Additional Volume, Off Forest Sources, using the following parameters:

- Page variable = Species
- Row variable = County code and name
- Column variable = Ownership class

## Lands Unsuitable for Timber Production

Table 7a. Estimate of available acres by timber suitability code, lands classified as unsuitable for timber production.

Timber suitability Code	Timber suitability description	Acres	No harvest	Accessible - within 1/4 mile of road infrastructure 67% of acres	Partial harvest - 50% of acres	Partial harvest - 33% of acres
701	Old-growth other than landscape areas (site level)	2,723		1,824	730	602
702	Old-growth landscape areas	5,217		3,495	1,748	1,153
710	Restocking within 5 years cannot be assured	1,504	1,504			
720	Irreversible resource damage likely with current logging technology	1,807	1,807			
721	Topography prevents harvesting by tractor or by cable	50,995	50,995			
722	Irreversible resource damage likely due to unstable soils	7,061	7,061			
723	Previously Suitable - topography prevents harvest	297	297			
740	Adequate response information is lacking (i.e. sites with low productivity)	40,779		27,322	13,661	9,016
800	Critical game habitat	22	22			
801	Old-growth other than landscape areas (site level)	17,491		11,719	5,860	3,867
802	Old-growth landscape areas	19,511		13,072	6,536	4,314
803	Botanical areas	6,999		4,689	2,344	1,547
804	Riparian areas	273	273			
805	Incompatible with multiple use - critical wildlife habitat	415	415			
810	Experimental Forest, Range or Watershed	4,804		3,219	1,609	1,062
811	Research Natural Area (RNA), not suitable lands	1,795		1,203	601	397
820	Minimum level allocation - uneconomical	9,989	9,989			
821	Steep slopes	8,398	8,398			
822	Timber type currently has low product value/lack of market (Aspen)	45,139	45,139			
823	Road construction problems prevent access development	4,047	4,047			
824	Isolated patch of forest land	10,030	10,030			

Timber suitability Code	Timber suitability description	Acres	No harvest	Accessible - within 1/4 mile of road infrastructure 67% of acres	Partial harvest - 50% of acres	Partial harvest - 33% of acres
825	Developed recreation site other than ski area	7,401		4,959	2,479	1,636
826	Bur Oak	13,585	13,585			
831	Paper Birch	3,610	3,610			
832	Other hardwoods	1,123	1,123			
850	Administrative site	289		193	97	64
860	Seed Collection Area	20	20			
871	Backcountry recreation	13,822		9,261	4,630	3,056
891	Converting pine to aspen	1,619	1,619			
892	Converting pine to meadow	1,602	1,602			
895	Converting conifers to hardwoods other than aspen	192	192			
896	Converting other conifers to meadows other than ponderosa pine	31	31			
900	Incapable of producing industrial wood	13	13			
		282,603	3,457			
Total unsuitable acres & total acres - no harvest						
Total remaining unsuitable acres - partial harvest may be possible			120,830	80,956	40,296	26,715

Wilderness was excluded from this quick assessment.

**Supplemental Information Document 8: Scenarios**

**8A. Net Annual Growth Adjustments for Management Direction**

This example of adjusting NAG indicates that unavailable NAG per the Forest Plan structural stage distribution ranges from -40% to -50%.

**Table 8a1.** Calculate net annual growth by structural stage example.

Scenarios (Annual CCF)	1	2	3A	3B	3C	4A	4B	4C	No SS assigned
NFAB WG 159,367	2,319	4,226	8,754	3,548	2,022	55,882	49,960	31,563	1,092
BKNF 1 142,192	2,069	3,771	7,811	3,166	1,804	49,860	44,576	28,162	974
BKNF 2 116,000	1,688	3,076	6,372	2,583	1,472	40,675	36,365	22,974	795
BKNF 3 89,426	1,301	2,372	4,912	1,991	1,134	31,357	28,034	17,711	613

**Table 8a2.** Apply ratios to calculate unavailable NAG by structural stage example.

Scenarios Annual CCF	Subtract 4A NAG meeting 25% obj.	Subtract 50% of 4B NAG retained after thinning	Subtract 75% of 4C NAG retained after thinning on 50% of SS area meeting obj.	Total Unavailable Net Annual Growth	Unavailable Net Annual Growth %
NFAB WG 159,367	-36,006	-24,980	-11,836	-73,822	-46%
BKNF 1 142,192	-32,126	-22,288	-10,561	-64,975	-46%
BKNF 2 116,000	-26,208	-18,182	-8,615	-53,005	-46%
BKNF 3 89,426	-20,205	-14,017	-6,642	-40,864	-46%

Total unavailable NAG = - 46% of NAG

Total unavailable NAG SS4A class = -23%

Total unavailable NAG SS4B class = -16%

Total unavailable NAG SS4C class = -7%

**8B. Adjustments to Net Annual Growth (Ingrowth)**

This example of calculating ingrowth from the SS 3 classes to the SS 4 classes to estimate new available volume per area that exceeds Forest Plan objectives indicates that net available annual ingrowth is 15,000 – 20,000 CCF per year (20-year planning period). This will not be an equal distribution. More ingrowth will become available during years 10-20 than during years 1-10.

**Assumptions**

1. 70% of the total SS 3 class is in the 5-9" dbh diameter classes per the 2017-2019 FIA inventory.
2. Stands in the SS 3 1 - 5" diameter classes will not grow into a sawtimber size class in 20 years with or without management.
3. There is an equal distribution of area by diameter class within the 5-9" diameter classes.

**Steps**

**1. Estimate annual diameter growth for trees 5.0 – 8.9" dbh from SS 3 classes into the SS 4 classes.**

5 Years				10 Years				15 Years				20 Years			
DBH	0.023	0.025	0.027	DBH	0.023	0.025	0.027	DBH	0.023	0.025	0.027	DBH	0.023	0.025	0.027
5	5.60	5.66	5.71	5	6.28	6.40	6.53	5	7.03	7.24	7.46	5	7.88	8.19	8.52
6	6.72	6.79	6.85	6	7.53	7.68	7.83	6	8.44	8.69	8.95	6	9.46	9.83	10.22
7	7.84	7.92	8.00	7	8.79	8.96	9.14	7	9.85	10.14	10.44	7	11.03	11.47	11.93
8	8.96	9.05	9.14	8	10.04	10.24	10.44	8	11.25	11.59	11.93	8	12.61	13.11	13.63

Different growth rates were applied to different densities: SS 3A = 2.7%, SS 3B = 2.5%, SS 3C = 2.3%



**2. Calculate estimated SS 3 class area in the 5-9" dbh class.**

SS	Acres	% acres > 5" dbh	GGR	5 YR	10 YR	15 YR	20 YR
3A	75,831	53,082	2.7	0.25	0.25	0	0.25
3B	44,761	31,333	2.5	0.25	0	0.25	0.25
3C	24,921	17,445	2.3	0	0.25	0.25	0.25
	145,513	101,859					

- Total SS area and area by density class was derived from 2020 FSveg layer.
- FIA data, 2017-2019 augmented inventory, used to estimate how much of the SS 3 Class total area is stocked with trees ≥ 5.0" dbh. 70% of the total SS area is stocked by trees ≥ 5.0" dbh.
- FSveg data was used to determine SS 3 area by class, i.e. density (3A, 3B, 3C).

**3. Calculate area that grows into SS 4 for 5-year periods from Table 2.**

SS	5 YR	10 YR	15 YR	20 YR	Total
4A	13,270	13,270	0	13,270	39,811
4B	7,833	0	7,833	7,833	23,500
4C	0	4,361	4,361	4,361	13,084
	21,104	17,632	12,194	25,465	76,395

**4. Apply area estimates to CCF/acre factors to estimate ingrowth.**

SS	CCF/Acre	5 YR	10 YR	15 YR	20 YR	Total
4A	4	53,082	53,082	0	53,082	159,245
4B	8	62,666	0	62,666	62,666	187,997
4C	6	0	26,167	26,167	26,167	78,502
<b>5 YR Total</b>		115,747	79,249	88,833	141,915	425,744
<b>CCF/YR</b>		23,149	15,850	17,767	28,383	21,287

**5. Apply management direction to ingrowth (same as Step 6A - make adjustments to net annual growth (unavailable volume)).**

a. Calculate % increase of area by SS class.

SS	5 YR	10 YR	15 YR	20 YR	Total	Comments
4A	1.5%	1.5%	0.0%	1.5%	4.6%	All available, > 25% FP objective
4B	0.9%	0.0%	0.9%	0.9%	2.7%	50% available only, SS 4B still <25% FP objective, can't modify SS class
4C	0.0%	0.5%	0.5%	0.5%	1.5%	All available, > 5% Forest Plan objective and 5% retained for SS 5

% of SS Distribution (870,829 ac)

b. Calculate available volume by SS class.

SS	5 YR	10 YR	15 YR	20 YR	Total
4A	53,082	53,082	0	53,082	159,245
4B	31,333	0	31,333	31,333	93,998
4C	0	26,167	26,167	26,167	78,502
<b>5 YR Total</b>	84,414	79,249	57,500	110,582	331,746
<b>CCF/YR</b>	16,883	15,850	11,500	22,116	<b>16,587</b>

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