Reconciliation of Comments for RMRS-GTR-422

A Scenario-Based Assessment to Inform Sustainable Ponderosa Pine Timber Harvest on the Black Hills National Forest

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Table of Contents

The Review Process and Reconciliation of Reviewer Comments

General Technical Reports (GTRs) produced by the USDA Forest Service are required to undergo a review process prior to publication. Four types of reviews have been conducted the interim report prior to releasing RMRS-GTR-422: (1) policy review, (2) technical peer review, (3) blind peer review, and (4) reviews by interested parties concerned with the Black Hills National Forest.

Policy Review: A policy review looks for manuscript content that compromises scientific integrity, credibility, and objectivity. The reviewer looks for opinions on laws or policy, speculation without peer-reviewed experimental data and citations, and provocative statements inappropriate for scientific publication. The policy review ensures that discussion of management implications, management considerations, and potential outcomes are objective and do not advocate for or discriminate against management approaches. Each draft of a GTR that has been released to the public has had a policy review. The policy review for RMRS-GTR-422 was conducted by the Rocky Mountain Research Station's Forest and Woodland Ecosystem Research Program Manager.

Technical Peer Review: The technical review includes a review of the statistics, research design, experimental methods, interpretation of results, and other technical aspects of the document to ensure maximum "quality, objectivity, utility, and integrity of information" (Office of Management and Budget Guidelines, Section 515, Public Law 106-554, Data Quality Act). The authors asked for a technical review from four U.S. Forest Service employees who are not Rocky Mountain Research Station scientists (external reviewers): one from the Pacific Northwest Forest and Inventory Analysis (FIA) program, one from the Interior West FIA program, and two from the U.S. Forest Service Washington Office. The comments from these technical reviewers were addressed and often integrated into RMRS-GTR-422.

Because RMRS-GTR-422, *A Scenario-Based Assessment to Inform Sustainable Ponderosa Pine Timber Harvest on the Black Hills National Forest,* may potentially have an economic impact, the Information Quality Act (Office of Management and Budget Guidelines, Section 515, Public Law 106-554) classifies the report as potentially influential. Therefore, the authors sent the interim report dated February 10, 2020, for a technical peer review.

Blind Peer Review: The interim report dated February 10, 2020, was reviewed by three non-Forest Service scientists through a blind review process in which the identity of the reviewer was not known to the authors (refer to Blind Peer Reviewer Comments and Reconciliation), but the reviewer knows who wrote the manuscript. Prior to publishing RMRS-GTR-422, the revised manuscript and reconciliation of comments were returned to the blind peer-reviewers to show how the authors had addressed the reviewer concerns. The concerns were addressed and often integrated into RMRS-GTR-422.

Interested Parties: The interim report dated February 10, 2020, was reviewed by interested parties associated with the Black Hills National Forest. The public review comment period was open from March 15 to May 1, 2020. The comments from the interested parties reviewers were considered, addressed, and often integrated into RMRS-GTR-422.

This reconciliation of comments includes the technical reviewer comments, blind reviewer comments, and interested parties associated with the Black Hills National Forest with the accompanying responses from the authors. Only the authors' responses have been edited for spelling, grammar, and clarity.

Technical Reviewer Comments and Reconciliation from interim report dated February 10, 2020. The technical reviewers were asked to respond to four questions and provide comments on the draft. The four questions were:

1) Does it make sense?
2) Are we interpreting and using the Forest and Inventory Analysis (FIA) data properly?
3) Are our assumptions explained well enough?
4) Are the displays clear?

Technical Reviewer #1

1) Does it make sense?

   Reviewer's response: Yes, the approach—i.e., learning from the past to lay out some possible future alternatives—is easy to follow as presented.

   Authors' response: No response is needed.

2) Are we interpreting and using the FIA data properly?

3) Are our assumptions explained well enough?

   Note: Reviewer combined the answer to these two questions.
   Reviewer's response: These two are related, and my answer is yes and no to both. As you will see in the commentary, yes, your interpretation and use of the values produced by FIA are proper and well-explained. But, and this is a huge BUT, given the goals of your report, it's important to make sure that the numbers mean what you think they mean. As you will also see in the commentary, there are a whole bunch of reasons why I think the most optimistic mortality rates – specifically the 0.26% that is used in two scenarios – is way too optimistic. There are many factors affecting the calculation of that rate, not the least of which is that FIA methodology of the time is known to omit certain categories of mortality. So, effectively by definition, it is guaranteed to be an underestimation. The vast majority of my comments relate to why I make that conclusion.

   I understand that one implication of my conclusion is that the BHNF is very unlikely to see harvest >100,000 CCF over the course of several FS career lengths, unless of course, there were to be a complete harvest hiatus and resumption of activity when net growth again achieved suitable levels. I don't mention that directly in the review because 1) I didn't want to be overly prescriptive or speculative, and 2) I'm guessing that cessation of harvest for any time period isn't really on the table, for a variety of reasons.

   In the comments I focus primarily on why the 0.26% figure seems overly optimistic, rather than proposing my own scenarios. If I were laying out my own scenarios along the lines of what you've done here, I would probably go with 0.75%, 1.0, and 1.25% for starters, and probably invoke a decent MBP outbreak every couple of decades. The combinations are obviously infinite, but my main concern would be to avoid scenarios that have relatively low probability of occurring. I think that 0.26% mortality, as it's calculated in FIA annualized inventory, is a low-probability outcome.

   Please let me know if you have any questions any time from here to the end of this process.

   Authors' response: We expanded our discussion on mortality to highlight the changes through time. We added a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West and we had an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity, which has already been

demonstrated in the Black Hills over the past 20 years. For a time, fuel loadings caused by mountain pine beetle (*Dendroctonous ponderosae*, MPB) mortality may increase wildfire hazard. Under the section titled *Scenario Development/Mortality Rates,* we describe in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and we have shown in table 1 those differences by mortality agent. We discuss the different mortality agents over time and how they have changed with the endemic and epidemic MPB activity as well as impacts from wildfire in the section titled *Understanding Disturbance and Tree Mortality.* We acknowledge that the current MPB epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB that can still support infestation. Furthermore, we place the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discuss this trend in wildfires for the Black Hills and potential impacts of an uncertain changing climate. In the section titled *Scenario Development,* we provide details on the identified range of mortality rates, growth, and harvest levels (see table 6 for a list of scenarios). In the final report, we use five mortality rates in our scenarios: 0.26%, 0.6%, 1.04%, 1.52%, and 2.0%.

4) Are the displays clear?

Reviewer's response: Yes, but the symbols could be reduced in size a bit so they don't bunch up. Also, Fig. 13 needs "Scenario" edited in the legend. The main tables and good, and essential. For the Appendix tables, I get showing annual resolution and annual rates, but I wonder if they could be presented at 5-year intervals since the graphs already show the shape of the trend lines.

Authors' response: We removed the appendix tables since they were redundant to the graph figures. We also updated the scenarios to reflect a full range of mortality and gross growth rates through time.

Technical Reviewer #1 General Comments

This report [interim report] summarizes data from past Forest Inventory and Analysis (FIA) reports and the results from a recent FIA intensified inventory and proposes several scenarios for future timber harvest on the Black Hills National Forest (BHNF). FIA data show that the BHNF has entered a state of negative net growth due to fire and insects, resulting in decrease of live timber inventory that is further reduced by recent harvest levels. The proposed scenarios combine the current inventory with likely future growth and mortality rates to evaluate possible alternative, sustainable future harvest levels. Sustainable harvest is possible, assuming a return to approximately normal natural mortality rates, but at reduced levels as compared to the past several decades.

The study relies on FIA data and reports spanning approximately 60 years. It does not attempt to re-analyze raw plot data from long past inventories but uses all data currently available from the FIA program. The FIA program advises caution to users who desire to compare inventories completed prior to the implementation of annual inventory (ca. <1998), which are commonly referred to as periodic inventories, with each other or results from annualized inventory (see, e.g., Goeking 2015). The reasons for caution include changes in methodology due to changes in monitoring goals, changing definitions (to include what is "forest"), changing forest products markets, improved scientific knowledge, budgetary constraints, and other factors. When such comparisons are made it is essential that users: 1) make a

determination that inventories are reasonably comparable, or use only the portions of inventories that are comparable, and 2) make reasonable assumptions about remaining differences and note those assumptions clearly in the comparison. An example of (1) could be approximately the same number of plots taken over approximately the same areal extent.

There are two other FIA reports covering western South Dakota: Clendenen et al. (1976) and Green (1978). Neither adds substantively to the inventory values provided in table 1 of the report [interim report], but Green (1978) raises an issue that is discussed in more detail below.

Given that the BHNF has a long history of active forest management and is relatively isolated, being surrounded primarily by non-forest land, FIA inventories of the area meet criterion (1) fairly well. The most recent inventory cycle, which was a temporal and spatial intensification as compared to the normal FIA inventory cycle, was well-suited to capture the recent and rapid changes due to insects and fire on the BHNF. Therefore, the FIA reports used in the analysis are appropriate for the application. In general, the authors do a thorough job explaining the differences among inventories and assumptions used in the analysis. These include some logical deductions, such as ponderosa pine being included in a generic "softwood" category in some statistics, but noting that other species in the same group, such as white spruce, are known from other sources as being exceedingly minor.

However, I know of one exception that is likely to be relevant to the alternative scenarios provided in the manuscript. Green (1978, p. 19) states:

> "Mortality is difficult to estimate, especially with the inventory procedures used. Also, increased insect activity since the inventory has made a substantial increase in the number of trees dying, and therefore, a reduction in net growth. There is some evidence that mortality actually may be 3 or 4 times that calculated from the basic inventory data."

To my knowledge, the 1970s inventory updates for the BHNF were at least partly based on remeasurement of the plots used in the 1960s inventory (Choate and Spencer 1969). The documents surrounding the 1960s and 1970s inventories are currently in the process of being digitized, but the project is not yet completed to the extent to fully understand Green's (1978) caveat on mortality. However, it is not necessary to fully understand the methodological differences to question mortality rates below 1% per year in ponderosa pine during the 1960s and 1970s, and even in the 1990s.

First, the 1960s and 1970s inventories coincide with the third and fourth largest epidemics of mountain pine beetle, as shown in Figure 1 of the current manuscript. This apparent contradiction is at least partly attributable to FIA methodology and the partitioning of mortality in the inventory. During periodic inventories, FIA estimates standing live volume, mortality, and harvest by what amount to three different methods. Live volume is a direct "snapshot", being based on the standing live volume at the time a plot is visited. Mortality is also based on standing trees, but because each periodic inventory was typically treated as an independent inventory (as opposed to a "true" remeasurement) it is only based on standing dead trees. Trees that were removed from the plot were not counted as mortality, creating an inherent, but quantitatively unknown, underestimation factor. In addition, the mortality estimate was not entirely concurrent with the live tree estimate – i.e., mortality trees were separated from other standing dead trees based on crews' judgment as to whether mortality occurred within a set window of time, in this case 5 years. Annual mortality, as reported by FIA in periodic inventories, is therefore based only on the trees that have died in the 5 years leading up to the plot measurement and also remain on the plot (usually standing). No attempt was made to account for mortality, represented only by stumps

at the time of plot measurement, that might have resulted from green-tree or dead-salvage harvest. The methodology also means that inventories done in the years immediately following bark beetle outbreaks (or late in the outbreak cycle) might not factor in a substantial fraction of beetle-caused mortality, owing to the fact that outbreaks tended to span 10 or 15 year periods (see report Figure 1). In such cases early-outbreak beetle-killed trees would be considered "old dead" rather than "mortality" trees. So, not only would annual mortality be averaged over the latter half of an outbreak, but the period immediately following the outbreak would be expected to have low density-dependent mortality as a result of reduced stand density.

In all FIA inventories conducted up until the first remeasurement cycle of annual inventory (generally starting in the year 2005, but much later in some states), estimation of harvest volume was based on mill surveys and other indirect means, as opposed to remeasurement of individual trees on revisited plots. Although these methods have a long history and are considered reliable, the limitation on reporting is that in older inventories it was not possible to partition volume, growth, mortality, and removals using repeated tree measures. Harvest volume comprises both green-tree removals and dead-tree salvage, and due to FIA methodology used in periodic and early annualized inventories, an increase in the latter would generally lead to a reduction in the mortality estimate – owing to the fact that salvaged trees were not included in mortality computations. Therefore, some unknown fraction of the harvest volume reported in table 1 would likely have been classified as mortality in the absence of removal.

An effective silvicultural system aims to capture imminent density-dependent mortality, so it is reasonable to expect that an active forest management program such as the one operating on the BHNF for over 100 years would keep naturally-occurring, density-dependent mortality (self-thinning) to a minimum and therefore lead to underestimation of "normal" mortality rates using FIA methodology. Therefore, the low annual mortality rates for the 1962, 1984, and 1999 inventories are almost certainly linked to the harvest rate, as well as the aforementioned omissions of certain categories of trees being considered as "mortality".

The reason this is important in the establishment of alternative future scenarios is that present and future inventories – i.e., continuation of the annualized system – captures mortality and harvest removals differently than the inventories of the past. There is no longer an unknown "missing" mortality component resulting from the "mortality window" approach, since remeasurement under the annualized system provides a full accounting of every tree $\geq$5 inches in diameter. Therefore, future mortality rates will be calculated as being somewhat higher than historic levels, even if the actual level of mortality were to be identical during both time periods. Likewise, removals are no longer estimated only using methods that are independent of the plot measurements. In effect, removals from the live inventory, whether utilized or left on site (e.g., pre-commercially thinned) effectively constitute a special case of mortality.

Finally, the establishment of reasonably realistic mortality rates can be assisted by the evaluation of other FIA data collected in the Interior West states during past inventories. Figure 1 illustrates the range of net growth that can occur among different species within a geographic area the scale of a national forest. In the example, ponderosa pine is the only species consistently exhibiting positive net growth over the 14-year period shown, with net growth ranging between 1.1% and 1.6% annually. With the exception of aspen, which was relatively stable during most of the 2000s and has seen a large increase of mortality in the example area during the past decade, other major species and all major species as a

group are in a period of gradual recovery following a period of increasing mortality and the resulting decreasing net growth. Most of these species realize gross growth rates in the range of 2.5% and net growth rates, in the absence of unusual disturbance factors, in the range of 1.5% annually. As in the Black Hills, net growth is driven primarily by disturbances, and for the major species on the Dixie NF, the last two decades show the effects of disturbance and recovery on net growth.

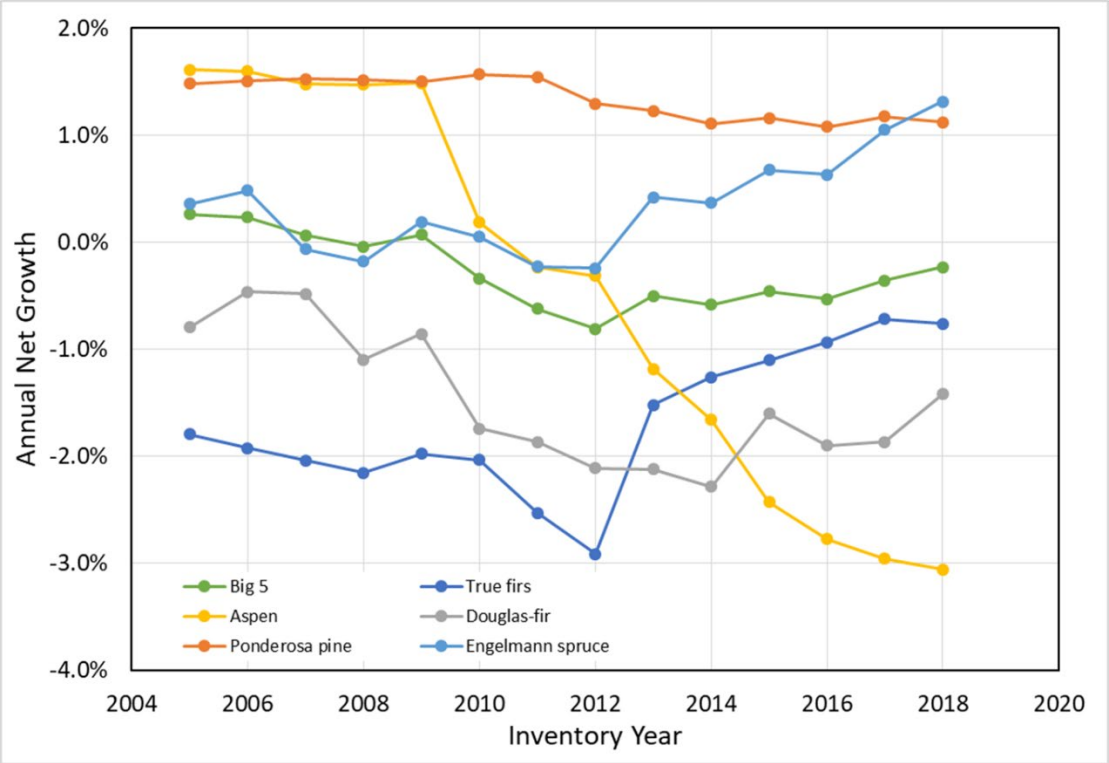

Figure 1—Net growth of major species on the Dixie National Forest

Based on annual inventory methods and observations during "normal" periods, gross growth remains around 2.5% for major species of the Interior West, while net growth commonly is found to be relatively close to 1.5%. Therefore, it is reasonable to conclude that the approximately 1.0% annual mortality rate observed for many timber types constitutes a "typical" background mortality rate, which includes self-thinning mortality, endemic insects and disease levels, and fire and weather events at moderate scale. In woodland species, such as pinyons and junipers, all rates tend to be lower, with gross growth generally $\leq$1.5% and mortality $\leq$0.5%, yielding approximately 1.0% net annual growth or less.

Lower gross growth in woodland types is not surprising given that they are drier and less productive than other forestland and timberland, but low background mortality rates are necessary for woodlands to persist. There seem to be two major factors contributing to woodland background mortality rates being much lower than other forestland and timberland: 1) unlike most other forest types, woodlands appear not to regenerate in abundance and develop by a self-thinning dynamic; rather, they exhibit gradual accretion of basal area over time following stand-replacing disturbance, due to slow growth rates, and 2) woodland species appear to experience relatively low rates of mortality caused by other agents at endemic levels; as an example, over the 18 years of annual inventory in Arizona, which includes nearly a full cycle of remeasurement, only 2.1% of all oneseed juniper trees have been recorded as mortality trees, and only half of those were due to non-fire causes; this works out to an annual

mortality rate of 0.06% due to non-fire causes (0.12% overall) on a number of trees basis. This remarkably low rate of mortality appears to be due to the lack of biotic agents that affect oneseed juniper, or at least the lack of agents that have been able to affect the species over the past 20 years. Other woodland species fall somewhere in between species like oneseed juniper and timber species, such as common pinyon, which has a variety of biotic mortality agents but few that are known to cause mortality in epidemic proportions (Shaw et al. 2005). Background mortality rate for common pinyon appears to be approximately 0.5% annually, or about double the rate considered in this report for ponderosa pine.

My reason for such an extensive discussion on mortality and net growth rates is that the assumptions made in the six scenarios are critical to interpretation of the report. The assessment of mortality and growth rates in the future will be based on FIA continuous forest inventory, whereas the assumptions used in the report are based on somewhat different methodology. That is not to say that the figures provided by earlier inventories were incorrect, per se, but it should be understood that they were computed using different methodology and with different caveats than is used in the current inventory and are therefore unlikely to be reproduced with current methods under the same conditions. Given what is known from the past 20 years of continuous monitoring by FIA, at the very least there should be stronger caveats and a lower probability of likelihood attributed to the very low rates of mortality used in scenarios 3 and 6, as they are shown in figure 14.

It should also be made clear that mortality rates, as recorded by FIA methodology are linked to harvest removals. With the full accounting of annualized inventory, there is much higher certainty about the fate of each tree in the inventory, whether mortality is caused by self-thinning, other natural biotic and abiotic agents, or harvest removals. In an ideal world, it is conceptually possible to capture the entirety of the ~2.5% annual gross growth by harvest on a sustainable basis (i.e., leaving no net change in live inventory). However, in reality that is neither practical nor desirable. It leaves no margin for other mortality agents and also precludes generation of dead wood that is critical for wildlife habitat and other ecosystem services. What is important for the goal of sustainability, and presumably some degree of recovery of live inventory of ponderosa pine on the BHNF is that the sum of captured mortality (salvage or imminent density-dependent), uncaptured mortality (future snags and downed woody material), and green-tree harvest remains below the average 2.5% of gross growth. So, while it is fair to calculate a population mortality rate in an unmanaged forest as a “natural” rate, as soon as harvest becomes a factor some component of what would have ordinarily been natural mortality becomes part of the harvest calculation and is therefore subtracted from the mortality category.

As shown in figure 1 above, mortality is the wildcard and is a very dynamic quantity in western forests. In the layout of alternative scenarios as shown in the report it is certainly fair to “smooth out” this variability and portray long-terms averages. However, as shown in report figure 1 and figure 1 above, good times don’t last long, and overly optimistic scenarios are unlikely to play out. Some additional discussion to this effect would undoubtedly help consumers of the report understand the likelihood of the various scenarios.

Other comments on the manuscript are included in the annotated PDF.

References Cited

Clendenen, G.W., Waters, S.H. and Born, J.D. 1976. Forest area and timber volume statistics for western South Dakota, 1974. Res. Note INT-208. Intermountain Forest and Range Experiment Station, US Dept. of Agriculture, Forest Service. 12 p.

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Shaw, John D.; Steed, Brytten E.; DeBlander, Larry T. 2005. Forest Inventory and Analysis (FIA) annual inventory answers the question: What is happening to pinyon-juniper woodlands? Journal of Forestry 103(6): 280-285.

Walters, Brian F.; Woodall, Christopher W.; Piva, Ronald J.; Hatfield, Mark A.; Domke, Grant M.; Haugen, David E. 2013. Forests of the Black Hills National Forest 2011. Resour. Bull. NRS-83. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 36 p.

Author response: To address the concerns presented by this reviewer, we added several sections under the heading *Approach* that expanded our description of the data, we added Box 1 which describes FIA calculations, and we utilized a range of mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2.0%) and gross growth rates (2.33%, 2.54%, and 2.73%) in the scenarios.

Technical Reviewer #1 PDF Annotated Comments

Comment:

Description of the comment/ issue /question: Abstract, page 3: Maybe more direct to say, 'lead to a decrease in volume of standing'.

Authors' response: The abstract in RMRS-GTR-422 states that of the final report, we opted to state that t*he current harvest level in the BHNF Forest Plan of 181,000 CCF/yr is not a sustainable option.*

Comment:

Description of the comment/ issue /question: Abstract, page 3: revise the sentence to 'assumptions made for growth and mortality'.

Authors' response: In the final report we highlight that the choice of mortality and/or growth rates can alter the answer.

Comment:

Description of the comment/ issue /question: Key points, page 4: revise the sentence to reflect '2.3 to 2.7% annually, while average annual mortality rates…'

Authors' response: In the interim report, the bullet point stated, "Ponderosa pine forest growth rates of trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.3 to 2.7% while mortality rates varied from 0.16 to 3.07% as wildfires and mountain pine beetles killed trees." We removed the key points section and do not report these values within the abstract. In RMRS-GTR-422 we report these values within table 4 and discuss the values throughout the sections *Understanding Disturbance and Tree Mortality*; *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time*; and *Scenario Development.*

Comment:

Description of the comment/ issue /question: Introduction, page 5: "This paragraph is a little disjunct, i.e., the first sentence speaks to frequency or return rate, while in the second sentence it is difficult to tell if the increase in "wildfire activity" refers to frequency, extent, or both."

Authors' response: The reviewer is referring to the paragraph in the interim report that discusses wildfires. Specifically, the reviewer wondered if the sentence, "However, since the 2000s, wildfire activity has increased and burned hundreds of thousands of acres (fig. 3)." In RMRS-GTR-422, we provide additional information to highlight that wildfire activity has increased in both frequency and extent. This can be found in the sections *Wildfires* and *Changing Climate*.

Comment:

Description of the comment/ issue /question: Figure, page 8. Authors didn't number the figure on page 8.

Authors' response: The figure has been designated with a figure number now. In the final document, the figure number is now figure 6.

Comment:

Description of the comment/ issue /question: Data acquisition, page 11. 'Probably remeasurement of the 1962 plots with some supplements and/or replacements, but I won't be sure on this for some time. I'm trying to piece that story together now.'

Authors' response: The reviewer was referring to the FIA measurements taken in the early 1980s (Collins and Green 1988). The description was revised and placed in the section *Assessing Past FIA Reports* in RMRS-GTR-422. There were 137 plots measured.

Comment:

Description of the comment/ issue /question: Annual mortality estimates and trends, page 17. "Weather as the primary cause of mortality in interior western forests is highly unusual. In most cases, insects, disease, and fire are the top 3, but not necessarily in the same order by forest type."

Authors' response: In RMRS-GTR-422, we examined the breakdown of the contribution of each mortality agent to the total mortality for each time period (table 1). In contrast to other areas within the Interior West, weather in the Black Hills was reported to contribute approximately 0.17 to 0.27% to mortality.

Comment:

Description of the comment/ issue /question: Annual mortality estimates and trends, page 17. "I could be wrong, but I don't think the 1.04% mortality figure represents mortality cause by most, if any of these fires. Walters et al. (2011; Table 12) shows that mortality calculations for the SD portion of the BHNF are based on comparison of 2002-2006 measurements vs 2007-2011 measurements. The Jasper fire, for example, occurred in 2000 and therefore that mortality would be reflected in comparison of 2002-2006 data to the data used by DeBlander (2002), assuming that was possible. The labels are somewhat difficult to read in the PDF version of Figure 3, but some of the ones I could find also appear to pre-date the Walters et al. time comparison. Also, only part of the epidemic that began in 2000 would be counted, since the remeasurement period consists of less than the latter half of the mortality histogram in Figure 1 from this report.

Authors' response: The reviewer is commenting on the interim report's sentence, "In 2011 (Walters et al. 2013), mortality levels increased to 1.04%, which represents the impacts of the Jasper, Ricco, Roger Shack, Battle Mountain, and other fires (figs. 3, 6) in combination with the commencing 2000 MPB epidemic." The reviewer is concerned that the wildfires mentioned and the MPB (mountain pine beetle) epidemic weren't reflected during these measurement periods and that mortality would actually be higher. Growth, removals, and mortality estimates were made using the 2002–2006 South Dakota inventory, which would have included some of these fires. The contribution of wildfire to the total mortality for the 2011 reporting year was 0.13. However, the mortality rate of 1.04% is likely lower than what was measured. To address these discrepancies, we evaluated a range of mortality levels in the scenarios in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Annual mortality estimates and trends, page 18. Although van Mantgem et al. (2009) is widely cited as showing increasing mortality rates, in reality what they really show are mostly background mortality rates due to self-thinning. There are few stands in their sample that have elevated rates, but those drive the conclusion for the majority of stands, which are effectively experiencing "normal" mortality.

Authors' response: The authors recognize that the van Mantgem et al. (2009) study was focused on background mortality in unlogged forests. The van Mantgem et al. (2009) manuscript does posit regional warming and drought as being the most likely drivers, both of which are occurring in the Black Hills.

Comment:

Description of the comment/ issue /question: Figure 7, page 19. "As I think I mentioned before, I was on the BHNF in 2000 and recall that there was some concern about overstocking. It's consistent that the available inventory data show that period as peak volume on the forest. It makes me wonder if >12MMCF represents an overstocked condition for the forest as a whole, and they just didn't get enough of a handle on density reduction before the MPB got rolling."

Authors' response: This is a general comment rather than a specific comment we can address. However, we did address this comment in the *Introduction* of RMRS-GTR-422 that the standing live volume at the beginning of the 21st century was high and Black Hills Forest assessments demonstrated high susceptibility to MPB and wildfire.

Comment:

Description of the comment/ issue /question: Scenarios, page 22: "As I note in the main comments, I think the 0.26% rate is way optimistic. I'm not sure if the prudent route is to eliminate two scenarios, use a "compromise" value ~0.5%, or what. Tough call. I think there's enough evidence, though, to NOT use 0.26% as any of them. On the flip side, since they are just example scenarios illustrating what's actually a huge range of possible outcomes, it's unlikely that any action will result from using 0.26% (since I don't think it will ever happen). What I do worry about, though, is that someone will latch on to the 115,000 CCF in Scenario 6 and advocate that as a way forward."

Authors' response: To address the reviewer's concern about the 0.26% rate, the authors used a range of mortality levels (0.26%, 0.60%, 1.04%, 1.52%, and 2.0%) to show a range of possible outcomes.

Technical Reviewer #2

1) Does it make sense?

Reviewer's response: Some of it does. Some scenarios seem unworthy of inclusion as they are poorly premised or justified. It would make more sense if there were a clearer statement of objectives or testable hypotheses up front. The first three questions are answered with estimates generated from FIA data of various vintages and coverages (sometimes reserved is lumped in, sometimes not; sometimes limited to ponderosa pine, sometimes not; sometimes limited as to tree size, sometimes not). The policy questions below the 4 are ambitious and contain subjective components. With changing extent and intensity of disturbances, GRM estimates are very much in flux, and the role of climate (e.g., in modifying future growth or mortality rates) is not discussed—it's an important caveat to trumpet when presenting an analysis that is entirely retrospective in deriving the parameters that drive stand dynamics. How different would your analysis look if you started from 2017 and the 2017 data instead of the 2019 data? The 2011 data? So the question isn't how this year's data informs about out-year options—it's the series of data that allows you to do this (since parameters for mortality and growth come from more than just the 2019 data). Also, while some inferences might be made from the MPB historical data, I am less sure this is possible from the fire data which appears to be non-stationary in terms of periodic extent, and I am not sure the extent to which fire and MPB disturbance patterns overlap. Venturing a guess as to the sustainability of any level of harvest in the face of climate and other uncertainties is more than I would be comfortable doing. The third policy question is absurd on its face. We don't know what level of inventory would be required to support this arbitrary ASQ—it is quite possible that an inventory of 12 million pushes the system over a tipping point that accelerates disturbance and loss of ability to maintain that ASQ.

What is the intent of the concluding remarks? The initial paragraph correctly indicates that the current ASQ is apparently not sustainable. The potentially sustainable ASQ of 70 – 115 is quite a broad range and points to the need for an adaptive ASQ that considers recent past and adjusts accordingly. Emphasizing the uncertainties and the potentially important drivers not considered (e.g., climate/drought, and associated changes in effective site class) is important. An adaptive ASQ would be a more conservative approach that based policy on facts on the ground (wrt the growth and mortality rates that end up occurring). It may make it harder to plan wood using facilities, but would be a more honest representation of what we don't know. You say that it would take 60 years to get to 6 million CCF and 100 years to get to 12, but are either of those the right levels to seek? And if so, why? Or why not? Do either of those inventory levels maximize commercial or biological productivity, or balance productivity against down-side risk? There is so much more that as a reader I find I want to know. And, I can't escape the feeling that lacking knowledge of the age class distribution is a big handicap to both understanding the where/why of mortality and the future prospects for this forest.

It is not entirely clear who is the audience for this report and how the report came to be. Was this solicited by NFS? It is helpful to have a really clear intended purpose, objectives and scope to interpret and evaluate a report like this, and to understand the latitude you enjoyed, if any, wrt recommendations and guidance. The literature supported information on thinning and management in the concluding reports looks to be useful in supporting and perhaps encouraging those options.

Authors' response: RMRS-GTR-422 contains a series of 60 scenarios that incorporated the uncertainty of future growth and mortality in response to changing climate and disturbances. These scenarios attempted to span a range of growth rates (2.33%, 2.54%, and 2.73%) and mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2.0%) to demonstrate a range of outcomes. We also expanded the discussion of the role of future climate and disturbances to highlight the important drivers of mortality to help justify these rates.

The calculation of identifying the level of inventory required to support the ASQ of 181,000 CCF/yr was a question posed by the stakeholders and isn't arbitrary. Rather, the 181,000 CCF/yr is the ASQ identified in the Black Hills National Forest. Our goal in answering this question was to determine the volume that would be needed to sustain this ASQ level under different growth and mortality levels, not to provide an ASQ that would be resilient. That decision is to be made by the National Forest and its stakeholders. The information provided in RMRS-GTR-422 will help in that decision.

The reviewer suggests that the ASQ of 70 to 115 was broad and points to the need for an adaptive ASQ. To address this, the authors added a section titled *Moving Forward* section in RMRS-GTR-422 that suggests continuous monitoring and flexibility is needed to adjust harvest levels based on realized mortality rates.

The reviewer suggested that knowing the age class distribution of the forest is important to understand the where/why of mortality and future prospects for this forest. The authors recognize that this more in-depth analysis could provide additional detail and finer resolution to these questions. However, our task was to provide a general overview of the landscape. A future analysis that examines specific stands, age-class distribution, and how it fits into the Forest Plan structural stage distribution and management areas would provide that level of detail.

The reviewer stated it wasn't clear who was the intended audience and rational for the interim report. In RMRS-GTR-422, the authors added a section titled *Recognizing an Information Need* to help the reader understand how this report was initiated and the intended audience.

2) Are we interpreting and using the FIA data properly?

Reviewer's response: I don't know that you are using it improperly—not enough detail is provided to indicate how, and whether, a stratification was used, or what adjustments were required to use the spatially intensified data. The lack of consistency in assumptions and definitions among inventories is a challenge, and it is not immediately clear what adjustments (if any) were made to address the inconsistencies. It seems a little hinky, though not necessarily invalid, to include the 2017 data in both the 2017 and the 2019 estimates. A bit more explication here could help. I don't know how all the plots were weighted in your analysis or how they were selected, so this area is a little murky. Although a few standard (sampling) errors are reported on page 16, these are not generally used in the analysis and there are no error bars in the figures so it is hard to know which scenarios, for example, are statistically distinct in their trajectories.

Authors' response: In RMRS-GTR-422, we expanded a section titled *Approach* and provided more detail on past FIA reports, including different sampling designs among the reports and how to properly interpret the data among reports. We further expanded this section to clearly state that we use these values to provide an indicator of past mortality rates and growth rates. We presented our

results from the scenarios and tested the volume values using the 95% Confidence Interval and determined if the standing live volume change was different from zero.

3) Are our assumptions explained well enough?

   Reviewer's response: Mostly; I've pointed out a couple places that could use some improvement.

   Authors' response: Thank you.

4) Are the displays clear?

   Reviewer's response: Mostly; I've indicated where improvement might be warranted.

   Authors' response: Thank you.

Technical Reviewer #2 General and PDF Annotated Comments

Comment:

Description of the comment/ issue /question: The title "A changing forest" does not seem quite right—it is a changed forest (relative to the past), and you have documented some of the past changes, but the future of the forest that you present here is driven in part by history (which you assume will repeat itself to some degree) and assumed management and growth and mortality scenario. The scale of the change that has already occurred is so great that one wonders how much more change would continue to occur, absent harvest. Also, why is "a changing forest" a hook? Aren't all forests changing all the time? Looking to the future, your report seems to present options for maintaining some harvest in the face of past and potential future changes, but is speculative as to what the future changes will be (in terms of mortality and gross growth rates, for example, which may or may not reflect history and which don't seem to account for climate change). Can you come up with a title that more directly reflects the messages you are trying to deliver? That would help the reader understand where you are going with this.

Authors' response: We changed the title to *A Scenario-Based Assessment to Inform Sustainable Ponderosa Pine Timber Harvest on the Black Hills National Forest* in RMRS-GTR-422

Comment:

Description of the comment/ issue /question: Abstract, pg.3. '60 years to get from 5.9 to 6? At 70 or 115K CCF per year harvest level?

Authors' response: This statement was removed in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Abstract, pg. 3. 'Same century whether harvest a 70 or 115?

Authors' response: The sentence was removed in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Key points, pg. 4. 'odd word choice obtainable from analysis of FIA data.. would be better'

Authors' response: The reviewer was referring to the word "disclosed." In RMRS-GTR-422, this statement was no longer used.

Comment:

Description of the comment/ issue /question: Key points, pg. 4. 'volume growth? On what? Live trees that remained live at the end of the remeasurement period? Or does this count ingrowth? Trees that grew and then died?

Authors' response: The reviewer was referring to the key point, "Ponderosa pine forest growth rates of trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.3 to 2.7% while mortality rates varied from 0.16 to 3.07% as wildfires and MPBs killed trees." The "forest growth rates" were volume gross growth rates, which include the components of gross growth. The authors added a Box within RMRS-GTR-422 to describe each component that contributes to gross growth.

Comment:

Description of the comment/ issue /question: Key points, pg. 4. 'stand level volumetric or percent of stems? And why the range – is this min and max among all stands? Species? What?

Authors' response: The reviewer was referring to the key point, "Ponderosa pine forest growth rates of trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.3 to 2.7% while mortality rates varied from 0.16 to 3.07% as wildfires and MPBs killed trees." The reviewer is referring the mortality rates (annotated in the pdf copy). The rates are based on volume as reported in the various FIA resource bulletins and evaluations. Most values are based on ponderosa pine; however, we do note within RMRS-GTR-422 when white spruce was included. The ranges are the minimum and maximum for the time periods evaluated.

Comment:

Description of the comment/ issue /question: Key points, pg. 4. 'confusing that this is called an annual sustainable harvest if it is not – is that really the correct label?'

Authors' response: The reviewer was referring to the key point, "The current conditions of the BHNF in 2019 do not support a sustainable Forest Plan annual sale quantity (ASQ) of 181,000 CCF (1 CCF = 100 cubic feet) of sawtimber (9 inches and greater d.b.h.) nor do these conditions support an annual sustainable harvest of 153,534 CCF that occurred in 2019." This has been changed and we have stated our assumptions in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Key points, pg. 4. 'their' refers to?

Authors' response: The reviewer was referring to the key point, "Using 2019 FIA data, several scenarios using an annual sawtimber growth rate of 2.5% were evaluated, varying harvest levels, mortality rates, and their timing and longevity…." The term "their" referred to the changing harvest levels and mortality rates in the initial scenarios.

Comment:

Description of the comment/ issue /question: Key points, pg.4. 'How is this conservative relative to the range endpoint of 3.07% referenced above?

Authors' response: The reviewer was referring to the 1.04% rate (long-term conservative estimate). We removed this language in RMRS-GTR-422 due to its appearance of bias.

Comment:

Description of the comment/ issue /question: Key points, pg.4. 'is this gross or net mortality (i.e., mortality offset by growth?) This seems like an impossibly low rate in the face of global stressors and climate change.'

Authors' response: The reviewer was referring to the 0.26% rate for mortality. The mortality rate represented gross mortality. This rate occurred during low periods of wildfire and MPB activity in the Black Hills. To account for the uncertainty of climatic change and future disturbance patterns, the authors utilized a range of mortality rates (0.26%, 0.6%, 1.04%, 1.52%, and 2.0%) in the scenarios presented in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Pg. 5. Introduction. 'isn't sawtimber part of roundwood? What does roundwood reference here? Confusing. And is 21 part of the 181 or is it something truly separate?'

Authors' response: Sawtimber refers to trees > 9 inches diameter at breast height (d.b.h.). Roundwood refers to trees > 5.0 to < 8.9 inches d.b.h. Round wood is not part of the 181,000 CCF.

Comment:

Description of the comment/ issue /question: p. 9, line 17: 'I don't see any info on net growth to removal ratio, per se.'

Authors' response: This information is available in the FIA reports and 2019 evaluation data. The net growth to removal ration was a question posed to FIA and this information was provided to the Black Hills National Forest (BHNF); it is not included in RMRS-GTR-422. The questions addressed in this document were focused on scenarios. We clarify this by stating the following:

Upon reviewing the questions posed to FIA, the leadership of the BHNF asked the USDA Rocky Mountain Research Station to form a team to address the following questions:

1. *What impact does the current 2019 forest condition (i.e., standing volume, mortality, and growth) have on the out-year timber program of harvesting at current levels compared to other harvest level scenarios using probable growth and mortality estimates?*
2. *What is a sustainable timber harvest estimate for the BHNF using the 2019 NRS-FIA data assuming rational tree mortality and growth rates are informed by those of the past?*
3. *What would be the standing inventory volume necessary using reasonable growth and mortality estimates to sustain a sawtimber allowable sale quantity (ASQ) of 181,000 CCF?*

Comment:

Description of the comment/ issue /question: p. 9 line 23: I don't think that the 2019 NRS FIA data can tell you what a sustainable harvest looks like as it does not account for climate change and given that future mortality from fire and MBP remains unknown.

Authors' response: To address the uncertainty in forest growth and mortality, the authors developed scenarios that encapsulated a range of growth rates (three levels) and mortality (five levels). These scenarios demonstrate a range of possibilities that the NFS and its stakeholders can use during discussions of future forest management. We discuss climate change and its potential impacts in the *Changing Climate* section in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: p. 9, line 25: The question is entirely backwards—it assumes/implies that 181 is reasonable today, and that seems arbitrary. I don't know the scientific standard for "reasonable" growth and mortality estimates—these are subjectively determined (and I realize that several scenarios were run using different values, but they do make a difference).

Authors' response: The BHNF Forest Plan has an ASQ of 181,000 CCF, so this value is not arbitrary. However, the authors recognize that the scientific standard for "reasonable" growth and mortality estimates are subjectively determined. The authors attempted to utilize a range of growth and mortality rates based on the historical measurements, rates from other ponderosa pine forests across the Interior West, and potential increases due to climatic change and future disturbances.

Comment:

Description of the comment/ issue /question: p. 14, last sentence is not grammatically correct or understandable

Authors' response: The authors fixed the sentence.

Comment:

Description of the comment/ issue /question: p. 19, line 6: standing LIVE tree inventory

Authors' response: The authors fixed the sentence.

Comment:

Description of the comment/ issue /question: P 19, lines 8 and 9: Does any of this harvest consist of salvaged trees? I don't think the FIA protocol will help you get a bead on this because status code three trees are harvested- and could have been live or dead immediately preceding the harvest as long as they were live at the previous inventory visit. It seems to me that we need to know what part of the harvest is of trees dead before the chainsaw hit them as this has policy relevance.

Authors' response: Based on the FIA data, it was unknown if any of the harvest consisted of salvaged trees. However, the authors added a section that addresses this in RMRS-GTR-422: *Most treated stands were adjacent to MPB-infested stands rather in the infested stands themselves* and we cited Thom et al. 2020.

Thom, D.; Warnke, M.; Garbisch, B.; [et al.]. 2020. Black Hills regional mountain pine beetle strategy collaborative accomplishments 2012–2017. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd721758.pdf.

Comment:

Description of the comment/ issue /question: p. 19 figure 7: An impressive figure but somewhat misleading owing to: X axis is not formatted as numeric, so horizontal displacement of a 22 year gap (62-84) is the same as a 2 year gap (17-19), which severely distorts the dynamics and rates of change (line slope and vertical displacements of adjacent bars)

Authors' response: The x-axis in the interim report's figure is intended to be categorical and not numerical (i.e., the data are a visualization of each value within that specific year). In RMRS-GTR-422, we removed the line between the inventory data (diamonds) to demonstrate that values between measurement periods did not necessarily increase/decrease linearly (i.e., the connected lines distorted the rate of change).

Comment:

Description of the comment/ issue /question: Figure 8 is opaque to me—what is it trying to say? I cannot understand what is being conveyed and the caption is of no help.

Authors' response: Figure 8 was removed in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: p. 22, line 2: accuracy seems to be the greater challenge and importance as compared to precision.

Authors' response: The language in the sentence was removed from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: P. 22, line 19: This annual growth rate of 2.5% surely reflects a given age class distribution. There's been a lot of tree death lately—has that age class distribution changed? If so, this may not be a good estimate. Applying a single percent growth rate (and death rate) for the whole forest without regard to stage of stand development, age, size etc. seems overly simplistic and poses risks of analysis artifacts, especially with so many stands' successional trajectories recently reset.

Authors' response: In RMRS-GTR-422, the authors utilized a range of growth and mortality levels in the scenarios to reflect a range of outcomes instead of using just one growth and mortality rate. We recognized that the analysis was simplified across structural stages, densities, and possible changes in age class distribution. We considered that RMRS-GTR-422 is a starting point for discussions about future management direction.

Comment:

Description of the comment/ issue /question: p. 22, scenarios: none of these labels prove out to be very accurate representations of the scenarios when the scenario text on the next page is read; for example, "with differing mortality rates" is not very informative; why not indicate that mortality rates decline from X to Y linearly over Z years? Ditto the harvest levels.

Authors' response: RMRS-GTR-422 has a range of new scenarios and a major revision in how the scenarios are presented.

Comment:

Description of the comment/ issue /question: Scenario 2 seems really unrealistic to the point of uselessness.

Authors' response: Scenario 2 in the interim report served to show the level of standing live sawtimber required to sustain the Forest Plan ASQ under average growing conditions and moderate mortality. In RMRS-GTR-422 we have revised our approach to assess how much volume is required to sustain the Forest 181,000 CCF/yr ASQ under three growth and five mortality rates (table 8).

Comment:

Description of the comment/ issue /question: The ASQ is arbitrary and was developed under a different state of the world that no longer exists. The amount of standing volume cannot immediately and heroically be more than doubled to 12 million CCF—yet that is what figure 11 shows—some kind of magical thinking has the inventory set at 12 million in 2019!

Authors' response: The ASQ value is not arbitrary since that is what is currently in the Forest Plan. However, in RMRS-GTR-422, we have revised our approach to assess how much volume is required to sustain the Forest 181,000 CCF/yr ASQ under three growth and five mortality rates (table 8).

Comment:

Description of the comment/ issue /question: Scenario 6 looks similarly pollyannish, and not necessarily worthy of keeping in the mix (since its most likely wishful thinking).

Authors' response: The reviewer is referring to the scenario that had 0.26% mortality and growth rates of 2.5%. Although in RMRS-GTR-422 we changed our approach to the scenario development, we did keep this scenario.

Comment:

Description of the comment/ issue /question: Page 24, line 5: Why stop at 1.04% mortality? What is this scenario trying to account for? Does it not go lower because you are assuming that fire activity will remain high? Also, what if the MPB epidemic is already over- then these continued high, though declining, mortality estimates could be way off. Are there any citations that could support your assumptions about the likely duration of the elevated mortality?

Authors' response: In RMRS-GTR-422, we expanded the scenario evaluation and developed 60 scenarios with five mortality levels, three growth rates, and four harvest levels. For specific details, please refer to the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time.*

The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These

values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment:

Description of the comment/ issue /question: Page 29, line 10-12: This would seem to be an argument to pursue salvage opportunities where possible

Authors' response: Salvage logging can be used as an opportunity to reduce future surface fuel loads. However, it was not implemented on a large scale in the BHNF during the epidemic.

Technical Reviewer #3

1) Does it make sense?

   Reviewer's response: The concepts are clear as to present sale volume, growth, and trends. I do have a few comments which I will note below.

   Authors' response: None required.

2) Are we interpreting and using the FIA data properly?

   Reviewer's response: Technical reviewer #1 is better qualified to answer this but from just a casual glance I would yes.

   Authors' response: None required.

3) Are our assumptions explained well enough?

   Reviewer's response: I think the assumptions are explained but the format might be clearer the way the document is set up.

   Authors' response: The revised report has changed the format to make the assumptions in the scenarios clearer.

4) Are the displays clear?

   Reviewer's response: As an example, are the scenarios for Figures 10, 11,12 the same and if so could you just use one set of the scenarios with the three graphs displaying the different results.

   Authors' response: These figures have all been altered in the revised report.

Technical Reviewer #3 Comments

Comment:

Description of the comment/ issue /question: Page 10 under Data. In the 3rd paragraph, 4th line there is a typo. I believe it should read revealing plot locations in such a way that …

Authors' response: The sentence was clarified in RMRS-GTR-422

Comment:

Description of the comment/ issue /question: In Table 1 on the right hand side you might add what the table is measuring – it now says Average annual as a percent… Annual ?

Authors' response: "Annual" in the title *Average Annual as a Percent of Inventory* refers to the average annual gross growth or average annual mortality, etc.

Comment:

Description of the comment/ issue /question: In Table 2, the same comment.

Authors' response: "Annual" in the title *Average Annual as a Percent of Inventory* refers to the average annual gross growth or average annual mortality, etc.

Comment:

Description of the comment/ issue /question: I find Figure 8 hard to interpret as to what the points on the graph represent.

Authors' response: Figure 8 was removed in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: There does not appear to be a Figure 9. Do the ones after 8 need to be renumbered?

Authors' response: The reviewer is correct. The figure numbers needed to be corrected in the interim report

Comment:

Description of the comment/ issue /question: As noted if the scenarios are meant to be the same for Figures 11,12,13, I'd suggest using the same symbol in each Figure and to use the same explanation like the one in Figure 3.

Authors' response: These figures have all been altered in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: On page 23, under Scenario the annual harvest is noted as per acre per year. I believe is per year.

Authors' response: Annual harvest should be per year and not per acre per year. This language has been corrected in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: In all these scenarios the harvest appears to be in volume larger than 5 inches. However, there are a couple of places where this volume is noted as saw timber. Either way I would suggest that the size be defined on Figures to make this clear.

Authors' response: The scenarios are based on harvests from volume larger than 9 inches (sawtimber), not 5 inches d.b.h. The authors have clarified this in the figure captions and text in RMRS-GTR-422to ensure there is no confusion.

Comment:

Description of the comment/ issue /question: Maybe contrary somewhat to what I have already said it would seem that Scenario One might raise concerns with some folks. First, again, the paper needs to be consistent as to what is included in the analysis. Does each scenario include both the 5-9 and 9 and above diameter sizes? Table 2 notes that in 2019 the average mortality is 3% while in the Appendix Scenario One notes the average mortality in 2019 is 2.8%. Why? I do note that Table 6 has info on both sizes but it is hard to continue to track this throughout the paper unless it is continually noted.

Authors' response: The scenarios in RMRS-GTR-422 are for sawtimber (> 9 inches d.b.h.) harvest only. Based on comments received from reviewers on the interim report, scenarios were revised to reflect a range of mortality and gross growth rates rather than just one rate.

Comment:

Description of the comment/ issue /question: Lastly in Scenario One the 2.8% mortality is used through the total time frame while is declining in all the other scenarios. Is this realistic with such a decline in inventory or in the minds of some done to scare folks about sustainability? The end result is the same but the numbers might be quite different.

Authors' response: RMRS-GTR-422 has scenarios that include a range of mortality and gross growth rates. The report no longer utilizes a mortality rate of 2.8%.

Technical Reviewer #4

Comment:

Description of the comment/ issue /question: You did a good job of answering the four questions given to the team by the working group, but I would like to see some different forecasts of future conditions and more information on things like structure. I understand that the projections are based off of the FIA and using current Forest Plan parameters. I ended up with a lot of questions about the projections and would like to throw them out for consideration.

Are the total volumes shown based on only the 774,573 suitable acres, or is it based on all Ponderosa Pine acres? If only operable, then can we get an idea on how much volume is available on other Pine areas? Operability/merchantability may have changed and we could treat these acres as well. I ask this because there may be new opportunities to treat unsuitable acres, either through new treatment approaches like DxP or new technologies such as tethered-logging on steeper slopes. Maybe we can pick up additional volume from these areas.

Authors' response: We added appendix A to clarify what was included in the land area we reported, and the total volumes reported in the report are based on the suitable acres across all slopes.

Comment:

Description of the comment/ issue /question: Do you know the stocking and structure of the Ponderosa Pine forest? Are the stands overstocked, not optimal structure? I ask this because there may be ways to increase the stocking if the structure is not optimal. Maybe by having better structure there could be an increase in gross growth, and a reduction in mortality. What would be the mortality rates if the stocking levels were managed at these optimal levels? Using past growth rates for future projects is okay, but

there are better ways to estimated projected volumes, such as FVS. Technical Reviewer 3 and I were discussing this and he mentioned that the Forest Plan has different scenarios for structure and that the structure for wildlife cover is being predominately used. I haven't looked at the Plan but this may be something that can be considered. I know there is a lot to this and one quick look doesn't answer all questions.

Authors' response: The stocking and structure of the ponderosa pine forests in the Black Hills have been altered dramatically by the mountain pine beetle epidemic. Before the epidemic, much of the forest was overstocked and susceptible to MPB and wildfire as noted by several assessments (cited within the revised report). The combination of the MPB epidemic and subsequent harvesting during the epidemic has led to below-optimum sawtimber stocking in many areas, but plenty of advanced regeneration that could be managed to enhance growth rates. Mortality rates would be expected to be lower in stands managed at lower densities, especially in response to MPB. However, mortality rates due to wildfire would depend on the forest structure and surface fuel loads. To address the projected volume over time, in RMRS-GTR-422, we utilized a range of growth rates to provide insight into the different outcomes.

Comment:

Description of the comment/ issue /question: Table 2. Is the third column labeled correctly? I assume it should be mortality. Not sure what "Standing Live Inventory" is telling.

Authors' response: Yes, it should be labeled mortality. This has been fixed in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Page 23, Scenario 1. There is an extra "per acre" in the sentence. (153,354 CCF per acre per year.)

Authors' response: This sentence has been fixed in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: There is no doubt there has been significant changes in the forest condition due to mortality and fire. But we should look to see how the forest may respond to these events and other treatments.

Authors' response: In RMRS-GTR-422, the section *Moving Forward* we discussed the need for continued monitoring to quantify how the forest responds after these events and to evaluate the future effectiveness of treatments toward achieving management goals.

Blind Peer Review and Reconciliation from February 10, 2020, Draft

Blind Reviewer #1

Comment:

Description of the comment/ issue /question: Line 115: Is the phrase beginning after the colon a quote? If so, please provide the reference. If not, why is the word "suitable" put in parentheses and before a comma?

Authors' response: In the appendix of RMRS-GTR-422, the section titled *Land Area,* we discussed how land is classified by FIA and the National Forest. "Suitable" refers to forested lands that are designated within the areas that are available for wood utilization.

Comment:

Description of the comment/ issue /question: Line 187: The relevance of the quoted passage running from line 187-218 is unclear. Can you simply summarize what the key points are that you need from this?

Authors' response: The quoted passage in the interim report was intended to repeat the language in the FIA brochure. We have removed this quoted passage in RMRS-GTR-422 and we described the FIA program in our own words.

Comment:

Description of the comment/ issue /question: Line 221: The descriptions of the various datasets are informative, but they do not readily permit the reader to understand the differences. Insert a table summarizing the different data sources. Columns in this table should include: Nominal date (e.g. 1962, 1984, etc.), Years of Collection, Number of Plots, Area Sampled, Components of Change Estimated? Reference

Authors' response: Thank you for the suggestion of having a table to distinguish differences in the FIA reports. Because of the detail in each description, we found it difficult to get all the information intointo one table in RMRS-GTR-422. Therefore, we clarified our descriptions in the *Assessing Past FIA Reports* and we added table 3 to show the sampling year and number of plots sampled.

Comment:

Description of the comment/ issue /question: Line 353: Uncertainty is not specified. Add +/- standard errors for annual gross growth in DBH 5+ and in DBH 9+.

Authors' response: It is difficult to assign standard errors to the values presented in the tables and graphs because of inconsistencies in FIA reports over time. We report values for National Forest lands and ponderosa pine when possible. The FIA reports we used provided did not provide standard errors for the entire sampling (i.e., across all species or all land ownerships). Also, sometimes a FIA report provided standard errors for volume and harvest, and other FIA reports provided standard errors of volume and mortality, etc.

- For 1962, standard error of growing stock volume (5.19%) and harvest (3.2%) was given for all ownerships and tree species. We were interested in only the softwoods on National Forest.

- For 1984, standard error values were only provided for other lands (private) and not National Forest.
- For 1999, standard error values were provided for all lands and all species combined.
- For 2011, standard error values were shown on graphs with bars, but no numbers provided in the tables.
- The 2019 estimates for sawtimber (9 inches d.b.h.) were able to be discerned for growth, mortality, and volume. Estimates for growing stock (> 5 inches d.b.h.) were not provided.

Comment:

Description of the comment/ issue /question: Line 367: What is considered "conservative" will vary by reader, and the qualifications of "reasonable" and "good estimate" appear to be entirely speculative. Simplify to "The 1.04% mortality rate observed by Walters et al. (2013) may reflect the long-term mortality trend of trees in the Black Hills and what might occur in future decades".

Authors' response: In the *Mortality Rates* section in RMRS-GTR-422 we discussed how mortality rates (we evaluated five mortality rates) were determined and what disturbances and or climate may influence these values.

Comment:

Description of the comment/ issue /question: Line 378: How prominent were "individual tree silvicultural systems" that were intended to provide openings for regeneration, as opposed to simple high-grading of timber? Clarify and provide reference regarding cutting practices up until the 1970s.

Authors' response: In RMRS-GTR-422, we removed language about specific silvicultural systems and harvesting through time. Instead, we cite Freeman 2015 *(Black Hills Forestry: A History)* and mention there has been a viable timber industry for over 100 years.

Comment:

Description of the comment/ issue /question: Line 382: Net growth hasn't been defined; also, can standard errors be provided for net growth, gross growth, and harvest? Add definition for net growth; add standard errors.

Authors' response: In RMRS-GTR-422, we defined each of the different components of growth and mortality in Box 1 and provided sampling errors for sawtimber in table 5.

Comment:

Description of the comment/ issue /question: Line 387: The various estimates in this paragraph (387-397) should be presented with the associated standard errors

*Authors' response: In RMRS-GTR-422, w*e provided sampling errors for values in table 5.

Comment:

Description of the comment/ issue /question: Line 401: Figure 7 does not establish that there is any MBP preference for trees 9-16" in DBH. It simply shows the average DBH of trees killed on a plot vs the average DBH of the trees present on a plot, and without any additional analysis it suggests that there is

an approximately 1:1 relationship between these (easily half the points are below the 1:1 line). In other words, the sizes of the trees killed appear to be about the sizes of the trees available for attack, which is consistent with the MPB having no size preference. Revise this paragraph to indicate a lack of MPB preference or conduct the necessary analyses to indicate such a preference.

Authors' response: We removed this figure in RMRS-GTR-422 and in the *Understanding Disturbance and Tree Mortality and Mountain Pine Beetle* section, we discussed MPB mortality over time, forest susceptibility to MPB, and other related research.

Comment:

Description of the comment/ issue /question: Line 407: Evidence that trees in the 9-16" DBH size class were "preferred harvest trees" is lacking. Add a reference or results from the FIA data to indicate that a harvest preference for this size class actually exists

Authors' response: In RMRS-GTR-422 we removed that statement.

Comment:

Description of the comment/ issue /question: Line 411: There is no indication of the uncertainty in the estimates presented in this paragraph (411-417)

Authors' response: In RMRS-GTR-422, we removed this section.

Comment:

Description of the comment/ issue /question: Line 413: Clarify units on site index. "site index of 55 feet (base age 100 years at breast height)"

Authors' response: While we removed that section from RMRS-GTR-422t, we did add a sentence and cite Myers and Van Deusen 1960: "This region has a well-developed road system and gentle topography that is well-suited for mechanized and efficient timber harvesting. Typical site index (base age 100) within the Black Hills ranges from 36 to 75 feet (Myers and Van Deusen 1960a)."

Comment:

Description of the comment/ issue /question: Line 414: Unclear what the "net productivity of 27.2 cubic feet per acre per year" is referring to - can't find this number listed in any of the tables

Authors' response: We removed that section from RMRS-GTR-422; the value 27.2 cubic feet per acre per year stated in the interim report was obtained and the table within the Meyer 1938 document.

Comment:

Description of the comment/ issue /question: Line 415: Missing words. "and mortality increased to 32.0…"

Authors' response: We have removed that section in RMRS-GTR-422, so edits were not needed on that sentence. Thank you for your careful proofreading.

Comment:

Description of the comment/ issue /question: Line 416: Are the per-acre estimates listed in this paragraph (411-417) obtained by division of the totals by a constant area? Or do the 2011 and 2017 use different timberland areas? If the former, then this paragraph is not needed: these estimates provide no information over and above the totals already presented. Explain whether the 2011 and 2017 per-acre estimates use different total timberland areas (if that is true); if the same total timberland areas are used, then explain why these estimates are being presented

Authors' response: We kept the paragraph the reviewer mentioned in RMRS-GTR-422. However, in the GTR we addressed the comment by providing estimates of acreage in the footnotes in table 4 and land definitions in appendix A.

Comment:

Description of the comment/ issue /question: Line 423: The first bullet is a statement "Determine…." while the other two are questions "What…?"; this isn't consistent with the language ahead of the colon on line 422, i.e., "asked the RMRS to what would be the standing inventory…?"Revise the pre-colon language to "asked the RMRS to determine:" and then the first bullet to "What impact does the current…?"

Authors' response: In RMRS-GTR-422, we revised and clarified the questions and the following lines are in the GTR:

Upon reviewing these questions, the leadership of the BHNF asked the USDA Rocky Mountain Research Station (RMRS) to form a team to address the following questions:

1. *What impact does the current 2019 forest condition (i.e., standing volume, mortality, and growth) have on the out-year timber program of harvesting at current levels compared to other harvest level scenarios using probable growth and mortality estimates?*
2. *What is a sustainable timber harvest estimate for the BHNF using the 2019 NRS-FIA data assuming rational tree mortality and growth rates informed by those of the past?*
3. *What would be the standing inventory volume necessary using reasonable growth and mortality estimates to sustain a sawtimber allowable sale quantity (ASQ) of 181,000 CCF?*

Comment:

Description of the comment/ issue /question: Line 431: Awkward language. "To that end, in consultation with the leadership of the BHNF and Rocky Mountain Region, we crafted…"

Authors' response: In RMRS-GTR-422, we removed the awkward sentence.

Comment:

Description of the comment/ issue /question: Line 438: The notion of using annual gross growth to project the growth of the standing volume is introduced here. It is also stated here that the 2019 annual gross growth estimates were used for this purpose. Yet gross growth is impacted by mortality in the sense that mortality trees achieve growth over only part of the period ("Growth on mortality" in Figure 4) and their growth would be expected to be higher if they survived for the whole period. As such, given that rates of mortality during the recent period were elevated (owing to MPB and/or wildfire), isn't it

reasonable to conclude that gross growth over the recent period will be an underestimate of what the forest could produce over the long term? Further explanation of the effects of mortality on gross growth should be provided and the authors should revisit or further justify their use of gross growth taken over the recent elevated-mortality period.

Authors' response: In RMRS-GTR-422, instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment:

Description of the comment/ issue /question: Line 445: extra comma. "future may bring us is to rely on"

Authors' response: We have removed that sentence from RMRS-GTR-422 but thank you for the proofreading.

Comment:

Description of the comment/ issue /question: Line 452: Missing word. 'at a rate of 3.12% and at 2.5% in 2019'

Authors' response: We have removed that sentence RMRS-GTR-422 but thank you for the proofreading.

Comment:

Description of the comment/ issue /question: Line 453: Typo. "no mathematical way to justify"

Authors' response: We have removed that sentence from RMRS-GTR-422 but thank you for the proofreading.

Comment:

Description of the comment/ issue /question: Line 464: See comment for line 401 - no such preference has been established. Revise.

Authors' response: This sentence was removed from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Line 471: See comment for line 367. "as we discussed before, a mortality estimate of 1.04% observed by Walters et al. (2013) may reflect the long-term mortality trend of trees in the Black Hills"

Authors' response: In the *Mortality Rates* section in RMRS-GTR-422, we discussed how mortality rates (we evaluated five mortality rates) were determined and what disturbances and or climate may influence these values.

Comment:

Description of the comment/ issue /question: Line 478: Scenario 2 does not start with the 2019 sawtimber standing live volume of 5,995,428 CCF. Revise.

Authors' response: Thank you for pointing that out. We realized when preparing RMRS-GTR-422 that was confusing. Scenario 2 (what volume is needed to sustain 181,000 CCF/yr) is no longer designated as scenario 2 in RMRS-GTR-422. In the GTR we clarified our analysis and provided the outcome in Table 8.

Comment:

Description of the comment/ issue /question: Line 482: The 6 scenarios are summarized starting here. Scenario 1 ties to the at-current-harvest-levels part of the bullet on line 423, and scenario 2 ties to the bullet on line 428. However, scenarios 3-6 appear to use arbitrarily varying sets of parameters (i.e. different long-term harvest levels, different years until long-term harvest level implemented, different patterns of mortality rates over years). This is confusing and unsatisfactory for the reader because it is impossible to determine if, say, the differences in outcomes between scenarios 4 and 5 are attributable to the differences in long-run harvest levels, or to the differences in the years-until-long-run-harvest-level is implemented, or to both. Ultimately, it's unclear what one is to learn from scenarios 3-6. Revise the parameters for scenarios 3-6, ideally using a factorial combination of a) long-term harvest levels, b) years-until-long-term-harvest-level-is-implemented, c) mortality rate decay trajectories. Doing so would allow identification of which of these factors are most important in achieving sustainable harvesting outcomes over different time scales.

Authors' response: Thank you for your comments on the scenarios. Based on this response as well as others, In RMRS-GTR-422, we approached the scenarios by looking at a range of growth rates, mortality rates, and harvest rates and provided a range of outcomes that can be compared.

Comment:

Description of the comment/ issue /question: Line 482: Unclear if the word "pessimistic" applies to 2019 harvest level, to the mortality rate, to the growth rate, or to the whole collection. Drop the word "pessimistic"

Authors' response: We removed word "pessimistic" from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Line 494: Only this scenario has a qualification having to do with whether it does or does not "reflect reality". Drop the sentence "However, the history…from reflecting reality"

Authors' response: We removed this sentence from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Line 497: Scenario 1 can be written out mathematically in a fairly straightforward way as a function of the initial standing volume, harvest level, mortality rate, and gross growth rate. The scenario is only evaluated with a mortality percentage of 2.97% and a gross growth rate of 2.513%. But it may be worth pointing out that the scenario equation can be solved such that, given the 2019 standing volume, the 2019 harvest level would only be sustainable if the gross growth rate exceeded the mortality rate by 2.5609%.

Authors' response: Excellent point. In RMRS-GTR-422, we clarified our approach and in addition, provided figures that showed a range of scenario parameters to give the reader this information.

Comment:

Description of the comment/ issue /question: Line 504: missing word. "nevertheless, it provides'

Authors' response: We have removed that sentence from RMRS-GTR-422, but thank you for the proofreading.

Comment:

Description of the comment/ issue /question: Line 507: To be more precise, for fixed harvest level 181000 CCF, mortality rate 1.038733%, and gross growth of 2.513482%, the scenario equation can be solved to find that the initial standing volume must be 12,273,275 CCF < 12,300,000 CCF.

Authors' response: Thank you for the calculation. In RMRS-GTR-422, we calculated the range of volumes needed to sustain a 181,000 CCF harvest across a range of growth and mortality rates. The results are in table 8.

Comment:

Description of the comment/ issue /question: Line 516. Missing word. (Through 2030).

Authors' response: Thank you for your proofreading. This sentence has been removed from RMRS-GTR-422 since we expanded the scenarios to include a range of mortality, growth, and harvest rates.

Comment:

Description of the comment/ issue /question: Line 518: Line 126 suggest that the major MPB event ran from 1998 to 2016; yet this line seems to suggest that the MPB epidemic might not subside until 2028.

Authors' response: This sentence has been removed from RMRS-GTR-422 since we expanded the scenarios to include a range of mortality, growth, and harvest rates.

Comment:

Description of the comment/ issue /question: Line 548: missing words. "wildfires being approximately 20 years, such continued"

Authors' response: Thank you for your proofreading. This sentence has been removed from RMRS-GTR-422 since we expanded the scenarios to include a range of mortality, growth, and harvest rates.

Comment:

Description of the comment/ issue /question: Line 552: The term "intensive" is subjective, undefined, and unnecessary. Drop "intensive"

Authors' response: We removed language that may be interpreted as subjective and or biased in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Line 556: Missing word. "Needs to exceed harvest".

Authors' response: Thank you for your proofreading.

Comment:

Description of the comment/ issue /question: Line 567: The potential acceleration of growth associated with pre-commercial thinning is noted in this paragraph, but not any associated impact on total growth stock. That is, will pre-commercial thinning accelerate merchantability without impacts on total volume per acre, or will this need to be considered as well? Explain whether there is an impact of pre-commercial thinning on total volume per acre.

Authors' response: In RMRS-GTR-422, we discussed precommercial thinning and other silvicultural activities in the *Management Opportunities* section.

Comment:

Description of the comment/ issue /question: Line 572: Reference need for "often stagnates" . Provide reference.

Authors' response: We added a reference in RMRS-GTR-422 to indicate that stagnation does occur in the Black Hills.

Comment:

Description of the comment/ issue /question: Line 580: missing words. "produced over the same or different time frames (Graham 2019)"

Authors' response: In RMRS-GTR-422, we added "over the same or different time frames" as suggested.

Comment:

Description of the comment/ issue /question: Line 594: This sentence is unclear: does it mean that no commercial material was produced in the intermediate thinnings (i.e., these were not commercial thinnings) or does it mean that no commercial material was produced after 48 years when multiple intermediate thinnings were used?

Authors' response: We revised text in RMRS-GTR-422, to reflect that commercial material was not produced each time the thinnings occurred.

Comment:

Description of the comment/ issue /question: Figure 4: No estimates of uncertainty provided.

Authors' response: We removed this figure from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Figure 5: Can uncertainty estimates be provided? Also, why are the mortality percentages written out when there is a y-axis provided? The text is redundant

Authors' response: We removed this figure from RMRS-GTR-422. Instead, we presented the information in a table.

Comment:

Description of the comment/ issue /question: Figure 6: Are these annualized rates, or CCFs over the change interval (5 years)? Clarify in the caption and on y-axis

Authors' response: This figure is now figure 9 in RMRS-GTR-422. The values were not annualized rates. Rather they are a snapshot in time and represent that specific measurement period. We have clarified the caption and the y-axis to illustrate that the data was a snapshot in time.

Comment:

Description of the comment/ issue /question: Figure 7: The caption indicates that the graph is based on 39 plots, but there are clearly far more than 39 points in the figure. Also, draw the figure at a 1:1 scale (currently the x-axis prints at about 1" per 2" of DBH while the y-axis prints at about 0.5" per 2" of DBH).

Authors' response: We removed this figure from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Figure 8: No estimates of uncertainty provided

Authors' response: We removed this figure from RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Other comments: Many specific terms are used repeatedly throughout the text, and it is difficult for the reader to trace back to the definitions provided on first usage. Add a glossary or list of definitions covering the following: timberland, growth (gross, net), removals, merchantable volume, ASQ, mortality (# trees vs volume), and other key terms.

Authors' response: We did not add a glossary but made sure to define the terms in RMRS-GTR-422.

Blind Reviewer #2

Comment:

Description of the comment/ issue /question: Line 60: Would all readers understand "intensified"? Include definition of "intensified", e.g., "one plot every 3,000 acres"

Authors' response: When we discussed the "intensified" plots, we made sure to highlight that it was one for every 3,000 acres in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Line 86: Are "growth rates" really "volume growth rates"? Considering adding the term "volume" if this is the meaning.

Authors' response: Yes, these rates are really volume growth rates, volume mortality rates, etc. We have fixed this in RMRS-GTR-422, by defining it within the text.

Comment:

Description of the comment/ issue /question: Lines 238 and 256: Should be "statute".

Authors' response: We fixed the misspelling of this word in RMRS-GTR-422

Comment:

Description of the comment/ issue /question: Line 364: "commencing" is a correct word here, but confusing to read unless one understands the MPB epidemic. Consider replacing with "increasing mortality commencing with the 2000 MPB epidemic".

Authors' response: This sentence was removed from RMRS-GTR-422 during the revision. Although the exact wording isn't present in this GTR, we still address the general statement.

Comment:

Description of the comment/ issue /question: Line 423: Consider rewriting: "Consider the impact that the current 2019 forest condition has…"

Authors' response: We have changed the wording of this statement in RMRS-GTR-422 to read, *What impact does the current 2019 forest condition (i.e., standing volume, mortality, and growth) have on the out-year timber program of harvesting at current levels compared to other harvest level scenarios using probable growth and mortality estimates?*

Comment:

Description of the comment/ issue /question: Line 509: Remove a period.

Authors' response: we removed extra period in RMRS-GTR-422

Comment:

Description of the comment/ issue /question: Line 561: Instead of listing the scenarios numbers, could the mortality percentages be listed?

Authors' response: In RMRS-GTR-422*,* the scenarios were expanded to include five mortality levels across three growth rates and four harvest levels. This should alleviate any confusion for which mortality level is being used for the scenario in question.

Comment:

Description of the comment/ issue /question: Lines 564 to 565: "…net growth needs to exceed harvest…"Fix sentence.

Authors' response: Thank you for your proofreading.

Comment:

Description of the comment/ issue /question: Figures: Capitalize them, e.g., "Fig. 3".

Authors' response: We follow the formatting for RMRS manuscripts.

Comment:

Description of the comment/ issue /question: Figure 5: Consider grouping the bars indicating the same year for ease of interpreting.

Authors' response: We no longer have this figure in RMRS-GTR-422.

Comment:

Description of the comment/ issue /question: Appendix: Consider rounding the percents for mortality and growth value to one of two decimals

Authors' response: We no longer have these tables in RMRS-GTR-422.

Blind Reviewer #3

Comment:

Description of the comment/ issue /question: Scenarios: The variability in mountain pine beetle mortality and wildfire effects on mortality is a major wildcard in this region in terms of timing and severity of the disturbances. Using a mean mortality rate that decreases over time in some scenarios makes sense. Maybe I missed it, but why did the mortality rate in Scenario 3 increase from 0.26% in 2047 to 1.038% in 2048 and then remain consistent at this mortality rate?

Authors' response: To address and simplify the issue of changes in growth/mortality over time, we changed our approach to the scenarios in RMRS-GTR-422. Instead of increasing/decreasing rates, we used five mortality rates, three growth rates, and four harvest levels to look at a range of options over time. In the section *Understand Disturbance and Tree Mortality,* we expanded our discussion of mortality and provided further explanation about mortality and gross growth for scenario development

Comment:

Description of the comment/ issue /question: Scenario 1: It seems that if the current harvesting level of 153,534 CCF were sustained along with a mortality of 2.98%, that there will be substantial regeneration. This makes me wonder if the 2.5% growth rate is a reasonable estimate of the growth into the future. I would assume the forest would be a mosaic of age classes, with 153,534 CCF potentially depleting growing stock with prolific natural regeneration following harvest that would begin to stagnate in growth. Would thinning be conducted to maintain tree vigor and growth?

Authors' response: In RMRS-GTR-422, we expanded the scenarios to reflect a range of mortality (five), growth (three), and harvest (four) levels. We did not include any thinning options in our scenarios;

however, in the *Moving Forward* section, we discussed potential options in the *Management Opportunities* section.

Comment:

Description of the comment/ issue /question: Scenario 3: What is the justification for the increased mortality from 0.26% in 2034 to 1.04% in 2048. Is the assumption this mortality is density-dependent mortality from the slow decrease in harvesting levels over the 10-year period and prolific regeneration?

Authors' response: Based on this comment and other similar comments, in RMRS-GTR-422, we simplified the scenarios to not shift mortality over time, but rather we focused on evaluating more scenarios and illustrated the interaction of mortality, growth, and harvesting over time.

Interested Parties and Reconciliation from Interim Report dated February 10, 2020

Reviewer #1

Comment #: 101 and 102

Line # or Figure #: Lines 71-73

Description of the comment/ issue /question: A 6 million CCF inventory is undesirable for a number of reasons including the history of that sort of density being at risk of mpb epidemic. Continuing to harvest at current (higher) rates will also lead to a 6 million CCF inventory. That is because it is the density of presently untreated young trees that will turn into the large inventory in a century, not the rate that currently mature trees are harvested which, as the GTR concludes, will come to an end in a few decades at current harvest rates. It seems incorrect to imply that running out of mature trees in 30 years (continuing the high rate of harvest as opposed to stretching it out over a longer period of time) would somehow control the outcome of young trees already growing unchecked – since these young trees are what will become the 6 million CCF forest a century from now.

The saw timber program is dysfunctional in that it isn't performing proper thinning or Rx burning required to have any control over the future inventory.

Reviewer's proposed or suggested change: It should say "Regardless of the harvest level and barring another large fire, beetle epidemic, or changes in management practices, the BHNF inventory will increase again to 6 million CCF within a century because of the unchecked understory".

Authors' response: Yes, we agree that trees will continue to grow. To better address the above comments by the reviewer, we have expanded two sections in RMRS-GTR-422. First, we added a section titled *Moving Forward,* where we discuss the need for continuous monitoring to highlight the need for flexibility to adjust harvest levels based on realized mortality rates which is crucial if long-term timber sustainability is to continue. Secondly, we expanded a section titled *Management Opportunities,* which discusses a variety of options that may be appropriate for the BHNF.

Comment #: 103

Line # or Figure #: Lines 80-83

Description of the comment/ issue /question: The Black Hills National Forest is rich with resources beyond timber; these include wildlife, botany, riparian, recreation, cultural, and the like.

Reviewer's proposed or suggested change: Restrictions should be added up and subtracted from scenarios in order to have an accurate depiction of what is possible in terms of timber harvests.

Authors' response: We were asked to only evaluate timber sustainability; therefore, that is the focus in RMRS-GTR-422. However, we added a section on other resources in the section titled *Moving Forward* where we discussed the possibility that other management objectives may influence harvest levels.

Comment #: 104

Line # or Figure #: 117-18

Description of the comment/ issue /question: Lands inaccessible and inoperable were included.

Reviewer's proposed or suggested change: Include number of acres in this calculation please.

Authors' response: To address this comment, the Northern Research Station FIA program and Black Hills National Forest address specific questions concerning inaccessible or inoperable acres. We added a section that discussed specific acres as an appendix in RMRS-GTR-422.

Comment #: 105

Line # or Figure #: Figure 2

Description of the comment/ issue /question: Typo in caption "thriugh" should be through.

Authors' response: Done.

Comment #: 106

Line # or Figure #: 435-37

Description of the comment/ issue /question: Forest Plan constraints such as slope steepness, wildlife, recreation, grazing, or other values were not considered in the scenarios. Restrictions should be added up and then subtracted from scenarios in order to have an accurate depiction of what is possible in terms of timber harvests.

Authors' response: The commenter is correct that our scenarios do not include harvest reductions for other resources. The objective of the interim report and subsequent RMRS-GTR-422was to focus on scenarios that include harvest levels, mortality, and growth and demonstrate potential sustainable harvest levels within the context of mortality and gross growth. We added a section on other resources in the section titled *Moving Forward* where we discussed the possibility that other management objectives may influence harvest levels.

Comment #: 107 and 108

Line # or Figure #: 457-63, 464, 877-924

Description of the comment/ issue /question: Could the increase in mortality rates be the result of cumulative effects of logging and/or fire suppression? Or perhaps the benefits of the 12,000 acres of understory thinning done by the CCC .Or that overall the forest still had fire resistant old growth?

It seems the need to mitigate overgrowth of the understory and doghair (either by avoidance of disturbance or use of prescribed burning or hand-thinning) cannot be stressed enough.

continue to emphasize the benefits of PCT and Rx burning to control advanced regeneration density

During the recent MPB epidemic, many large trees were surrounded by an overgrown understory. Did this congestion in the understory contribute to the susceptibility of the large trees to MPB? Can this factor be linked to higher mortality rates?

Authors' response: To address this comment, we added a section to RMRS-GTR-422 that includes an expanded discussion in the section titled *Disturbance and Tree Mortality.* As mentioned earlier, we expanded the section called *Management Opportunities,* where we discussed thinning, burning, and a variety of methods for treating advanced regeneration.

Comment #: 109

Line # or Figure #: 474-5

Description of the comment/ issue /question: "Similarly, van Mantgem et al. (2009) indicated that recent trends in mortality in pines across the Western United States over the past 4 decades have been

increasing…" What factor(s) did Mantgem et al. attribute the increase to? And are similar factors present in the Black Hills? Provide more information about trends across the Western US in fire, beetles, etc. Bentz paper? Negron paper?

Authors' response: In RMRS-GTR-422, in the section titled *Mortality Trends Across the Interior West,* we added table 2 that describes mortality across the Interior West in ponderosa pine. We also added more literature concerning trends in mortality that have similar statements, such as Van Mantgem et al. 2009, who suggested that regional warming and consequent drought stress were the likely drivers. In the section titled *Management Opportunities,* we discussed the importance of thinning and prescribed fire that could benefit forest management to address concerns from reviewers associated with lines 877-924 in the interim report.

Comment #: 110

Line # or Figure #: 502-3

Description of the comment/ issue /question: "This scenario, by far represents the worst and most extreme possible future for forests of the Black Hills and its likelihood of occurring is minimal."

Reviewer's proposed or suggested change: Would authors provide reasons this scenario would be bad for the future for forests of the Black Hills, and why it seems unlikely (because this is what industry and politicians seem to be pushing for). Remove editorialization; we will provide a full range of alternatives for the scenarios.

Authors' response: The choice of growth and mortality rates used in the scenarios has an impact on how much sawtimber can be harvested on a sustainable basis. In RMRS-GTR-422, we expanded the scenario evaluation and developed 60 scenarios five mortality levels, three growth rates, and four harvest levels. For specific details, please refer to the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time.*

The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 111

Line # or Figure #: 599-602

Description of the comment/ issue /question: "The use of prescribed fire to reduce tree density is also warranted in this fire-adapted ponderosa pine ecosystem. Using prescribed fire would reduce tree densities, reduce surface fuels, and increase nutrient cycling. The reduction of surface fuels would result in less intense wildfires and help keep future tree mortality low."

Authors' response: Absolutely, prescribed fire can contribute to all the elements the reviewer stated. We have added the following sentence in the section titled "Management Opportunities" in RMRS-GTR-422: "*Using prescribed fire could reduce tree regeneration densities (fig. 16), reduce surface fuels, and increase nutrient cycling."*

Comment #: 112

Description of the comment/ issue /question: General – Scenario, Should the process of adjusting annual sales be more agile? If yes, how could that be achieved?

Authors' response: In our expanded scenarios in RMRS-GTR-422 we illustrated how different harvest levels, when combined with growth and mortality, influenced the available volume over time. We also discussed options in the section titled *Moving Forward* and discussed the need for monitoring to inform future adjustments to harvest levels over time based on the growth and mortality and the need to continue monitoring to inform harvest levels. Please refer to the *Moving Forward* section for more details.

Comment #: 113

Description of the comment/ issue /question: General - forest structure. In terms of public safety (wildfire) and a balance of multiple uses, is it reasonable to maintain pine plantations with 2 or 3 stories (ladder fuels) across an entire landscape and still have a capability to serve the other interests, i.e. why does it seem like so much of the Black Hills is either torn up by machinery or chuck full of doghair, or both?

Authors' response: Balancing the multiple resource use of the Black Hills is complex. In the *Management Opportunities* section of the report, we discuss a variety of silvicultural systems and the ways it could create a heterogeneous landscape.

Comment #: 114

Description of the comment/ issue /question: General – scenario. Ecol Appl. 2010 Oct;20(7):1851-64. Interactive effects of historical logging and fire exclusion on ponderosa pine forest structure in the northern Rockies. Naficy C1, Sala A, Keeling EG, Graham J, DeLuca TH. Are any of the scenarios presented in the GTR more congruent with a restoration approach given the management history of our forest?

Authors' response: RMRS-GTR-422 focuses on identifying a harvest level that is sustainable now and into the future; although not directly reported, harvest levels could be placed within the context of meeting a management objective within a theme of "restoration." However, it was not our objective to conduct scenario planning that includes other elements that might be part of a restoration theme. However, in our section titled *Understanding Disturbance and Tree Mortality,* we have discussed the ability for prolific regeneration in stands with an overstory seed source and the lack of regeneration in wildfire areas without a seed source. Also, in the *Moving Forward* section, there is a section on the range of structural stages as defined by the current Forest Plan. In the *Management Opportunities* section, we discuss different silvicultural methods that can be applied to reduce dense regeneration.

Comment #: 115

Description of the comment/ issue /question: General - climate change. To have the data in the General Technical Report (GTR) used as "best available science", we would have to also apply what we know

about climate change -- what factors concerning climate change will be imposed on the data so decisions made are based "on the best available science"?

Authors' response: Under the section *Understanding Disturbance and Tree Mortality* in RMRS-GTR-422, we added a subsection on the potential climatic effects on disturbances and mortality. We expanded our scenarios to capture the potential effects from a future climate such as the 1.52% or 2.0% mortality rates if there were a large wildfire, although we did not include a specific model hypothesis associated with climate change.

Comment #: 116

Description of the comment/ issue /question: General - scenario on pct/burning. More than once, the GTR mentions the issue of too many small trees, and the need to employ more thinning of these and to use more prescribed burning to manage the forest? Can the scientists add scenarios that show future yields with and without thinning and burning, i.e. what happens to future yields if the young trees are allowed to just grow like they are (climate change figured in)?

Authors' response: To conduct on analysis, as the reviewer suggested on such a scenario would have required very specific tree data, and this was beyond the scope of RMRS-GTR-422. Under the section *Management Opportunities,* the RMRS-GTR-422 does have a section on silvicultural methods that may lead to the potential increase in tree growth.

Reviewer #2

Comment #: 247

Line # or Figure #: General - land allocation

Description of the comment/ issue /question: Although the GTR discusses inventory, growth and mortality on a subset of suited base acres, we do not find any reference within the document to timber resources on forested lands within the suited base or on timberlands outside the suited base. Forested lands within the suited base are still part of the suited base and should be utilized in any discussions of timber resources within the suitable base. Timberlands outside the suited base also represent opportunities for necessary forest management activities such as timber harvest. Within the Forest Plan, there are extraordinarily few areas excluded from timber harvest. As an example, MA 3.7 (old growth) in the BHNF is often considered one of the most restrictive MAs regarding timber harvest but MA3.7 does not preclude timber harvest. The Forest Plan reads: "Late successional stands may contain large trees with open branches and irregular crowns in a savannah-like mosaic..." The Plan further states, "Timber harvest may be used if necessary to move stands toward late-successional conditions." Realistically, areas within MA 3.7 are not likely to contribute to long-term, scheduled harvest treatments but are offered as an example of the very limited restrictions on harvest activities outside the suited base, and that timberlands outside the suited base can contribute to forest management activities in the near-term. There are numerous areas outside the suited base that have been without forest management for multiple decades, are in need of forest health treatments through timber harvest, and represent opportunities for forest management activities. This was exemplified earlier this year by Jerry Kreuger (Deputy Forest Supervisor, BHNF) in an email where he stated: "In discussion, the FIA data produced over the last four years broken out by timberlands and suitable base likely contain accurate estimates of opportunity in the timberlands outside the current designated suitable base." (Personal communication

available upon request). Figures for forested lands within the suited base are readily available through the data provided by FIA or upon request.

We recommend using figures from all forested lands within the suited base when describing timber resources including inventory, growth, and mortality - instead of only a subset (timberlands) within the suited base. We also recommend adding additional analysis within the GTR that discusses timber resources on timberlands outside the suited base. Any discussions of timber resources should also include the acres those resources apply to.

Authors' response: We have added a section as an appendix in RMRS-GTR-422 describing the various land categories and clarify the area we analyzed. In addition, Northern Research Station FIA and the BHNF have discussed how these lands are categorized. For this report we focused on FIA suitable timber base (see appendix A). Although, the concerns raised by the reviewer are important, our objectives did not include timberlands outside the suitable base.

Comment #: 248

Description of the comment/ issue /question: General - land allocation. Comments continued from above: Additionally, there is no risk of including reserved lands as evidenced by the already reduced suitable base GIS layer provided by the BHNF to FIA. Figures for timberlands outside the suited base are also readily available through the data provided by FIA or by request.

Authors' response: We have added a section as an appendix in RMRS-GTR-422, describing the various land categories and clarify the area we analyzed. In addition, Northern Research Station FIA and the BHNF have discussed how these lands are categorized. For this report we focused on FIA suitable timber base (see appendix A).

Comment #: 249

Description of the comment/ issue /question: General - land allocation. The authors of the GTR make direct comparisons of the capacity of the timber resources on the BHNF, as reported by FIA, to meet the ASQ as written in the 1997 Forest Plan. Unfortunately, the authors have excluded spruce from any analysis in the GTR. Spruce contributes to the ASQ in the Forest Plan and should contribute to any discussions where the timber resources are compared to the Forest Plan ASQ. While we generally agree with the authors and their statements regarding pre-commercial thinning and potential increases to standing inventory, we find that immediately available timber resources are not being reported in the GTR.

Reviewer's proposed or suggested change: We recommend including timber resources from spruce in all tables and scenarios within the GTR and in the text of the paper.

Authors' response: Ponderosa pine was the species that was of most concern given the most recent MPB and wildfires. For RMRS-GTR-422, we were asked by the BHNF to just focus on this species.

Comment #: 250

Line # or Figure #: 450-455, and other places where gross growth is discussed.

Description of the comment/ issue /question: When discussing gross growth rates, the authors state they, "found no mathematically [sic] way to justify a gross growth rate to use…" Instead, they arbitrarily picked a number lower than the lowest sawtimber gross growth rate they report, despite stating that the gross growth rate was 3.12 percent in 2017. However, a meaningful process to justify the gross

growth rate would be to use the average of the two stated values: 2.815. Another way to look at this, would be to look at the growth rate reported by FIA for all plots that were measured in the year 2019. Importantly, the plots measured in 2019 were all permanent plots - the only plots used in the FIA study to report growth and mortality. This provides a good estimate of the actual growth in 2019. When the permanent plots measured in 2019 (approx 75 percent of total permanent plots) are used to report gross growth, the reported value is 4.16 percent (FIA reports available upon request). The authors could just as easily use the figure (4.16 percent) from the most current measurements which also contains 75 percent of all the remeasured plots from which gross growth was reported from throughout the FIA measurements. Notably, a higher gross growth figure is in-line with previously published work from the authors, including the 2019 publication "Differing Ponderosa Pine Forest Structures, Their Growth and Yield, and Mountain Pine Beetle Impacts: Growing Stock Levels in the Black Hills".

We recommend using a minimum gross growth value of 2.815 along with the more supportable value of 4.16 percent in all scenarios. Both numbers are supported mathematically and by the FIA data.

Authors' response: The choice of growth rates used in the scenarios has an impact on how much sawtimber can be harvested on a sustainable basis. To address this in RMRS-GTR-422, we examined the range of gross growth rates. For the growth rates, we derived an average growth rate of 2.54% from the 1962, 1984, 1999, 2011, and 2019 values. We bracketed the minimum gross growth rate at 2.33% that was reported in 2019 and a maximum growth rate of 2.73% reported in 1962. We developed scenarios that utilize these three growth rates. The use of Growing Stock Levels (GSL) growth data to infer Forest-wide growth rates isn't appropriate. The GSL growth rates are based on specific stand densities within a specific site location and site productivity. The FIA data provides a robust Forest-wide estimate of gross growth. Furthermore, the use of a 4.16% growth rate may occur on the Forest in some locations but not reflect an average Forest-level growth as we move into the future, similarly, the use of a mortality level of 3.07% although may be present in some locations does not reflect forest-level average mortality.

Comment #: 251

Line # or Figure #: 450-455, and other places where gross growth is discussed.

Description of the comment/ issue /question: The authors make a point to discuss their 2016 publication regarding mountain pine beetles in the Black Hills. However, the authors make no mention of their most recent (August 2019) publication "Differing Ponderosa Pine Forest Structures, Their Growth and Yield, and Mountain Pine Beetle Impacts: Growing Stock Levels in the Black Hills". The 2019 publication holds information relative to the discussion in the GTR, especially in the sense that it studies growth on varied levels of stand density in stands that were 65 years old when the study was initiated in 1961 and 1962 - now ~123 years old stands. This is likely a relevant study to include in the GTR because the majority of the plots reported more than .4 ccf of merchantable sawtimber growth per acre per year and total growth figures that exceeded .7 ccf per acre per year within more than one GSL density and more than one year. Importantly, the same trend of merchantable growth was observed post-thinning, in fact at statistically greater levels, which exemplifies the response of ponderosa pine to reduced stocking densities.

We recommend the authors incorporate finding from their recent publication, "Differing Ponderosa Pine Forest Structures, Their Growth and Yield, and Mountain Pine Beetle Impacts: Growing Stock Levels in the Black Hills" and contrast those findings to the FIA data. As demonstrated in presentations on April 3rd, the provided FIA dataset can show gross growth per basal area class by year (2017-2019).

Authors' response: The GSL growth rates are based on specific stand densities within a specific site location and site productivity. The FIA data provides a Forest-wide estimate of gross growth. But we did recognize we had to adjust our gross growth estimates. Therefore, in RMRS-GTR-422, we examined the range of gross growth rates and we derived an average growth rate of 2.54% from the 1962, 1984, 1999, 2011, and 2019 values. We bracketed the minimum gross growth rate at 2.33% that was reported in 2019 and a maximum growth rate of 2.73% reported in 1962. We developed scenarios that utilize these three growth rates. Although, the use of GSL growth data to infer Forest-wide growth rates isn't appropriate we added information about the GSL study in the section *Moving Forward.*

Comment #: 252

Line # or Figure #: 367-369

Description of the comment/ issue /question: "As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."" In lines 362-366 the authors describe the 2013 report, which is used to establish the 1.04 percent mortality level, as ""represent(ing) the impacts of the Jasper, Ricco, Roger Shack, Battle Mountain, and other fires (figs. 2, 6) in combination with the commencing 2000 MPB epidemic (fig. 2). Basing long-term mortality trends on a report that contains mortality from the largest wildfire in recorded history in the Black Hills, three other large fires, ""other fires"", and 11 years of pine beetle mortality is illogical when looking at the long-term trends outlined in table 1. There has not been a large fire on the Black Hills National Forest in nearly a decade, and it has been more than 15 years since a large fire burned any significant portion of the suited base. The pine beetle epidemic was declared "over" 4 years ago with only 20 acres of pine beetle damage recorded during the last aerial survey."

We recommend using .16 mortality for all scenarios and discussion of what an appropriate mortality level is. That level of mortality was recorded over 37 years, with similar to higher timber inventories and is supported by the most recent monitoring of mountain pine beetle damage in the Black Hills. Further, the editorial comment of "conservative" seems out of place in a scientific publication and we recommend removing that phrase.

*Authors' response: In RMRS-GTR-422, w*e expanded our mortality discussion to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In this GTR, we added a section titled *Understanding Disturbance and Tree Mortality* that included discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). In addition, fuel loadings caused by MPB mortality is expected to increase wildfire hazard as dead trees decay and fall to the ground. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we describe in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and we have shown in table 1 those differences by mortality agent. In RMRS-GTR-422, we discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledged that the current

epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 253

Line # or Figure #: 369-370

Description of the comment/ issue /question: "In addition it is a good estimate of what might occur in future decades." See comments above regarding the validity of this statement. Additionally, this statement seems repetative based on the sentence immediately before it. We recommend removing this sentence.

Authors' response: Sentence was removed.

Comment #: 254

Line # or Figure #: 370-372

Description of the comment/ issue /question: "Similarly, van Mantgem et al. (2009) indicated that recent trends in mortality in pines across the Western United States over the past four decades have been increasing and ranged from 1 to 2%." This publication is self-described as analyzing information "from unmanaged old forests in the western United States" and contains zero sample points from the Black Hills area. Further, the authors of the GTR state "The Black Hills forests have maintained a viable timber industry for over a century." The statements from the GTR authors seem to be in contrast to the intents, analysis, and results of the van Mantgem publication.

We recommend deleting reference to this publication because it is not applicable to the Black Hills National Forest.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, we looked at recent FIA reports from across the Interior West. We have added in RMRS-GTR-422 a section titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we provided scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 255

Line # or Figure #: Table 1

Description of the comment/ issue /question: Although this table has footnotes that describe the publications and where the information is originally published, there are no references to the amount of area accounted for in each temporal point. As an example, DeBlander 2002 cites standing inventory on all forested acres of the Black Hills National Forest, including Wilderness and Roadless areas, compared to the 765,000 acres used in the GTR. This is an important component for readers to understand the table and changes.

We recommend amending table 1 to include a column for acres represented in each report and a column that shows the volume per acre based on the inventory and acres represented. We have attached a suggested table for inclusion in the report as table 1. See appendices.

Authors' response: The original table 1 in the interim report has been amended and is now table 4 in RMRS-GTR-422. We also added the estimated acreage value for each of the inventory periods listed in table 4 in the footnotes for table.

Comment #: 256

Line # or Figure #: 112-117

Description of the comment/ issue /question: "The BHNF is approximately 1.2 million acres in size, of which the Forest Plan Amended in Phase II (USDA FS 2005, Appendix G-3) identifies 865,890 acres as suitable and available for timber harvest. In 2019 the USDA Forest Service, Forest Inventory and Analysis Program (USDA 2019) identified 765,733 acres of timberland: (suitable), as forestland that is producing or is capable of producing 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn from timber utilization by statute or administrative regulation." Although it is helpful for readers to know what acres are covered in this GTR, it is discouraging to see the authors quickly dismiss this without any further discussion. The difference in reported acres is not insignificant and could lead to different results and discussion from the authors. This difference in acres and the potential impacts on reported timber resources should be discussed by the authors. Importantly, the BHNF has made it abundantly clear there is a bright line between the BHNF and the GTR authors. As such, it would be inappropriate to use explanations from the BHNF as to why the acres have changed - a discussion of the impacts solely is more relevant than an explanation of why acres may or may not have changed.

Reviewer's proposed or suggested change: We recommend the authors discuss that the acres of suited base reported by FIA remained steady from 2011 through 2016, and began dropping in 2017 to the amount stated in the FIA data; reduced by ~100,000 acres. The authors should also discuss any impacts this may have on reported timber inventories, growth, etc with peer reviewed citations to accompany these discussions.

Authors' response: In RMRS-GTR-422*, w*e addressed the difference in suitable and available timber harvest in appendix A; please refer to this section for specific details.

Comment #: 257

Line # or Figure #: 112-117

Description of the comment/ issue /question: "Timberlands" and "suitable base" are not interchangeable terms. The GTR specifically discusses timberlands within the suited base on the BHNF.

We recommend the authors delete the reference to timberlands here, and elsewhere throughout the document, and the accompanying definitions of timberlands. References to timberlands should be replaced with "765,000 acres of timberlands within the suited base".

Authors' response: In RMRS-GTR-422, *w*e address the difference in suitable and available timber harvest in appendix A; please refer to this section for specific details.

Comment #: 258

Line # or Figure #: Table 1

Description of the comment/ issue /question: It is logical that gross growth, as a percent, would decrease as total standing inventories increase, and would increase as inventories decrease. This trend is apparent in table 1 from 1962 all the way through 2017. However, in 2019, that trend abruptly reverses without discussion a to why 55 years of trend data would suddenly reverse so sharply. No discussion of this or why - suggest recognizing this anomaly in the text.

We recommend acknowledging this anomaly in the trend of gross growth, as a percent, and also how timber inventory from the temporary plots measured in 2017 and 2018 was redistributed among all three years and what effect that has on reported figures such as gross growth which rely on remeasured plots that were predominantly measured in 2019.

Authors' response: We have added a paragraph under the section titled *Assessing Past FIA Reports* in RMRS-GTR-422 that expanded discussion on each of the past FIA reports and included in this section the differences between Periodic inventory and Annual inventory. We also presented more details concerning the 2017 and 2019 data collection. To specifically address the reviewer's comment, we added the following sentence: *It should be noted that the 2017 evaluation presented in this document was summarized and presented to the stakeholder group in 2018 to provide preliminary results and progress; however, these data were not the complete data set until the 2019 evaluation data was added to be used for the final analysis.*

Comment #: 259

Description of the comment/ issue /question: General - active management and disturbance. Although we disagree with the scenarios presented by the authors, to the extent the authors feel inclined to speculate about future mountain pine beetle epidemics and the effects from those epidemics, it would be relevant for the authors to also discuss recent publications from their research station on this topic. Specifically, Negron, et al 2017, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA (published in Forest Science). This peer reviewed publication draws clear conclusions that active forest management is tremendously successful at abating mortality caused by mountain pine beetles.

We recommend the authors discuss the well-researched potential for success in abating mortality from mountain pine beetles through active forest management wherever the authors speculate on future pine beetle infestations.

Authors' response: We added the section titled *Understanding Disturbance and Tree Mortality* in RMRS-GTR-422, where we expanded the discussion of potential sources of mortality and expanded the literature cited (please refer to this section for details). We also added tables 1 and 2 that focus on an expanded discussion on sources of mortality. We then added two sections titled *Moving Forward* and *Management Opportunities;* both of these sections discussed opportunities and the role of forest management in creating resilient forests. We also included a discussion on monitoring that would and could inform harvest levels through time. Please refer to these sections for specific details.

Comment #: 260

Line # or Figure #: Table 1

Description of the comment/ issue /question: We find there is an error in reporting the inventory and growth figures for Collins and Green 1988 in table 1. Table 1 in the GTR reports a standing live inventory of 13,449,000 ccf. That number is correct for all softwoods, but the publication also reports the standing inventory for only ponderosa pine at 12,974,000 ccf. This becomes important because the GTR reports

net growth only for ponderosa pine, which makes the growth percent calculation erroneous. The GTR reports net growth of 301,660 ccf but Collins and Green, in table 13 on page 22, report total softwoods net growth of 304,630 ccf for softwoods. This would also affect other calculations in the table, including net growth as a percent, and net change as a percent.

We recommend only displaying information in an "apples to apples" format by not mixing ponderosa pine growth figures with inventory for all softwoods, or vice-versa. The authors should change table one to reflect the growth for all softwoods or the standing inventory, mortality, etc. for ponderosa pine only.

Authors' response: In RMRS-GTR-422, table 4 contains the elements that were in the original table 1. And as the reviewer specified, depending on the report there were estimates of all softwoods versus estimates of only ponderosa pine. As the reviewer stated: It is important for the authors to document the nuances, assumptions, and interpretation of past reports, to address this we expanded table 4 with detailed footnotes. We expanded the section titled *Assessing Past FIA Reports* and have an introductory paragraph that identified the nuances associated with the different reports through time (please refer to this paragraph for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* described our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions.

Comment #: 261

Description of the comment/ issue /question: Scenarios 1-6. The assumptions used in the scenarios are inaccurate by reflecting lower than average growth rates and higher mortality rates than reality. As an example, only 20 acres of pine beetle damage were detected in the Black Hills NF in 2019 (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd700752.pdf) and the previous mountain pine beetle epidemic was declared "over" four years ago.

Description of the comment/ issue /question: with mortality percentages of .16 percent, with growth percentages that reflect the variability observed over time by including growth percentages at the average of 2.58 percent, 3.12 percent as indicated as possible in table 1, and 4.16 percent as indicated by the 75 percent of FIA permanent plots that were measured in 2019.

Authors' response: In RMRS-GTR-422*, w*e expanded our mortality discussion to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality is expected to increase wildfire hazard as trees decay and fall. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognized that mortality rates over the past 60 years have varied and we have shown in table 1 those differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledged that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 262

Line # or Figure #: Scenarios 1-6

Description of the comment/ issue /question: The scenarios do not reflect any opportunities for forest management outside timberlands within the suited base, let alone outside the suited base. Very few acres of timberlands in the BHNF are precluded from forest management activities. The Forest Plan even describes forest management as potentially necessary within MA 3.7 (old growth). As described earlier, figures for inventory, growth, etc for forest lands within the suited base, and timberlands outside the suited base are readily available with the information that was provided by FIA.

We recommend scenarios that are based on all timberlands within the BHNF. We recognize lands outside the suited base may not be best suited for scheduled re-entries and understand that harvested volumes. We have provided some examples of scenarios that use this information.

Authors' response: We appreciate the comment from the reviewer that all timberlands within the BHNF be considered. We address the difference in suitable and available timber harvest in RMRS-GTR-422, appendix A, in the second paragraph; please refer to this section for specific details.

Comment #: 263

Description of the comment/ issue /question: Reliable data is core to any scientific publication. Unfortunately, the authors have not spent the requisite amount of time vetting the data received through channels other than their own data collection. As such, important details within the data have been overlooked. One example is that the FIA data reports more than 8000 ccf of annual negative gross growth. After examination of the data, it has become clear that is caused by one tree in the 25-26.9 inch diameter class. This tree has a profound effect on the reported annual gross growth of growing stock. If that tree is removed from the database, the total average annual gross growth on growing stock on timberlands within the suited base increases by nearly 10,000 ccf/yr to 194,810 ccf. (Evalidator outputs and databases available upon request) This also has the effect of increasing the gross growth as a percent to 2.45% from 2.33 percent. Other important aspects of the data that warrant additional discussion in the GTR include the aforementioned reduction in acres, despite using the same plots.

We recommend using the reported average annual gross growth, with this tree removed, of 194,810 ccf for growing stock trees on timberlands within the suited base of the BHNF and an adjustment to the sawtimber average annual gross growth using this same method.

Authors' response: The Northern Research Station Forest Inventory and Analysis (NRS-FIA) responded to these concerns in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns,*

Challenges, and Assertions in April 2020 (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733565.pdf) . They state the following: "1) The most accurate way to estimate change is to use FIA's 'Accounting Method.' This creates credits and debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. 2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25"–26.9" diameter class had a large measured 'loss' of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. 3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. 4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period."

Comment #: 264

Description of the comment/ issue /question: Analysis to support recommendation above - definitions are published by FIA: The Forest Service has offered the explanation that this tree has a broken top. We don't believe that is true for multiple reasons:1) First and foremost, we don't believe this tree was ever 101' tall. Between 2003 and 2008, the tree height went from 76' to 99'. 23' in 5 years seems unlikely, especially given the tree was already 26.2" DBH and the dry environmental conditions during those years. It is unclear why it was recorded to have grown another 2' from 2008 to 2013. 2) Based on the tree data from FIA, there is no reason to think this tree has been damaged in any way, other than 8 percent deduction for form which could be sway or other qualities that make it lees than 100 percent perfect for utilization. See below: 3) Actual height: IMPORTANT "(All live and standing dead tally trees >1.0 inch d.b.h./d.r.c.) The length (height) of the tree to the nearest foot from ground level to the highest remaining portion of the tree still present and attached to the bole. If ACTUALHT = HT, then the tree does not have a broken top. If ACTUALHT <HT, then the tree does have a broken or missing top. " 4) CULL = 0 = Rotten and missing cull. The percent of the cubic-foot volume in a live or dead tally tree that is rotten or missing. This is a calculated value that includes field-recorded cull (CULL_FLD) and any additional cull due to broken top. 5) DamLOC = Null = Damage Location: A code indicating where damage (meeting or exceeding a severity threshold, as defined in the field guide) is present on the tree. 6) CCLCD = 2 = Crown class code. A code indicating the amount of sunlight received and the crown position within the canopy. 2 = Dominant: Trees with crowns extending above the general level of the canopy and receiving full light from above and partly from the sides; larger than the average trees in the stand, and with crowns well developed, but possibly somewhat crowded on the sides. 7) CR = 40 (same as last measurement) = Crown Ratio 8)TREECLCD = 2 = Tree class code. A code indicating the general quality of the tree. 2 = Growing Stock, no notes of substantial defect or cull 9)HTCALC = 85 = HTCALC: Current height calculated. If the height is unmeasurable (i.e., the tree is cut or dead), the height is calculated (in feet) and stored in this variable. 10) CULLFORM = 8 = Form cull: The percent of the gross cubic-foot volume that is cull due to form defect. It is unclear why this was never recorded before 2019.

11) CULLMSTOP = 0 = Missing top cull. The percent of the gross cubic-foot volume that is cull due to a missing (broken) merchantable top.

Authors' response: NRS-FIA responded to these concerns in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns, Challenges, and Assertions* in April 2020 (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733565.pdf). They state the following: "1) The most accurate way to estimate change is to use FIA's 'Accounting Method.' This creates credits and debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. 2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25"–26.9" diameter class had a large measured 'loss' of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. 3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. 4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period."

Comment #: 265

Description of the comment/ issue /question: Scenarios 1-6. We have outlined numerous reasons why the scenarios in the GTR should be revised in the next version of the GTR. We offer four scenarios in the appendix below as rationale and supported possibilities for the future sawtimber harvest program on the BHNF. All scenarios are for ponderosa pine only unless otherwise stated in the scenario description. Evalidator outputs and/or analysis of FIA data are available upon request for all scenarios. (see attachment)

We recommend incorporating the five scenarios below into the revised GTR.

Authors' response: Thank you for providing some suggestions for new scenarios. In RMRS-GTR-422, we have expanded from 6 to 60 scenarios using five mortality rates, three growth rates, and four harvest levels. In the section titled *Scenario Development,* we explained the rationale we used to develop the scenarios. We recommend referring to this section where we provided the rationale for selecting the five mortality rates, three growth rates, and four harvest levels.

Reviewer #3

Comment #: 117

Line # or Figure #: Lines 25 - 41; Lines 58-67 (NOTE: These line items refer to BHG letter, dated 4/15/20, not GTR line number)

Description of the comment/ issue /question: The BHG believes that the BHNF timber program is not being managed for a sustained yield as required by the National Forest Management Act (16 USC §1611)

Authors' response: In RMRS-GTR-422*, t*hrough our evaluation of 60 scenarios, we presented what is plausible on the BHNF. We also provided a definition of "sustainable" from the Dictionary of Forestry. In the section titled *Scenario Outcomes,* we concluded that the current forest conditions (2019) and probable growth and mortality estimates suggest an average annual harvest for the timber program on the BHNF in the range of 72,400 to 90,500 CCF/yr. This appeared to be the best option, in the short-term, for sustainable harvest levels. A second section titled *Moving Forward* discussed how our conclusions could be placed in context within the BHNF including references to several laws as referenced by the reviewer's comment. Please refer to these sections to read the details.

Comment #: 118

Line # or Figure #: 130-139.

Description of the comment/ issue /question: The BHG believes that Draft 1 of the Timber Growth & Yield Report should be published in its present form, based upon the peer review of the technical reviewers selected by the RMRS

Authors' response: Based on comments we received from the reviewers (over 350 comments), RMRS-GTR-422 has 60 management scenarios, discussions on disturbance and tree mortality, and climate change. We also have added discussions concerning the rationale behind the scenario development and placed this in context in the section titled *Moving Forward* that includes a management option section.

Comment #: 119

Line # or Figure #: 90 - 118

Description of the comment/ issue /question: The BHG objects to the RMRS allowing the peer review process for the Timber Growth & Yield Report to be corrupted by allowing stakeholder groups to participate in the final stage of the peer review process. The stakeholder groups, despite their varying degrees of training and expertise in forest management, are not peers of the Report's authors. The stakeholder groups tend to be biased along philosophical and financial lines and their criticisms of the Report will come after the completion of the reviews by the Technical Reviewers. Such criticisms could alter the Report and the Technical Reviewers will not have an opportunity to review the Report again and submit additional comments

Authors' response: We understand the reviewer's concern about the representation of the stakeholders and possible bias. However, stakeholder input and review allowed us to identify weaknesses and lack of clarity in the interim report. These reviews resulted led to the major revision and the subsequent published RMRS-GTR-422.

Comment #: 120

Line # or Figure #: 68 - 89

Description of the comment/ issue /question: It is the function of the RMRS to publish the best available science on the questions presented to the authors of the Timber Growth & Yield Report. The RMRS cannot determine the sustainable yield and ASQ for the BHNF. Those matters are solely within the jurisdiction of the appropriate decision maker for the BHNF. That is an entirely separate process where

the comments of the stakeholders, as well as the published Timber Growth & Yield Report, are rrelevant and admissible for consideration by the BHNF decision maker.

Authors' response: We agree that RMRS cannot determine the sustainable yield and ASQ for the BHNF. These decisions are for the National Forest to make. The authors in RMRS-GTR-422, provided information that can be used by the National Forest and stakeholders to inform decisions associated with planning.

Reviewer #4

This reviewer contained multiple comments in a letter. These were all addressed under one letter.

Comment#: 246

Line # or Figure #: According to GTR Abstract:

Description of the comment/ issue /question:

1. IDENTIFYING THE CAUSES OF NON-SUSTAINABLE LOGGING.

> "To meet the current allowable sale quantity (ASQ) of 181,000 CCF as described in the BHNF Plan, a standing live sawtimber volume of approximately 12 million CCF would be required. However, current standing live sawtimber volume is approximately 5.9 million CCF.
>
> This constitutes and admission that the BHNF timber program is not sustainable, in contravention of the Multiple-Use Sustained-Yield Act and National Forest Management Act. The GTR suggests this situation is largely attributable to unexpected tree mortality due to wildfires and pine beetles. Notably, page 14 of the GTR asserts weather is "the primary mortality agent" of trees on the forest. Over the past century, however, logging has killed far more trees on the BHNF than any other cause. Please revise the text to reflect this.
>
> I am also requesting that the final GTR include data disclosing the relative contributions to the non-sustainable situation from logging, weather, beetles and other causes. The timber industry has pressured the BHNF to maintain excessively high levels of logging for decades. The industry has also lobbied Congress to weigh in and pressure the agency to maintain excessively high levels of logging. For instance, when the original BHNF LRMP was being revised in the 1990s, I spent months working with other concerned citizens to develop a Forest Plan alternative that would ensure a sustainable harvest level while accounting for the needs of vulnerable species such as the Northern Goshawk and endemic land snails. The agency promised us our alternative would be fully analyzed and considered in the Forest Plan EIS, provided we submitted the details of the alternative by a certain date. We met the deadline. In response to timber industry pressure, the agency reversed position and refused to analyze the alternative in the EIS. Instead, the EIS fully analyzed an alternative submitted by the timber industry after the deadline had passed. That alternative was endorsed by U.S. Senator Tom Daschle even though it was built around a non-sustainable harvest level.
>
> Because the BHNF Revised Forest Plan that was adopted failed to ensure viable populations of Northern Goshawks and other vulnerable species, I initiated a lawsuit along with other

concerned individuals and organizations. We spent many hours meeting with USFS and timber industry representatives to come up with a settlement agreement that would allow numerous timber sales to proceed with modest modifications to protect the most vulnerable species on the Forest. All the parties seemed pleased with the agreement, and the court signed off on it and then dismissed the case. However, within a couple of years the timber industry had a change of heart and lobbied Senator Daschle to introduce a rider that nullified the settlement agreement. The BHNF then went back to a non-sustainable harvest program with virtually no protections for vulnerable species.

In my estimate, the timber industry — by relentlessly pressuring the agency to maintain excessively high timber harvest levels — is largely responsible for the current non- sustainable situation on the BHNF. It is true there has been tree mortality from beetles and fires, but if the timber program had been managed to allow sufficient latitude to adjust for such foreseeable changes (as required by MUSYA), the logging program would not be facing a significant change now.

Page 20 of the draft GTR says “As a result of both harvest and trees being killed by MPB, live standing inventory decreased from 15,353,000 in 1999 to 13,477,960 CCF in 2011.” This suggests MPB was not the dominant factor in reducing timber supply from the estimated 12 million CCF needed to achieve the ASQ to the 6 million CCF that is left on the forest. Page 20 also states that BHNF timber ""harvest peaked at 261,721 CCF in 2017, far exceeding net growth, and declined to 183,592 CCF in 2019.” This indicates excessive harvesting is the primary cause of the non-sustainable situation.

Reviewer's proposed or suggested change: In any event, I am requesting that the final GTR evaluate the extent to which the timber industry contributed to the shortage of merchantable sawtimber and non-sustainable ASQ. This should include an estimate of whether the BHNF ASQ would have been sustainable (accounting for constraints on harvesting such as CMAI and Forest Plan standards and guidelines) if tree mortality from beetles and fires had not increased.

Authors' response: In RMRS-GTR-422*, w*ithin the section *The Setting,* we included information about how the Forest Service and stakeholders responded to the increased MPB and wildfire hazard to provide context to the harvest levels in the 2000s. We added Box 2 on the definition of sustainability and have shown the effect of multiple disturbances, including harvest, on the standing live volume in tables 1, 4, and 5. In table 1, we showed the contribution of natural disturbances to the mortality rates. In table 4 and 5, we showed the contribution of mortality (natural disturbance) and harvesting to the reduction in standing live volume. In table 8, the authors showed the standing live sawtimber volume needed to maintain the ASQ of 181,000 CCF/yr. According to table 8 of this document, if there had not been mortality due to beetles or wildfires (for example the lower mortality rates of 0.26% or 0.60%), the estimates of standing live volume in 1999 and 2011 would have supported the ASQ of 181,000 CCF/yr. To conduct an analysis on such a scenario, as the reviewer suggests, would have required very specific tree data, and this was beyond the scope of this report. Under the section *Management Opportunities,* the GTRt does have a section on silvicultural methods that may lead the potential increase tree growth.

2. ACCOUNTING FOR RESTRICTIONS ON LOGGING

Most of my remaining comments will focus on the following question which the GTR was partly commissioned to address (page 7): "What is a sustainable timber harvest estimate for the BHNF using the 2019 Northern FIA data assuming rationale tree mortality and growth rates informed by those of the past?"

Unfortunately, the GTR does not answer this critically important question, and the methodology underlying the GTR are incapable of providing the answer. The GTR estimates how many trees at least 9" DBH will exist on the BHNF in the years ahead and then assumes these trees can be harvested if they are within the suitable timber base. This approach ignores numerous important legal constraints on logging, including Culmination of Mean Annual Increment of Growth, Forest Plan Standards and Guidelines, and soil restrictions. Just because a tree may be large enough to log and is located within the suitable timber base does not mean that tree can be logged.

Indeed, as noted on page 4 of the GTR: "All scenarios assume no harvest reduction for other resources (e.g., wildlife, botany, aquatics, and so on) or for Forest Plan adjustments. However, Black Hills National Forest (BHNF) may have restrictions that could alter the amount of area treated and the volumes removed."

As a threshold matter, there is no doubt that protecting other resources will restrict the amount of area treated and volumes of timber that can be "removed" on many parts of the Forest. The final GTR should replace the "may" and "could" wording to reflect this reality. More important, to provide a reliable estimate of the sustainable harvest level on the BHNF, all significant constraints on logging must be included in the calculus. In particular, I am requesting that the following constraints be evaluated in the final GTR.

*Authors' response***:** In RMRS-GTR-422, we have described constraints on harvesting due to Forest Plan structural stage designation and other factors under the sections titled *Moving Forward* and *Management Opportunities.*

3. CULMINATION OF MEAN ANNUAL INCREMENT OF GROWTH

To maximize the volume of saw timber that can be sustainably harvested from an acre of forested land it is necessary to wait for the trees to reach the Culmination of Mean Annual Increment of growth or CMAI. If trees are cut while they are still growing rapidly, i.e., before reaching CMAI, that parcel of land will produce less saw timber over the long-term than if the stand was managed for harvest at CMAI. For public lands, this means the taxpayers and government will be short-changed on the revenues that could be obtained from selling the trees for harvest. For wildlife, logging on a short rotation before CMAI also means lower quality habitat for species that depend on mature forest conditions.

The importance of CMAI was recognized by Congress in Section 1604(m) of NFMA:

"The Secretary shall establish—

(1) standards to insure that, prior to harvest, stands of trees throughout the National Forest System shall generally have reached the culmination of mean annual increment of growth

(calculated on the basis of cubic measurement or other methods of calculation at the discretion of the Secretary):

Provided, That these standards shall not preclude the use of sound silvicultural practices, such as thinning or other stand improvement measures:

Provided further, That these standards shall not preclude the Secretary from salvage or sanitation harvesting of timber stands which are substantially damaged by fire, windthrow or other catastrophe, or which are in imminent danger from insect or disease attack; and

(2) exceptions to these standards for the harvest of particular species of trees in management units after consideration has been given to the multiple uses of the forest including, but not limited to, recreation, wildlife habitat, and range and after completion of public participation processes utilizing the procedures of subsection (d) of this section."

Although this provision of NFMA includes sensible exceptions for thinning, stand improvement, salvage or sanitation harvesting, the language instructing the Secretary to "insure that, prior to harvest, stands of trees throughout the National Forest System shall generally have reached" CMAI indicates Congress intended for pre-CMAI harvesting used in exceptional circumstances.

NFMA also allows exceptions to harvest pre-CMAI trees to be established based on consideration of multiple uses when the exceptions are established following the public participation procedures required for Forest Plan development, revision and significant amendments (subsection (d)). Nevertheless, the agency has, for many years, allowed the timber industry to harvest most trees on the BHNF before they reach CMAI. In my estimation, this has played a significant role in the current non- sustainable situation. To my knowledge, the agency has not established any exceptions in accordance with public participation provisions of subsection (d). It did establish a sweeping and generic "any reason at all" exception to CMAI through a less extensive public process, but it did not justify this exception based on multiple use needs. It has served as a carte blanche to ignore the CMAI restriction, ostensibly to provide the timber industry with more short-term volume at the expense of sustainable long-term yield. This exception was not needed for multiple use reasons; it was established to cut more trees to the detriment of other forest uses. This makes a mockery of NFMA and short-changes the public out of the possible return on investment for the BHNF timber program, while at the same time reducing wildlife habitat across the forest.

The draft GTR continues this pattern by completely ignoring the CMAI restriction. It assumes any trees at least 9 inches DBH that exist in the suitable timber base will be considered harvestable. Trees on the BHNF rarely reach CMAI at 9" DBH. While CMAI varies by stand condition, in many parts of the forest trees do not reach CMAI until they are 14-20" DBH. Unlike the "black bark" ponderosa that are typically harvested, trees this large are developing "yellow bark" conditions that are more resistant to fire and beetles. It can be argued that the USFS's failure to administer the BHNF's timber program to ensure harvested trees have generally reached CMAI has contributed to the increase in fires and beetle outbreaks.

The Rocky Mountain Research Station has sufficient growth and yield data available to estimate the CMAI for most if not all stands on the Forest. I am requesting that this data be compiled and

the final GTR include estimates of the long-term sustainable harvest level assuming trees will generally be allowed to reach CMAI before harvest. Your team should not assume the BHNF will be allowed to continue ignoring the CMAI restriction in the future. It is a legal requirement that must be considered in estimating sustained yield. Accounting for CMAI will likely reveal the sustained yield is below 70,000 CCF per year. If the data are available, I am also requesting the final GTR answer the following questions on this issue:

Reviewer's proposed or suggested change: What percentage of the non-salvage / non-thinning logging on the BHNF over past 20 years has included trees that had not yet reached CMAI? How does the sustainable harvest level vary with different levels of pre-CMAI logging? It is possible to compare yields based on no pre-CMAI logging versus an assumption that 10% or 20% of trees sold as sawtimber are pre-CMAI. Regarding the latter question, if your team elects to consider a scenario where the USFS continues to ignore the "general" prohibition on logging trees pre-CMAI, I am requesting that the final GTR also fully evaluate and disclose the NFMA-compliant scenario which assumes trees will not be harvested before reaching CMAI.

Authors' response: We agree that Culmination of mean annual increate (CMAI) is an important component of forest management planning. However, determining management scenarios that included CMAI was beyond the scope of RMRS-GTR-422. While we do not account for CMAI, Graham et al. 2019 demonstrated that CMAI in ponderosa pine forests of the Black Hills occurs around 95 to 105 years of age. Unstagnated stands with sawtimber sized trees (> 9 inches d.b.h.) have typically met CMAI. The intent of this GTR was to provide an initial and simple assessment to provide a starting point for conversations about sustainable harvesting of timber.

4. FOREST PLAN STANDARDS AND GUIDELINES

Page 18 of the draft GTR states: "Forest Plan constraints such as slope steepness, wildlife, recreation, grazing, or other values were not considered in the scenarios."

The technology exists to account for the effects of such constraints on the harvestable timber supply. This was done by the Medicine Bow National Forest back in the 1990s.

After the 1985 MBNF LRMP was issued, the timber industry there (comprising just three modest mills) pressed the agency to look for more harvestable trees on the Forest than was included in the ASQ. The Forest Service responded by initiating a "Timber Supply Study." At my request, the agency did do modeling to account for many of the Forest Plan constraints such as slopes, wildlife habitat restrictions (e.g., elk thermal cover), soils, riparian areas, visual quality, and old growth minima per watershed.2

Given that the USFS was able to account for the MBNF LRMP constraints back around 1990, with relatively slow computers and without modern GIS tools, surely the RMRS can do the same for the BHNF for the final GTR. For this reason, I am requesting that the final GTR account for all potentially significant Forest Plan restrictions on logging on the BHNF, including (but not limited to) the following: visual quality, road buffers (beauty strips), recreation area and interpretive site buffers ROS restrictions, riparian area buffers, other soils susceptible to irreversible damage from heavy machinery steep slopes, wildlife habitat restrictions, including snag retention / recruitment old growth / potential future old growth and other structural stage restrictions.

Authors' response: Incorporating Forest Plan restrictions was beyond the scope of RMRS-GTR-422. Our objective was to show the maximum amount of timber harvest that could be sustainable to serve as a starting point for discussions among the National Forest and its stakeholders.

Comment # 246 continued:

Description of the comment/ issue /question: After completing the timber supply study on most of the MBNF lands, the agency did a preliminary calculation and found that it showed the amount of available sawtimber on the forest was not greater than assumed in the ASQ but significantly less. In fact, the TSS revealed the sustainable harvest level was at most 25% of the ASQ. Rather than reduce the logging level, the agency canceled the study, refused to publicly release the results, and proceeded to resume issuing "maximum harvest" timber sales. For instance, the Supervisor selected the highest volume option for the Banner timber sale which, according to project EA, was going to leave virtually no remaining merchantable sawtimber in the entire project area. A USFS whistle-blower informed to me the MBNF TSS was canceled so the agency would not be forced to initiate a Forest Plan amendment and lower the ASQ. In other words, the agency decided to ignore the sustained yield legal obligations for the short-term benefit of a few mills.

A similar incident occurred on the Bighorn National Forest in northern Wyoming. I was involved in litigation brought by the Sierra Club around 1990 challenging the BNF's use of a 7-year restocking standard that was blatantly contrary to the NFMA 5-year restocking requirement. In response to the lawsuit, the USFS prepared an EA purporting to address the question of how the harvest level would need to change in response to changing to the 5- year standard. However, the agency concurrently significantly loosened the definition of what constitutes a "restocked" stand so that the final number it came up with suggested there would not be a significant effect on the logging program by changing from the 7-year standard to the 5-year standard. Judge Finesilver in Colorado apparently recognize this ploy and refused to lift the injunction. The USFS appealed his decision to the Tenth Circuit and argued that it was working on an ASQ amendment that would more definitively address the timber supply question. The higher court lifted the injunction on the agency's promise that the ASQ amendment would be soon completed. However, after the BNF spent hundreds of thousands of dollars (an amount comparable to the MBNF TSS) an EIS was produced, but in response to pressure from the timber industry and a Wyoming Congresswoman, that EIS was never released to the public. The ASQ amendment never occurred.

In light of this history, it is likely the BHNF will refuse to amend the current LRMP to lower the harvest level and achieve sustainable harvest within the foreseeable future. In my assessment, such a pattern of misconduct could lead to a challenge under the Racketeering, Influenced and Corrupt Organizations Act (RICO).

Authors' response: We did not address this comment because it is not specific to the interim report. The interim report and RMRS-GTR-422 was intended to provide science-based information for future discussions on forest management on the BHNF.

1. OPERABILITY, ACCESSIBILITY AND RESTOCKING RESTRICTIONS

Page 6 of the draft GTR states:

"In 2019 the USDA Forest Service, Forest Inventory and Analysis Program (USDA 2019) identified 765,733 acres of timberland: (suitable), as forestland that is producing or is capable of producing 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn from timber utilization by statute or administrative regulation. Lands inaccessible and inoperable were included."

(emphasis added.). The underlined sentence is ambiguous. Does it mean the 2019 inventory accounted for trees on these lands as being not harvestable? Or does it mean the inventory assumed trees on these lands could be harvested? Please clarify this in the final GTR. If the latter interpretation is correct, this further undermines the reliability of the draft GTR analysis by assuming trees on such lands could be harvested and contribute to the sustained yield.

NFMA prohibits logging on lands where regeneration cannot be assured within 5 years of harvest. For the BHNF, this includes lands with high (e.g., 25%) rock content, and hydric soils. Restocking is also problematic at lower elevations and on hotter, drier sites, such as south-facing slopes. If lands are inaccessible, this also implies any mature trees growing in those areas will not be harvestable.

Please ensure the final GTR properly accounts for all such restrictions on timber harvest, including rock content, soil conditions, inaccessibility, and all other operability and accessibility constraints that would preclude logging on lands that are in the suitable timber base and contain trees that might otherwise be harvestable.

Authors' response: In RMRS-GTR-422, appendix A we included a section on land area. In this appendix we acknowledged the difference between available and suitable lands for timber production. We suggest that the reviewer read *Appendix A: Land Area* for a detailed discussion concerning the comment.

2. ESTIMATING TREE MORTALITY

Beyond accounting for the influence of logging constraints, estimating the sustainable harvest level also requires an estimation of the effects of tree mortality. Mortality does vary based on climate, pine beetle abundance and other factors (e.g., blow down).

Although pine beetles are declining, it is reasonable to expect fires to increase in the coming years. This is partly due to climate change and partly to the creation of a younger forest dominated by black bark ponderosa that are not as fire resistant as the older yellow bark trees. Many sites that are logged also tend to exhibit considerable regeneration which not only requires future thinning but also results in increases in ladder fuels which contribute to the incidence of catastrophic fires rather than less intense understory fires.

For these reasons, the final GTR should err on the side of caution and assume tree mortality in the coming decades will be comparable to the past decade. This will help ensure whatever number the agency derives for sustained yield will, in fact, be sustainable. If the agency were to assume an overly conservative mortality rate which underestimates the true loss of trees from fire, beetles and other influences, this may only perpetuate the non-sustainable condition on the BHNF.

Authors' response: In RMRS-GTR-422, the 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

3. ENSURING SUSTAINABLE HARVEST

> Page 19 of the draft GTR lists the following 6 scenarios considered in the report:
>
> Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5%.
>
> Scenario 2: amount of standing volume required to sustain an ASQ of 181,000 CCF (i.e., Forest Plan) using a growth rate of 2.5% and a long-term mortality rate of 1.04%.
>
> Scenario 3: reduction of harvest from 153,534 CCF (2019) to 85,000 CCF with
>
> differing mortality rates (0.26 to 2.98%).
>
> Scenario 4: reduction of harvest from 153,534 CCF (2019) to 75,000 CCF with
>
> differing mortality rates (1.04 to 2.98%).
>
> Scenario 5: reduction of harvest from 153,534 CCF (2019) to 70,000 CCF with
>
> differing mortality rates (1.04 to 2.98%).
>
> Scenario 6: the potential harvest if mortality decreases and remains at the historical low of 0.26%.
>
> Scenarios 1 and 2 are admittedly not sustainable and do nothing to achieve a sustainable timber program. Page 25 of the draft GTR describes Scenario 3 as "reducing harvest volume from 153,534 CCF that occurred in 2019 to 125,000 CCF in 2020 and continuing in a linear fashion to decrease the harvest volume to 85,000 CCF per year over the next 10 years." Scenario 4 is similar. Scenario 5 represents a 5-year reduction. In my assessment, all of these scenarios are unlawful. MUSYA and NFMA do not allow the agency to continue selling timber from a National Forest at a non-sustainable rate for years. They impose an on-going obligation to ensure each Forest has a sustainable logging program. It is shocking that the draft GTR does not include a single scenario where logging is immediately reduced to comply with the law.
>
> I realize the RMRS is the research arm of the Forest Service, and its role is providing the best available information rather than using information to make policy decisions on National Forest timber programs. However, the RMRS does have an obligation to help provide information that

will help the administrative arm comply with the law. To this end, the final GTR should include scenarios where the timber harvest level is reduced immediately to a sustainable level.

If new information comes to light in the future that would allow for higher harvest levels than are calculated in the final GTR , this can be addressed through a Forest Plan amendment or revision to account for the new information. For now, the best available information indicates the BHNF logging program is not sustainable, has not been sustainable for years, and must be reformed as quickly as possible to achieve sustainability. There is no legal obligation for the agency to continue selling timber non- sustainably for the benefit of private corporations; there are obligations to ensure timber and other forest resources are managed for yields that can be sustained in perpetuity.

The timber industry has profited from decades of non-sustainable harvest. It is time to end this illegal program and return the Black Hills to sustained yield as quickly as possible. I implore the RMRS to develop a final GTR that will help the BHNF meet these obligations.

Authors' response: In RMRS-GTR-422, we changed our approach to the scenario development and increased the number of scenarios from 6 to 60. In this report, table 4 contains the elements that were in the draft report table 1. And as the reviewer specified, depending on the FIA report there were estimates of all softwoods versus estimates of only ponderosa pine. We expanded table 4 with detailed footnotes to document the nuances, assumptions, and interpretation of past reports. We expanded the section titled *Assessing Past FIA Reports* to identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these reports, and we describe how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* described our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions.

Comment: Conclusion

During the Black Hills Stakeholders Meeting on April 3, 2020, I was not surprise to hear representatives of the timber industry making the same claims they've been making since I first became involved in National Forest issues back in the 1980s — that the USFS needs to maintain a high level of harvest to protect the forest and the industry itself. As the past 20 years have demonstrated, the BHNF logging program has actually increased the risk of fires and pine beetle spread. Furthermore, by incessantly pressuring the USFS and Congress to maintain excessively high logging levels on this public forest, the timber industry has become the source of its own crisis: it has cut so many trees that there are no longer enough remaining to sustain the logging program at anywhere close to the levels it has profited from in recent decades. It is my hope that the analysis you are performing in the GTR study will help resolve this crisis once and for all, shifting the BHNF to a sustainable timber harvesting program while protecting wildlife and other important components of this unique forested ecosystem.

Authors' response: RMRS-GTR-422 was intended to provide science-based information for future discussions on forest management on the BHNF.

Reviewer #5

Comment #: 335

Description of the comment/ issue /question: Consideration of climate change. The Draft GTR acknowledges the importance of climate and weather in forest dynamics. The long-term mortality of ponderosa pine on the Black Hills NF has likely already been influenced by our warming climate. We recommend that the GTR acknowledge this ongoing change. Climate warming is only likely to accelerate in the coming decades, which will likely cause increased mortality from fire and beetle epidemics on the Black Hills. Inferring potential forest dynamics only from past conditions, as the Draft GTR states, is likely to underestimate future mortality.We note that some industry and local government commentators argue that forest mortality rates over the last two decades are likely higher than the historical average and so the Draft GTR should not use recent mortality rates as a basis for projections. Climate change projections suggest that precisely the opposite is true: that recent mortality events due to fire and beetle infestations on the Black Hills NF have likely been worsened by climate warming, and that such events are likely to recur more often as climate warming accelerates.

Reviewer's proposed or suggested change: We suggest that the Draft GTR acknowledge that the ongoing and future impacts of climate change will likely increase the annual mortality rate on the Black Hills National Forest above the average of the last 60 years, demonstrating that the selected 1.04% rate is likely very conservative.

Authors' response: In RMRS-GTR-422, we expanded our mortality discussion to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In this GTR, we also added a section titled *Understanding Disturbance and Tree Mortality* that included discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence showed longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality as they begin to fall, will increase wildfire hazard. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognized that mortality rates over the past 60 years have varied and we have shown this variation in table 1 t by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledged that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #335 continued.

Description of the comment/ issue /question: – Lands with restricted logging in the current forest plan. For purposes of estimating sustainable levels of logging, the Draft GTR appears to assume that lands that cannot be logged are available for sawtimber production.

It is possible that suitable lands that are inoperable, uneconomic, restricted, or constrained from commercial logging by standards and guidelines or other Forest Plan provisions may add up to tens of thousands of acres, representing a sizable fraction of the 765,733 acres the Draft GTR assumes to be suitable. Removing those acres from the report's estimate of lands available for sawtimber would result in a more accurate picture of the volume of timber that the Black Hills NF can sustainably produce for industry.

Description of the comment/ issue /question: We suggest that the Draft GTR: (1) estimate how standards, guidelines and other constraints influence how much of the sawtimber in the suitable base can actually be harvested; (2) base its analysis of suitable lands on an estimate that excludes acreage that is, as the report describes them, inoperable, uneconomic, restricted, or constrained from commercial logging; and (3) at a minimum, explain why the Draft GTR retained those lands inoperable, uneconomic, restricted, or constrained from commercial logging in its estimate of the acreage and volume of timber in the suitable base.

Authors' response: Our scenarios are based on the acres defined as the suitable timber base within the FIA. We address the difference in suitable and available timber harvest in RMRS-GTR-422 appendix A. The reviewer is correct that our scenarios do not exclude acreage within the suitable timber base that is inoperable, uneconomic, restricted, or constrained from including harvest reductions for other resources. The intent of RMRS-GTR-422 was to demonstrate different impacts of harvesting and mortality levels using 60 different combinations of harvest, mortality and growth rate. As a part of USFS Research and Development, we provide science-based information that may inform planning. Our analysis in this GTR provided a broad look at the entire BHNF and did not include estimates by forest structural stages.

We were charged to provide scenarios that estimate only harvest levels within the context of growth and mortality and did not address other natural resources such as wildlife or recreation. However, we acknowledged that balancing timber management with other resources was designated in the Black Hills National Forest Plan.

Description of the comment/ issue /question: – Omitted word? The Draft GTR states: "The bottom line is that net growth (gross growth minus mortality) needs exceed harvest to accumulate wood volume in the Black Hills." Draft GTR, lines 564-565.

Reviewer's proposed or suggested change: We suggest that the Draft GTR, lines 564-565, state: "The bottom line is that net growth (gross growth minus mortality) needs **to** exceed harvest to accumulate wood volume in the Black Hills," adding the word in bold.

Authors' response: While that exact phrasing is no longer in RMRS-GTR-422, we appreciate the proofreading.

Reviewer #6

Comment #: 336

Line # or Figure #: Title

Description of the comment/ issue /question: Change "Nation" to "National"

Reviewer's proposed or suggested change "…National…"

Authors' response: We have changed the title of the document but thank you for noting the typo.

Comment #: 337

Description of the comment/ issue /question: It is important to understand that any data that is collected for inventory or research has inherent limitations. Those limitations are the result of protocols developed for collection of the data. Unfortunately, limitations can introduce biases in the data. Recognizing these limitations and biases is critical to proper interpretation of the data, and even is even more important if management decisions are to be made from the data that will have far-reaching long-term impacts.

Reviewer's proposed or suggested change: The authors need to review the limitations of FIA data with FIA analysts. Those limitations should be recognized and incorporated into the analysis and discussion.

Authors' response: In RMRS-GTR-422, table 4 contains the elements that were in the interim report table 1. And as the reviewer specified, depending on the FIA report there were estimates of all softwoods versus estimates of only ponderosa pine. In RMRS-GTR-422, we expanded table 4 with detailed footnotes to document the nuances, assumptions, and interpretation of past reports. We expanded the section titled *Assessing Past FIA Reports* to identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* describes our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions.

Comment #: 338

Line # or Figure #: 296

Description of the comment/ issue /question: The authors indicate the inventory sampling intensity was increased by establishing and collecting data from 130 additional plots in 2017 and 147 additional plots in 2019. Data from these newly established plots was combined with data from 255 previously established plots so that 438 plots provided data for the 2019 estimates including growth, mortality, removals and standing live volume for merchantable ponderosa pine 5 inches d.b.h and larger.

According to the Northern Research Station data for growth, mortality, and removals are calculated from the changes that occur on a plot between two points in time. The 225 previously established plots

are from the annualized inventory and reflect change because data was collected from two points in time: an earlier inventory and the inventory that provides the current data. The 277 plots established for the double intensification inventory were only measured once so the changes that provide growth, mortality, and removal data could not be measured. The error tables confirm this. Each table that reflects sampling error for growth, mortality, or removals includes the note “total number of plots in selected evaluations=225.”

Conversely, the error tables indicate standing live volume estimates reflect data collected from all 438 plots.

The error rates themselves also reveal limitations in the data. Higher sampling errors suggest more variation and diversity between plots. Because the standing volume tables are based on more plots the percent sampling error is much lower than for growth, mortality, and removals. Also, stratification of data into diameter classes and structural stages can also contribute to higher percent sampling error. The larger sample size for standing volumes appears to have helped compensate for stratification. A discussion of the percent sampling error and what it means would help readers understand the inherent limitations of the data."

Correct the paper to indicate that data collected from only 225 plots was used for the analysis of growth, mortality, and removals. However, 438 plots contributed to standing live volume analysis. Also, an explanation of the percent errors would be helpful so the reader understands the accuracy of the data.

Authors’ response: In RMRS-GTR-422, the section titled *Assessing Past FIA Reports,* we described where the values for the 2019 data came from in detail. In addition, we added table 3, which shows the number of plots measured for the 2017 to 2019 time-period and how it relates to past plot measurements. Providing this information allows the reader to understand which data is contributing to growth, mortality, removals, and standing live volume. FIA provided additional information based on stakeholder questions about measurement that can be found *Responses to Lawrence County Questions Regarding Black Hills National Forest Timber* (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733564.pdf).

Comment #: 339

Line # or Figure #: Table 1 caption

Description of the comment/ issue /question: Refers to figure 5 for a description of gross growth. Figure 4 has the description of gross growth. Correct the reference to figure 4.

Authors’ response: In RMRS-GTR-422, we added Box 1 to replace figure 4, which reviews the calculations of the gross growth, mortality, and other terms used in figure 11 in this GTR.

Comment #: 340

Description of the comment/ issue /question: The authors decided to use the 1.04% mortality rate observed by Walters et al. (2013) as a reasonable reflection of the long-term mortality that can be expected in the Black Hills. I disagree. That estimate is influenced by large fires and one of the largest mountain pine beetle epidemics to affect the Black Hills in 100 years.

A very conservative estimate going forward might be an average of the 1962 - 2011 mortality figures which would be 0.43%. Considering the current mortality as reflected by USFS Forest Health Protection monitoring is .003% (see calculations below) the actual mortality for the next 20 years may 0.26% or less. I say 20 years because that's probably when the next MPB epidemic will start.

Authors' response: The 60 scenarios in RMRS-GTR-422, included a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 341

Description of the comment/ issue /question: The scenarios developed for the modeling projections are based on direction from leadership on the Black Hills National Forest. The three questions that formed the basis of the scenarios were not developed in a collaborative atmosphere as indicated would occur during previous stakeholder meetings.

Authors' response: Based on the comments we received, we changed our approach to the scenario development and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 342, 343, 344, 345

Description of the comment, issue, or question: All scenarios developed were to be based on probable growth and mortality estimates. Unfortunately, mortality estimates used in the scenarios do not reflect current mortality and overestimate projected mortality.

it is important to understand data limitations when using the data to model into the future. Mortality data is based on change over time. The data reflects all of the tree mortality that occurred on a plot during every year between re-measurements. As previously stated, only data collected from the annual inventory was used to estimate mortality. The annual inventory is designed to re-measure plots every seven years in South Dakota, and every 10 years in Wyoming. So, mortality volume is the sum of volume of trees that died over the seven years between re-measurement of plots in SD, and 10 years in WY. Since this is not a real time estimate of mortality, it is sometimes referred to as a delay factor inherent in FIA data.

The Black Hills experienced a mountain pine beetle (MPB) epidemic that started in 1996 and ended in 2016. During that time ponderosa pine mortality was monitored annually by USFS Forest Health Protection (FHP) as opposed to being summarized over time by FIA. FHP uses a combination of techniques to estimate tree mortality. Prior to 2010 used a process called aerial sketch mapping in which the Black Hills were flown and a passenger in the aircraft drew polygons on a map indicating areas of mortality. From 2010 through 2016 high resolution aerial imagery was acquired and analysts used geographic information system tools to heads up digitize areas of mortality providing a highly accurate estimate of acres affected. After 2016 FHP returned to aerial sketch mapping but used a more refined digital mapping tool. All during the epidemic and through 2018 the remote sensing detection was combined with ground truthing using FHP survey and monitoring protocols.

According to insect and disease condition reports prepared by FHP ponderosa pine mortality caused by MPB in the Black Hills peaked in 2011 and steadily decreased thereafter.

By 2016, MPB had returned to endemic population levels across the Black Hills (Schotzko and Allen, 2016). By 2018 only 230 acres were affected by bark beetles in the Black Hills, and these were mostly scattered individual trees (Allen, Schotzko, and Dymerski, 2019). By 2019 only 29 acres of forest land on all ownerships (state, private, and all federal ownerships) in the Black Hills was affected by MPB caused tree mortality (2019 Aerial Detection Survey of the Rocky Mountain Region).

Given that MPB needs to mass attack trees 8 inches d.b.h. and larger in order to survive and reproduce, and that MPB must kill the host tree in order to survive, it is reasonable to assume a positive relationship between acres of dead trees and volume of dead trees. That is, the more acres of trees killed by MPB the more volume of trees killed by MPB. The reverse should also be true; that is, as fewer acres of trees are killed by MPB, less volume of trees are killed.

According to the FIA data and as presented in the draft GTR:

- The area of suitable timber base is 765,733 acres.
- The merchantable sawtimber volume on BHNF suitable timberland is 5,995,428 ccf.
- The average annual mortality in the BHNF in 2019 is 178,409 ccf

Given the above figures the average volume per acre on BHNF timberlands can be calculated as:

5,995,428 ccf / 765,733 acres = 7.82 ccf/acre

Given the average annual mortality expressed in the FIA data, the acres of dead trees would need to be:

178,409 ccf / 7.82 ccf/acre = 22,814 acres of timber

However, FHP data indicates that only 230 acres of timber were killed in 2018 and only 29 acres of timber were killed across all ownerships in 2019. Based on the average 7.82 ccf per acre the following volume losses should be expected:

2018: 230 acres * 7.82 ccf/acre = 1,789 ccf mortality forest wide

2019: 29 acres * 7.82 ccf/acre = 227 ccf mortality forest wide

The percent mortality of 227 ccf forest wide would translate to something less than .003% mortality. (227 ccf / 5,995,243 ccf = .003%) It is actually less than .003% because the 227 ccf is forest-wide across all ownerships; the 5,995,243 reflects BHNF Suitable timberland volume.

Why the big difference between FHP mortality and FIA mortality? FHP estimates mortality every year as part of their monitoring protocol. FIA summarizes mortality over time, and the time period used in this inventory included mortality that occurred during the MPB epidemic.

Nevertheless, the authors used the FIA mortality data and assumed that 178,409 ccf died in 2019. They further assumed in their modeling scenarios that MPB caused mortality would slowly decrease over the next 8 years to background levels. In reality, by 2019 MPB caused mortality had already decreased to background levels. By using the FIA mortality data the modeling scenarios gave inaccurate results. For these modeling projections, the FIA mortality data should not be used as a starting point, but should be considered as a guide over the long term.

None of the scenarios in the publication should start with the assumption that current annual mortality is 178,409 ccf. They should start with no more than .026% mortality. Scenarios should be built with input from the stakeholders group.

Authors' response: Based on the comments we received, we changed our approach to the scenario development and increased the number of scenarios from 6 to 60 in RMRS-GTR-422. We also added sections in the report that described the nuances, assumptions, and interpretation of past reports, by expanding table 4 to include detailed footnotes. We expanded the section titled *Assessing Past FIA Reports* and have an introductory paragraph that identified the nuances associated with the different reports through time (please refer to this paragraph for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* the second paragraph summarized the nuances associated with these reports, and we described how we used these reports to provide some context for the scenario development. In the section titled *Scenario Development,* the first paragraph described our assumptions and discusses in detail how the scenarios were developed and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions.

The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 346

Description of the comment/ issue /question: Scenario 1 assumes the 178,409 ccf mortality and current harvest level (153,534 ccf) will continue for the next 35 years when the Forest will run out of timber.

While the authors admit this is not realistic, it doesn't even reflect reality for 2019. Unfortunately, some participants in the April 3rd stakeholders meeting quoted this scenario as if it will happen under current timber harvest levels. Consequently, the scenario did not meet the authors intent to provide "context for evaluating and planning future timber management options for BHNF". Because this scenario uses inaccurate and misleading mortality data and is being misinterpreted by readers, we recommend it be excluded from the publication.

Authors' response: Scenario 1 and the mortality rate of 2.98% in the interim report were not used in RMRS-GTR-422 because we received many comments concerning the scenarios. Based on the comments we received we changed our approach to the scenario development and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled U*nderstanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 347

Description of the comment/ issue /question: The second scenario is difficult to accept because it is overly simplistic. Growth and mortality are not constants, but they are modeled as such with variation averaged away in percentiles. Also, the mortality rate seems high. Prior to the MPB epidemic average mortality was 0.26% or less. Historically, MPB epidemics of the magnitude recently experienced occur once every hundred years. Given that mortality on the Black Hills is currently close to zero, and that climate change could negatively affect net growth, an average mortality of 0.43 percent would be very conservative and should probably be closer to 0.26%. Fire will contribute to mortality in the future, but the extent of that mortality is not predictable. We are currently in a wet period. If this continues we can probably expect little fire activity well into the future. More large fires could have significant a significant affect on future timber harvests and sustainability should be re-evaluated if and when they occur. Considering the impact of the scenarios on management decisions and the future of the forest products industry, the scenarios should not be based on presumptions that may or may not occur for a long time.

Reduce the expected average annual mortality in Scenario 2 to 0.26%.

Authors' response: Based on the comments we received we changed our approach for the scenario development in RMRS-GTR-422 and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the

1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 348

Description of the comment/ issue /question: Scenarios 3-6 all begin with 178,409 ccf annual mortality and slowly reduce that on the assumption that mortality will decrease as the MPB epidemic subsides. As exemplified by FHP data the MPB has been in endemic population since 2016, and by 2019 mortality from MPB was at background levels – as low as 227 ccf across all ownerships of the Black Hills. The scenarios need to be re-calibrated to reduce the effects of mortality particularly in the first decade.

Start with the actual annual mortality of 0.26% or less and slowly increase it over time. Obtain input from stakeholders.

Authors' response: Based on the comments we received we changed our approach for the scenario development in RMRS-GTR-422 and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 349

Description of the comment/ issue /question: In the discussion the authors discuss the value of thinning to increase tree growth rates. However, they also need to discuss the value of thinning to reduce mortality from MPB epidemics and fire. There should also be mention of the need for faster response to MPB population outbreaks that occur at the beginning of epidemics. If the Forest does not respond quickly to outbreaks, the size and scope of the affected area can quickly overwhelm the ability of the Forest to respond. There is a growing pool of photographic and written evidence supporting the resiliency of ponderosa pine forests to MPB epidemics and fire if the forest is thinned.

Authors' response: In RMRS-GTR-422 the *Introduction* and *Management Opportunities* sections of the report, we added discussion of the value of thinning to reduce mortality from MPB, wildfire, and drought. Specifically, we highlighted some of the long-term research studies conducted on the BHNF that study the relationship of stand density to resistance and resilience to various disturbances. Within the *Moving Forward* section, we discussed the need for monitoring to provide realized growth and mortality rates in order to adjust harvest levels to maintain long-term timber sustainability.

Comment #: 350 was a list of literature and this was not a comment it was the literature cited that was attached to the reviewer comments.

Authors' response: Thank you for the references to highlight your comments.

Reviewer #7

Comment #: 302

Line # or Figure #: General - climate change

Description of the comment/ issue /question: Thank you for the opportunity to comment on the draft report: "Timber Growth and Yield in the Black Hills Nation Forest: A Changing Forest" dated March 2020.

This report represents a rigorous analysis of the changing condition of the Black Hills National Forest, and provides critical information needed to ensure sustainable management. The situation is concerning and challenging, with strong implications for the forest industry, jobs, tourism, ecological values, wildlife, and forest ecosystem services including freshwater and carbon sequestration.

The course ahead may be challenging, but we believe there are many opportunities for stakeholders and the USFS to work together to improve the condition and sustainability of the forest. The report suggests that "Both mechanical thinning and prescribed fire are warranted to produce large trees of both commercial and ecological value at a faster rate."

Reviewer's proposed or suggested change: One area that warrants further analysis is how climate change may impact timber supply and the whole suite of benefits that the forest provides.

We look forward to continued engagement on the BHNF advisory committee, the subcommittee/working group on timber sustainability, and other opportunities to collaborate and engage that may arise. "

Authors' response: We added a section in RMRS-GTR-422 on the potential impacts of climate change under the sections titled *Understanding Disturbance and Tree Mortality* and *Changing Climate* and discussed how climate might influence disturbances and subsequent tree mortality. This section also was expanded to focus on a diversity of disturbances that can lead to different levels of mortality.

Reviewer #8

Comment #: 67

Line # or Figure #: 84/85

Description of the comment/ issue /question: Because the additional FIA plots have not been remeasured, there is no growth or mortality data for these plots.

Reviewer's proposed or suggested change: Add a section regarding the lack of remeasurement of new plots, and the associated impacts on the FIA data.

Authors' response: In RMRS-GTR-422 the section titled *Assessing Past FIA Reports,* we described where the values for the 2019 data came from in detail. In addition, we added table 3, which shows the number of plots measured for the 2017 to 2019 time-period and how it relates to past plot

measurements. Providing this information allows the reader to understand which data is contributing to growth, mortality, removals, and standing live volume. FIA provided additional information based on stakeholder questions about measurement that can be found in *Responses to Lawrence County Questions Regarding Black Hills National Forest Timber* (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733564.pdf).

Comment #: 68

Line # or Figure #: 96

Description of the comment/ issue /question: The growth rate only includes plots remeasured in 2019, not new plots established as part of the double-intense plots. Add a section regarding the lack of remeasurement of new plots, and the associated impacts on the FIA data.

Authors' response: In RMRS-GTR-422 the section titled *Assessing Past FIA Reports* we described where the values for the 2019 data came from in detail. In addition, we added table 3, which shows the number of plots measured for the 2017 to 2019 time-period and how it relates to past plot measurements. Providing this information allows the reader to understand which data is contributing to growth, mortality, removals, and standing live volume. FIA provided additional information based on stakeholder questions about measurement that can be found in *Responses to Lawrence County Questions Regarding Black Hills National Forest Timber* (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733564.pdf).

Comment #: 69

Line # or Figure #: 121

Description of the comment/ issue /question: Inconsistency in acers between FIA and Forest Plan. Add the information that provided separately which described the acreage differences between FIA and Forest Plan

Authors' response: We addressed the difference in suitable and available timber harvest in RMRS-GTR-422 appendix A.

Comment #: 70

Line # or Figure #: 170

Description of the comment/ issue /question: Change rationale to rational and change 'rationale' to rational.

Authors' response: We have fixed the misspelling in RMRS-GTR-422.

Comment #: 71

Line # or Figure #: 331

Description of the comment/ issue /question: Discuss the impacts of small samples of large diameter trees and negative gross growth.

Authors' response: The NRS-FIA responded to these concerns in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns, Challenges, and Assertions* in April 2020

(https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733565.pdf). They state the following: "1) The most accurate way to estimate change is to use FIA's 'Accounting Method.' This creates credits and debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. 2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25"–26.9" diameter class had a large measured 'loss' of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. 3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. 4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period."

Comment #: 72

Line # or Figure #: 70

Description of the comment/ issue /question: The van Mantgem paper, Widespread increase of tree mortality rates in the western United States is taken wildly out of context in its citation. The study "limited our analyses to data from repeated censuses in undisturbed forest stands more than 200 years old"; as such, the mortality rate of 1-2% is hardly applicable to the most heavily managed forest in the USFS system. Remove the reference to the van Mantgem paper.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, we looked at recent FIA reports from across the Interior West and in RMRS-GTR-422 we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West,* which includes van Mantgem but also other authors. By expanding the literature, we calculated mortality for the ponderosa pine forest type across all land ownership. Based on that widespread information, the average mortality was 0.79% (table 2 in RMRS-GTR-422) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 73

Line # or Figure #: 373

Description of the comment/ issue /question: Discuss the "lag factor" in FIA data and how mortality data will continue to show previous MPB mortality,

Authors' response: While the MPB epidemic has been declared over for now, mortality rates in the future derived from remeasurement of FIA plots will demonstrate the change in mortality. In RMRS-GTR-422 within the *Moving Forward* section of the report, we discussed the need for monitoring to provide realized growth and mortality rates in order to adjust harvest levels to maintain long-term

timber sustainability. The "lag factor" mentioned in the comment is about the temporal resolution of the remeasurement period. For example, a plot first measured in 2012 (Time 1) and then remeasured in 2019 (Time 2) calculates the mortality rate between that time period. It is not the mortality rate in 2019, but the mortality rate over that 7-year period (Time 1 to Time 2). From a MPB disturbance mortality contributor, a future remeasurement at this same plot would likely have a lower mortality rate due to the end of the MPB epidemic, if no other disturbances at that location occurs. Plots remeasured with Time 1 in 2020, 2021, etc., will not reflect MPB mortality, but plots measured in 2020, 2021 at Time 2 measurements will reflect mortality since the first measurement was within the epidemic window.

Comment #: 74

Description of the comment/ issue /question: 387

Description of the comment/ issue /question: The high gross and net growth in 1999 shows the potential of the BHNF to produce and accumulate fiber volume even though harvest was at high levels.

Authors' response: In the section *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time* in RMRS-GTR-422, we discussed the changes in growth and mortality over the past 60 years. Up until 1999, many years of low mortality rates and harvest levels that did not exceed net growth allowed standing live volume to increase, which demonstrated the potential of the BHNF to produce and accumulate sawtimber, even at high harvest levels. However, as shown in the 2000s, high levels of standing live inventory can lead to greater susceptibility to insects and fires.

Comment #: 75

Line # or Figure #: 394-397

Description of the comment/ issue /question: This section portrays harvest as the primary driver in loss of standing inventory, even during the peak of the MPB epidemic. Detail should be added that harvest increased as a component of the joint response plan developed by industry, the USFS, state forestry agencies, and counties in Wyoming and South Dakota. The harvest increase was being driven by the MPB epidemic; a point that is absent from the discussion.

Authors' response: In the *Introduction* of RMRS-GTR-422, we discussed the high standing live volume around 1999 and the collaborative approaches to coordinate efforts to reduce MPB mortality across the Black Hills to provide context.

Comment #: 76

Line # or Figure #: 431-433

Description of the comment/ issue /question: The growth and yield calculations and scenarios appear to have been designed to present a limited set of outcomes. I'm curious why was the stakeholder group not asked to assist in the development of these scenarios? From the beginning, it was agreed that the process would be collaborative and cooperative, and that didn't occur on the scenarios.

Authors' response: We received similar comments and therefore we expanded the number of scenarios we evaluated in RMRS-GTR-422. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on

the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development*. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 77

Line # or Figure #: 440-442

Description of the comment/ issue /question: This sentence appears to show bias regarding the way the scenarios were developed. I highly recommend this be reworked.

Authors' response: In RMRS-GTR-422, we changed our approach and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these FIA reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* describes our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 78

Line # or Figure #: 452

Description of the comment/ issue /question: Again, more information should be added regarding new plots not remeasured, and how the growth rate is only based on the existing plots that were remeasured.

Authors' response: In RMRS-GTR-422, the section titled *Assessing Past FIA Reports* we describe where the values for the 2019 data came from in detail. In addition, we added table 3, which shows the number of plots measured for the 2017 to 2019 time period and how it relates to past plot measurements. Providing this information allows the reader to understand which data is contributing to

growth, mortality, removals, and standing live volume. FIA provided additional information based on stakeholder questions about measurement that can be found in *Responses to Lawrence County Questions Regarding Black Hills National Forest Timber* (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733564.pdf).

Comment #: 79

Line # or Figure #: 453-455

Description of the comment/ issue /question: Missing word, change to "no mathematically sound way" or just "no mathematical way". Additional justification for the 2.5% would be appreciated, rather than simply stating that it's an assumption. Also, given the higher growth rates experienced in years immediately prior to the MPB epidemic, this value likely underestimates the growth potential of the BHNF. This is compounded by the fact that with reduced competition, increased available water, and favorable conditions following the mountain pine beetle epidemic, there is a high likelihood that ingrowth and gross growth will increase in future years. Potential increased annual growth should be modeled.

Authors' response: In RMRS-GTR-422, we changed our approach and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled U*nderstanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these FIA reports, and we describe how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* describes our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 80

Line # or Figure #: 471-476

Description of the comment/ issue /question: There is continued reference to 1.04% mortality as the "historical norm", however the data doesn't support that assumption. For at least some scenarios, net growth and % mortality data prior to 2011 should be used, ~.25%. Certainly not the 1.04%. The

difference in these two values equates to ~50,000 CCF/yr. difference. For at least some scenarios, net growth and % mortality data prior to 2011 should be used.

Authors' response: In RMRS-GTR-422, we changed our approach and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these FIA reports, and we describe how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* described our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 81

Line # or Figure #: 481

Description of the comment/ issue /question: Add a methodology section detaining how every scenario was run, what software, any additional assumptions not listed, and any other pertinent methodology information.

Authors' response: We provided additional information on our assumptions and methodology for the scenarios we evaluated in RMRS-GTR-422. Refer to the sections *Approach* and *Scenario Development* for further detail.

Comment #: 82

Line # or Figure #: 493-494

Description of the comment/ issue /question: "However, the history of MPB activity shown in figure 1 precludes this scenario from reflecting reality" This is an opinion, there is sufficient data to show that this could indeed be a viable scenario. Revise sentence

Authors' response: We have revised the section in RMRS-GTR-422 and this statement is no longer there.

Comment #: 83

Line # or Figure #: 495

Description of the comment/ issue /question: While there were several "worst case" scenarios, there was there no "Best Case" scenario presented for sustainable harvest, a high growth rate of 2.5-3.12%, and low mortality of ~.26%. The stakeholders should be involved in developing some of the scenarios.

Authors' response: In RMRS-GTR-422, we changed our approach and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current the MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled Growth*, Mortality, Harvests, and Standing Live Tree Inventory Over Time,"* we summarized the nuances associated with these FIA reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* describes our assumptions, discusses in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 84

Line # or Figure #: 550

Description of the comment/ issue /question: Revise to include optimistic scenario outcomes rather than only pessimistic outcomes, as outlined above.

Authors' response: In RMRS-GTR-422, we changed our approach and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019.We expanded our discussion in the section titled U*nderstanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these FIA reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* describes our assumptions, discussed in detail how the scenarios were

developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 85

Line # or Figure #: 580

Description of the comment/ issue /question: Again, current low stocking levels could result in greater growth rates going forward.

Authors' response: In RMRS-GTR-422, we changed our approach and increased the number of scenarios from 6 to 60. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time (please refer to this section for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* we summarized the nuances associated with these FIA reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* described our assumptions, discussed in detail how the scenarios were developed, and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 86

Line # or Figure #: 582-598

Description of the comment/ issue /question: How could this information be applied in the scenarios to optimize growth rates?

Authors' response: In the *Management Opportunities* section of RMRS-GTR-422, we discussed several opportunities that can enhance tree growth and reduce future mortality rates. By expanding the growth and mortality rates within the scenarios evaluated, we have included some of these management opportunity outcomes.

Reviewer #9

Comment #: 266

Line # or Figure #: 64-68

Description of the comment/ issue /question: "If the current (2019) annual sawtimber harvest of 153,534 CCF per year (CCF = 100 cubic feet) were to continue, the live sawtimber volume will be depleted in the next several decades."

Authors should include the side-boards being used to make such a bold statement. For example, the authors should state that this is based on mortality rates only seen during high wildfire and mountain pine beetle epidemics and that gross growth in the FIA data is low due to an issue with the 25.0"-26.9" size class (shows a negative gross growth due to error in data collection).

Authors' response: Throughout RMRS-GTR-422, we added information about our assumptions and definitions concerning how we developed and applied the scenarios. We added Box 2 to describe and clarify the term "sustainable."

The NRS-FIA responded to the concern about the 25.0-–26.9" size class in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns, Challenges, and Assertions* in April 2020 (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733565.pdf). They state the following: "1) The most accurate way to estimate change is to use FIA's *Accounting Method.* This creates credits and debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. 2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25"–26.9" diameter class had a large measured 'loss' of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. 3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. 4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period."

Comment #: 267

Line # or Figure #: 66-68

Description of the comment/ issue /question: "To meet the current allowable sale quantity (ASQ) of 181,000 CCF as described in the BHNF Plan, a standing live sawtimber volume of approximately 12 million CCF would be required." Authors should include the side-boards being used to make such a bold statement. For example, the authors should state that this is based on mortality rates only seen during high wildfire and mountain pine beetle epidemics and that gross growth in the FIA data is low due to an issue with the 25.0"-26.9" size class (shows a negative gross growth due to error in data collection).

Authors' response: Based on the comments we received we changed our approach concerning scenario development and increased the number of scenarios from 6 to 60 in RMRS-GTR-422. The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over;, however, the risk for wildfire, weather events, and other disturbances is still plausible. The Northern Research Station Forest Inventory and Analysis (NRS-FIA) responded to the concern about the 25.0–26.9" size class in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns, Challenges, and Assertions* in April 2020 (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733565.pdf). They state the following: "1) The most accurate way to estimate change is to use FIA's 'Accounting Method.' This creates credits and debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. 2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25"–26.9" diameter class had a large measured 'loss' of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. 3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. 4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period."

Comment #: 268

Line # or Figure #: 71-73

Description of the comment/ issue /question: "Nevertheless, these harvest levels would allow the live sawtimber inventory amounts to increase to 6 million CCF in approximately 60 years and return to the level needed to support ASQ as identified in the current forest plan (181,000 CCF) within a century" Authors infer that there is no difference in harvesting 70k - 115k ccf/yr on net growth. They also don't show a scenerio run for the next century. Please explain further.

Authors' response: We removed this statement from RMRS-GTR-422 and although we do not evaluate the scenarios for 100 years, we increased the scenarios from 6 to 60 and calculated change in volume for 80 years for all 60 scenarios (refer to figure 13).

Comment #: 269

Line # or Figure #: 77

Description of the comment/ issue /question: "…especially mortality rate disclosed by Forest Inventory and Analysis (FIA) data." Authors need to include under this keypoint that the most recent mortality rates in the FIA data (2017/2019 have a delay factor to them. As the epidemic was declared over in 2016, the measurement of FIA plots from 2017-2019 will capture epidemic level mortality and does not reflect current mortality rates.

Authors' response: In RMRS-GTR-422, the 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development*. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 270

Line # or Figure #: 111-118

Description of the comment/ issue /question: "The BHNF has supported a thriving forest industry for over 100 years (Freeman 2015). The BHNF is approximately 1.2 million acres in size, of which the Forest Plan Amended in Phase II (USDA FS 2005, Appendix G-3) identifies 865,890 acres as suitable and available for timber harvest. In 2019 the USDA Forest Service, Forest Inventory and Analysis Program (USDA 2019) identified 765,733 acres of timberland: (suitable), as forestland that is producing or is capable of producing 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn from timber utilization by statute or administrative regulation. Lands inaccessible and inoperable were included."

Authors attempt to disclose that there is a difference in suitable and available acres for timber harvest between the Forest Plan and the FIA suitable acres of approximately 100k acres but fail to address how this has underestimated standing live volume available for timber harvest under the FIA analysis.

Authors' response: We addressed the difference in suitable and available acres for timber harvest in RMRS-GTR-422, appendix A; please refer to this section for specific details.

Comment #: 271

Line # or Figure #: 329-331

Description of the comment/ issue /question: "Growth, mortality, removals, and standing live volume of the merchantable 5 inch plus and 9 inch plus were estimated the same for 2019 as estimated for the 2017 data."

Please explain the almost 13% change in mortality listed in Table 1 from 2017-2019. Please explain how mortality was collected and analyzed through FIA for 2017 and 2019 data and how that compares to 2011 data.

Authors' response: In RMRS-GTR-422, the section *Assessing Past FIA Reports* we discuss how each of the FIA reports sampled the plots. We provided information about the 2011 and 2017/2019 measurement periods and added table 3 to show how many plots were measured for calculation of the different variables.

Comment #: 272

Line # or Figure #: 335-337

Description of the comment/ issue /question: "Using the above sources, data were compiled for the ponderosa pine forests of the BHNF from 1962 through 2019. In addition, the 1962 and 1984 reports included a small quantity of white spruce (*Picea glauca*) volume as the publications only reported softwoods.

Authors need to disclose that the 2017/2019 FIA reports do not include white spruce, however, it is part of the ASQ and timber sale program on the BHNF.

Authors' response: RMRS-GTR-422 was intended to address the sustainability of ponderosa pine sawtimber. However, we recognize that white spruce could contribute to ASQ and the timber sale program. In table 4, we highlight which years included white spruce and ponderosa pine in the volume estimates versus those that only report ponderosa pine.

Comment #: 273

Line # or Figure #: 367-369

Description of the comment/ issue /question: "As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

The statement is contradicted by other facts presented in this GTR. The 1.04% mortality rate represents a period of above average mortality in the Black Hills (see table 1). The weighted average mortality percent from 1962 through 1999 is 0.23%. 1962 through 1999 included the 3rd largest mpb epidemic in the last 120 years and 94,000 acres of wildfire damage. Additional support for the conclusion that the 1.04% mortality factor is too high is that the BHNF has just gone through two decades of significantly higher mortality. In fact, it is likely that the BHNF has not seen this type of high mortality for over 100 years. Going forward, the result of this mortality will be dramatically reduced stocking levels of 4C and 3C stands which have the highest risk to mountain pine beetles and, to a lesser extent, reduced the fire hazard rating for the Black Hills National Forest.

Authors' response: In RMRS-GTR-422, we expanded our mortality discussion to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In this GTR, we added a section titled *Understanding Disturbance and Tree Mortality* that included discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality as it falls down is expected to increase wildfire hazard. Under the subsection titled *Mortality*

Rates within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and we have shown in table 1 those differences by mortality agent in RMRS-GTR-422. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 274

Line # or Figure #: 370-372.

Description of the comment/ issue /question: "...van Mantgem recent trends in mortality in pines across the Western United States over past 4 decades have been increasing and ranged from 1 to 2%."

Van Mantgem study involved "...data from unmanaged old forests…" and the Black Hills NF is not an unmanaged old growth forest. The use of van Mantgem's data to indicate trends in mortality with the Black Hills NF is not applicable to the Black Hills NF. It is recommended to remove the van Mantgem paper as a reference for mortality rate.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, for RMRS-GTR-422, we looked at recent FIA reports from across the Interior West. In this GTR, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West,* which includes van Mantgem but also other authors. Based on FIA reports from across the Interior West, the average mortality was 0.79% (table 2) and provides good rationale that mortality rates around the 0.16 to 0.26%. However, we did provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 275

Line # or Figure #: 100

Description of the comment/ issue /question: "Using 2019 FIA data as a starting point and an annual mortality rate of 0.26% (i.e. optimistic), an annual sawtimber harvest of 115,000 CCF could be realized."

Authors should remove the word, "(i.e. optimistic)", as it injects bias in a scientific GTR. The authors indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity..." in this GTR. Current forest health surveys in the Black Hills states, "Black Hills NF, 20 acres, aerial detection of MPB in 2019." and "Mountain pine beetle remains low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." (see USDA

Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. See page 8 and 12)

Authors' response: We tried to remove editorialized statements. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 276

Line # or Figure #: 387-397

Description of the comment/ issue /question: This GTR indicates that in 1999 the live standing inventory was 15,353,000 ccf with a gross growth of 380,000 ccf a noted peak in gross growth.

It is recommended that the GTR address the strong correlation between mountain pine beetle mortality and higher stocked ponderosa pine stands. (see José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061)

Authors' response: In RMRS-GTR-422, we added discussions about stand density and MPB susceptibility in several sections including *The Setting* and *Moving Forward.*

Comment #: 277

Line # or Figure #: 450-455, and other places where gross growth is discussed.

Description of the comment/ issue /question: When discussing gross growth rates, the authors state they, "found no mathematically [sic] way to justify a gross growth rate to use…" Instead, they arbitrarily picked a number lower than the lowest sawtimber gross growth rate they report, despite stating that the gross growth rate was 3.12 percent in 2017. However, a meaningful process to justify the gross growth rate would be to use the average of the two stated values: 2.815. Another way to look at this, would be to look at the growth rate reported by FIA for all plots that were measured in the year 2019. Importantly, the plots measured in 2019 were all permanent plots - the only plots used in the FIA study to report growth and mortality. This provides a good estimate of the actual growth in 2019. When the permanent plots measured in 2019 (approx 75 percent of total permanent plots) are used to report gross growth, the reported value is 4.16 percent (FIA reports available upon request). The authors could just as easily use the figure (4.16 percent) from the most current measurements which also contains 75 percent of all the remeasured plots from which gross growth was reported from throughout the FIA measurements. Notably, a higher gross growth figure is in-line with previously published work from the authors, including the 2019 publication "Differing Ponderosa Pine Forest Structures, Their Growth and Yield, and Mountain Pine Beetle Impacts: Growing Stock Levels in the Black Hills".

We recommend using a minimum gross growth value of 2.815 along with the more supportable value of 4.16 percent in all scenarios. Both numbers are supported mathematically and by the FIA data.

Authors' response: The choice of growth rates used in the scenarios has an impact on how much sawtimber can be harvested on a sustainable basis. To address this, in RMRS-GTR-422, we examined the range of gross growth rates. For the growth rates, we derived an average growth rate of 2.54% from the 1962, 1984, 1999, 2011, and 2019 values. We bracketed the minimum gross growth rate at 2.33% that

was reported in 2019 and a maximum growth rate of 2.73% reported in 1962. We developed scenarios that utilize these three growth rates. The use of Growing Stock Levels (GSL) growth data to infer Forest-wide growth rates isn't appropriate. The GSL growth rates are based on specific stand densities within a specific site location and site productivity. The FIA data provides a robust Forest-wide estimate of gross growth. Furthermore, the use of a 4.16% growth rate may occur on the Forest in some locations but not reflect an approximation at the Forest-level growth as we move into the future, just like the use of a mortality level of 3.07% wouldn't be appropriate as pointed out by several stakeholders.

Comment #: 279

Line # or Figure #: 474-475

Description of the comment/ issue /question: "...van Mantgem et al. (2009) indicated that recent trends in mortality in pines across the Western United States over past 4 decades have been increasing and ranged from 1 to 2%."

Van Mantgem study involved "...data from unmanaged old forests…" and the Black Hills NF is not an unmanaged old growth forest. The use of van Mantgem's data to indicate trends in mortality with the Black Hills NF is not applicable to the Black Hills NF. It is recommended to remove the van Mantgem paper as a reference for mortality rate.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, we looked at recent FIA reports from across the Interior West. In RMRS-GTR-422, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on FIA reports from across the Interior West, the average mortality was 0.79% (table 2) and provides good rationale that mortality rates are around the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 280

Line # or Figure #: 482-483

Description of the comment/ issue /question: "Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic)."

According to José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061 "Thinning dense stands reduces competition for resources among trees and fosters increased growth and vigor of residual trees. Although the response of increased growth, basal area increment, and growth efficiency after thinning is well documented (Myers 1958, 1963, Markstrom et a. 1983, Skov et al. 2005, Fajardo et al. 2007), how quickly trees can respond to increased growing space is variable and take on (Hood et al. 2016) to several years (Oliver 1979, Yang 1998, Kolb et al. 2007). In the case of ponderosa pine, the response may not be evident for at least 10 years postthinning (Oliver and Edmister 1988).", and "...whereas the increase in tree growth and vigor may take longer to occur but have a long-term effect." This GTR indicates that the average growth rate of 2.58% over the 6 years it was documented (1962-2.73%, 1984-

2.52%, 1999-2.48%, 2011-2.66%, 2017-2.74%, & 2019-2.33%). According to Negrón et al. 2017 the growth "...response may not be evident for at least 10 years posttihinning...". It is requested the authors review the historical data and run scenarios with growth rates ranging from 2.5% to 2.74%.

Authors' response: The 60 scenarios presented in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019.

Comment #: 281

Line # or Figure #: 492-494

Description of the comment/ issue /question: "Scenario 6: the potential harvest if mortality decreases and remains at the historical low of 0.26%. However, the history of MPB activity shown in figure 1 precludes this scenario from reflecting reality."

There is no evidence or literature to support the authors editorialized statement "However, the history of MPB activity shown in figure 1 precludes this scenario from reflecting reality." It is requested that this statement be removed from the GTR as it in fact, when presented with the authors own evidence in Table 1, the mortality rate was 0.16% in 1962, 0.26% in both 1984 & 1999, and is in fact a very good if reflection of reality in Black Hills NF today.

Authors' response: We tried to remove editorialized statements and during the formal editing process we searched for any terms that may be considered bias or editorialized. The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 282

Line # or Figure #: 514-524

Description of the comment/ issue /question: "Scenario 3: This scenario illustrates reducing harvest volume from 153,534 CCF that occurred in 2019 to 125,000 CCF in 2020 and continuing in a linear fashion to decrease the harvest volume to 85,000 CCF per year over the next 10 years (2030) (fig 10). The growth rate remained constant at 2.5%, however the mortality rate decrease linearly from 2.98% to 1.04% by 2028, reflecting what might occur as the MPB epidemic subsides (fig. 11). Also reflecting what occurred historically between MPB epidemics (fig. 1), the scenario decreased the mortality rate to 0.26% by 2034 and increasing the mortality rate to 1.04% in 2048. Once again showing how variable mortality rates may affect future forest volumes (fig. 11). This scenario illustrates when the mortality rate was at its historical low (2034) standing volume would accumulate with an annual harvest of 85,000 CCF. However, when the mortality rate returned to 1.04%, reflecting the 2011 value (Walters et al. 2013) standing volume decreased (fig. 12)."

Historical trends as indicated in Table 1 of this GTR indicate that the morality rate remained between 0.16 to 0.26% for 49 years, almost 5 complete decades. Scenario 3 in no way reflects "…what might occur as the MPB epidemic subsides (fig. 11)." It is requestd the authors recognize that any mortality rate above 0.26% is reflective of an MPB epidemic that is most likely to be casued, again, by high live standing inventory, such as the live standing inventory of 1999 at 15,535,000 ccf that lead direclty into the 1997-2017 MPB epidemic.

Authors' response: The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 283

Line # or Figure #: 521-523

Description of the comment/ issue /question: "This scenario illustrates when the mortality rate was at its historical low (2034) standing volume would accumulate with an annual harvest of 85,000 CCF"

This statement has another falsehood reporting that a "…historical low…" of 0.26%, when in fact this GTR reports the historic low as 0.16% in Table 1 and Line#s 359-360. It is requested the authors correct this error to read "This scenario illustrates when the moratlity rate was at 0.26% (2034) standing volume would accumlate with an annual harvest of 85,000 ccf."

Authors' response: The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 284

Line # or Figure #: 529-531

Description of the comment/ issue /question: "These changes in mortality rates would reflect the long-term trends observed in the Black Hills as discussed earlier when MPB were endemic and weather and wildfire were determinants of mortality."

If the authors are going to use "…long-term…" trends then they should use the data in Table 1 of this GTR, and also reflected in Line@#s 359-360 of this GTR, which shows that mortality rates were between 0.16% to 0.26% for 49 of the 57 years reported on in Table 1. It is requested the authors remove this sentence.

Authors' response: The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario*

Development. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 285

Line # or Figure #: 540-541

Description of the comment/ issue /question: "Also, depending on precommercial thinning operations, growing stock amounts could likely be increased."

Remove/omit this sentence. PCT is not applied to Scenario 5, nor is it mentioned in any other scenario. To include it here is trivial. PCT is mentioned on Line#s 103 & 567 and should be discussed further there in those sections of the GTR.

Authors' response: This statement has been removed from the scenario description in RMRS-GTR-422. We discuss precommercial thinning operations in the *Management Opportunities* section instead.

Comment #: 286

Line # or Figure #: 552-555

Description of the comment/ issue /question: "The intensive 2017-2019 FIA data demonstrated that the BHNF has undergone a substantial decline in ponderosa pine standing live volume. The impacts of the MPB, wildfires, and other natural disturbances combined with timber harvest during the past decade contributed to this decline (fig. 6)"

It is requested that the authors remove the word "intensive" as 1 plot every 3,000 acres is not intensive. It is more than historically has been measured through FIA on the Black Hills.

Authors' response: We have removed the word "intensive" or "intensified" in RMRS-GTR-422 when discussing the recent FIA sampling.

Comment #: 287

Description of the comment/ issue /question: None of the scenarios included any ingrowth of trees <5" d.b.h.

Authors' response: The scenarios we evaluated in RMRS-GTR-422 do include ingrowth of < 5" d.b.h trees. Part of the gross growth component includes ingrowth. To clarify this we added Box 1, which provides the calculation FIA uses to estimate gross growth.

Comment #: 288

Line # or Figure #: Figure 2

Description of the comment/ issue /question: In contrast to the authors' report, the most recent mpb outbreak did not start in the northeastern portion of the BHNF and then spread from there. While there was a (significant) epidemic that occurred in the Beaver Park area in 1998 significantly impacting about 500 acres of the Forest, there were also many other small isolated areas (Bug Town and Harney Peak) where endemic populations were starting to increase in numbers and expand in area due to the large acreage areas of overstocked forest in the BHNF.

Authors need to better detail how mountain pine epidemics develop. Large scale epidemics usually do not start in one spot and spread there.

Authors' response: Several areas were epicenters and then spread. Endemic populations spread across the Black Hills, while some areas became outbreak areas and spread. We have revised the language in the figure caption (now fig. 5) in RMRS-GTR-422 as suggested by the reviewer.

Comment #: 289

Line # or Figure #: 362

Description of the comment/ issue /question: The 1.04% mortality number represents a period of above average mortality in the Black Hills. The 1999 to 2011 period includes the largest wildfire on the Black Hills in recorded history and many other large wildfires that collectively burned about 220,000 acres on both public and private land in the Black Hills. This period also includes a significant portion of mortality from the most recent mountain pine beetle epidemic.

Lawrence County does not believe that the 1.04% mortality factor represents an average mortality factor for the BHNF and the mortality factor should be around .23% which is the weighted average of 1961-1999 FIA data.

Authors' response: We recognize that mortality rates over the past 60 years have varied, and in RMRS-GTR-422, we showed in table 1 those differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledged that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential

impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Until the “annualized” protocol for FIA was implemented in the early 2000s, periodic inventory data from 1962 to 1999 were snapshots in time. The reviewer suggested a 0.23% mortality, we used 0.26% as our lowest mortality which is very close to the 0.23%.

Comment #: 290

Line # or Figure #: 366

Description of the comment/ issue /question: "The high mortality rates observed in the 5 to 9 inch d.b.h. class in 2017 and 2019 suggest fewer trees will transition to the sawtimber size class in the future." This statement does not concur with observations stated on line 40-402. Mountain pine beetle do not generally infest small trees <8”. Is this high mortality associated with mpb? Otherwise, does the FIA data conclude what was the cause of tree mortality?

Authors’ response: We agree there are other sources of mortality. We now address the source of mortality in table 1 and the section titled *Understanding Disturbance and Tree Mortality.*

Comment #: 291

Line # or Figure #: Table 1

Description of the comment/ issue /question: Regarding Table 1, it is not clear why the Gross Growth in 2019 is more than 25% less than what it was in 2017? Were there any differences in the way the growth was calculated? Keeping in mind there were no major natural mortality events that could have contributed to this loss of growth. Please explain why 2019 gross growth is 25% less than 2017 measurements.

Authors’ response: The 2017 evaluation presented in this document was summarized and presented to the stakeholder group in 2018 to provide preliminary results and progress; however, these data were not the complete data set until the 2019 evaluation data were added to be used for the final analysis in RMRS-GTR-422. This helps explain the discrepancy.

Comment #: 292

Line # or Figure #: Table 1

Description of the comment/ issue /question: Considering the following, "[g]rowth, mortality, removals, and standing live volume of the merchantable 5 inch plus and 9 inch plus were estimated the same for 2019 as estimated for the 2017 data", it appears that the mortality listed in Table 1 for 2019 is almost 13% more than the 2017 number.

Authors’ response: The 2017 evaluation presented in this document was summarized and presented to the stakeholder group in 2018 to provide preliminary results and progress; however, these data were not the complete data set until the 2019 evaluation data were added to be used for the final analysis in RMRS-GTR-422. This helps explain the discrepancy.

Comment #: 293

Line # or Figure #: 343-344

Description of the comment/ issue /question: As reported, "[t]he FIA reports we tabulated did not include metrics for trees smaller than 5 inches d.b.h (table 1)." However, no explanation is offered as to why the FIA did not include trees smaller than 5 inches. To this point, does FIA collect information on this diameter class? If not, did the GTR not calculate this growth?

Omitting this information from the growth calculations means that a very important piece of the growth projections is missing. This is especially true considering the number of acres present on the landscape. The BHNF claims that the number of SS3 acres are below the Forest Plan Goal, yet a major concern voiced by the BHNF over the last 5 years by the Forest Silviculturist is that the forest contains thousands of acres of dog hair either under existing live overstory or in areas where there was significant mpb mortality. To illustrate why this tree size class is important the following example is provided: 10,000 acres of saplings averaging 3" in diameter stocked at 300 trees per acre (12 by 12 spacing) growing at 3" in diameter every decade will grow into 50,000 million board feet of merchantable timber (9") in 20 years assuming no mortality. Basal area will be around 134 square feet.

Authors' response: FIA classifies trees less than 1 inch d.b.h. as seedlings; those trees from 1 inch to < 5 inches d.b.h. as saplings; and trees ≥ 5 inches d.b.h. as trees. FIA only estimates volume on *trees*, and merchantable volumes that are up to a 4-inch top. We agree there is potential for smaller trees (< 5 inch d.b.h.) to contribute to volume in the future and therefore we advised in RMRS-GTR-422 that continued monitoring is warranted to assess growth and mortality so harvesting levels can be adjusted (section titled *Moving Forward*). We also discussed the importance of tending small diameter trees to enhance growth in section titled *Management Opportunities.* However, as shown by the recent MPB epidemic and wildfires in the past 20 years, growing trees at 134 square feet basal area, as the reviewer highlights, could make them highly susceptible to MPB mortality.

Comment #: 294

Line # or Figure #: 364-365

Description of the comment/ issue /question: Mortality levels for trees 9 inches d.b.h. and greater increased from 2.48% in 2017 to 2.98% in 2019 showing the full impact 366 of the MPB epidemic (fig. 5). The 2019 data does not concur with what was happening on the ground.

Please explain why the mortality numbers are so much higher in the 2017 and 2019 than in 2011. Why does the mortality increase between 2017 and 2019? Mountain pine beetle epidemic was essentially over in 2016.

Authors' response: The 2017 evaluation presented in this document was summarized and presented to the stakeholder group in 2018 to provide preliminary results and progress; however, these data were not the complete data set until the 2019 evaluation data were added to be used for the final analysis in RMRS-GTR-422. This helps explain the discrepancy.

Comment #: 295

Line # or Figure #: Page 12

Description of the comment/ issue /question: Please explain how 2019 FIA inventory collected mortality since it did not re-measure the 2017 inventory points.

Authors' response: As noted in RMRS-GTR-422, *Assessing Past FIA* reports : *Values for the 2019 data came from three sources: (1) plots that were remeasured from previous FIA inventories that fell within the normal measurement cycle (panel base plots); (2) plots that were remeasured from previous FIA inventories but that were measured ahead of schedule (off-panel base plots); and (3) new plots that were installed in 2017 and 2018 field seasons to increase the sample size and spatial extent (one plot every 3,000 acres; 2X PLOTS). Data from panel base plots and off-panel base plots (table 3) were used to calculate GRM because these values require two separate measurements over a time period (Time 1 and Time 2). Typically, the time period between the two measurement periods is on a 5- to 10-year measurement cycle, depending on the state. However, the 2019 final inventory for the analysis used in this document includes repeat measurements that vary in time between measurements to facilitate the most-up-to-date estimates. For example, the 2019 GRM estimates include plots that were initially measured (Time 1) between 2011 and 2016 and remeasured (Time 2) between 2017 and 2019 for a total of 225 plots (table 3). Estimates of volume do not require two separate measurements over a time period. Therefore, the panel base plots, the panel off-base plots, and the 2X PLOTS contributed to estimates of volume for a total of 438 plots. However, the 2X PLOTS that were established in 2017 and 2018 did not contribute to the GRM estimates.*

Comment #: 296

Line # or Figure #: General - scenarios

Description of the comment/ issue /question: The growth and yield sce nerios that are illustrated are pretty rudimentary and do not include the ingrowth from the 1" to 4.9" d.b.h size class.

We believe that the FIA data should be modified to be able to be run on through FVS Growth and Yield Model. The BHNF said that they are under no time limit so let use the best science out there.

Authors' response: FVS is used for stand level growth and development using individual tree data. While FVS is another tool to be used for the analysis of forest growth and development, it requires additional inputs and assumptions. Furthermore, the use of FVS to grow each FIA stand into the future would require the ability to distinguish which data came from the suitable timber base and then applied to that land base. This fine-scale analysis was not the objective we addressed in RMRS-GTR-422.

Comment #: 297

Line # or Figure #: General - scenarios

Description of the comment/ issue /question: There was no scenario that illustrated the FIA recorded highest growth projection of 2.74 and the lowest mortality factor of .16. It would be helpful to run a scenario that illustrates the most optimum numbers using the best growth and lowest mortality numbers. Can this be done?

Authors' response: The 60 scenarios presented in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific

growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. Authors did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 298

Line # or Figure #: General - data

Description of the comment/ issue /question: Groups are now passing the GTR as gospel and using it to convince the public that it proves that the USFS is over cutting the BHNF. What is the USFS going to do if there are major errors in the interpretation or judgement of the data?

Authors' response: We understand your concern, and as part of the documentation, we publicly posted a peer review plan and we include the different reviews we used at the beginning of this report (refer to "The review process and reconciliation of reviewer comments." and will do the same with this reconciliation of comments report. This provides context for the process we used as we prepared and revised the document.

Furthermore, the authors of this GTR received over 300 comments from interested parties.

Comment #: 299

Line # or Figure #: Forest plan

Description of the comment/ issue /question: It seems likely that a Forest Plan revision will occur in the near future. Accepting that as true, should the goal of this process simply be to find agreement on the timber sale program covering the interim period?

Authors' response: This is a better question to be discussed with the BHNF Leadership and stakeholders.

Comment #: 300

Line # or Figure #: General - GSL

Description of the comment/ issue /question: In Mike Battaglia's presentation he showed 4 different tree cookies of different diameters and led the audience to believe we should be favoring growing our young trees at wider spacing such 17 by 17 to maximize the diameter growth of each individual tree without any mention that growing young trees at say 12 by 12 spacing would result in 67% more volume per acre over the same time period. This example has been used ostensibly for the purpose of demonstrating growth rates of individual trees; however, it would seem to be overly simplistic in that it ignores stocking levels and accumulative growth?

GTR 97. Shepard and Battaglia modeled several scenerios for trying optimize ponderosa pine growth through two different rotation ages 80 and 120. Their work indicated that 10' by 10' precommercial thinning spacing would produce the most board feet at the end of a 120 year rotation but would also have very high basal area increasing its risk to mountain pine beetle. 12' by 12' spacing optimized the board foot production while having an acceptable risk to mountain pine beetle. Neither scenerio included any intermediate thinning where stocking levels would be reduced. Alexander and Edminster in RM-228 stated that the highest growth rate for ponderosa pine in the Black Hills occurs at around 140 square feet of basal area per acre on site index 70 using a cutting cycle 30 years.

Authors' response: The presentation was illustrating how intermediate thinning could enhance tree growth; however, in RMRS-GTR-422, we did not include any intermediate treatments in the scenarios, but we discuss these options in the section titled *Management Opportunities.*

Comment #: 301

Line # or Figure #: General - land allocation

Description of the comment/ issue /question: Although the GTR discusses inventory, growth and mortality on a subset of suited base acres, we do not find any reference within the document to timber resources on forested lands within the suited base or on timberlands outside the suited base. Forested lands within the suited base are still part of the suited base and should be utilized in any discussions of timber resources within the suitable base. Timberlands outside the suited base also represent opportunities for necessary forest management activities such as timber harvest. Within the Forest Plan, there are extraordinarily few areas excluded from timber harvest. As an example, MA 3.7 (old growth) in the BHNF is often considered one of the most restrictive MAs regarding timber harvest but MA3.7 does not preclude timber harvest. The Forest Plan reads: "Late successional stands may contain large trees with open branches and irregular crowns in a savannah-like mosaic..." The Plan further states, "Timber harvest may be used if necessary to move stands toward late-successional conditions." Realistically, areas within MA 3.7 are not likely to contribute to long-term, scheduled harvest treatments but are offered as an example of the very limited restrictions on harvest activities outside the suited base, and that timberlands outside the suited base can contribute to forest management activities in the near-term. There are numerous areas outside the suited base that have been without forest management for multiple decades, are in need of forest health treatments through timber harvest, and represent opportunities for forest management activities. This was exemplified earlier this year by Jerry Kreuger (Deputy Forest Supervisor, BHNF) in an email where he stated: "In discussion, the FIA data produced

over the last four years broken out by timberlands and suitable base likely contain accurate estimates of opportunity in the timberlands outside the current designated suitable base." (Personal communication available upon request). Figures for forested lands within the suited base are readily available through the data provided by FIA or upon request.

We recommend using figures from all forested lands within the suited base when describing timber resources including inventory, growth, and mortality - instead of only a subset (timberlands) within the suited base. We also recommend adding additional analysis within the GTR that discusses timber resources on timberlands outside the suited base. Any discussions of timber resources should also include the acres those resources apply to.

Authors' response: We have added a section in RMRS-GTR-422 in appendix A describing the various land categories and clarify the area we analyzed. In addition, Northern Research Station FIA and the BHNF have discussed how these lands are categorized. For this GTR we focused on FIA suitable timber base (see appendix A). These concerns are important, but it may be more appropriate to engage the BHNF on this issue.

Reviewer #10

Comment #: 147

Line # or Figure #: 367 - 372

Description of the comment/ issue /question: 1.04% is a high mortality rate which has a profound effect on the harvest scenarios. I don't see how it can be called a "conservative estimate." One of the references used to justify the 1.04% (van Mantgem et al 2009) is a study done on unmanaged forests…this does not appear to be a citable reference since the Black Hills are very heavily managed. The other reference used for justification (Walters et al 2013) comes up with a 1.04% mortality rate from a relatively small dataset. Walters et al shows a 1.04% mortality from 2007 - 2011 wheras mortality on the BHNF ranged from 0.16% to 0.26% from 1962 - 1999 (seems like a much more credible sample size which includes mpb epidemics and fires).

Reviewer's proposed or suggested change: Further discussion on mortality.

Authors' response: In RMRS-GTR-422, we expanded our mortality discussion to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality as they fall down will increase wildfire hazard. Under the subsection titled *Mortality Rates* within the *Scenario Development* section in RMRS-GTR-422, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and we showed table 1 those differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Authors did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 148

Line # or Figure #: 93-95

Description of the comment/ issue /question: Live volumes of over 12,000,000 ccf resulted in the most recent mpb epidemic. Why would we want to return to such stocking levels? We need to collaboratively define what a healthy BHNF looks like.

Authors' response: In RMRS-GTR-422, the authors intentionally did not provide an estimate of what the BHNF should maintain as a landscape level volume level. Rather, we provided information in table 7 and table 8 along with the associated text in *Scenario Outcomes* to demonstrate what would be needed to sustain the current ASQ of 181,000 CCF/yr. In table 7, the change in standing live volume with different mortality and growth rates for the 181,000 CCF/yr harvest level provides insight into how volume would change over the next 5 years. The negative values indicate what is not sustainable and the positive values indicate a level of sustainable timber harvest. Table 8 provided the amount of standing live volume that would be required right now to maintain 181,000 CCF/yr harvest levels at different mortality and growth rates. The authors do point out that some of the standing live volume values could be subject to large mortality events like those observed in the early 21st century.

Reviewer #11

Comment #: 190

Line # or Figure #: 370-372.

Description of the comment/ issue /question: "...van Mantgem recent trends in mortality in pines across the Western United States over past 4 decades have been increasing and ranged from 1 to 2%."

Reviewer's proposed or suggested change: 1) van Mantgem study involved "...data from unmanaged old forests…" and the Black Hills NF is not an unmanaged old growth forest. 2) van Mantgem mortality study did not include any forested land in or near the Black Hills NF. 3) The GTR states "The Black Hills forests have maintained a viable timber industry for over a century." This indicates that the Black Hills NF does not fit the data used by van Mantgem to indicate a mortality rate of 1 to 2%. The use of van Mantgem's data to indicate trends in mortality with the Black Hills NF is unreasonable as it applies to the Black Hills NF and this Black Hills Timber Growth and Yield Draft General Technical Report. 4) It is recommended to remove the van Mantgem paper as a reference for mortality rate.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, in RMRS-GTR-422, we looked at recent FIA reports from across the Interior West. We have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we did provide scenarios across a range of mortality levels (including 0.26%) and show the outcome of different harvest levels.

These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 191

Line # or Figure #: 367-369

Description of the comment/ issue /question: "As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

1) Current and future conditions, under an appropriate timber management level such as the current standing live inventory, reflect and indicate low (endemic) levels of MPB activity. This supports the use a mortality rate in the range of 0.16 to 0.26% (Line# 359-360 this GTR). 2) Bark beetle activity by national forest indicates only 20 acres of activity in the Black Hills NF. See page 8: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. 3) See page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. page 12. 4) The use of 1.04% mortality rate observed by Walters et al. (2013) is unreasonable a will not reflect long-term mortality trend of trees killed in the Black Hills under current inventory levels. 5) The authors indicate on Line#s 78-79 that "...potential forest dynamics and growth can only be inferred from past conditions." Yet, instead of using accurate historical data, presented in this GTR (Line#s 359-360), that are the most similar to current conditions for mortality, and choosing to use a mortality rate range from 0.16-0.26%, they continually choose higher mortality rates that do not accurately reflect the current conditions of the forest, but are a direct reflection of the height of the 2000-2017 MPB epidemic. It is requested that the authors consistently choose mortality rates between 0.16-0.26% for scenarios.

Authors' response: We have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West.* Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 192

Line # or Figure #: 367-369

Description of the comment/ issue /question: As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

This statement is in direct contrast to the historical data presented on Line#s 359-360 of the GTR, representing a total of 37 years, almost 4 decades. All scientific evidence points to current endemic levels of MPB activity within the Black Hills NF and therefore the mortality levels used in this GTR should range from 0.16 - 0.26%. USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect

and Disease Conditions in the Rocky Mountain Region, 2019. See page 8 & 12. There is no evidence that a mortality level higher than 0.26% has happened in previous endemic levels of MPB activity. (Line #359-360 this GTR). It is requested that the authors correct the mortality rate used to that which reflected during 37 years of endemic MPB endemic levels. (Line #359-360 this GTR).

Authors' response: We have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West.* Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 193

Line # or Figure #: 367-369

Description of the comment/ issue /question: As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

The 1.04% mortality rate reflects the mortality caused by the MPB epidemic in the Black Hills NF. "Although the BHNF is currently experiencing an MPB epidemic that is increasing tree mortality, abundant live growing-stock and sawtimber volume is still available." Walters, B.F.; Woodall, C.W.; [et al.]. 2013. Forests of the Black Hills National Forest 2011. Resource Bull. NRS-83. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. page 17. The 1.04% mortality rate is representative of the MPB epidemic and does not reflect endemic levels of mortality as indicated on Line#s 359-360 of this GTR. This is also a biased statement as it is written "...is reasonable and may reflect...". It is recommended that the authors retain the "Walters et al" reference but remove the biasness from this sentence. It is also recommended that the authors assign the 1.04% mortality rate to the 1996-2017 MPB epidemic and not to possible mortality rates during endemic MPB levels, as the conditions currently are in the BHNF and will be into the foreseeable future. See page 8, Table 2: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. 3) See page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019.

Authors' response: We tried to remove editorialized statements. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

We have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West.* Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 194

Line # or Figure #: 100

Description of the comment/ issue /question: "Using 2019 FIA data as a starting point and an annual mortality rate of 0.26% (i.e. optimistic), an annual sawtimber harvest of 115,000 CCF could be realized."

It is requested the authors remove the editorialized remark, "(i.e. optimistic)", as it represents severe bias in a scientific GTR. remove all editorialized statements.

Authors' response: We tried to remove editorialized statements when preparing RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 195

Line # or Figure #: 100

Description of the comment/ issue /question: "Using 2019 FIA data as a starting point and an annual mortality rate of 0.26% (i.e. optimistic), an annual sawtimber harvest of 115,000 CCF could be realized."

As the authors own reference on Line#s 359-360 of this GTR indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity...". USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. See page 8: "Black Hills NF, 20 acres, aerial detection of MPB in 2019." See page 12: "Mountain pine beetle remains low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." It is suggested the authors use a starting point and annual mortality rate of 0.16% on their scenarios.

Authors' response: We recognized that mortality rates over the past 60 years have varied and we have added table 1 in RMRS-GTR-422 to show differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Authors did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 197

Line # or Figure #: 369-370

Description of the comment/ issue /question: "In addition it is a good estimate of what might occur in future decades."

This is a biased statement and has no reference cited to explain it. It also contradicts the authors own reference on Line#s 359-360 of this GTR indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity...". It is recommended the authors remove this editorialized and biased statement from the GTR.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

We recognized that mortality rates over the past 60 years have varied and we added table 1 in RMRS-GTR-422 to show the differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 198

Line # or Figure #: 387-397

Description of the comment/ issue /question: Authors fail to mention the 18-month period in 2000-2001 where the volume in timber sales was zero (0) ccf, or the equivalent of 25,000 - 30,000 acres left at high live standing inventory levels, thusly more likely to be infested by MPB. The authors fail to equate the lack of timber management for 18 months and the impact it had on escalating MPB activity from an

endemic to an epidemic level. Subsequent harvests were not only based on timber management, but also green MPB sales to stop the epidemic.

It is requested that the authors more accurately depict the reason for the MPB epidemic being components of lack of timber management coupled with high live standing inventory, 1999 was 15,353,000 ccf, between 1999-2001.

Authors' response: In RMRS-GTR-422 we expanded the introduction to include more information about the relationship of high standing live volume and susceptibility to MPB and wildfire. Furthermore, we discussed the various collaborative efforts with the Black Hills Regional Mountain Pine Beetle Strategy. While an 18-month period of no harvest activity allowed forests to increase in density, the standing live volume and dense forest stand conditions were already set up for the MPB epidemic. A combination of climatic conditions, MPB population growth, forest stand conditions, and other factors all contributed to the MPB epidemic.

Comment #: 199

Line # or Figure #: 387-397

Description of the comment/ issue /question: It is requested that the authors accurately reflect the positive effectiveness of having a stable and intact timber industry had on stopping the MPB epidemic & helping bring the MPB levels back to an endemic level. See page 1: "Stand density reductions through silviculture across a large geographical area can abate MPB-caused tree mortality." and "...silvicultural thinning can be a useful tool to mitigate tree mortality caused by MPB across a large area." José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061. See page 6: "Removal of infested trees was done through timber harvest, which proved to be the most effective and economical method of treatment." Forest Health Report - Black Hills NR/R2, SPF & TR, FHP, RCSC-SR-01

Authors' response: Yes, we agree that trees will continue to grow, and forest management can aid in helping to mitigate tree mortality. To better address the above comments by the reviewer, we have expanded two sections in RMRS-GTR-422. First, we added a section titled *Moving Forward,* where we discuss the need for continuous monitoring and flexibility to adjust harvest levels based on realized mortality rates as being crucial if long-term timber sustainability is to continue. Secondly, we expanded a section titled *Management Opportunities,* which discussed a variety of long-term research studies investigating the role of tree density, growth, and MPB susceptibility. We also provided a variety of management options that may be appropriate for the BHNF.

Comment #: 200

Line # or Figure #: 392

This GTR indicates that in 1999 the live standing inventory level was 15,353,000 ccf.

It is requested that the authors discuss the effect of the 1999 live standing inventory of 15,353,000 ccf had on potentially causing an endemic population level of MPB to become epidemic. See page 1: "Eruptive MPB populations occur when conditions become favorable for the insect and unfavorable for its host trees (Thompson and Shrimpton 1984, Mattson and Haack 1987, Boone et al. 2011, Preisler et

al. 2012). Populations thrive in overstocked stands composed of an abundance of suitable-sized trees (Safranyik et al. 1974, Sartwell and Stevens 1975, Amman et al. 1977).

Authors' response: We have expanded the introduction in RMRS-GTR-422 to include more information about the relationship of high standing live volume and susceptibility to MPB and wildfire. In addition, a section on *Understanding Disturbance and Tree Mortality* was added for more context.

Comment #: 201

Line # or Figure #: 387-397

This GTR indicates that in 1999 the live standing inventory was 15,353,000 ccf with a gross growth of 380,000 ccf a noted peak in gross growth.

It is requested that the authors further discuss this peak live standing inventory as it relates to likelihood that it led to the 2000-2017 MPB epidemic. As it is was stated in the Forest Health Report - Black Hills NF/R2, SPF & TR, FHP, RCSC-SR-01, USDA Forest Service, January 2020 on page 19, "Despite a thriving forest industry and a national forest that led the nation in timber harvest, much of the forested land across all ownerships was overstocked with ponderosa pine setting the stage for the epidemic mountain pine beetle populations."

Authors' response: We have expanded the introduction in RMRS-GTR-422 to include more information about the relationship of high standing live volume and susceptibility to MPB and wildfire. In addition, a section on *Understanding Disturbance and Tree Mortality* was added for more context.

Comment #: 202

Line # or Figure #: 474-475

Description of the comment/ issue /question: van Mantgem et al. (2009) indicated that recent trends in mortality in pines across the Western United States over past 4 decades have been increasing and ranged from 1 to 2%."

1) van Mantgem study involved "...data from unmanaged old forests…" and the Black Hills NF is not an unmanaged old growth forest. 2) van Mantgem mortality study did not include any forested land in or near the Black Hills NF. 3) The GTR states "The Black Hills forests have maintained a viable timber industry for over a century." This indicates that the Black Hills NF does not fit the data used by van Mantgem to indicate a mortality rate of 1 to 2%. The use of van Mantgem's data to indicate trends in mortality with the Black Hills NF is unreasonable as it applies to the Black Hills NF and this Black Hills Timber Growth and Yield Draft General Technical Report. 4) It is recommended to remove the van Mantgem paper as a reference for mortality rate.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, in RMRS-GTR-422 we looked at recent FIA reports from across the Interior West. We added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we did

provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 203

Line # or Figure #: 471-474

Description of the comment/ issue /question: "However, as we disused before, a conservative mortality estimates of 1.04% rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

The 1.04% mortality rate reflects the first 10 years of mortality caused by the MPB epidemic in the Black Hills NF. "Although the BHNF is currently experiencing an MPB epidemic that is increasing tree mortality, abundant live growing-stock and sawtimber volume is still available." Walters, B.F.; Woodall, C.W.; [et al.]. 2013. Forests of the Black Hills National Forest 2011. Resource Bull. NRS-83. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. page 17. The 1.04% mortality rate is representative of the early stages of an MPB epidemic and do not reflect endemic levels of mortality as indicated on Line#s 359-360 of this GTR. This is also a biased statement as it is written "...a conservative mortality estimate..."; "...is reasonable and may reflect that the long-term trend of trees killed in the Black Hills." It is recommended that the authors retain the "Walters et al" reference but remove the biasness from this GTR. It is also recommended that the authors correctly indicate that the 1.04% mortality rate is a result of the 2000-2017 MPB epidemic and not to possible mortality rates during endemic MPB levels, as they currently are and will be into the foreseeable future. See page 8: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. 3) See page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. page 12. 4) The use of 1.04% also does not support the question posited on Line#s 169-170, which asked for "...data assuming rationale tree mortality..." as any "...rationale tree mortality..." would be based on historical mortality rates with endemic MPB populations such as those from 1962-1999 that were 0.16% to 0.26% as stated on Line#s 359-360 of this GTR.

Authors' response: We changed our approach to the scenario development in RMRS-GTR-422 and increased the number of scenarios from 6 to 60. These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct “snapshot,” based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a “true” remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 204

Line # or Figure #: 473-474

Description of the comment/ issue /question: In addition, we feel this rate is a good estimate of what might occur in future decades."

This is a biased statement and has no reference cited to explain it. It also contradicts the authors own reference on Line#s 359-360 of this GTR indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity...". It is recommended the authors find literature to support this biased statement or remove it from the GTR.

Authors’ response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered bias or editorialized.

We have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 205

Line # or Figure #: 482-483

Description of the comment/ issue /question: "Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic)."

It is requested the authors either remove the biased remark, "(pessimistic)", as it represents severe bias in a scientific GTR. remove all biased and editorialized statements.

Authors’ response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered bias or editorialized.

Comment #: 206

Line # or Figure #: 482-483

Description of the comment/ issue /question: "Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic)."

The authors own Table 1 (5" DBH and greater), the lowest growth rate recorded from 1962 through 2019 was 2.33% in 2019 and had arithmetic average of 2.58%, median value of 2.59%, and had 4 of the 6 values were higher than the "pessimistic" 2.5% growth rate used. Furthermore, using the authors own Table 2 (9" DBH and greater), with growth rate values from 2017 & 2019, are also both higher than the "pessimistic" 2.5% growth rate, respectively being 3.12% and 2.51%. It is requested the authors use a growth rate of 3.12% that was found in 2017.

Authors' response: The 2017 evaluation presented in the document referred to in the comment and these data were summarized and presented to the stakeholder group in 2018 to provide preliminary results and progress; however, these data were not the complete data set until the 2019 evaluation data was added, which we used in the final analysis for RMRS-GTR-422 t This is why we did not use the 3.12% growth rate or the 2.72% mortality rate.

The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 207

Line # or Figure #: 482-483

Description of the comment/ issue /question: Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic)."

According to José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061 "Thinning dense stands reduces competition for resources among trees and fosters increased growth and vigor of residual trees. Although the response of increased growth, basal area increment, and growth efficiency after thinning is well documented (Myers 1958, 1963, Markstrom et a. 1983, Skov et al. 2005, Fajardo et al. 2007), how quickly trees can respond to increased growing space is variable and take on (Hood et al. 2016) to several years (Oliver 1979, Yang 1998, Kolb et al. 2007). In the case of ponderosa pine, the response may not be evident for at least 10 years postthinning (Oliver and Edmister 1988).", and "...whereas the

increase in tree growth and vigor may take longer to occur but have a long-term effect." This GTR indicates that the average growth rate of 2.58% over the 6 years it was documented (1962-2.73%, 1984-2.52%, 1999-2.48%, 2011-2.66%, 2017-2.74%, & 2019-2.33%). According to Negrón et al. 2017 the growth "...response may not be evident for at least 10 years posttihinning...". It is requested the authors review the historical data and run scenarios with growth rates ranging from 2.5% to 2.74%.

Authors' response: The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 208

Line # or Figure #: "76-77, 98-99, 100, 482-483"

Description of the comment/ issue /question: These findings are dependent on estimates of standing live volume, tree growth rates, and especially mortality rates disclosed by Forest Inventory and Analysis (FIA) data."

I recommend that the authors remove any and all biased and/or editorialized statements that they chose to include. This report is presented as a "scientific general technical report." It my personal opinion that the authors have diminished the pureness of this scientific report by adding these comments of extreme bias and editorializing.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 209

Line # or Figure #: 58-59

Description of the comment/ issue /question: Harvest scenario with 1.04% mortality rate (i.e., long-term conservative estimate) indicated an annual sawtimber harvest of 70,000 CCF."

I recommend that the authors remove any and all biased and/or editorialized statements that they chose to include. This report is presented as a "scientific general technical report." It my personal opinion that the authors have diminished the pureness of this scientific report by adding these comments of extreme bias and editorializing.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 210

Line # or Figure #: 86-88

Description of the comment/ issue /question: Using 2019 FIA data as a starting point and an annual mortality rate of 0.26% (i.e. optimistic), an annual sawtimber harvest of 115,000 CCF could be realized."

I recommend that the authors remove any and all biased and/or editorialized statements that they chose to include. This report is presented as a "scientific general technical report." It my personal opinion that the authors have diminished the pureness of this scientific report by adding these comments of extreme bias and editorializing.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 211

Line # or Figure #: 98-99

Description of the comment/ issue /question: "Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic)."

I recommend that the authors remove any and all biased and/or editorialized statements that they chose to include. This report is presented as a "scientific general technical report." It my personal opinion that the authors have diminished the pureness of this scientific report by adding these comments of extreme bias and editorializing.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 212

Line # or Figure #: 122-123

Description of the comment/ issue /question: "At the same time, timber harvests increased on the BHNF."

Authors' response: In RMRS-GTR-422, tables 4 and figure 11 demonstrate an increase in timber harvest on the BHNF over the past several decades. The data used to populate this table and figure came from previous FIA reports.

Comment #: 213

Line # or Figure #: 135-136

Description of the comment/ issue /question: "Ponderosa pine forests growth rates of trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.3 to 2.7% while mortality rates varied from 0.16 to 3.07% as wildfires and mountain pine beetles killed trees."

It is requested that the authors accurately reflect that for 37 of the 57 years, from 1962 to 1999, that the mortality rates of 0.16 to 0.26% reflect endemic levels of MPB (Line#s 359-360 this GTR), and that the higher mortality rates from 2000-2019 reflect epidemic levels of MPB. It is also requested authors fully

acknowledge that current levels of MPB are endemic. See page 8: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. 3) See page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. It is requested that the authors correct their biased sentence to be "Ponderosa pine forest growth rates for trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.33% to 2.73%, while mortality rates remained low during endemic MPB population levels from 1962 through 1999, ranging from 0.16% to 0.26%, and increased during the 2000 - 2017 MPB epidemic ranging from 1.04% to 3.07%. All data indicate MPB population levels after 2016 have fallen and are now considered endemic, reflective of the time period between 1962 through 1999, indicating that mortality rates should also fall into the historical range of 0.16% to 0.26% for the foreseeable future."

Be specific in the text about when MPB epdiemic happened and how it relates to the mortality rate and how the MPB epidemic is over for now.

Authors' response: We recognize that mortality rates over the past 60 years have varied and in RMRS-GTR-422 we added table 1 to show differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Authors did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e,. reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 214

Line # or Figure #: 388-391

Description of the comment/ issue /question: "A harvest scenario with 1.04% mortality rate (i.e., long-term conservative estimate) indicated an annual sawtimber harvest of 70,000 CCF."

It is requested the authors remove the biased remark, "(i.e., long-term conservative estimate)", as it represents severe bias in a scientific GTR, and is not representative of the authors own reference on Line#s 359-360 of this GTR indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity...".

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 215

Line # or Figure #: 388-397

Description of the comment/ issue /question: "Mountain pine beetle (MPB) (Dendroctonous ponderosae) epidemics and wildfires have impacted forests of the BHNF for centuries"

It is requested that the authors predicate this sentence with the acknowledgement of the high standing live timber inventories that lead to the MPB epidemics, especially the most current 2000-2017 MPB epidemic, which was preceded high standing live inventory of 15,535,000 ccf (Line 392 of this GTR). It is suggested authors correct this sentence to be "Mountain pine beetle (MPB) (Dendroctonous ponderosae) epidemics and wildfires have impacted the BHNH for over a century and are largely preceded by high standing live inventory such as it was in 1999 (15,353,000 ccf), preceding the 2000-2017 MPB epidemic and the Jasper fire (2001), Ricco fire (2005), Roger Shack fire (2001), & the Battle Mountain fire (2016)."

Authors' response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). We added a section in the report in a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. We recognize that mortality rates over the past 60 years have varied and in table 1 we show differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire.

Comment #: 216

Line # or Figure #: 492-494

Description of the comment/ issue /question: "However, since the 2000s, wildfire activity has increased and burned hundreds of thousands of acres (fig. 2)"

This statement has no literature cited to account for the use of the term "increased" which would be related to frequency as it relates to wildfire research. The listed (fig. 2) only shows the spatial location of wildfires from 1988-2016, and in no way indicates an increased frequency of wildfires in the Black Hills. This sentence presents a false narrative without supported literature. There is also no data on the severity, frequency, location of severity, fuel type of wildfire (grassland, meadow, forest, timberland, etc), or severity of fuel type. It is requested the authors remove this sentence as it represents a biased and editorialized statement with no citations or wildfire research details.

Authors' response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total

mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality after trees come down is expected to increase wildfire hazard. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

Comment #: 217

Line # or Figure #: 388-391

Description of the comment/ issue /question: Harvest was 204,000 CCF in 1999, and 40,000 CCF died (fig. 6). By 2011, the MPB began killing more trees (140,000 CCF) and net growth (210,000 CCF) was far below gross growth (380,000 CCF). However, harvest continued to increase to 240,000 CCF, exceeding net growth."

There are numerous errors in these sentences. According to Table 1 of this GTR in 1999 harvest was 204,628 CCF and not 204,000 CCF; in 2011 mortality was 140,460 CCF and not 140,000 CCF, Net Growth was 217,710 CCF and not 210,000 CCF, Gross Growth was 358,170 CCF and not 380,000 CCF and Harvest was 246,630 and not 240,000. It is recommended that the authors correct their errors.

Authors' response: These have been corrected in RMRS-GTR-422

Comment #: 218

Line # or Figure #: 500-502

Description of the comment/ issue /question: "Harvest was 204,000 CCF in 1999, and 40,000 CCF died (fig. 6). By 2011, the MPB began killing more trees (140,000 CCF) and net growth (210,000 CCF) was far below gross growth (380,000 CCF). However, harvest continued to increase to 240,000 CCF, exceeding net growth. As a result of both harvest and trees being killed by MPB, live standing inventory decreased from 15,353,000 in 1999 to 13,477,960 CCR in 2011 (fig, 6). The downward trend in net growth continued with 1,646 CCF occurring in 2017 and net growth went negative to -59,654 CCF in 2019. At the same time, harvest peaked at 261,721 CCF in 2017, far exceeding net growth, and declined to 183,592 CCF in 2019 when the net growth was negative (fig. 6), resulting in live standing inventory of 7,958,314 CCF (table 2, fig. 6)."

This is a misleading paragraph that seems to be introducing more bias into this GTR. The authors appear to be insinuating that harvest was the primary reason for the loss in live standing inventory with statement such as "However, harvest continued to increase to 240,000 CCF, exceeding net growth." (Line#s 390-391) and "At the same time, harvest peaked at 261,721 CCF in 2017, far exceeding net growth, and declined to 183,592 CCF in 2019 when the net growth was negative (fig. 6), resulting in live standing inventory of 7,958,314 CCF (table 2, fig. 6)." According to the Black Hills Regional Mountain Pine Beetle Strategy 5/21/12 Page 4 states "The BHNF is continuing to provide timber sales through projects that focus on proactive thinning which reduces the susceptibility to future infestation. Another effort includes sanitation of infested trees within current timber sale boundaries. This helps in reducing

beetle numbers and the inherent spread to adjacent timbered stands." The authors fail to connect the MPB epidemic of 2000-2017 with the high live standing volume present in 1999, which was 15,353,000 ccf and according the Black Hills Regional Mountain Pine Beetle Strategy 5/21/12 Page 1 states "The epidemic is growing exponentially..." and "The driving cause behind this epidemic continues to be large acreages of even-aged forest of dense, mature trees." The authors also fail to positively credit the harvest with having a significant impact in the ultimate mitigation of the MPB epidemic as stated in Black Hills Regional Mountain Pine Beetle Strategy 5/21/12 Page 4 "The forest products industries in the Black Hills have also been helpful in slowing the epidemic. Unique to much of the West, the Black Hills still have a prominent forest industry that provides cost-effective treatments and contribute greatly to local economies." The authors choose to insert their bias here instead of recognizing that harvest and mortality levels were a combined were 387,090 ccf in 2011, 507,843 ccf in 2017 and fell to 428,295 in 2019, and without the harvest levels it is predicted that the mortality alone would have equaled these same numbers if not greatly exceeded them. All one has to do is look at Colorado, where there was very limited to no forest products industries to help slow and mitigate that epidemic. According to José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061 "Realizing that there is a suite of objectives that a land manager needs to consider while implementing management strategies, silvicultural thinning can be a useful to mitigate tree mortality caused by MPB across a large area." It should also be noted that the same research states "The thinning treatments in this study were implemented amid an extensive MPB epidemic and therefore were implemented under a worst-case scenario. Because bark beetles exhibit periodic eruptive outbreaks, the current thinking is that silvicultural management should be conducted between outbreaks when populations are at low levels and not implemented when insect populations are active (Fettig et al. 2007)." It is requested that the authors remove their biased and editorialized language from this paragraph (Line#s 388-397) and correctly define why the harvest levels were at the stated levels and correctly explain that without these harvest levels there would not have been any significant mitigating factors that would have stopped the MPB epidemic except for the total loss of the entire forest, as in Colorado, with the exhausting of the MPB food source, the 1.2 million acres of ponderosa pine.

Authors' response: We agree that forest management can help mitigate tree mortality. To better address the above comments by the reviewer, in RMRS-GTR-422, we expanded several sections. First, in the *Introduction* we included more information about the relationship of high standing live volume and susceptibility to MPB and wildfire. In addition, a section on *Understanding Disturbance and Tree Mortality* was added for more context. We also added a section titled *Moving Forward,* where we discuss the need for continuous monitoring and flexibility to adjust harvest levels based on realized mortality rates as being crucial if long-term timber sustainability is to continue. Furthermore, we expanded a section titled *Management Opportunities,* which discussed a variety of long-term research studies investigating the role of tree density, growth, and MPB susceptibility. We also provided a variety of management options that may be appropriate for the BHNF.

Comment #: 219

Line # or Figure #: 508-510

Description of the comment/ issue /question: Scenario 6: the potential harvest if mortality decreases and remains at the historical low of 0.26%. However, the history of MPB activity shown in figure 1 precludes this scenario from reflecting reality."

As documented in the GTR on Line#s 359-360 the historical low mortality is 0.16% and not 0.26%. It is suggested the authors use the historical low of 0.16% as they have presented on Line#s 359-360 and also in Table 1 of this GTR.

Authors' response: The reviewer is correct about the historical low of being 0.16% and not 0.26%. However, based on current trends of mortality across the western United States, the 0.16% mortality value was based on one measurement period in the 1960s and only for South Dakota forests. It also occurred during a time period with low wildfire activity, a situation that is not the case in the Black Hills or the western United States anymore. In RMRS-GTR-422, we expanded our discussion in the *Understanding Disturbance and Tree Mortality* section to provide context for different mortality rates used. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the scenarios. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019.

We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 220

Line # or Figure #: 514-524

Description of the comment/ issue /question: "Scenario 6: the potential harvest if mortality decreases and remains at the historical low of 0.26%. However, the history of MPB activity shown in figure 1 precludes this scenario from reflecting reality."

There is no evidence or literature to support the authors editorialized statement "However, the history of MPB activity shown in figure 1 precludes this scenario from reflecting reality." It is requested that this statement be removed from the GTR as it in fact, when presented with the authors own evidence in

Table 1, the mortality rate was 0.16% in 1962, 0.26% in both 1984 & 1999, and is in fact a very good if reflection of reality in Black Hills NF today.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Based on many comments about the scenarios, we changed our approach in RMRS-GTR-422. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates.

We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 221

Line # or Figure #: 517-518

Description of the comment/ issue /question: Under these assumptions (pessimistic), including all of the components of gross growth (e.g., ingrowth, growth on mortality) sawtimber in the Hills would be depleted by 2054 (fig. 9)."

It is suggested to remove more editorializing comments, "(pessimistic)", from this scientific GTR.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 222

Line # or Figure #: 517-518

Description of the comment/ issue /question: The scenario assumes a mortality rate of 1.04% and a 2.5% growth rate which are very possible in the future. See the earlier discussion of annual mortality estimates and trends."

Authors, again, need to eliminate biased and editorialized statements. In this case, it is suggested the authors remove "…which is very possible in the future. See the earlier discussion of annual mortality estimates and trends." The trends shown in table 1, indicate a mortality rate of 0.16% is closer aligned with today's live standing inventory, 1962 - 7,810,000 ccf vs 2019 - 7,958,314 ccf, then it does with

mortality rate in 2011 which had a live standing inventory 40% higher at 13,477,960 ccf, than 1962 and 2019. It should also be noted that the average growth rate across all 6 measured years was 2.58% with 4 of the 6 growth rates being above 2.5% at 2.73% in 1962, 2.52% in 1984, 2.66% in 2011 & 2.74% in 2017.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

The 60 scenarios in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section title *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 223

Line # or Figure #: 521-523

Description of the comment/ issue /question: Scenario 3: This scenario illustrates reducing harvest volume from 153,534 CCF that occurred in 2019 to 125,000 CCF in 2020 and continuing in a linear fashion to decrease the harvest volume to 85,000 CCF per year over the next 10 years (2030) (fig 10). The growth rate remained constant at 2.5%, however the mortality rate decreases linearly from 2.98% to 1.04% by 2028, reflecting what might occur as the MPB epidemic subsides (fig. 11). Also reflecting what occurred historically between MPB epidemics (fig. 1), the scenario decreased the mortality rate to 0.26% by 2034 and increasing the mortality rate to 1.04% in 2048. Once again showing how variable mortality rates may affect future forest volumes (fig. 11). This scenario illustrates when the mortality rate was at its historical low (2034) standing volume would accumulate with an annual harvest of 85,000 CCF. However, when the mortality rate returned to 1.04%, reflecting the 2011 value (Walters et al. 2013) standing volume decreased (fig. 12)."

Historical trends as indicated in Table 1 of this GTR indicate that the morality rate remained between 0.16% to 0.26% for 49 years, almost 5 complete decades. Only 8 years, all recorded during the height of the 2000-2017 MPB epidemic, had mortality rates above 0.26%. Scenario 3 in no way reflects "…what might occur as the MPB epidemic subsides (fig. 11)." It is requested the authors recognize that any mortality rate above 0.26% is reflective of an MPB epidemic that is most likely to be caused, again, by high live standing inventory, such as the live standing inventory of 1999 at 15,535,000 ccf that lead directly into the 2000-2017 MPB epidemic.

Authors' response: We disagree that any mortality rates above 0.26% is reflective of a MPB epidemic. In table 1 and table 2 in RMRS-GTR-422t, we provided mortality data from the Black Hills through time and from across the Interior West. The mortality rates before 1999 in the Black Hills were lower but must also be taken into context. The data from that timeframe was calculated based on the periodic measurements rather than annualized. Periodic inventories tend to underestimate mortality. In addition, wildfires over the past 20 years have contributed more to mortality on the Black Hills. Without any insect activity, mortality rates of 0.44 to 0.47% were reported for 2011 and 2019.

We recognize that standing live volume, if allowed to accumulate to the levels of 1999, could create a landscape that would be impacted by mountain pine beetle and wildfires. Within RMRS-GTR-422, we cited several research studies that discussed the relationship between density and mortality susceptibility in ponderosa pine. We emphasize that monitoring growth and mortality rates would help provide information on changing forest landscape conditions and could inform future harvest levels as the Black Hills recovers from MPB.

Comment #: 224

Line # or Figure #: 529-531

Description of the comment/ issue /question:..however, the mortality rate decreases linearly from 2.98% to 1.04% by 2028, reflecting what might occur as the MPB epidemic subsides (fig. 11)."

The MPB epidemic was declared over in 2016. It is requested the mortality accurately reflect an endemic level mortality rate between 0.16% to 0.26%.

Authors' response: Based on the comments we received, in RMRS-GTR-422, we changed our approach on how we developed the scenarios and increased the number of scenarios from 6 to 60. We represent a low mortality rate (i.e., endemic MPB and low wildfire activity) of 0.26%.

Comment #: 225

Line # or Figure #: 537-538

Description of the comment/ issue /question: "...however, the mortality rate decreases linearly from 2.98% to 1.04% by 2028, reflecting what might occur as the MPB epidemic subsides (fig. 11)."

It is requested the authors delete this biased and editorialized comment and rewrite it to be "The growth rate remained constant at 2.5% and the mortality rate decreased from 2.98% to 1.04% by 2028."

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422 During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 226

Line # or Figure #: 540-541

Description of the comment/ issue /question: This scenario illustrates when the mortality rate was at its historical low (2034) standing volume would accumulate with an annual harvest of 85,000 CCF"

This statement has another falsehood reporting that a "…historical low…" of 0.26%, when in fact this GTR reports the historic low as 0.16% in Table 1 and Line#s 359-360. It is requested the authors correct this error to read "This scenario illustrates when the mortality rate was at 0.26% (2034) standing volume would accumulate with an annual harvest of 85,000 ccf." It is also requested the authors run a scenario that includes the documented historic low mortality rate of 0.16% and range it to 0.26% for 50-year post 2019, to reflect to actual trend in the data used by the authors.

Authors' response: We have removed the statement that was suggested by the reviewer in RMRS-GTR-422. In addition, based on the comments we received, we changed our approach to scenario development and increased the number of scenarios from 6 to 60. Within this change, we evaluated five different mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2.0%). Our approach used to determine mortality values can be found in the sections *Assessing Past FIA Reports; Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time;* and *Scenario Development.*

We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 227

Line # or Figure #: 543-548

Description of the comment/ issue /question: These changes in mortality rates would reflect the long-term trends observed in the Black Hills as discussed earlier when MPB were endemic and weather and wildfire were determinants of mortality."

The use of "…long-term…" trends should use the data in Table 1 of this GTR, and also reflected in Line@#s 359-360 of this GTR, which shows that mortality rates were between 0.16% to 0.26% for 49 of the 57 years reported on in Table 1. It is requested the authors rewrite the sentence to read, "These changes in mortality reflect the mortality rates during the 2000-2017 MPB epidemic and do not reflect the mortality rates during endemic population phases from 1962-1999."

Authors' response: We have removed the sentence fromRMRS-GTR-422. Instead, in the *Mortality Rates* section of the report, we discuss how mortality rates (five evaluated) were determined and what those values might reflect.

Comment #: 228

Line # or Figure #: 543-548

Description of the comment/ issue /question: Growth rates remained at 2.5%, but mortality rates decreased from 2.98% in 2020 to 1.04% by 2030 (fig. 11), reflecting the historical norm."

There is no evidence or literature to support the authors editorialized statement "*…reflecting the historical norm*." As noted numerous times before if the authors wish to reflect the "*…historical norm..."* then they should use the data in Table 1 of this GTR, and also reflected in Line@#s 359-360 of this GTR, which shows that mortality rates were between 0.16% to 0.26% for 49 of the 57 years reported on in Table 1. It is requested that this statement be corrected to read, *"Growth rates remained at 2.5%, but mortality rates decreased from 2.98% in 2020 to 1.04% by 2030 (fig. 11), reflecting the mortality rates that occurred during the 2000-2017 MPB epidemic, and do not reflect historical mortality rates during endemic MPB population phases from 1962-1999."*

Authors' response: This sentence was removed from RMRS-GTR-422 due to the different approach taken for the scenario development. Instead, in the *Mortality Rates* section of the report, we discussed how mortality rates (five evaluated) were determined and what those values might reflect.

Comment #: 229

Line # or Figure #: 552-555

Description of the comment/ issue /question: "Also, depending on precommercial thinning operations, growing stock amounts could likely be increased."

It is recommended the authors run more scenarios with an increased PCT program on the BHNF.

Authors' response: Our methodology for the scenarios in RMRS-GTR-422 do not directly address scenario outcomes with an increased precommercial thinning program on the BHNF. However, three growth rates (2.33%, 2.52%, and 2.73%) and five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2.0%) can be utilized to infer increased growth rates/decreased mortality rates outcomes in line with an expanded precommercial thinning program.

Comment #: 230

Line # or Figure #: 552-555

Description of the comment/ issue /question: This scenario illustrates the potential harvest if mortality decreases from 2.98 to 2.43% in 2020 and to 0.26% by 2028 (fig. 11). This historically low mortality rate did occur when few wildfires burned and MPB activity was minimal (figs. 1, 2). Growth rates were maintained at 2.5% and, after 2029, standing live volume increased and a potential annual harvest of 115,000 CCF could be realized (fig. 10). However, with return intervals of MPB and wildfires approximately 20 years such continued low mortality rates are highly unlikely."

It is recommended the authors remove/omit the editorialized statement, "This historically low mortality rate did occur when few wildfires burned and MPB activity was minimal (figs. 1, 2)." First, the listed (fig. 2) only shows the spatial location of wildfires from 1988-2016, and in no way indicates any level of frequency, severity, location of severity, vegetation type of severity, or vegetation type of wildfires, in the Black Hills. Second, the listed (fig. 2) does not show any historical fires prior to 1988, making a false assumption that there were no fires in the Black Hills NF between 1962-1999 when there were historical lows in mortality rates ranging from 0.16% to 0.26%. Third, the wording used by the authors, "...and MPB activity was minimal..." contradicts previous statement on Line numbers 124-125, "The Black Hills have experienced MPB epidemics recurring somewhere in the Forest about every 20 years (fig. 1),...", whereas the mortality rates recorded between 1962-1999 ranged from 0.16% to 0.26% and encompassed two separate MPB epidemic events from 1961-1966 & 1970-1978 (fig. 1), showing that MPB was in fact not minimal, yet the historical low range of mortality rates still ranged from 0.16% to 0.26%. It is recommended the authors remove the editorialized statement and use the suggested edit of, "The mortality rate of 0.26%, although not the historical low of 0.16% recorded in 1962, was recorded as the high mortality rate for 37 years between 1962 to 1999, which also spanned many wildfires (not documented in this GTR) and two MPB population epidemic level events from 1961-1966 & 1970-1978."

Authors' response: We have attempted to remove all biased and/or editorialized statements in RMRS-GTR-422. In this GTR we have added more information about wildfires in the Black Hills and the increase in frequency and acreage. For clarification in the interim report, our statement about wildfires prior to 1988 was that the FIA data didn't pick up mortality from wildfires in those measurement periods, we gleaned this from statements in the FIA resource bulletins. In RMRS-GTR-422, we changed our approach for scenarios. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the scenarios. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion of *Understanding Disturbance and Mortality* to provide context for different mortality rates.

We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 231

Line # or Figure #: 558-560

Description of the comment/ issue /question: Scenario 6: This scenario illustrates the potential harvest if mortality decreases from 2.98 to 2.43% in 2020 and to 0.26% by 2028 (fig. 11). This historically low mortality rate did occur when few wildfires burned and MPB activity was minimal (figs. 1, 2). Growth rates were maintained at 2.5% and, after 2029, standing live volume increased and a potential annual harvest of 115,000 CCF could be realized (fig. 10). However, with return intervals of MPB and wildfires approximately 20 years such continued low mortality rates are highly unlikely."

It is recommended the authors remove/omit the editorialized statement, "However, with return intervals of MPB and wildfires approximately 20 years such continued low mortality rates are highly unlikely." There is no supporting data for this statement to be used in anyway in this GTR.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 232

Line # or Figure #: 561-565

Description of the comment/ issue /question: The intensive 2017-2019 FIA data demonstrated that the BHNF has undergone a substantial decline in ponderosa pine standing live volume. The impacts of the MPB, wildfires, and other natural disturbances combined with timber harvest during the past decade contributed to this decline (fig. 6)"

It is suggested the authors correct this sentence to read, "The 2017-2019 FIA data demonstrate that the 1999 live standing volume of 15,535,000 ccf lead to the 2000-2017 MPB epidemic and helped fuel numerous, large wildfires, in the Black Hills NF. The collaborative actions taken by the Black Hills MPB working group, and its partners, helped to mitigate the exponentially expanding MPB population in the Black Hills NF. Their actions from 2010 through 2016 helped to lower the overall live standing inventory to conditions that are more resilient and sustainable through commercial thinning 188,000 acres and pre-commercial thinning approximately 73,000 acres. Together industry and local governments non-commercially treated over 1.3 million infested trees and sent about 1.4 million infested to local sawmills, supporting the overall economy in the Black Hills region. These actions have not yet been fully realized in the lag-statistics, such as growth and mortality rates (Negron et al. 2017) that take 5-10 years to fully recognize. Research shows today's live standing inventory will have growth rates in excess of 2.5% (Table 1) and could possibly be as high as 3.12% as they were observed in 2017 (Line# 452 of this GTR). Based on the 2019 live standing level of 5,995,428 we credit the industry and local governments for their actions that saved the Black Hills NF from complete devastation, such as the millions of trees and extensive acres killed in Colorado from their own MPB epidemic that did not have such progressive and engaged partners."

Authors' response: This paragraph no longer exists in RMRS-GTR-422. However, in the GTR we added additional information in the *Introduction* to highlight a brief history of the high standing live volume, high MPB and wildfire susceptibility, and the collaborations to address the issue. We also added the

sections *Understanding Disturbance and Tree Mortality* and *Scenario Development* to provide context and describe our assumptions.

Comment #: 233

Line # or Figure #: 60-62

Description of the comment/ issue /question: "The intensive 2017-2019 FIA data demonstrated that the BHNF has undergone a substantial decline in ponderosa pine standing live volume. The impacts of the MPB, wildfires, and other natural disturbances combined with timber harvest during the past decade contributed to this decline (fig. 6)"

It is requested that the authors remove the word "intensive" as 1 plot every 3,000 acres is not intensive, it is simply more than before. It is requested the authors remove the editorializing in this sentence. There was a decline in live standing volume of ponderosa from 15,535,000 ccf in 1999 to 5,995,428 ccf in 2019. The subsequent timber harvest levels were not dictated by ASQ, forest plan, or the industry pushing for more green volume. The subsequent timber harvest levels were dictated by the MPB epidemic, "The USFS responded to the growing epidemic through adjustments in their timber sale program." Page 4 Forest Health Report - Black Hills NF/R2, SPF & TR, FHP, RCSC-SR-01, January 2020. The authors chose to editorialize the way they describe "timber harvest". Instead of fully attributing the decline in live standing inventory to the MPB epidemic and wildfires, they try to lump timber harvest in with catastrophic & fully unsustainable natural disasters. This is careless & unprofessional, and most urgently un-scientific. The MPB epidemic and wildfires were immediately preceded by a live standing inventory of 15,535,000 ccf. That excessive live standing inventory is what caused the MPB epidemic, see Negron et al. 2017, "Eruptive MPB populations occur when conditions become favorable for the insect and unfavorable for its host trees (Thompson and Shrimpton 1984, Mattson and Haack 1987, Boone et al. 2001, Preisler et al. 2012). Populations thrive in overstocked stands composed of an abundance of suitable-sized trees (Safranyik et al. 1974, Sartwell and Stevens 1975, Amman et al. 1977)." It should also be noted that "...much of the forested land across all ownerships was overstocked with ponderosa pine setting the stage for epidemic mountain pine beetle populations." according to Forest Health Report - Black Hills NF/R2, SPF & TR, FHP, RCSC-SR-01, January 2020.

Authors' response: We removed the word "intensified" from RMRS-GTR-422 and replaced it with text that describes the plot density of 1 every 3,000 acres vs. the common density of 1 every 6,000 acres. We also tried to remove editorialized statements. We added a section about the status of the forest inventory at the beginning of the 21st century, the high volume, and potential for epidemic and wildfire. This was followed by a paragraph describing the coordinated efforts to slow the MPB epidemic.

Comment #: 234

Line # or Figure #: 77-79

Description of the comment/ issue /question: "Furthermore, the current forest conditions (2019) and probable growth and mortality estimates suggest an annual harvest for the timber program on the BHNF in the range of 70,000 to 115,000 CCF, depending on mortality assumptions (scenarios 3 to 6)."

It is requested the authors remove the biased term "probably" from this sentence. The authors should strike the term "Furthermore" as well. As I have stated previously, the authors own Table 1 and Line#s

359-360 of this GTR show that the authors chose not to use the historical data they themselves referenced when subjecting the readers to inappropriately used growth and mortality rates of only 2.5% and above 1.0% respectively. It is suggested the authors correct this sentence to be "The current forest conditions, now have endemic MPB populations, and a live standing inventory of 5,995,428 ccf. The growth rate of 2.5% (historically low, Table 1) and mortality rates >1.0% (historically high, Table 1) that we subjectively chose to use show an annual harvest program between 70,000 to 115,000 ccf. The harvest program we suggest uses mortality rates at the height (2011 - 1.04%, Table 1) of the 2000-2017 MPB epidemic and do not reflect that of the historical values we depict in Table 1 and are 4 to 6.5 times higher than the timeframe from 1962-1999 when mortality rates were recorded between 0.16% to 0.26%."

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

In RMRS-GTR-422, we changed our approach to the scenario development to include a range of mortality and growth rates to allow the readers to evaluate the change in standing live volume based on various assumptions of the future. We expanded the section titled *Assessing Past FIA Reports* and identify the nuances associated with the different reports through time. In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time* we summarized the nuances associated with these reports, and we described how we used these reports to provide some context for the scenario development. The section titled *Scenario Development* described our assumptions, discussed in detail how the scenarios were developed and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions. Also, in this section we discussed the rationale behind how we developed the scenarios.

Comment #: 235

Line # or Figure #: Figure 6

Description of the comment/ issue /question: Nevertheless, these harvest levels would allow the live sawtimber inventory amounts to increase to 6 million CCF in approximately 60 years and return to the level needed to support ASQ as identified in the current forest plan (181,000 CCF) within a century (fig. 6). The bottom line is that net growth (gross growth minus mortality) needs exceed harvest to accumulate wood volume in the Black Hills."

It is requested the authors remove the term "Nevertheless" as it does not add to the paper and in fact takes away from it. Here is an example, "The authors of this GTR presented historical data on growth and mortality rates that indicate endemic MPB populations live standing inventories of less than 15,535,000 will produce growth rates in excess of 2.5% and mortality rates between 0.16% to 0.26%, NEVERTHELESS, the authors chose to ignore that data and presented mortality rates 4 to 6.5 times higher than historical data from 1962-1999 suggest and a static growth rate of 2.5%, 0.08% less than the arithmetic average in Table 1, and 0.62% less than the 2017 growth rate of 3.12% (Line# 452 of this GTR)".

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 236

Line # or Figure #: 80-83

Description of the comment/ issue /question: BHNF Leadership and stakeholders agreed upon an intensified Forest Inventory and Analysis (FIA) sampling grid to assess the current trends in ponderosa pine (Pinus ponderosa) standing volume, growth, and mortality over the past several years."

It is suggested that the sentence be corrected to read "…BHNF Leadership and stakeholders agreed upon additional plot in a Forest Inventory and Analysis (FIA) sampling grid to assess the current trends in ponderosa pine (Pinus ponderosa) standing volume." The additional plots were not more intense than previous sample plots, there were simply 130 more plots measured in the same manner, with the exception of being able to collect Growth, Mortality, and Removals. It is editorialization to indicate the FIA evaluation was "intensified".

Authors' response: We removed the term "intensified" and we made sure to highlight that it was one plot for every 3,000 acres in RMRS-GTR-422. We also added a section to identify which plots contributed to the standing live volume and which plots contributed to the growth, mortality, and harvests during the 2019 evaluation.

Comment #: 237

Line # or Figure #: 84-85

Description of the comment/ issue /question: Future climate, weather, mountain pine beetle activity, and wildfire are unknown and potential forest dynamics and growth can only be inferred from past conditions."

It is suggested the authors remove this sentence. As the authors state on Line#s 76-78, "This GTR's findings are dependent on estimates of standing live volume, tree growth rates, and especially mortality rates disclosed by Forest Inventory and Analysis (FIA) data." It is not a key point that future catastrophes are unknown. It is a key point that the forest dynamics from this point on are best inferred from looking at past conditions and data. It is also a key point that the authors failed to accurately look at the past conditions in an unbiased manner. See next point on Figure 6

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized. This sentence has been removed from the report.

Comment #: 238

Line # or Figure #: 93-94

Description of the comment/ issue /question: Figure 6, Scenario 3, Scenario 6.

Figure 6 is a misrepresentation of the truth. The graph indicates that there are only 6 equal data points (1962, 1984, 1999, 2011, 2017, & 2019), all of equal value, equal importance, and equal weight. This is far from a correct representation of the truth. The first three data points, 1962, 1984, & 1999, represent 37 years if the 57 years the graph covers, or 65% of the timeline assessed, vs 35% of the timeline from 1999 - 2019. If you look at the mortality rate it was 0.16% from 1962 to 1984, and then raised 0.10% to

0.26% from 1984 to 2011, when it changed to 1.04%. This indicates that the mortality rate ranged from 0.16% to 0.26% for 49 of the 57 years or 86% of the timeline vs 14% of the timeline above 0.26%. The 14% also represents a catastrophic event, that was precluded by the highest standing live inventory recorded along the same timeline, at 15,535,000 CCF. At no other time, not even preceding the MPB epidemics from 1961-1966 & 1971-1978, was the standing live inventory so high. The truth then, is that for 37 years the forest was managed to a lower standing live inventory and withstood 2 MPB epidemics and still had a mortality rate that ranged from 0.16% to 0.26% and was never higher until the standing live inventory reached the timeline high volume of 15,535,000 CCF. The key point, as referenced in the comment line above is that forest dynamics from this point on are best inferred from looking at past conditions and data. The authors failed to follow their own credence in all 6 scenarios. They did this by limiting any mortality rates in the range of 0.16% to 0.26% to only 2 of the 6 scenarios. In Scenario #3, the mortality rate never dropped below 0.26% as it was historically recorded to be from 1962 to 1984, and also was at 0.26% for 13 of the 45 years in the scenario, or 28.9% of the timeline, also not representative of the historical record from 1962 through 2011 as indicated in the author's own Table 1. In Scenario #6, the mortality rate never dropped below 0.26% as it was historically recorded to be from 1962 to 1984, but then was at 0.26% for 36 of the 45 years, or 80% of the timeline, which closer to the historical record that was at 0.26% or less for 84.5% of the time. However, the authors presented a false narrative by stating "Mortality rates were predicted to decrease linearly from 2.98% to 1.04% by 20285, reflecting what might occur as the MPB epidemic subsides (fig. 14)." It is common knowledge that the MPB epidemic was declared over in 2016. It is requested the authors remove this misleading graphic from this scientific general technical report.

Authors' response: The figure (6) in the interim report was revised and is now figure 11 in RMRS-GTR-422. We realize that this made the reader think that this was continuous data rather than individual data for that specific measurement period. In the revised figure, we added a line between each measurement year and did not connect the standing live inventory line. Until the "annualized" protocol was implemented in the early 2000s, periodic inventory data from 1962 to 1999 were snapshots in time. Therefore, stating that the "mortality rate was 0.16% from 1962 to 1984" and 0.26% from 1984 to 2011 is incorrect.

To address the comment of the authors "limiting mortality rates in the range of 0.16% to 0.26%," we changed the approach to scenario development. Of the 60 scenarios evaluated, 12 of the 60 had mortality rates of 0.26%. We also expanded our discussion of mortality rates and the assumptions we used to generate these rates throughout the *Approach* and *Scenario Development* sections in RMRS-GTR-422.

Comment #: 239

Line # or Figure #: 439-442

Description of the comment/ issue /question: All scenarios assume no harvest reduction for other resources (e.g., wildlife, botany, aquatics, and so on) or for Forest Plan adjustments. However, Black Hills National Forest (BHNF) may have restrictions that could alter the amount of area treated and the volumes removed."

This is not a key point and has no place in this scientific general technical report. There are no data to support leaving these statements in the GTR and is requested the authors remove these sentences.

Authors' response: In RMRS-GTR-422 we needed to clearly state our assumptions associated with the objectives which included that our estimates assume that all the suitable timberlands were available for timber harvest. However, in reality, not all acres are available for harvest due to Forest Plan restrictions. Therefore, RMRS-GTR-422 results should be placed in context with other potential management objectives.

Comment #: 240

Line # or Figure #: 594-597

Description of the comment/ issue /question: The intensified 2019 FIA sampling scheme for the BHNF provided robust and high-quality data."

It is requested the authors remove this sentence from the GTR as it is not supported by statistical data. The 2019 FIA sampling scheme was not intensified, it simply had an additional 130 plots that contributed to standing live inventory but not to growth, mortality, or removals, thusly not provided robust or high-quality data. These are qualitive or editorialized remarks and should not be in the GTR let alone the "Key Points" section.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized. We no longer have a key points section, so this sentence no longer appears in the document.

Comment #: 241

Line # or Figure #: 111-117

Description of the comment/ issue /question: To sustain the Forest Plan ASQ of 181,000 CCF would require a standing live sawtimber volume of more than 12,000,000 CCF. Current (2019) standing live sawtimber volume is 5,995,428 CCF."

This is a misrepresentation of the truth as it is based on false assumptions moving forward and violates the authors own credence that "…potential forest dynamics and growth can only be inferred from past conditions." This statement, on Line#s 93-94 is based on Scenario #2, which in and of itself, does not infer the past onto the future. Scenario #2 uses a mortality rate of 1.04%, which is a mortality rate from the 2000-2017 MPB epidemic, and only represents 10.3% of the timeline from 1962 - 2019, as it was only measured once out of 6 data points, in 2011. The authors use of a single data point that is represented by 1 of 6 data points and making it into a "Key Point" is biased, and not based on the historical record. It is requested the authors remove this statement.

Authors' response: This statement has been removed from RMRS-GTR-422. However, we expanded the scenarios to examine a range of mortality rates and growth rates evaluated. We also expanded our analysis to determine how standing live volume would be required to be sustainable at 181,000 CCF/yr. We address the amount of standing live volume needed to sustain the 181,000 CCF/yr in table 8. Based on these analyses, it is demonstrated that 181,000 CCF/yr is not sustainable.

Comment #: 242

Description of the comment/ issue /question: Numerous combinations of annual mortality rates and harvest levels could have been modeled. We choose ones we feel encompass future possibilities of forest development in the Black Hills and would be applicable for informing Forest planning."

It is requested the authors remove this editorial comment from this scientific general technical report. Science isn't based on what the authors "feel" would encompass future forest dynamics. The authors themselves set the standard by stating "potential forest dynamics and growth can only be inferred from past conditions." This would remove all "feel" for the future from their scenarios. This scientific GTR is not a crash course in Humanities 101 but is meant to aid Forest planning that is based on Forest Science and Silviculture.

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422.

Comment #: 243

General - Density management GSL

Description of the comment/ issue /question: Furthermore, Graham et al. (2019) noted that several thinnings over the course of the 48-year study to maintain the density treatments did not produce commercial material, indicating that one thinning close to the desired density at rotation is warranted."

This is an incorrect assessment of what was actually written in the Graham et al. (2019). Graham et al. (2019) wrote "However, on the minimally commercial growing sites in the Black Hills, multiple thinnings that have no commercial value only add to the financial uncertainties of growing commercial forests in the Black Hills. Myers (1967) did provide excellent TPA suggestions for producing a tree with a 10-inch d.b.h. when a desired BA is achieved. Instead of using multiple thinnings to achieve these targets, one precommercial thinning near the final desired TPA for a 10-inch tree and given BA may be preferred since too much regeneration is the norm in the Black Hills." This actual statement, from the Graham et al. (2019) GTR, differs from this GTR's assessment that "...several thinning over the course of the 48-year study to maintain density treatments did not produce commercial material...". Graham et al. (2019) never stated multiple thinning entries "did not produce commercial material", this is the fallacy presented on Line#s 597-597. The Graham et al. (2019) GTR indicates it is not financially responsible (based on Kline and Coleman 2010; Sucheta et al. 2009, assessment of PCT material has no commercial value) to conduct multiple pre-commercial thinnings (PCT) in the Black Hills due to the cost of every entry of a PCT and carried out over the full rotation of the that stand, and that there is not sufficient return to conduct multiple PCT entries. The Graham et al. (2019) GTR suggests that the USFS on the BHNF specifically can maximize commercial volume growth while minimizing PCT costs with one well timed entry. I agree that one well timed PCT entry will greatly increase growth of non-commercial stems into commercial stems as well as dramatically increasing growth on residual commercial stems, without the same number of trees per acre to compete with, all the while saving on costs. It is recommended the authors correct the statement to read "Graham et al. (2019) noted that one pre-commercial thinning nearer the final desired TPA for a 10-inch DBH, and a given basal area per acre, is preferred and warranted in producing commercial material."

Authors' response: In RMRS-GTR-422, the section titled *Management Opportunities,* we discussed the various long-term tree growth related research specific to the Black Hills. We also clarified our statements.

Comment #: 244

Description of the comment/ issue /question: The BHNF is approximately 1.2 million acres in size, of which the Forest Plan Amended in Phase II (USDA FS 2005, Appendix G-3) identifies 865,890 acres as suitable and available for timber harvest. In 2019 the USDA Forest Service, Forest Inventory and Analysis Program (USDA 114 2019) identified 765,733 acres of timberland: (suitable), as forestland that is producing or is capable of producing 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn from timber utilization by statute or administrative regulation."

There are numerous discrepancies stated here by the authors. The authors are also mixing & interchanging terms that are not interchangeable, i.e. suitable (base), timberlands, forestland. The authors are also mismanaging the use of acres from 865,890 acres down to 765,733 acres and making direct comparisons on the BHNF between 2017 and 2019, as if 100,157 acres are no longer within the suitable base and available for harvest. This is patently false and a misrepresentation of the actual acres in the BHNF and suitable base and drastically reducing the starting point for standing live inventory in Table 1 and all 6 scenarios the authors ran. The 1997 FP Revision Phase II Amendment 2006 (Appendix G) stated 865,890 acres, then the FSVeg 2015 0205 stated 824,238 acres, the FSVeg Dec 2015 Suitable Base stated 824,240 acres, FIA Inventory 2017 - 2019 stated 828,925 acres, and the FSVeg 2020 0101 stated 828,192 acres. If you average the final four figures you get 826,399 acres or 7% more acres than the authors chose to use in Table 1 in determining standing live inventory. If you use the 1997 FP Revision Phase II Amendment 2006 (Appendix G) 865,890 acres the authors are 12% off in their use of acres and thusly 12% off in standing live inventory. That completely changes the straight arithmetic spreadsheet scenarios they used in determining future production on the suitable base of the BHNF. Using the range of 7% to 12 % the 2019 standing live inventory changes from 7,958,314 ccf to a range between 8,515,396 ccf to 8,913,312 ccf. It is requested the authors update the 2019 standing live inventory to reflect the acres used in the 1997 FP Revision Phase II Amendment 2006 (Appendix G) of 865,890 acres and the CCF volume per acre of 10.4 CCF/acre that the 2019 standing live inventory produced (7,958,314 CCF / 765,733 acres).

Authors' response: We appreciate the comment from the reviewer that all timberlands within the BHNF should be considered. We address the difference in suitable and available timber harvest in RMRS-GTR-422, appendix A.

Comment #: 245

Line # or Figure #: Table 1

Description of the comment/ issue /question: Authors table 1 contained errors in calculations, see red/bold font. The author's Table 1 indicates that there are only 6 equal data points (1962, 1984, 1999, 2011, 2017, & 2019), all of equal value, equal importance, and equal weight. This is far from a correct representation of the truth. The first three data points, 1962, 1984, & 1999, represent 37 years if the 57 years the graph covers, or 65% of the timeline assessed, vs 35% of the timeline from 1999 - 2019. If you look at the mortality rate it was 0.16% from 1962 to 1984, and then raised 0.10% to 0.26% from 1984 to 2011, when it changed to 1.04%. This indicates that the mortality rate ranged from 0.16% to 0.26% for

49 of the 57 years or 86% of the timeline vs 14% of the timeline above 0.26%. The 14% also represents a catastrophic event, that was precluded by the highest standing live inventory recorded along the same timeline, at 15,535,000 CCF. At no other time, not even preceding the MPB epidemics from 1961-1966 & 1971-1978, was the standing live inventory so high. For 37 years the forest was managed to a lower standing live inventory and withstood 2 MPB epidemics and still had a mortality rate that ranged from 0.16% to 0.26% and was never higher until the standing live inventory reached the timeline high volume of 15,535,000 CCF. The key point, as referenced in the comment line above is that forest dynamics from this point on are best inferred from looking at past conditions and data. The authors failed to follow their own credence in all 6 scenarios. They did this by limiting any mortality rates in the range of 0.16% to 0.26% to only 2 of the 6 scenarios. In Scenario #3, the mortality rate never dropped below 0.26% as it was historically recorded to be from 1962 to 1984, and also was at 0.26% for 13 of the 45 years in the scenario, or 28.9% of the timeline, also not representative of the historical record from 1962 through 2011 as indicated in the author's own Table 1. In Scenario #6, the mortality rate never dropped below 0.26% as it was historically recorded to be from 1962 to 1984, but then was at 0.26% for 36 of the 45 years, or 80% of the timeline, which closer to the historical record that was at 0.26% or less for 84.5% of the time. However, the authors presented a false narrative by stating "Mortality rates were predicted to decrease linearly from 2.98% to 1.04% by 20285, reflecting what might occur as the MPB epidemic subsides (fig. 14)." It is common knowledge that the MPB epidemic was declared over in 2016. It is requested the authors remove this misleading graphic from this scientific general technical report. It is requested the authors update their Table 1 to reflect the below "Corrected Table 1 - MJK version" into the GTR. It is requested the authors use the weighted averages based on the data they presented to determine future growth and mortality rates. Afterall, future growth and mortality can "...only be inferred from past conditions."

Authors' response: Until the "annualized" protocol for FIA was implemented in the early 2000s, periodic inventory data from 1962 to 1999 were snapshots in time. Therefore, we changed our approach in RMRS-GTR-422 and described the rationale on selecting the 5 mortality rates we evaluated.

Reviewer #12

Comment #: 124

Line # or Figure #: General - economic impact

Description of the comment/ issue /question: There is no mention in the GTR of economic impact of forest management activities in the Black Hills. Although this will not affect scenarios, it is important to understand the reliance of local communities on the employment opportunities offered by forest products companies.

Reviewer's proposed or suggested change: We recommend presenting the economic impact of forest products companies in the Black Hills. The timber industry is responsible for $120 million in annual revenue and 1,400 jobs. The most recent publication from the FS may help in comparing impacts from forest products to other sectors: https://www.fs.fed.us/emc/economics/contributions/documents/at-a-glance/published/rockymountain/AtaGlance-BlackHills.pdf

Authors' response: There are several components in an economic evaluation. For the Black Hills there are several types (e.g., recreation, tourism, hunting) of economic benefits coming from National Forest lands, some of which benefits do not have a specified economic value, such as scenic beauty. Our goal in RMRS-GTR-422 was only to provide an estimate of potential sustainable timber harvests. To conduct a thorough economic analysis would require different data (economic value from all resources that are valued from the National Forest) than what we had to conduct the assessment. Therefore, the authors considered this outside the scope of this report.

Reviewer #13

Comment #: 125

Description of the comment/ issue /question: General - Pine beetles /fire

See Hilding Firerisk attachment. I am sorry, but I did not have time to go searching around for article's in my computer or links to it and be sure to get my letter in before midnight. However here is a link of a short version of an article that I wanted to send you. Friends of the Norbeck commissioned professional statistician Grant Foster, of Tempo Analytics, to look at possible relationships between large fires, on the one hand, and weather, logging, and beetle tree-mortality levels on the other. He created an longer article, which I have on my computer some place and can't find just now, or at least not before midnight..(It's eight years old). It is titled: ""Pine Beetle Infestation and Fire Risk in the Black Hills"" But Mr. Foster posted a more ""accessible"" (i.e., less mathematical) online version of this analysis at his Climate Blog Open Mind, entitled: Pine Beetles and Fire Hazard in the Black Hills This might be useful to figuring out what the future holds with climate change. Here is the link: https://tamino.wordpress.com/2012/02/10/pine-beetles-and-fire-hazard-in-the-black-hills/, posted on February 10, 2012. This is a statistical review of data on fire and beetles in the Black Hills, that challenges many of the assumptions the Forest Service likes to make about fire and beetles and raises interesting questions about the future and what will happen .

Within the text of this simplified on-line version, it notices increased risk of wildfire twelve years after timber sales, but allows that may be coincidental: ""This might suggest that greater timber harvest increases the risk of wildfire, with a time delay of about 12 years. But "it ain't necessarily so." Timber harvest has increased over the years, so to a large degree the timber harvest resembles a steady increase over time. Perhaps there has simply been an increase in wildfire activity over time due to some other factor, and the timber harvest simply mimics this effect, acting as a "proxy" for a simple time trend."" Here is a quote at the conclusion: ""Clearly, the Black Hills region, like most Western U.S. forests, is at greater risk of wildfire than during most of the 20th century. But there is little, if any, evidence to implicate pine beetle infestation as the culprit in that increased risk. Other factors, including drought, changing climate conditions, and perhaps changes in forest management (including fire suppression) are at work, and their impact seems to overwhelm the results of pine beetle infestation. Wildfire hazard is a crucial issue which must be addressed with as clear as possible a perception of the actual risk factors. A focus on pine beetle infestation seems misplaced, threatening to draw attention away from factors which have strong and demonstrable impact on fire hazard and to divert limited resources to less productive strategies. Surely, excessive rhetoric about the urgent fire danger posed by pine beetle infestation, sometimes to the point of hysteria, does not serve the public interest.""

Authors' response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In this GTR, we added a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality is expected to increase wildfire hazard. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we describe in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and in RMRS-GTR-422 we added table 1 to show the differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development*, we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 126

Line # or Figure #: Page 2, Lines 35-45

Description of the comment/ issue /question: This section of the report lists the three authors & their qualifications. These three authors appear to need some help in the Scenario section, with designing scenarios that comply with the Forest Plan's goals, standard & guidelines that are designed to insure sustainability of other resources besides timber. You also need folks who know about other limiting issues that make an area unsuitable for logging (like improper soil, steep slopes, slow tree regeneration) and thus puts an area in the unsuitable category (See Appendix G of BHNFLRMP). It seems that you failed to create any scenario that incorporates limits due to wildlife, botany, aquatic, scenic resources etc. or allows limits due unsuitable lands. So maybe these folks don't understand those limits and are describing scenarios that will be illegal. You might also need some legal staff to help you write this, to explain which scenarios you devise are illegal...I.e. it might be good to have at least one scenario that is legal and can survive a court challenge.

Reviewer's proposed or suggested change: "We suggest you add some authors that understand the BHNF Land & Resource Management Plan.

Authors' response: The authors were tasked with applying scenarios to only assess the potential harvest levels that are sustainable on the BHNF based on the suitable timberlands as defined in RMRS-GTR-422, appendix A. However, we recognize the reviewers' comment concerning other values or management objectives associated with the BHNF and so we added sections in the introduction that discuss other values that come from the Black Hills. In the section titled *Moving Forward*, we also introduced other

potential management objectives that may limit harvesting. We have added Box 2, which defines sustainability from the Dictionary of Forestry. We also have stated our assumptions and referred to what is a sustainable harvest using the definitions in Box 2.

Comment #: 127

Line # or Figure #: 69-71

Description of the comment/ issue /question: "Furthermore, the current forest conditions in 2019 and probable growth and mortality estimates suggest a saw timber program on the BHNF with an annual harvest of 70,000 to 115,000 CCF per year would be possible." You are ignoring legal constraints. Thus, these proposed annual cuts might not be possible, because folks would sue and win an injunction. You need to qualify the comment with a clause saying that it might be physically possible, but it might not be legally allowed due to many legal constraints.

Authors' response: We recognize the reviewer's comment concerning other values or management objectives associated with the BHNF and in RMRS-GTR-422 we added sections in the introduction that discussed other values that come from the Black Hills. In the section titled *Moving Forward,* we also introduced other potential management objectives that may limit harvesting.

Comment #: 128

Line # or Figure #: 77-79

Description of the comment/ issue /question: You write: "Future climate, weather, mountain pine beetle activity, and wildfire are unknown and potential forest dynamics and growth can only be inferred from past conditions. "

We believe that due to climate change, inferring from the past may not be correct. We also believe that the recent aggressive and extensive over-story removal (tree harvest) during the last 10 or so years may have been unprecedented.

Authors' response: We have added a section in RMRS-GTR-422 that addressed the potential impacts of climate change to mortality under a section titled *Understanding Disturbance and Tree Mortality.* Looking at the past climate and disturbance history, as well as recent events from across the Interior West, provided us with science-based rationale for potential mortality. Furthermore, we employed a range of mortality rates to provide the reader with different scenario outcomes.

Comment #: 129

Line # or Figure #: 80-82

Description of the comment/ issue /question: "All scenarios assume no harvest reduction for other resources (e.g., wildlife, botany, aquatics, and so on) or for Forest Plan adjustments. However, Black Hills National Forest (BHNF) may have restrictions that could alter the amount of area treated and the volumes removed". This likely means, that none of your scenarios will be legally viable. Why have you not considered scenarios with reductions in scenario's cuts to address restrictions?

Authors' response: The authors were tasked with applying scenarios to only assess the potential harvest levels that are sustainable on the BHNF based on the suitable timberlands as defined in RMRS-GTR-422,

appendix A. However, we recognize the reviewer's comment concerning other values or management objectives associated with the BHNF and so we added sections in the introduction that discuss other values that come from the Black Hills. In the section titled *Moving Forward,* we also introduced other potential management objectives that may limit harvesting.

Comment #: 130

Line # or Figure #: 86-87

Description of the comment/ issue /question: "Ponderosa pine forest growth rates of trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.3 to 2.7% while mortality rates varied from 0.16 to 3.07% as wildfires and mountain pine beetles killed trees. ""Clarify that this refers to natural mortality. We ask if the leading cause of tree mortality on the Black Hills is actually removal by chain saw or tree cutting machine, not 'natural death"".

Authors' response: In RMRS-GTR-422, we highlighted the natural disturbances in table 1 that contribute to mortality. In table 4, we showed both the mortality and the harvest removals separately so the reader can assess how much each contribute to the reduction in standing live volume. In Box 1, we discussed how each component increases or decreases the standing live volume. Furthermore, in figure 9 we showed mortality and harvest separately so that the reader can visually observe the differences in amount each factor contributes. We also added a climate change section to address how it might impact MPB, wildfires, and tree regeneration.

Comment #: 131

Line # or Figure #: 89-92

Description of the comment/ issue /question: "The current conditions of the BHNF in 2019 do not support a Forest Plan allowable sale quantity (ASQ) of 181,000 CCF (1 CCF = 100 cubic feet) of sawtimber (9 inches and 90 greater d.b.h.), nor do these forest conditions support an annual harvest of 153,534 CCF that occurred in 2019. " "Please clarify whether this harvest (153,534 CCF per year) is sustainable in perpetuity - is it consistent with relevant language from MUSYA (reiterated in NFMA): ''Sustained yield of the several products and services'' means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable re-sources of the national forests without impairment of the productivity of the land.""

Authors' response: Based on the results we present in RMRS-GTR-422, from the various scenarios evaluated, an annual harvest of 153,534 CCF would still exceed net growth and would result in a reduction in standing live volume.

Comment #: 132

Line # or Figure #: 96-101

Description of the comment/ issue /question: Harvest scenario with 1.04% & 0.26% mortality rate are discussed. "Please clarify whether the 1.04% & 0.26% mortality rates are from the various causes other than human timber harvest.

We question if the forest after beetles & ""logging to prevent beetles"" has too much understory pine regrowth, and that the Forest does not have adequate pre-commercial thinning budget & that this vast

understory is a greater fire risk than the beetle infested & killed trees ever were. We believe there are scientific papers showing more fire risk existing about 20 years after the beetle kill than during the beetle epidemic itself. We believe Brian Brademeyer contracted for a statistical study that showed increased fire risk about 20 years after timber sales in the Black Hills. Could the massive timber sales of recent past - have created a more fire prone forest than you are acknowledging?

Authors' response: The reviewer questions if the recent timber sales have created a more fire prone forest than we are acknowledging. To address the potential increase in fire risk, fire behavior, and fire effects, we provided the reader with a range of mortality rates to use when evaluating the harvest scenarios in RMRS-GTR-422. Stands with high density of small diameter trees are susceptible to fire due to lower resistance to fire (thinner bark), crowns close to the ground that would allow a surface fire to transition into the crown, and the high density of these trees that would facilitate crown spread. Furthermore, adjacent stands that were not harvested would likely have high surface fuel loads from the MPB-killed trees that have fallen (or will in the near future).

Comment #: 133

Line # or Figure #: 102-107

Description of the comment/ issue /question: "Both growth and mortality rates could be modified by stand management. In particular, precommercial thinning of tree regeneration by age 30, both through mechanical means or prescribed fire, could significantly increase residual tree growth rate and shorten the time in which trees become merchantable. Such thinnings could be designed to make forests resistant and resilient to mountain pine beetle attack and wildfire, reducing mortality rates over time."

You need to discuss if you have the budget for this. We have heard that KV dollars can pay for only a quarter of thinning needed. The federal government will be in a huge debt over corona virus expenses - what or who will pay for the needed thinning? Exactly what thinning can you realistically afford? Please consider a future where you have acres of dog hair you can't afford to thin & please consider the associated fire risk & failure to produce enough saw timber.

Authors' response: We cannot address this comment because it is beyond the scope of RMRS-GTR-422 and its intent. Funding projects is under the responsibility of the USFS Black Hills and Regional Office.

Comment #: 134

Line # or Figure #: 111-120

Description of the comment/ issue /question: " identified 765,733 acres of timberland: (suitable), as forestland that is producing or is capable of producing 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn from timber utilization by statute or administrative regulation. Lands inaccessible and inoperable were included." "Please clarify what you mean by ""withdrawn...by...administrative regulation"". There are areas where you can't cut for saw-timber production, but you can cut for other reasons, such as to protect resources. Which type(s) of administrative withdrawal do you mean? You should actually provide a chart for all the areas described in line 111-120, this whole discussion is confusing. How can timberland be ""(suitable)"" when it is "" inaccessible and inoperable""? Inaccessible and inoperable lands belong in the unsuitable category - see

Appendix G of the BHLRMP. Check acreage based on FIA analysis. Define the type of lands that were withdrawn. Add a table that clarifies this information.

Authors' response: We appreciate the comment from the reviewer that all timberlands within the BHNF be considered. We address the difference in suitable and available timber harvest in RMRS-GTR-422, appendix A.

Comment #: 135

Line # or Figure #: 140-141

Description of the comment/ issue /question: "These questions centered on developing a rigorous and statistically sound understanding of the commercial forest within the suitable land base (timberland) as defined by FIA on the BHNF." "It is very confusing about what is the suitable land base via the ""timberland"" process of the FIA compared to what is ""suitable"" land base as identified in Appendix G of the BHLRMP. You should provide a contrasting chart between suitable/tentatively suitable/unsuitable of Appendix G and the suitable ""timberland"" area of FIA. Using the FIA classification may include areas you may not be able to legally cut. Clarity on this might expose legal limits and pie-in-the-sky dreaming. This has a typo, you need to insert a verb: ""These questions are""

Authors' response: We appreciate the comment from the reviewer that all timberlands within the BHNF be considered. We address the difference in suitable and available timber harvest in RMRS-GTR-422, appendix A.

Comment #: 136

Line # or Figure #: 162-172

Description of the comment/ issue /question: This section lists questions the report is expected to answer. The report was not directed to answer enough questions. The 3 questions don't recognize various limits on harvest like -- the restrictions on cut posed by the requirement to log after "Cumulation of Mean Annual Increment" is reached, by the need to comply with standards and guidelines, by the need to avoiding damage to other resources like soils or water quality and need to manage for sustainability of other forest resources besides timber.

Authors' response: RMRS-GTR-422 focuses on identifying a harvest level that is sustainable now and into the future. In the *Moving Forward* section, we discussed the assumptions associated with the scenarios including that all the standing live tree volume is available for harvest within the suitable timberlands. However, we also stated that national forests provide a variety of resources that are subject to other management restrictions.

Comment #: 137

Line # or Figure #: 343-345

Description of the comment/ issue /question: "The FIA reports we tabulated did not include metrics for trees smaller than 5 inches d.b.h (table 1)."Failure to calculate how large an area has the huge understory of baby pine trees (for which there is insufficient budget to pre-commercial thin) may result in over optimistic tree growth calculations and over optimistic view of fire risk.

Authors' response: In Box 1 within RMRS-GTR-422, we described in detail the elements that are in FIA reports (please refer to this section for details) and the high density of small diameter trees that are actually being incorporated into the gross growth rates because (1) there is ingrowth between measurement periods; and (2) this situation of high-density regeneration has been a common occurrence on the Black Hills for a very long time. By utilizing three growth rates (2.33%, 2.52%, and 2.73%) we try to incorporate the impact of high-density regeneration development over time that may influence growth rates.

Comment #: 138

Line # or Figure #: 358-372

Description of the comment/ issue /question: "Weather (e.g., wind, snow, ice), diseases (e.g., root, stem, foliage), insects (e.g., beetles, moths), animals (e.g., mice, gophers, elk, cattle), and fire kill trees in the Black Hills." "Once again, what we suspect is the leading cause of death of trees on the Black Hills--- death by chain saws and timber machines -- is not seen as a source of tree mortality in the Black Hills. How ironic. Please always clarify that the ""mortality"" you refer to is not tree harvest by humans.

Lots of rain, under a very open over-story created during ""logging to fight beetles"", may increase baby pine tree growth, may increase dog-hair and actually increase fire risk. Too much regeneration may not be good, if you don't have a thinning budget. You need to consider possible impacts of climate change and the huge understory of baby pines on future tree mortality.

Authors' response: In RMRS-GTR-422, we highlighted the natural disturbances in table 1 that contribute to mortality over the past several decades. In table 4, we showed both the mortality and the harvest removals separately so the reader can assess how much each contribute to the reduction in standing live volume. In Box 1, we discussed how each component increases or decreases the standing live volume. Furthermore, in figure 9 we showed mortality and harvest separately so that the reader can visually observe the differences in amount each contributes. We also added a climate change section to address how it might impact MPB, wildfires, and tree regeneration.

Comment #: 139

Line # or Figure #: 391-392 and 394-395

Description of the comment/ issue /question: "The report says at lines 391-392:""As a result of both harvest and trees being killed by MPB, live standing inventory decreased from 15,353,000 in 1999 to 13,477,960 CCF in 2011." The report says at lines 394-395: ""harvest peaked at 261,721 CCF in 2017, far exceeding net growth, and declined to 183,592 CCF in 2019..." " "This suggests MPB was not the only factor in tree death. How much reduction in the "live tree volume"" is attributable to:

a. Pine beetles

b. Wildfires & prescribed burns

c. Other natural disturbances

d. Timber sales

Wasn't the epidemic was over by 2017 and thus the peak cutting occurred after the epidemic?

Authors' response: In RMRS-GTR-422, we highlighted the natural disturbances in table 1 that contribute to mortality; however, we did not calculate the amount of volume impacted for each disturbance type. However, in table 4, we showed both the mortality and the harvest removals separately so the reader can assess how much each contribute to the reduction in standing live volume. Furthermore, in figure 9 we showed mortality and harvest separately so that the reader can visually see the differences in amount each contributes.

Comment #: 140

Line # or Figure #: 431-442

Description of the comment/ issue /question: "Forest Plan constraints such as slope steepness, wildlife, recreation, grazing, or other values were not considered in the scenarios." "Above at lines 80 to 82 you said: "All scenarios assume no harvest reduction for other resources (e.g., wildlife, botany, aquatics, and so on) or for Forest Plan adjustments. However, Black Hills National Forest (BHNF) may have restrictions that could alter the amount of area treated and the volumes removed."Given these two statements, each scenario is going to be illegal and can likely be taken out in court if actually implemented. Why aren't you creating scenarios that comply with the Forest Plan? Conversely if you plan to revise the Forest Plan to allow these cuts -- can you create a Plan that supports these aggressive cuts, that won't be taken out in court?

Please make some scenarios that comply with laws about CMAI, that comply with standards and guidelines of the Forest Plan and that don't plan to log in unsuitable lands. You need to factor in complying with rules/laws about Cumulation of Mean Annual Increment (CMAI). You need scenarios that factors in CMAI.

We have been watching the Forest since before the 1996 Forest Plan Revision. You have had a 5% old growth (SS 5) requirement per diversity unit (or something similar) for at least 30 years, probably more like 40 years. You have less than 1% old growth left. The standard and guidelines, goals and objectives of the Forest Plan obviously have not worked very well for protecting old growth and you need some new standards, guidelines, goals and objectives. It was not just the mountain pine beetle or fire, but it was also the perpetual shell game, where areas with more than 5% SS5 were cut down to 5%, when the neighboring area had too little SS 5. It has been going on for the 30 years I (Nancy) have watched. Please consider a new scenario with a larger percent of any area is set aside for old growth--more than 5% in each timber sale or DU or Management Area. Please also set aside more 4B and 4C, as that is what will grow to SS 5. Please evaluate some of the 4A stands to see if they would move into 4B with time. Obviously just saving some extra 4C or 3C for future growth into SS 5 doesn't work very well either - as that is what you have been doing for at least 30 years. You need an alternative with much more aggressive saving of dense stands than the current Forest Plan provides. Current guidance in the Plan did not protect SS5 or late successional landscapes.

We also think aspen is more resistant to fire than pine and also areas with aspen can break up a mountain pine beetle infestation and slow it down. Aspen don't need constant three-step shelter wood logging. The Forest Service should have a goal to increase area of the forest, especially in the WUI. We suggest an alternative with goal of doubling the amount of aspen in 10 years or 15 years.

Please clarify whether the scenarios that gradually reduce the timber harvest would still allow non-sustainable levels of harvest to occur for years out.

Authors' response: The intent of RMRS-GTR-422 was to provide an initial and simple assessment to provide a starting point for conversations about sustainable harvesting of timber. Within the revised report, we expanded the scenarios from 6 to 60. Some of these scenarios are sustainable while others are not. We also agree that CMAI (culmination of mean annual increment) is an important component of forest management planning. However, determining management scenarios that included CMAI, old growth management areas, or aspen was beyond the scope of this document. While we do not account for CMAI, Graham et al. 2019 demonstrated that CMAI in ponderosa pine forests of the Black Hills occurs around 95 to 105 years of age. Thrifty growing stagnated stands with sawtimber sized trees (> 9 inches d.b.h.) have typically met CMAI.

Comment #: 141

Line # or Figure #: 444-446

Description of the comment/ issue /question: The accuracy of estimating future climate, weather, wildfires, and MPB activity for the Black Hills is far from perfect. The best estimate of what the future may bring, is to rely on the past to make reasonable assumptions as to how future forests may develop."

This does not take climate change into consideration. Please make at least two scenarios where climate change creates different conditions than the past -- such as lots of rain (combined with very open over-story) making lots of dog hair and clogged stands slow regrowth or conversely lots of dry & hot weather combined with huge pine understory growth creates more fire. Please consider that maybe the not-thinned huge growth of the pine understory is more of a problem now than it was in the past.

Authors' response: We changed our approach to the scenario development in RMRS-GTR-422 and increased the number of scenarios from 6 to 60. Within some of these scenarios, there were some mortality rates that included an element of uncertainty associated with changes in climate. We added a section titled *Changing Climate* to provide some context on the uncertainty associated with a changing climate under the subsection titled *Mortality Rates* within the *Scenario Development* section, we describe in detail how we developed the mortality rates we used in the revised scenarios.

Comment #: 142

Line # or Figure #: 457-469

Description of the comment/ issue /question: Once again "mortality rates" references don't include human harvest of trees. Please clarify how you are limiting "mortality" to mortality that is not caused by chainsaw or tree cutting machine.

Authors' response: In RMRS-GTR-422, we highlighted the natural disturbances in table 1 that contribute to mortality; however, we did not calculate the amount of volume impacted for each disturbance type. However, in table 4, we showed both the mortality and the harvest removals separately so the reader can assess how much each contribute to the reduction in standing live volume. Furthermore, in figure 11 we showed mortality and harvest separately so that the reader can visually see the differences in amount each contributes.

Comment #: 143

Line # or Figure #: 480-494 see also 497- 548

Description of the comment/ issue /question: These are the lists of the 6 scenarios. "Please clarify which scenarios would gradually reduce timber harvest, but would still allow non-sustainable levels of harvest to occur for years out.

For instance, page 25 describes Scenario 3 as follows: “This scenario illustrates reducing harvest volume from 153,534 CCF that occurred in 2019 to 125,000 CCF in 2020 and continuing in a linear fashion to decrease the harvest volume to 85,000 CCF per year over the next 10 years.” Scenario 4 is similar. Scenario 5 is a 5-year reduction. Is the cut sustainable during reduction years?

You must create scenarios where you do not cut in unsuitable lands, where you provide for sustainability of other resources besides timber, comply with the standards & guidelines, factor in meeting CMAI requirements, and provide for required structural stages in each management area.

We also request scenarios that more aggressively protect dense stands than the current 2006 amended Forest Plan does. We also request scenarios with double the aspen stands, especially focused in WUI.

Please be clear for each scenario you present, if it is legal & if it complies with the current Forest Plan. Please state if changes in the Forest Plan, the National Forest Management Act, the Multiple Use Sustained Yield Act, the Forest Services CFRs, The Endangered Species Act, the Clean Water Act and/or the FSH and FSM would be required before you can move your 6 scenarios forward.

Please clearly state if each scenario will -- provide for the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable re-sources of the national forests without impairment of the productivity of the land. Please state if the ASQ or proposed harvest rate for each scenario can be maintained in perpetuity.

Questions about Standards and Guidelines (S&G) of the Forest Plan. How much of the timber supply in the past 10 years was attributable to waiving, relaxing or disregarding Forest Plan standards & guidelines? If the USFS has been authorizing extensive logging by waiving or relaxing or ignoring standards & guidelines then this suggests the reduction in logging should be larger. We would like to see the data on what percent of harvest over the past 10 years involved a conflict with S&Gs. Please include this in the final report. This is relevant to determining future sustainable harvest … because we need to know if the USFS projections would assume future deviations from S&Gs designed to protect wildlife, soils, water quality and other resources.

Authors’ response: RMRS-GTR-422 presents outcomes of 60 scenarios and we emphasized that the scenarios focus on timber harvest within the context of growth and mortality. The section titled *Scenario Outcomes* described in detail our assumptions and specifically answers the three questions that were identified in the section titled *Information Need.* Information in table 7 and 8 and figures 12 and 13 provide insight into scenarios that are sustainable. This section is followed by a discussion concerning how our results influence a sustainable harvest into the future.

Comment #*: 143a*

Description of the comment/ issue /question: Culmination of MAI and Scenarios

Cumulation of Mean Annual Increment (CMAI)

3a. How much of the cutting on the BHNF over past 10 years has been below culmination of mean annual increment of growth (CMAI)?

3b. Did the analysis summarized in the draft report assume trees would generally be allowed to reach CMAI before harvest? We would like to see the data on what % of predicted harvest involves trees that have reached CMAI.

3c. How would the results change if most trees would be required to reach CMAI before harvest? Please include this in the final report.

3d. Will the USFS ensure the analysis and final report account for the CMAI restriction and assume most trees will be allowed to reach CMAI before being logged?

The draft report suggests CMAI was ignored in the timber supply estimates and suggests the agency assumed any trees at least 9 inches DBH were fair game to log. For instance on page 4 it describes saw timber that contributes to the ASQ as "9 inches and greater DBH"". Figures 4 and 5 are also based on 9+ inch assumptions for harvest. However, as I recall most trees on the BHNF do not reach CMAI until 12-18 inches DBH. If that is the case, then the draft report over-estimates actual timber supply that can be legally harvested. Accounting for CMAI will likely bring the sustained yield below 70,000 CCF.

Authors' response: In RMRS-GTR-422 the section titled *Scenario Outcomes* described in detail our assumptions and specifically answers the three questions that were identified in the section titled *Information Need.* That includes table 7 and 8 figures 13 and 14. This section is followed by a discussion concerning how our results influence a sustainable harvest into the future. We suggest the reviewer read these sections.

We also agree that CMAI is an important component of forest management planning. However, determining management scenarios that included CMAI was beyond the scope of this document. While we do not account for CMAI, Graham et al. 2019 demonstrated that CMAI in ponderosa pine forests of the Black Hills occurs around 95 to 105 years of age. Unstagnated stands with sawtimber sized trees (> 9 inches d.b.h.) have typically met CMAI. The intent of this document was to provide an initial and simple assessment to provide a starting point for conversations about sustainable harvesting of timber.

Comment #: 144

Line # or Figure #: 561-563,

Description of the comment/ issue /question: Nevertheless, these harvest levels would allow the live sawtimber inventory amounts to increase to 6 million CCF in approximately 60 years and return to the level needed to support ASQ as identified in the current forest plan (181,000 CCF) within a century (fig. 6).""

"Please read this sentence carefully, it does not make sense. There must be a typo. Increasing the inventory to 6 million over 60 years will not allow a return to 181,000 CCF. Maybe you meant, increasing it by 6 million CCF?

Authors' response: This sentence has been removed in RMRS-GTR-422 since we revised our approach to the scenarios. Table 7, figure 12, and figure 13 help the reader understand what scenarios are sustainable. Furthermore, table 8 provides the standing live volume that is required to maintain 181,000 CCF/yr under various mortality and growth rates.

Comment #: 146

Description of the comment/ issue /question: General - Scenarios

"Statements we would like you to agree with or deny

* The current harvest and ASQ are not sustainable in perpetuity

* The timber report's scenarios did not account for S&Gs or other constraints that limit harvest

* The timber report's scenarios did not account for CMAI restriction (It just assumed 9"+ is fair game)

* The timber report scenarios considered trees harvestable even if on lands that are inaccessible and inoperable.

Authors' response: This is a comment we cannot address because it appears to be requesting an opinion. RMRS-GTR-422was intended to assess the potential for timber harvest in the short term, mid term, and long term and we have clearly stated our assumptions. Therefore, we recommend that the reviewer refer to the sections titled *Scenario Development* and *Scenario Outcomes* to understand what we included and the analysis and the results of the assessment.

Based on our analysis, we report that (1) current harvest and ASQ is not sustainable; (2) scenarios do not account for other resources/constraints defined in the Forest Plan; (3) scenarios did not account for the CMAI restriction; and (4) scenarios consider trees within the suitable timberland base only.

Comment #: 352

Description of the comment/ issue /question: General-forest cover type

I am sitting and thinking about it this morning, I requested an alternative that increased aspen in the forest, but as I am sitting here I remembered that the Forest Service in it's stand inventories will classify a stand as a pine stand, if it has 6 adult pines per acre and the rest is aspen. The BHNF percentage of area covered in aspen vs pine stands may be very deceptive. Does your process use that juxtaposition...6 pine per acre means it is not aspen but pine?. I don't know what the rule is for oak or spruce that are mixed with pine. If the stand inventories are so biased towards pine, we don't see a clear picture of the forest and the diversity of plant communities that are out there. I would like you to provide a chart with the relative areas in each type of cover type and a clear explanation of the criteria used to class as meadow/grass/shrub, vs. hardwoods, vs. spruce vs. juniper vs. pine, ...Do you all use the 6 adult pines per acre makes it a pine stand? We would like to see more area in aspen, but if any stand that is mostly

aspen but has 6 pines per acre is classified as a pine stand or if it has 6 spruce per acre with aspen, it is classified as spruce, that is disingenuous. Please explain how you classify and deal with mixed stands.

Authors' response: The report's only focus is on ponderosa pine standing live volume. If a stand had other species within the mix of species, only the volume of ponderosa pine was considered

Comment #: 145a

Line # or Figure #: 567-597 & 102-107

Description of the comment/ issue /question: "Both growth and mortality rates could be modified by stand management. In particular, precommercial thinning of tree regeneration by age 30, both through mechanical means or prescribed fire, could significantly increase residual tree growth rate and shorten the time in which trees become merchantable. Such thinnings could be designed to make forests resistant and resilient to mountain pine beetle attack and wildfire, reducing mortality rates over time. "

""Precommercial thinning the small sized ponderosa pine trees can help accelerate the production of sawtimber. Across the Black Hills, ponderosa pine seedling densities exceeding 10,000 per acre after a disturbance (e.g., natural or mechanical) are not extraordinary (Battaglia et al. 2008; Shepperd and Battaglia 2002). Even though tree mortality from wind, snow, and suppression in such stands is substantial, it is inadequate to allow for tree crown differentiation into dominants and intermediates because the growth of such stands often stagnates. In the past, frequent fire was the thinning agent that reduced small tree density and reduced stagnation (Battaglia et al. 2008; Brown and Sieg 1996; Brown and Sieg 1999; Brown et al. 2008; Hunter et al. 2007). Both mechanical thinning and prescribed fire are warranted to produce large trees of both commercial and ecological value at a faster rate. Tree thinning does not increase the productivity of a site, which is controlled by climate and soils, but rather distributes the growth to fewer stems. As a result, depending on the frequency of thinnings and the number and juxtaposition of trees left after a thinning, a wide variety of stand structures, tree sizes, and timber volumes can be produced (Graham et al. 2019).""....

Both studies demonstrate that thinning to the desired stand density early in stand development would yield larger diameter trees and volume outputs much sooner""

"We again point out, we don't think the Forest Service has the budget to pay for the needed thinning. We want you to discuss in your scenario section, if you would be cutting merchantable timber or saw timber.

Do you need to cut mature commercial trees that have reached the CMAI, in order to generate KV dollars to pay for thinning? How many older commercial trees do you have, that you can cut down for KV dollars, and still provide for SS 3, SS 4 and SS 5 area requirements in each Management Area type?

Authors' response: This comment about U.S. Forest Service budget to pay for thinning and the need to harvest mature commercial trees to pay for thinning is outside of the scope of RMRS=GTR-422. However, in the *Moving Forward* section, there is a section on the range of structural stages as defined by the current Forest Plan, and in the section *Management Opportunities* we discuss different silvicultural methods that can be applied to reduce dense regeneration.

Reviewer #14

Comment #: 149

Line # or Figure #: 57-64

Description of the comment/ issue /question: The opening 2 sentences infer that mpb epidemic and wildfires have been occurring over the past several years. It also infers that timber harvests have increased over the last several years on the BHNF. USFS cut/sold report for the BHNF shows a downward trend in volume harvested on the BHNF over the past 10 years. Also, the mpb epidemic was declared over in 2016 and our last major wildfire on the BHNF was almost a decade ago. However, there was an increase in volume cut on the BHNF in direct response to the mpb epidemic. Industry made a conscious decision to harvest almost entirely on the BHNF in order to remove green infested trees from the forest to help reduce the spread of the mpb.

Reviewer's proposed or suggested change: Rewrite the abstract using facts to say the following, "Over the past several years, wildfires, mpb caused mortality, and timber harvest on the Black Hills National Forest (BHNF) have been on the decline. Thanks to the capacity of the timber industry (which has also been reduced over the past 20+ years) in the BHNF, significant efforts were made to reduce the impacts of those events over the past 20 + years. To better understand the changed landscape, ..."

Authors' response: We have altered the abstract in RMRS-GTR-422 to reflect that since 2000, the BHNF has experienced several disturbances that have reduced standing live volume. We removed reference to an increased timber harvest on the Black Hills over the past decade. However, our inquiry into the USFS Forest Product Cut and Sold from the National Forests data (https://www.fs.fed.us/forestmanagement/products/cut-sold/index.shtml) indicates that over the past decade (2009 to 2019), ponderosa pine sawtimber volume cut averaged 190,203 CCF/yr, which exceeds the Forest Plan ASQ. It is true that recent harvests in the past several years have declined from their highs of 2009 to 2011 (212,532 to 222,212 CCF/yr).

Comment #: 150

Line # or Figure #: 64-68

Description of the comment/ issue /question: The statements made are based on the outputs of the scenarios run in this report, which, are based on assumptions of current mortality.

Authors should include the side-boards being used to make such a bold statement. For example, the authors should state that this is based on mortality rates only seen during high wildfire and mountain pine beetle epidemics. Gross growth in the FIA data is low due to an issue with the 25.0"-26.9" size class (shows a negative gross growth due to error in data collection), as well as, a lower suitable base acres than the Forest Plan. The FIA data also excludes white spruce *(Picea glauca)* which contributes to the timber program.

Authors' response: The NRS-FIA responded to these concerns in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns, Challenges, and Assertions* in April 2020. They state the following: "(1) The most accurate way to estimate change is to use FIA's 'Accounting Method.' This creates credits and debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few

trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. (2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25”–26.9” diameter class had a large measured ‘loss’ of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. (3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. (4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period.”

We address the difference in suitable and available timber harvest in RMRS-GTR-422, appendix A second paragraph.

Comment #: 151

Line # or Figure #: 71-73

Description of the comment/ issue /question: Authors infer that there is no difference in harvesting 70k - 115k ccf/yr on net growth and they would reach the same standing inventory at 60 years and 100 years.

Please explain how that is possible in more detail. There are no scenarios that run for 60 or 100 years, nor are there any scenarios that can be compared to each other since there are no constants between scenarios.

Authors’ response: In RMRS-GTR-422 we changed our approach to the scenario development and increased the number of scenarios from 6 to 60.

The 60 scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability over 5, 20, and 80 years. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. The proposed mortality rate to use in scenarios is a complicated one. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development*. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 152

Line # or Figure #: 76-77

Description of the comment/ issue /question: Since the findings are "especially" dependent on mortality, the qualifier of the FIA mortality needs to be discussed.

Please include the explanation to the readers how the 2017/2019 FIA mortality numbers have a delay factor due to the remeasurement cycle of FIA plots and explain how the intensified plot's did not measure (since no tree has a previous measurement in the intensified plots).

Authors' response: While the MPB epidemic has been declared over for now, mortality rates in the future derived from remeasurement of FIA plots will demonstrate the change in mortality. In RMRS-GTR-422, within the *Moving Forward* section of the report, we discussed the need for monitoring to provide realized growth and mortality rates in order to adjust harvest levels to maintain long-term timber sustainability. The "lag factor" mentioned in the comment is about the temporal resolution of the remeasurement period. For example, a plot first measured in 2012 (Time 1) and then remeasured in 2019 (Time 2) calculates the mortality rate between that time period. It is not the mortality rate in 2019, but the mortality rate over that 7-year period (Time 1 to Time 2). From a MPB disturbance mortality contributor, a future remeasurement at this same plot would likely have a lower mortality rate due to the end of the MPB epidemic, if no other disturbances at that location occurs. Plots remeasured with Time 1 in 2020, 2021, etc., will not reflect MPB mortality, but plots measured in 2020, 2021 at Time 2 measurements will reflect mortality since the first measurement was within the epidemic window.

Comment #: 153

Line # or Figure #: 84-85

Description of the comment/ issue /question: The 2019 FIA data reports high sampling errors. It is true that the FIA data was collected following statistically sound protocols, however, due to low sample numbers there are high standard errors for annual growth and mortality at a 95% confidence level. Change it to 'provided an unbiased estimate of growth and mortality'

Authors' response: We changed our approach to the scenario development in RMRS-GTR-422 and increased the number of scenarios from 6 to 60. In this report, table 4 contains the elements that were in the original table 1. And as the reviewer specified, depending on the report there were estimates of all softwoods versus estimates of only ponderosa pine. It is important for the authors to document the nuances, assumptions, and interpretation of past reports, so we expanded table 4 with detailed footnotes. We expanded the section titled *Assessing Past FIA Reports* and have an introductory paragraph that identifies the nuances associated with the different reports through time (please refer to this paragraph for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* the second paragraph summarized the nuances associated with these reports, and we described how we used these reports to provide some context for the scenario development. In the section titled *Scenario Development,* the first paragraph described our assumptions and discussed in detail how the scenarios were developed and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions.

Comment #: 154

Line # or Figure #: 98-99, 100, 482-483"

Description of the comment/ issue /question: A harvest scenario with 1.04% mortality rate (i.e., long-term conservative estimate) indicated an annual sawtimber harvest of 70,000 CCF.""

Using 2019 FIA data as a starting point and an annual mortality rate of 0.26% (i.e. optimistic), an annual sawtimber harvest of 115,000 CCF could be realized.""

Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic).""

I strongly urge/recommend that the authors fully correct and remove any and all biased and/or editorialized statements that they chose to include in what has been presented as a "scientific general technical report." Including the adjectives optimistic, conservative, pessimistic is misleading and unethical. For example, as stated on line 100 of the GTR, describing the mortality rate of 0.26% as optimistic is contradictive since the authors include data in table 1 showing mortality rates of 0.16% and 0.26% were measured for 37 of the 57 years covered, and those 37 years had similar inventory levels and some mpb epidemics and wildfire seems

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized. We have attempted to remove all biased and/or editorialized statements.

Comment #: 155

Line # or Figure #: 86-88

Description of the comment/ issue /question: "Ponderosa pine forests growth rates of trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.3 to 2.7% while mortality rates varied from 0.16 to 3.07% as wildfires and mountain pine beetles killed trees."

It is requested that the authors accurately reflect that for 37 of the 57 years, from 1962 to 1999, that the mortality rates of 0.16 to 0.26% reflect endemic levels of MPB (Line#s 359-360 this GTR), and that the higher mortality rates from 2000-2019 reflect epidemic levels of MPB. It is also requested authors fully acknowledge that current levels of MPB are endemic. See page 8: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. 3) See page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. It is requested that the authors correct their biased sentence to be "Ponderosa pine forest growth rates for trees (5 inches plus in diameter at breast height; d.b.h.) from 1962 through 2019 ranged from 2.33% to 2.73% and averaged 2.58%, while mortality rates remained low during endemic MPB population levels from 1962 through 1999, ranging from 0.16% to 0.26%, and increased during the 2000 - 2017 MPB epidemic ranging from 1.04% to 3.07%. All data indicate MPB population levels after 2019 have fallen and are now considered endemic, reflective of the time period between 1962 through 1999, indicating that mortality rates should also fall into the historical range of 0.16% to 0.26% for the foreseeable future."

Authors' response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that included discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing*

Climate) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality as trees fall is expected to increase wildfire hazard. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and in RMRS-GTR-422 we showed in table 1 those differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we place the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development*, we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 156

Line # or Figure #: 102-107

Description of the comment/ issue /question: Given the objective of this GTR is to address the growth and yield on the BHNF to help guide decisions directly related to the timber harvest levels, the authors need to include not only how precommercial thinning effects individual tree growth, but include information from GTR 393 *Differing Pond. Pine Forest Structures, Their Growth and Yield, and Mountain Pine Beetle Impacts: Growing Stock Levels in the Black Hills*, on the relationship between precommercial thinning to different GSLs effect volume production.

Authors' response: To include intermediate treatments would require an individual tree modeling simulation such as Forest Vegetation Simulator, which is used for stand level growth and development using individual tree data. RMRS-GTR-422 was to look at the entire BHNF; that is why we used FIA data. The kind of analysis requested by the reviewer would be more appropriate for Individual Projects.

We added information from GTR-393 concerning precommercial thinning and GSLs impact on volume production in the section titled *Management Opportunities.*

Comment #: 157

Line # or Figure #: 135-136

Description of the comment/ issue /question: "However, since the 2000s, wildfire activity has increased and burned hundreds of thousands of acres (fig. 2)"

This statement has no literature cited to account for the use of the term "increased" which would be related to frequency as it relates to wildfire research. The listed (fig. 2) only shows the spatial location of wildfires from 1988-2016, and in no way indicates an increased frequency of wildfires in the Black Hills. This sentence presents a potentially false narrative without supported literate. It is requested the authors support this sentence with appropriate literature, give the amount that wildfire activity has increased in the 2000s vs other timeframes in the Black Hills, or edit the sentence to be "As in decades past, wildfires have burned many acres in the Black Hills (fig. 2)."

Authors' response: In the *Wildfires* section of the *Understanding Disturbances and Tree Mortality* section in RMRS-GTR-422, we document the increase in wildfire acreage over the past several decades.

Comment #: 158

Line # or Figure #: 138-140

Description of the comment/ issue /question: The report continuously fails to connect the relationship between the mortality cause by wildfires and mpb and stand conditions on the BHNF created by a timber sale program on the BHNF that was inadequate in size through the second half of the 20th century to keep up with the net growth. This led to historically high standing sawtimber inventories (see table 1 in this GTR) by the end of the 20th century, setting the stage for large scale mpb outbreaks and wildfires. Timber harvest over the past two decades changed the forest conditions by creating more resilient stands through commercial thinning and reducing the spread of mpbs and reducing the fuel loading caused by mpb and wildfire mortality through salvage and sanitation harvests.

Please include this more accurate historical representation of how the BHNF got to where it currently is. This provides context for readers to help insure the same mistakes are not repeated in the future of allowing the BHNF to grown to those high standing inventories again.

Authors' response: In RMRS-GTR-422 we added a paragraph in the introduction before the section titled *Recognizing an Information Need* that provides a more detailed history of what occurred on the Black Hills in relation to the response to the MPB and wildfires.

Comment #: 159

Line # or Figure #: 112-117

Description of the comment/ issue /question: "Timberlands" and "suitable base" are not interchangeable terms. The GTR specifically discusses timberlands within the suited base on the BHNF.

We recommend the authors delete the reference to timberlands here, and elsewhere throughout the document, and the accompanying definitions of timberlands. References to timberlands should be replaced with "765,000 acres of timberlands within the suited base".

Authors' response: We address the difference in suitable and available timber harvest in RMRS-GTR-422, appendix A.

Comment #: 160

Line # or Figure #: 138-151

Description of the comment/ issue /question: Authors leave out important details related to the data collection. We recommend including information here as to the fact that the intensified plots were not used to calculate growth, removals, or mortality, and they only contributed to current acres and volume.

Authors' response: The 2017 and 2019 data were specific inventories requested by the BHNF from FIA to address changes in forest conditions observed most noticeably by recent MPB and wildfire activity (figs. 5 and 6). The data have been quality checked by FIA but have not been published as a Resource Bulletin yet. Data for these measurements cover both the South Dakota and Wyoming portions of the BHNF. Tree growth, mortality, removals, and standing live volume for ponderosa pine trees > 5 inches d.b.h. and sawtimber sized trees (> 9 inches d.b.h.) were described. Merchantable volume for trees > 5 inches d.b.h. used a 4-inch top and sawtimber volumes were computed to a 7-inch top. Both merchantable volume classes used a 1-foot stump. In RMRS-GTR-422, we added a paragraph that discusses the 2017 and 2019 in the section titled *Assessing Past FIA Reports.* We also added table 3 to demonstrate which plots were used to estimate growth and mortality versus those that were used to estimate standing live volume.

As shown by the previous reports, BHNF FIA data from 1962 through the present covered a wide variety of areas, used various sampling methods, presented different forest metrics, and assessed different time frames. These data provide context that can be used in helping understand how the forests of the Black Hills have changed and provide insights of how they may change and be managed in the future.

We have added Box 2 in RMRS-GTR-422 on the definition of sustainability and have shown the effect of multiple disturbances, including harvest, on the standing live volume in tables 1, 4, and 5. In table 1, we show the contribution of natural disturbances to the mortality rates. In table 4 and 5, we showed the contribution of mortality (natural disturbance) and harvesting to the reduction in standing live volume. In table 8, we showed the standing live sawtimber volume needed to maintain the ASQ of 181,000 CCF/yr. According to table 8 of this document, if there had not been mortality due to beetles or wildfires, the estimates of standing live volume in 1999 and 2011 would have supported the ASQ of 181,000 CCF/yr. To conduct an analysis on such a scenario would have required very specific tree data, and this was beyond the scope of this report. Under the section *Management Opportunities,* the report does have a section on silvicultural methods that may lead to the potential increase tree growth.

We also added Box 1 to show FIA calculations of different sources of gross growth and mortality.

Comment #: 161

Line # or Figure #: 272-274

Description of the comment/ issue /question: If a qualifying statement regarding how the data measured does not include 130k acres of wildfires that burned between inventory and publication of this data, then the follow-up qualifying statement needs to be included and reported under the description of the

2011 inventory report. If not, it would appear the authors are trying to lead readers to conclusions regarding the validity of the 1999 data.

Add the following sentence to line 294-295: These data do incorporate changes in standing live inventory caused by the 130,000 acres that burned in the Black Hills as mention above in the 1999 data acquisition description.

Authors' response: In RMRS-GTR-422, we added a sentence that documents the 1999 data acquisition; the description does not include the 130,000+ acres burned in the Jasper Fire. This is the sentence: *Although DeBlander (2002) commented that over 130,000 acres of the BHNF had been impacted by large fires, the mortality caused by these fires was not included in the report since the measurements were made before the wildfires. However, Walters et al. (2013) did report tree mortality from the Jasper fire as well as other wildfires.*

Comment #: 162

Line # or Figure #: 306

Description of the comment/ issue /question: Authors include contradiction information within the report as to when MPB mortality was declining. Figure 1 shows # Trees killed declining by 2012, however, figure 2 shows the number of acres killed begins declining in 2014.

Please explain the discrepancy.

Authors' response: We understand why that might be confusing. In RMRS-GTR-422, we have removed the acres infested by year information. We did keep the figure with number of trees killed each year (now fig. 4). We also recognize that the number of trees killed by beetles started to decline in the early 2010s. However, number of trees killed still was high. In addition, the number of trees killed versus amount of acreage impacted are two different metrics.

Comment #: 163

Line # or Figure #: 304-313, 326-331

Description of the comment/ issue /question: Concerned the authors are unclear on the data they are using in the GTR. Growth, mortality, and removals were NOT tabulated for the 130 additional plots.

Documentation from FIA can be provided. The authors should properly vet data they are using to answer such consequential questions as this report aims to do.

Authors' response: In RMRS-GTR-422, we expanded the section titled *Assessing Past FIA Reports* and have an introductory paragraph that identifies the nuances associated with the different reports through time (please refer to this paragraph for specific details). In the section titled *Growth, Mortality, Harvests, and Standing Live Tree Inventory Over Time,* the second paragraph summarized the nuances associated with these reports, and we described how we used these reports to provide some context for the scenario development. In the section titled *Scenario Development,* the first paragraph described our assumptions and discusses in detail how the scenarios were developed and documents the rationale. Through this process, the reader was made aware of how the data from past reports were applied and how we developed the scenarios with the specified rationale including assumptions.

Comment #: 164

Line # or Figure #: 359-362

Description of the comment/ issue /question: This statement about mortality rates from 1962 to 1999 reflecting low levels of MPB activity and minimal wildfires is contradicted by the authors own research. In Mountain Pine Beetles: A Century of Knowledge, Control Attempts, and Impacts Central to the Black Hills (see pg 36, "In 1962, MPB infestations within the Black Hills continued to increase in area and intensity (fig. 31)." It should be noted that fig. 31 in the Mountain Pine Beetles GTR is the same as figure 1 in this GTR, and yet the authors are drawing a different conclusion than their first publication. There was also at least 50,000 acres of wildfires within the Black Hills National Forest between 1980 and 1999 (black hills fires shapefile provided by the BHNF).

Sentence should be changed to "The low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect both endemic and epidemic levels of MPB activity (fig. 1) and moderate levels of wildfire occurrence, signifying that these have always been a contributing component of mortality. These low mortality rates may be expected to occur again now that the most recent epidemic is over and we have a similar inventory now as we did then."

Authors' response: In RMRS-GTR-422, we added table 1 to show how each mortality agent contributed to the overall mortality through the different measurement periods. Based on the data that informed that table, it is obvious that the recent MPB epidemic and wildfire activity was much larger in extent and severity than those observed from 1962 to 1999. Furthermore, mortality rates calculated during the periodic inventory method tend to underestimate the rates compared to those estimated based on the annualized methodology deployed in the early 2000s.

Comment #: 165

Line # or Figure #: 367-369

Description of the comment/ issue /question: "As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

The statement is contradicted by other facts presented in this GTR. The 1.04% mortality rate represents a period of above average mortality in the Black Hills (see table 1). The 0 mortality percent from 1962 through 1999 is 0.23%. 1962 through 1999 included the 3rd largest mpb epidemic in the last 120 years and 94,000 acres of wildfire damage. Also, bark beetle activity by national forest indicates only 20 acres of activity in the Black Hills NF. See page 8: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. Also, see page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. page 12

Authors' response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that included discussions on disturbances that have occurred in the Black Hills. In addition, we

included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality is expected to increase wildfire hazard as trees fall. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and in RMRS-GTR-422 we added table 1 to show those differences by mortality agent. We discuss the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Until the “annualized” protocol for FIA was implemented in the early 2000s, periodic inventory data from 1962 to 1999 were snapshots in time. Therefore, we changed our approach in RMRS-GTR-422 and described the rationale on selecting the 5 mortality rates we evaluated.

Comment #: 166

Line # or Figure #: 369-370

Description of the comment/ issue /question: "In addition it is a good estimate of what might occur in future decades."

This is a biased statement and has no reference cited to explain it. It also contradicts the authors own reference on Line#s 359-360 of this GTR indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity...". It is recommended the authors find literature to support this biased statement or remove it from the GTR.

Authors’ response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category’s contribution to the total mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that included discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality is expected to increase wildfire hazard as trees fall. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and we added table 1 to show those differences by mortality agent. We discussed the different mortality agents over time and how

they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we place the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 167

Line # or Figure #: 370-372.

"...van Mantgem recent trends in mortality in pines across the Western United States over past 4 decades have been increasing and ranged from 1 to 2%."

Van Mantgem study involved "...data from unmanaged old forests…" and the Black Hills NF is not an unmanaged old growth forest. The use of van Mantgem's data to indicate trends in mortality with the Black Hills NF is not applicable to the Black Hills NF. It is recommended to remove the van Mantgem paper as a reference for mortality rate.

Authors' response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, we looked at recent FIA reports from across the Interior West. In RMRS-GTR-422, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we did provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 168

Line # or Figure #: 387-397

Description of the comment/ issue /question: This GTR indicates that in 1999 the live standing inventory was 15,353,000 ccf with a gross growth of 380,000 ccf a noted peak in gross growth.

It is recommended that the GTR address the strong correlation between mountain pine beetle mortality and higher stocked ponderosa pine stands. (see José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand; *Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills*, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061)

Authors' response: In the *Introduction* of RMRS-GTR-422 we discussed results from long-term and recent studies across the BHNF that link forest susceptibility to MPB induced tree mortality.

Comment #: 169

Line # or Figure #: 387-397

Description of the comment/ issue /question: The intent of this paragraph is to inform the readers as to the events that lead to the drop in standing inventory. The authors are missing key points 1) harvest levels dramatically declined beginning in the mid-1990s (see BHNF cut and sold report), 2) The increase in harvest from 2006-2011 was a direct response to the mpb epidemic. BHNF leadership and other stakeholders worked together to increase the direct attack and stand density reductions to curtail the epidemic, 3) sawtimber harvest peaked in 2011 (see BHNF cut and sold report), however, it was reported in the 2017 FIA report 4) fig 6 compares different acreages and species being reported. Not a good comparison to show current inventory on a subset of acres compared to the rest of the data

It is recommended these clarifying comments are included in the GTR.

Authors' response. In the *Introduction* of RMRS-GTR-422 we provide information on the U.S. Forest Service and stakeholder collaborative approach to coordinate management strategies to reduce MPB mortality.

While we agree that figure 6 (interim report)/figure 9 (RMRS-GTR-422) is based on different acres and species being reported, we find the figure to be quite useful to look at the trend within a specific measurement period (i.e., When does mortality exceed gross growth? When does net growth exceed harvest? When does harvest exceed net growth?).

Comment #: 171

Line # or Figure #: 392

Description of the comment/ issue /question: This GTR indicates that in 1999 the live standing inventory level was 15,353,000 ccf.

It is requested that the authors discuss the effect of the 1999 live standing inventory of 15,353,000 ccf had on potentially causing an endemic population level of MPB to become epidemic. See page 1: "Eruptive MPB populations occur when conditions become favorable for the insect and unfavorable for its host trees (Thompson and Shrimpton 1984, Mattson and Haack 1987, Boone et al. 2011, Preisler et al. 2012). Populations thrive in overstocked stands composed of an abundance of suitable-sized trees (Safranyik et al. 1974, Sartwell and Stevens 1975, Amman et al. 1977). These stand conditions contribute to tree stress and provide an abundance of suitable host trees for insect populations to successfully colonize and reproduce, eventually causing considerable ponderosa pine mortality over large areas." José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061

Authors' response: In the *Introduction* of RMRS-GTR-422 we discuss results from long-term and recent studies across the BHNF that link forest susceptibility to MPB induced tree mortality.

Comment #: 172

Line # or Figure #: 387-397

Description of the comment/ issue /question: This GTR indicates that in 1999 the live standing inventory was 15,353,000 ccf with a gross growth of 380,000 ccf a noted peak in gross growth.

It is requested that the authors further discuss this peak live standing inventory as it relates to likelihood that it lead to the 2000-2017 MPB epidemic. As it is was stated in the Forest Health Report - Black Hills NF/R2, SPF & TR, FHP, RCSC-SR-01, USDA Forest Service, January 2020 on page 19, "Despite a thriving forest industry and a national forest that led the nation in timber harvest, much of the forested land across all ownerships was overstocked with ponderosa pine setting the stage for the epidemic mountain pine beetle populations."

Authors' response: In the *Introduction* of RMRS-GTR-422 we discuss results from long-term and recent studies across the BHNF that link forest susceptibility to MPB induced tree mortality.

Comment #: 173

Line # or Figure #: 415-417

Description of the comment/ issue /question: Authors fail to qualify their statements with the fact that the FIA data reports a lag in mortality and the 2017 and 2019 data are still reporting epidemic levels of mortality due to this lag. These data do not reflect current mortality, but rather mortality of the past 7-9 years.

Please include this information.

Authors' response: The reviewer is correct that the mortality values reported for 2017/2019 are reporting mortality for the MPB epidemic of the past decade. Plots that were initially established in 2017 and 2018 did not contribute to mortality calculations, only current estimates of standing live volume. However, these plots, if remeasured in 2024 (BHNF has the option to do so), would provide additional mortality information. Depending on what happens on those plots over the next several years, we might observe an increase or decrease in mortality across the Forest. Since the MPB epidemic has currently been stated as over, it is unlikely that mortality would be influenced on these plots by MPB, unless these plots are located in areas not impacted yet. However, other disturbances are common across the Black Hills, such as wildfires, weather (i.e., tornados and snow breakage), and disease, and can contribute to mortality that we showed in table 1 in RMRS-GTR-422. In the section *Moving Forward* we suggest that continuous monitoring and flexibility to adjust harvest levels on realized mortality rates is crucial for long-term timber sustainability.

While the MPB epidemic has been declared over for now, mortality rates in the future derived from remeasurement of FIA plots will demonstrate the change in mortality. Within the *Moving Forward* section in RMRS-GTR-422, we discussed the need for monitoring to provide realized growth and mortality rates in order to adjust harvest levels to maintain long-term timber sustainability. The "lag factor" mentioned in the comment is about the temporal resolution of the remeasurement period. For example, a plot first measured in 2012 (Time 1) and then remeasured in 2019 (Time 2) calculates the mortality rate between that time period. It is not the mortality rate in 2019, but the mortality rate over that 7-year period (Time 1 to Time 2). From a MPB disturbance mortality contributor, a future

remeasurement at this same plot would likely have a lower mortality rate due to the end of the MPB epidemic, if no other disturbances at that location occurs. Plots remeasured with Time 1 in 2020, 2021, etc., will not reflect MPB mortality, but plots measured in 2020, 2021 at Time 2 measurements will reflect mortality since the first measurement was within the epidemic window.

Comment #: 174

Line # or Figure #: 421-442

Description of the comment/ issue /question: Given the questions asked of the researchers from the BHNF leadership, the authors chose a too narrowly focused analysis to answer those questions.

We recommend using figures from all forested lands within the suited base when describing timber resources including inventory, growth, and mortality - instead of only a subset (timberlands) within the suited base. We also recommend adding additional analysis within the GTR that discusses timber resources on timberlands outside the suited base. Any discussions of timber resources should also include the acres those resources apply to. We recommend including timber resources from spruce in all tables and scenarios within the GTR and in the text of the paper.

Authors' response: We appreciate the comment from the reviewer that all forested lands within the suitable base be used as well as spruce to describe timber resources. However, we were specifically asked to provide scenarios based on ponderosa pine within the suitable timberlands within the BHNF. We utilized the FIA definition of timberlands and the acreage of suitable base as provided by that dataset (see RMRS-GTR-422, appendix A). An additional analysis that includes timberlands outside of the suitable base was not considered.

Comment #: 175

Line # or Figure #: 450-455, and other places where gross growth is discussed.

Description of the comment/ issue /question: When discussing gross growth rates, the authors state they, "found no mathematically [sic] way to justify a gross growth rate to use…" Instead, they arbitrarily picked a number lower than the lowest sawtimber gross growth rate they report, despite stating that the gross growth rate was 3.12 percent in 2017. There is no mention of 2018 by the authors. However, a meaningful process to justify the gross growth rate would be to use the average of the two stated values: 2.815. Another way to look at this, would be to look at the growth rate reported by FIA for the only plots that were measured in the year 2019. Importantly, the plots measured in 2019 were all permanent plots - the only plots used in the FIA study to report growth and mortality. This provides a good estimate of the actual growth in 2019. When the permanent plots measured in 2019 (approx 75 percent of all permanent plots) are used to report gross growth, the reported value is 4.16 percent (FIA reports available upon request). The authors could just as easily use the figure (4.16 percent) from the most current measurements which also contains 75 percent of all the remeasured plots from which gross growth was reported from throughout the FIA measurements. Notably, a higher gross growth figure is in-line with previously published work from the authors, including the 2019 publication "Differing Ponderosa Pine Forest Structures, Their Growth and Yield, and Mountain Pine Beetle Impacts: Growing Stock Levels in the Black Hills".

We recommend using a minimum gross growth value of 2.815 and a more supportable value of 4.16 percent in all scenarios. Both numbers are supported mathematically and by the FIA data.

Authors' response: The 60 scenarios, in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development*. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 176

Line # or Figure #: 471-474

Description of the comment/ issue /question: "However, as we disused before, a conservative mortality estimate of 1.04% rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills."

The 1.04% mortality rate reflects the first 10 years of mortality caused by the MPB epidemic in the Black Hills NF. "Although the BHNF is currently experiencing a MPB epidemic that is increasing tree mortality, abundant live growing-stock and sawtimber volume is still available." Walters, B.F.; Woodall, C.W.; [et al.]. 2013. Forests of the Black Hills National Forest 2011. Resource Bull. NRS-83. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. page 17. The 1.04% mortality rate is representative of the early stages of a MPB epidemic and do not reflect endemic levels of mortality as indicated on Line#s 359-360 of this GTR. This is also a biased statement as it is written "...a conservative mortality estimate..."; "...is reasonable and may reflect that the long-term trend of trees killed in the Black Hills." It is recommended that the authors retain the "Walters et al" reference but remove the biasness from this GTR. It is also recommended that the authors correctly indicate that the 1.04% mortality rate is a result of the 2000-2017 MPB epidemic and not to possible mortality rates during endemic MPB levels, as they currently are and will be into the foreseeable future. See page 8: USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. 3) See page 12: "Mountain pine beetle activity remains at low (endemic) levels across most of the Region after a large outbreak which peaked in 2009." USDA Forest Service, Forest Health, R2-RO-20-01, January 2020. Forest Insect and Disease Conditions in the Rocky Mountain Region, 2019. page 12. 4) The use of 1.04% also does not support the question posited on Line#s 169-170, which asked for "...data assuming rationale tree mortality..." as any "...rationale tree mortality..." would be based on historical mortality rates with endemic MPB populations such as those from 1962-1999 that were 0.16% to 0.26% as stated on Line#s 359-360 of this GTR. 5) Lines 444-448 support the use of 0.16-0.26% mortality.

Authors' response: We did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct “snapshot,” based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a “true” remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 177

Line # or Figure #: 474-475

"...van Mantgem et al. (2009) indicated that recent trends in mortality in pines across the Western United States over past 4 decades have been increasing and ranged from 1 to 2%."

van Mantgem study involved "...data from unmanaged old forests…" and the Black Hills NF is not an unmanaged old growth forest. 2) van Mantgem mortality study did not include any forested land in or near the Black Hills NF. 3) The GTR states "The Black Hills forests have maintained a viable timber industry for over a century." This indicates that the Black Hills NF does not fit the data used by van Mantgem to indicate a mortality rate of 1 to 2%. The use of van Mantgem's data to indicate trends in mortality with the Black Hills NF is unreasonable as it applies to the Black Hills NF and this Black Hills Timber Growth and Yield Draft General Technical Report. 4) It is recommended to remove the van Mantgem paper as a reference for mortality rate.

Authors’ response: We agree that the van Mantgem paper was focused on unlogged forests across the West. To address this, we looked at recent FIA reports from across the Interior West. In RMRS-GTR-422, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we did provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB

epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 178

Line # or Figure #: 473-474

Description of the comment/ issue /question: "In addition, we feel this rate is a good estimate of what might occur in future decades."

This is a biased statement and has no reference cited to explain it. It also contradicts the authors own reference on Line#s 359-360 of this GTR indicate that "…low (0.16 to 0.26%) ponderosa pine mortality rates from 1962 to 1999 reflect the low (endemic) levels of MPB activity...". It is recommended the authors find literature to support this biased statement or remove it from the GTR.

Authors' response: In RMRS-GTR-422, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we did provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 179

Line # or Figure #: 478-494

Description of the comment/ issue /question: All scenarios should not just start with the same standing live volume and growth rates and should start with a mortality rate of 0.16% based on historical data provided by the authors (see comments above for lines 421-442 and 450-455 and 474-475)

We recommend using a minimum gross growth value of 2.815 and a more supportable value of 4.16 percent in all scenarios. Both numbers are supported mathematically and by the FIA data. We recommend using .16 mortality for all scenarios and discussion of what an appropriate mortality level is. That level of mortality was recorded over 37 years, with similar to higher timber inventories.

Authors' response: In RMRS-GTR-422, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

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- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct "snapshot," based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a "true" remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 180

Line # or Figure #: 482-548

Description of the comment/ issue /question: All scenarios run in the drat GTR do not reflect current mortality

Revise all scenarios to begin in year 2019 with 0.16% mortality. The 2019 FIA data only measures the average annual mortality over the past remeasurement cycle. It cannot be used to calculate current mortality when the last remeasurement cycle spans a major natural disturbance event that is no longer causing mortality. Please delete all scenarios from the GTR and run new scenarios with the collaborative input from the stakeholders as promised by the BHNF Leadership team in 2017 (see Lines 157-161)

Authors' response: In RMRS-GTR-422, we have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated

work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we do provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

These new scenarios, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled Understanding Disturbance and Mortality to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible. Authors did not use the value of a 0.16% mortality rate previously reported for the 1962 periodic inventory, for several reasons:

- The 0.16% mortality rate was reported under the periodic inventory methodology. With this inventory method, live volume is a direct “snapshot,” based on the standing live volume at the time a plot is visited and does not measure trees that died and fell on the ground.
- Removals (harvests) were based on other sources of data (i.e., reports from sawmills), not from removals measured at the plot.
- The periodic inventory method tends to underestimate mortality and removals.
- In contrast, the annual inventory utilized after 2000 is a “true” remeasurement because it provides a full accounting of every tree > 5 inches in diameter, even if mortality does not increase from one measurement to the next measurement period. Therefore, mortality rates quantified under the annual inventory is a better estimate of mortality.

Comment #: 181

Line # or Figure #: 500-502

Description of the comment/ issue /question: "Under these assumptions (pessimistic), including all of the components of gross growth (e.g., ingrowth, growth on mortality) sawtimber in the Hills would be depleted by 2054 (fig. 9)."

It is suggested to remove more editorializing comments, "(pessimistic)", from this scientific GTR.

Authors’ response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 182

Line # or Figure #: 552-555

Description of the comment/ issue /question: When describing the impacts on standing live volume by natural disturbance and timber harvests, the authors are attempting to incorrectly portray once again

that timber harvest activities have been a separate source of removal and fail to provide a reader with knowledge of over a century of forest management research describing the benefits of timber harvesting to reduce the impacts of these natural disturbances (most recently in Negron, et al 2017, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA (published in Forest Science). This peer reviewed publication draws clear conclusions that active forest management is tremendously successful at abating mortality caused by mountain pine beetles.)

It is suggested the authors correct this sentence to read, "The 2017-2019 FIA data demonstrate that the 1999 live standing volume of 15,535,000 ccf lead to the 2000-2017 MPB epidemic and helped fuel numerous, large wildfires, in the Black Hills NF. The collaborative actions taken by the Black Hills MPB working group, and its partners, helped to mitigate the exponentially expanding MPB population in the Black Hills NF. Their actions from 2010 through 2016 helped to lower the overall live standing inventory to conditions that are more resilient and sustainable through commercial thinning 188,000 acres and pre-commercial thinning approximately 73,000 acres. Together industry and local governments non-commercially treated over 1.3 million infested trees and sent about 1.4 million infested to local sawmills, supporting the overall economy in the Black Hills region. These actions have not yet been fully realized in the lag-statistics, such as growth and mortality rates (Negron et al. 2017) that take 5-10 years to fully recognize. Research shows today's live standing inventory will have growth rates in excess of 2.5% (Table 1) and could possibly be as high as 3.12% as they were observed in 2017 (Line# 452 of this GTR). Based on the 2019 live standing level of 5,995,428 we credit the industry and local governments for their actions that saved the Black Hills NF from complete devastation, such as the millions of trees and extensive acres killed in Colorado from their own MPB epidemic that did not have such progressive and engaged partners."

Authors' response: In RMRS-GTR-422, we added a paragraph in the introduction last paragraph before the section titled *Recognizing an Information Need* that provides a more detailed history of what occurred on the Black Hills in relation to the response to the MPB and wildfires. We also further discussed the effect of density management in the *Management Opportunities* section.

Comment #: 183

Line # or Figure #: 552-555

Description of the comment/ issue /question: "The intensive 2017-2019 FIA data demonstrated that the BHNF has undergone a substantial decline in ponderosa pine standing live volume. The impacts of the MPB, wildfires, and other natural disturbances combined with timber harvest during the past decade contributed to this decline (fig. 6)"

It is requested that the authors remove the word "intensive" as 1 plot every 3,000 acres is not intensive. It is simply more than historically has been measured through FIA on the Black Hills. The FIA data still reports high Sampling error for most of the information it provides at a 95% confidence level.

Authors' response: We have removed the words "intensive" or "intensified" when we discussed the recent FIA sampling in RMRS-GTR-422

Comment #: 184

Line # or Figure #: Table 1

Description of the comment/ issue /question: There is an error in reporting the inventory and growth figures for Collins and Green, 1988 in table 1. Table 1 in the GTR reports a standing live inventory of 13,449,000 ccf. That number is correct for all softwoods, but the publication also reports the standing inventory for only ponderosa pine at 12,974,000 ccf. This becomes important because the GTR reports net growth only for ponderosa pine, which makes the growth percent calculation erroneous. The GTR reports net growth of 301,660 ccf but Collins and Green, in table 13 on page 22, report total softwoods net growth of 304,630 ccf for softwoods. This would also affect other calculations in the table, including: net growth as a percent, and net change as a percent.

We recommend only displaying information in an "apples to apples" format by not mixing ponderosa pine growth figures with inventory for all softwoods, or vice-versa. The authors should change table one to reflect the growth for all softwoods or the standing inventory, mortality, etc. for ponderosa pine only.

Authors' response: In RMRS-GTR-422, table 4 contains the elements that were in the interim report table 1. And as the reviewer specified, depending on the report, there were estimates of all softwoods versus estimates of only ponderosa pine. It is important for the authors to document the nuances, assumptions, and interpretation of past reports, so we expanded table 4 with detailed footnotes. However, the reviewer is correct that we report the volume for all softwoods for the 1984 data. In that FIA resource bulletin, ponderosa pine only data was presented in that document for the net growth and inventory volume. In addition, other data (i.e., mortality) as well as net growth and inventory volume were presented in softwoods. So, calculations and table should reflect only data from softwoods.

Comment #: 185

Description of the comment/ issue /question: Reliable data is core to any scientific publication. Unfortunately, the authors have not spent the requisite amount of time vetting the data received through channels other than their own data collection. As such, important details within the data have been overlooked. One example is that the FIA data reports more than 8000 ccf of annual negative gross growth. After examination of the data, it has become clear that is caused by one tree in the 25-26.9 inch diameter class. This tree has a profound effect on the reported annual gross growth of growing stock. If that tree is removed from the database, the total average annual gross growth on growing stock on timberlands within the suited base increases by nearly 10,000 ccf/yr to 194,810 ccf. (Evalidator outputs and databases available upon request) This also has the effect of increasing the gross growth as a percent to 2.45% from 2.33 percent. Other important aspects of the data that warrant additional discussion in the GTR include the aforementioned reduction in acres, despite using the same plots.

We recommend using the reported average annual gross growth, with this tree removed, of 194,810 ccf for growing stock trees on timberlands within the suited base of the BHNF and an adjustment to the sawtimber average annual gross growth using this same method.

Authors' response: The NRS-FIA responded to these concerns in *Responses to Black Hills National Forest Timber Stakeholder Questions, Concerns, Challenges, and Assertions* in April 2020 (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd733565.pdf). They state the following: "(1) The most accurate way to estimate change is to use FIA's 'Accounting Method.' This creates credits and

debits in each cell as trees grow into and out of diameter classes. Overall negative growth within a diameter class may be observed as a result of this accounting if there are relatively few trees in the estimate or any time a pattern of stand dynamics results in more growth out of a given size class than is accumulated. (2) Additionally, tree height is a difficult attribute to measure. One of four trees in the 25”–26.9” diameter class had a large measured ‘loss’ of tree height resulting in a large negative growth for that tree as well as the whole diameter class. Overall negative growth in this particular diameter class is an artifact of a very small sample size in that diameter class. (3) FIA staff assessed the impact of this tree on overall growth estimates. Removing this tree from the database does not change the overall growth estimate significantly (see below). The published data tool facilitates transparency and can be used to reproduce these estimates with and without the tree. Est sawlog gross growth WITH the tree (95% CI): 150,694 ± 23,629 CCF. Est sawlog gross growth WITHOUT the tree (95% CI): 152,422 ± 22,526 CCF. (4) FIA measurements of tree height changes in the new inventory data have a mean height GAIN of 1.1 feet over the remeasurement period.”

Comment #: 186

Description of the comment/ issue /question: Was there ever an understanding between the FS and the Stakeholders that a GTR would be conducted prior to the release of the FIA data?

Authors’ response: No. The decision to publish RMRS-GTR-422 was made by the Rocky Mountain Research Station (RMRS). The topic of sustainability of harvest on the BHNF has generated much interest from the stakeholders. The analysis in RMRS-GTR-422 may have the potential to have an economic impact, so to ensure maximum “quality, objectivity, utility, and integrity of information” (OMB Guidelines), RMRS decided to publish the report as a General Technical Report and go through the process of technical and blind review, as well as providing stakeholders the ability to comment.

Comment #: 187

Description of the comment/ issue /question: What does “: a Changing Forest” mean? This is a technical report. This is a vague description that does not lead the reader a greater understanding of the report’s content. Think about changing the title.

Authors' response: Thank you for your comment. We have changed the title in RMRS-GTR-422, which is now *A Scenario-Based Assessment to Inform Sustainable Ponderosa Pine Timber Harvest on the Black Hills National Forest.*

Comment #: 188

Description of the comment/ issue /question: Who selected the photos of logging, MPB, and fire that were placed on draft 1 of the GTR? Change the pictures

Authors’ response: The authors chose the photographs for the interim report and RMRS-GTR-422. The comment doesn’t provide a reason why the pictures need to be changed.

Comment #: 189

Description of the comment/ issue /question: The FIA data review process was initiated to understand the state of the forest after several historical events had occurred. The Forest with the longest history of forest management had just peaked in standing inventory. The GTR should be focused on assisting the

reader with answering the questions put forward by the Stakeholder working group. Such as determining what the appropriate inventory should be. Ensure that we help the reader understand what is happening

Authors' response: The appropriate inventory and future monitoring for the BHNF is an important decision that needs to be made. The objective of RMRS-GTR-422 has succeeded in answering the questions posed by the U.S. Forest Service and its stakeholders and provide science-based information to BHNF and interested parties.

Comment #: 154a

Line # or Figure #: "98-99, 100, 482-483"

Description of the comment/ issue /question: A harvest scenario with 1.04% mortality rate (i.e., long-term conservative estimate) indicated an annual sawtimber harvest of 70,000 CCF.

Using 2019 FIA data as a starting point and an annual mortality rate of 0.26% (i.e. optimistic), an annual sawtimber harvest of 115,000 CCF could be realized.""

Scenario 1: continuation of the 2019 harvest level (153,534 CCF) and mortality rate of 2.98% (2019) and a growth rate of 2.5% (pessimistic)."" "

I strongly urge/recommend that the authors fully correct and remove any and all biased and/or editorialized statements that they chose to include in what has been presented as a "scientific general technical report." Including the adjectives optimistic, conservative, pessimistic is misleading and unethical. For example, as stated on line 100 of the GTR, describing the mortality rate of 0.26% as optimistic is contradictive since the authors include data in table 1 showing mortality rates of 0.16% and 0.26% were measured for 37 of the 57 years covered, and those 37 years had similar inventory levels and some mpb epidemics and wildfire seems

Authors' response: We tried to remove editorialized statements in RMRS-GTR-422. During the formal editing process, we searched for any terms that may be considered biased or editorialized.

Comment #: 170A and 170B

Line # or Figure #: 111, 376-77"

Description of the comment/ issue /question: The BHNF has supported a thriving forest industry for over 100 years (Freeman 2015).

The Black Hills forests have maintained a viable timber industry for over a century (Freeman 2015; Sheppard and Battaglia 2002).

See page 1: "Areas designated for timber production are also impacted, affecting forest planning process and negating timber management investments." Negron, J.F., K. Allen, B. Cook, and J.R. Withrow Jr. 2008a. Susceptibility of ponderosa pine, Pinus ponderosa (Dougl. Ex Laws.), to mountain pine beetle, *Dendroctonus ponderosae* Hopkins, attack in uneven-aged stands in the Black Hills of South Dakota and Wyoming, USA. For. Ecol. Manage. 254(2):327-334. doi:10.1016/j.foreco.2007.08.018. See page 1: "For example, tree mortality in fiber production-oriented stands can negate prior investments and management practices." José F. Negrón, Kurt K. Allen, Angie Ambourn, Blaine Cook, Kenneth

Marchand, Large-Scale Thinnings, Ponderosa Pine, and Mountain Pine Beetle in the Black Hills, USA, Forest Science, Volume 63, Issue 5, October 2017, Pages 529–536, https://doi.org/10.5849/FS-2016-061 It is requested that the authors address devastating effects the 6 scenarios will have on the timber industry and the less than likely return of it to the Black Hills, fully "negating" previous timber management investments and how, as demonstrated on national forest throughout the west that have lost their timber industry capacity, it will have consequential effects on the future capability of the BHNF to deal with wildfires and insect and disease outbreaks.

Authors' response: RMRS-GTR-422 reports the timber sustainability in the Black Hills under different scenarios. It is not intended to discuss how timber industry or other industries will be impacted by a reduced timber harvest. However, the results from these scenarios will provide some insight into discussions about how industry and National Forests move forward during the planning process.

Reviewer #15

Comment #: 122

Line # or Figure #: 102 - 107

Description of the comment/ issue /question: The GTR points out that both growth rate and mortality rates could be modified by stand management. The GTR states "Both growth and mortality rates could be modified by stand management. In particular, precommercial thinning of tree generation by age 30, both through mechanical means or prescribed fire, could significantly increase residual tree growth rate and shorten the time which trees become merchantable. Such thinnings could be designed to make forests resistant and resilient to mountain pine beetle attack and wildfire. reducing mortality rates over time."

Reviewer's proposed or suggested change: Would like to see scenarios with various rates of Timber Stand Improvement and prescribed fire acres. How that would affect mortality rates, timber growth and yield?

Authors' response: To conduct an analysis on such a scenario would have required very specific tree data and this would require extensive forest simulation modeling and is more appropriate for Forest Plan/Timber Planning. Incorporating TSI and RX fire would likely increase growth rates, but how to model that in conjunction with FIA data is not the intent of this publication. However, we did approach these scenarios with a range of growth and mortality rates to provide potential increases in growth due to these activities that we published in RMRS-GTR-422.

Comment #: 123

Line # or Figure #: 111 - 120

Description of the comment/ issue /question: The GTR takes into account the amount of harvest on "suitable" timberlands, how much harvest is available on all timberlands outside of the suitable base? The Black Hills also grows white spruce, that has a commercial value. How many acres of white spruce is available for harvest, what is the potential annual CCF harvest?

Reviewer's proposed or suggested change: Would like to see a scenario that figures the additional CCF from white spruce harvest and commercial harvest outside of the suitable base. How much CCF would this add to the potential annual harvest?

Authors' response: Our task was to address ponderosa pine sustainable harvest on the suitable timberlands. While white spruce does have commercial value and can contribute to the annual CCF for harvest, it was not the scope of RMRS-GTR-422.

Comment #: 121c

Line # or Figure #: 359 - 360; 457 - 469; 478 - 494

Description of the comment/ issue /question: The Pennington County Board of County Commissioners realizes how import the Black Hills National Forest is to the region and the impact it has on the economy, property values, agricultural industry, tourism, recreation, and quality life. In order to maintain a healthy diverse forest a vibrant forest products industry is needed in the area. We want the forest products industry here for perpetuity, we are concerned that the recommend sustainable yield outlined in the various scenarios in the draft GTR will have a devastating effect on the current forest products industry. We are concerned the draft GTR makes some invalid assumptions that misrepresent the current condition of the forest, affecting the sustainable yield output. Since the settlement of the Black Hills, previous Mt Pine Beetle epidemics have had reactionary management practices to minimize their impact. Through the BHNF Conservation Leaders group, the Black Hills Resilient Forest Strategy has been developed in attempt to manage the forest to be more resilient to future MPB epidemics and severe wildfire. Implementation of the strategy's goals and objectives will reduce the build up of the mortality rate and increase the timber stand improvement acres. We would like to see how a lowered sustained mortality rate and increased timber stand improvement acres affect growth rate and the suitable yield. The GTR will be used as a reference for the next Black Hills National Forest Plan revision, we want to be sure that all plausible sustainable yield scenarios are explored in the GTR.

Reviewer's proposed or suggested change: The most recent Mt Pine Beetle epidemic in the Black Hills peaked in 2011 and has been on the decline since, to as little as 29 acres affect in 2019. The use of a 2.98% or 2.5% rate of mortality in the scenarios is not representative of the current condition of the Black Hills. The current condition of the forest more reflects the 1962 to 1999 mortality rates of 0.16 to 0.26%. Would like to see all scenarios start with a mortality rate in the range of 0.16 to .026%.

Authors' response: In RMRS-GTR-422, we have expanded from 6 to 60 scenarios using five mortality rates, three growth rates, and four harvest levels. In the section titled *Scenario Development,* we explained the rationale we used to develop the scenarios. We recommend referring to this section where we provided the rationale for selecting the five mortality rates, four growth rates, and four harvest levels.

Reviewer #16

Comment #: 2

Line # or Figure #: Abstract, line 15

Description of the comment/ issue /question: "States ""these harvest levels would allow the live sawtimber inventory amounts to increase to 6 million CCF in approximately 60 years…""If current live

standing timber is 5.9 mill CCF, is this stating that it would take 60 years to increase volume by only .1 mill CCF?"

Reviewer's proposed or suggested change: If my interpretation is correct, then no further change is necessary. If not, please clarify.

Authors' response: Our current revision has expanded the scenarios, and therefore this sentence was removed. However, for clarification, based on that scenario, it would take 60 years to increase volume by another 6 million CCF.

Comment #: 3

Line # or Figure #:figure 1

Reviewer's proposed or suggested change: Overlap of y-axis with axis label, fix formatting on the Figure 1

Authors' response: We have revisited all the figures and have revised them in RMRS-GTR-422 to fix formatting issues.

Comment #: 4

Description of the comment/ issue /question: Figure 2 description, lines 3 and 4

Reviewer's proposed or suggested change: Says "an additional 13,700 acres were "i" fested and "As a result from 1985 thriugh 2016", correct spelling

Authors' response: Thank you, we have fixed spelling in all the figures and tables in RMRS-GTR-422.

Comment #: 5

Description of the comment/ issue /question: Figure 2 description, line 6. "In addition to MPB wildfires burned large portions…" "In addition to MPB, wildfires burned large portions…" Add comma add comma after MPB in Figure 2 caption

Authors' response: The figure and figure caption has changed in RMRS-GTR-422. Thank you for your proofreading

Comment #: 6

Description of the comment/ issue /question: Data Compilation/Results

Reviewer's proposed or suggested change: Absence of p-values, R^2 values. Although not imperative for your audience, I think it would add further weight to your findings to provide key statistical information like R^2 values. How robust are your findings? How did the increase in sample size statistically affect your results?

Authors' response: We did pursue other statistical values that we could add to the report. We tried to provide the reader with statistics when possible or stated in RMRS-GTR-422 (i.e., FIA data when provided). We added information under the section titled *Assessing Past FIA reports,* where we attempted to add more standard errors, when we were able to obtain. We also expanded this discussion to include our assumptions and rationale. Furthermore, we presented our results from the scenarios

and tested the volume values using the 95% Confidence Interval to determine if the standing live volume change was different from zero.

Comment #: 7

Line # or Figure #: Figure 9

Description of the comment/ issue /question: Difficult to differentiate between Scenarios 3-6 trend lines. Overlap of Scenario 6 adds to difficulty. Maybe consider a figure that isolates the scenarios that are close together. Can still be on the same graph, but with a smaller net volume range since they all fall between 5 and 6 mill CCF.

Authors' response: We have revised the visualization of the scenario figures and added tables for more detailed information in RMRS-GTR-422. Figure 13 shows all of the scenarios together and appendix B.1, B.2, and B.3 show each scenario based on growth rate. Figure 12 shows the change in standing live volume in 20 years. Table 7 shows the change in standing live volume in 5 years. Our hope is that the reader can now see the trends better.

Comment #: 8

Line # or Figure #: Figure 9

Description of the comment/ issue /question: Scenario 4 trend line, reduction to 75,000 CCF, appears to show less net volume growth over time than Scenario 3 trend line, with a reduction to 85,000 CCF. Yet, Scenario 5 trend line, reduction to 70,000 CCF shows greater net volume than all. If this is true, please explain why this might be.

Reviewer's proposed or suggested change: Explain possibility for difference in Scenarios/Discussion

Authors' response: We have eliminated the scenarios in the interim report from our analysis and have expanded from 6 to 60 scenarios using five mortality rates, three growth rates, and four harvest levels in RMRS-GTR-422. In the section titled *Scenario Development,* we explained the rationale we used to develop the scenarios. We recommend you please refer to this section *Scenario Development* where we provided the rationale for selecting the five mortality rates, three growth rates, and four harvest levels.

No Comment #9

Comment #: 10

General-inoperable lands

"This is just a general comment as a Black Hills NF Forester and observations I've made working here.

First, thank you for your hard work in organizing and analyzing this data, and offering the Forest and it's multiple interest groups the hard evidence that we have needed for a very long time.

Description of the comment/ issue /question: I am concerned that because the plots did not exclude inaccessible and inoperable lands, that the various scenarios give a more positive outlook as to what the Forest can sustain. The Hills have a lot of areas that are inoperable or not accessible, and if we concentrate an annual harvest of say, 70k CCF on only the areas that are harvestable, then we will be left only with our sawtimber, big trees existing only in these areas.

I do question the ability to continue to harvest even at your most conservative scenario of 70K CCF. The reason for that is because we have been re-entering/re-surveying sale areas that have just been thinned/logged or are still in the process of being logged, only to remove the remaining overstory that is left. We do not have fresh areas left to harvest. Where is this 70K CCF going to come from? It is probably too late at this point, but if you overlayed a GIS layer of inoperable ground, I wonder how many plots would drop out and how would this affect your results?

Authors' response: The values used in RMRS-GTR-422 for the scenarios were from the FIA-defined suitable timberlands. In appendix A, we discuss how lands are allocated. By creating 60 scenarios, we improved the ability to investigate what is plausible. In the section titled *Moving Forward,* in the second paragraph of this section, we did include a discussion on other values that may affect our assessment.

Reviewer #17

Comment #: 1

Line # or Figure #: 562

Description of the comment/ issue /question: "inventory amounts to increase to 6 million CCF in aprox. 60 years"

Reviewer's proposed or suggested change: Shouldn't it read "12 million CCF" it currently is estimated to be at 6 million CCF. In 60 years of reduced harvest and in order to get to the ASQ of of 181,000 CCF, it needs to get to 12 million CCF.

Authors' response: This sentence has been removed in RMRS-GTR-422 since we revised our approach to the scenarios. Table 7 helps the reader understand what scenarios are sustainable in the next 5 years and table 8 provides the standing live volume that is required to maintain 181,000 CCF/yr under various mortality and growth rates.

Reviewer #18

Comment #: 303

Line # or Figure #: 71-73

Description of the comment/ issue /question: See R-2 Attachment. Sentence assumes that an inventory of 6 million CCF and harvest levels of 181,000 CCF annuals are the desired goal, when a resilient landscape may be the goal instead.

Nevertheless, these harvest levels would allow the live sawtimber inventory amounts to increase to 6 million CCF in approximately 60 years and return to the level needed to support ASQ as identified in the current forest plan (181,000 CCF) within a century. However, this may not be the long-term goal, but rather a resilient landscape.

Authors' response: Since the target standing live volume was never defined, we do not specifically state which scenario would be the best in RMRS-GTR-422. However, we do discuss the scenarios that either

maintain the current standing live volume or increase the standing live volume, which is consistent with the definition of sustainable harvest.

Comment #: 304

Line # or Figure #: 89-95

Description of the comment/ issue /question: "See R-2 Attachment. I would clarify that this applies to the suitable timberlands - areas within the BHNF suitable base that also meet the FIA definition of timberland.

I would state up front in one of the first couple bullets that the areas included in this analysis are the suitable timberlands - areas within the BHNF suitable base that also meet the FIA definition of timberland. I would include the FIA definition of timberland and also include a description of the suitable base layer file that was received from the forest (# of acres).

Authors' response: In RMRS-GTR-422, we expanded our discussion of land classification including the definitions of suitable timberlands based on the FIA and BHNF in appendix A. We also mentioned throughout the report that these scenarios are based on suitable timberlands.

Comment #: 305

Line # or Figure #: 113-117

See R-2 Attachment. We need a very clear explanation of the acreage difference. Why the suitable base on the Black Hills now has less than 865,890 acres and how that was narrowed even further to only include areas that qualify as timberland under the FIA definition.

I would include a description of the suitable base layer file that was received from the forest (# of acres), since the suitable base layer that was used had fewer than 865,890 acres. Also discuss the reasoning for that discrepancy (with the forest providing data/information as needed). Then state directly that this analysis was based on the 765,733 acres that are suitable timberland (the subset of the BHNF suitable base that is producing or is capable of producing 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn from timber utilization by statute or administrative regulation.)

Authors' response: In RMRS-GTR-422, we expanded our discussion of land classification including the definitions of suitable timberlands based on the FIA and BHNF in appendix A.

Comment #: 306

Line # or Figure #: 117-118

Description of the comment/ issue /question: See R-2 Attachment. Looking at the logic used for the suitable base in 1997, it appears inaccessible areas, steep slopes, isolated patches, and areas with road construction problems were removed from the suitable base. So I would delete the sentence that says "lands inaccessible and inoperable areas are included." I'm sure that's normally true with FIA timberland, but since we are focused on timberland within the BH suitable base and it was removed from there, it doesn't seem to hold.

I would delete the sentence that says "lands inaccessible and inoperable areas are included."

Authors' response: In RMRS-GTR-422, we expanded our discussion of land classification including the definitions of suitable timberlands based on the FIA and BHNF in appendix A.

Comment #: 307

Line # or Figure #: 142

Description of the comment/ issue /question: See R-2 Attachment. reference to suitable land base (timberland) is unclear. "I would be consistent with terminology here and throughout the document. the BHNF suitable base is not exactly the same as timberland and the FIA analysis was focused on timberland within the suitable base (so a subset of the suitable base that also meets the definition of timberland). One option would be to define suitable timberland in the introduction and then use that term throughout the document. In other parts of the document I see the phrase suitable land base and suitable land base (timberland) and timberland (suitable land) and timberlands (suitable land base), timberlands/suitable base, timber lands, and timberland: (suitable)."

Authors' response: In RMRS-GTR-422, we expanded our discussion of land classification including the definitions of suitable timberlands based on the FIA and BHNF in appendix A. We went through the document and made sure to be consistent with our terminology.

Comment #: 308

Line # or Figure #: 166 -172

Description of the comment/ issue /question: See R-2 Attachment. The fifth question that was agreed upon with the stakeholder group is the second bullet here re: sustainable timber harvest estimate. This should be the focus. Delete the first and third bullet points.

Authors' response: In RMRS-GTR-422, we provided a section titled *Information Need* where we state our objectives that are specific to three questions that guide the section titled S*cenario Outcomes.*

Comment #: 309

Line # or Figure #: 221

Description of the comment/ issue /question: See R-2 Attachment. Somewhere in the data acquisition section, it would be good to highlight that "While some of the reports below are only based on the South Dakota portion of the forest and do not include the Wyoming portion, South Dakota makes up 87% of the suitable base". Provide information about how these estimates contribute to 87% of the land base (South Dakota)

Authors' response: In RMRS-GTR-422, we expanded the section titled *Assessing Past FIA Reports* to increase the detail from the reports. We have added the estimated acreage and information about that sampling in the footnotes for each of the inventory periods listed in table 4 for the readers.

Comment #: 310

Line # or Figure #: 272-274

Description of the comment/ issue /question: See R-2 Attachment. Suggestion to include a clear reference to the Jasper Fire. These data do not incorporate changes in the standing live inventory

caused by the 130,000 acres that burned in the Black Hills between the inventory date (1999) and the publication date (2002), such as the Jasper Fire, which burned in 2000.

Authors' response: In RMRS-GTR-422, we added a sentence that documents that the 1999 data acquisition description does not include the 130,000+ acres burned in the Jasper Fire.

Comment #: 311

Line # or Figure #: 370-372

Description of the comment/ issue /question: See R-2 Attachment. Suggestion to reword this to simply reference the Mantgem publication. In addition, it is a good estimate of what might occur in future decades and is similar to other observed mortality rates (van Mantgem et al. 2009).

Authors' response: In RMRS-GTR-422, we have revised the sentence and expanded on it. We have added a section that is titled *Understanding Disturbance and Tree Mortality* where we have expanded the discussion and added more references and integrated work specific to the Black Hills. We also added a section titled *Mortality Trends Across the Interior West* that includes van Mantgem but also other authors. Based on that widespread information, the average mortality was 0.79% (table 2) and provided good rationale for mortality rate trends that exceed the 0.16 to 0.26%. However, we did provide scenarios across a range of mortality levels (including 0.26%) to show the outcome of different harvest levels.

Comment #: 312

Line # or Figure #: 396

Description of the comment/ issue /question: See R-2 Attachment. I would clarify this is for ponderosa pine 5"+ resulting in live standing inventory of ponderosa pine, 5" and larger, of 7,958,314 CCF add text to reflect it is 5" and larger

Authors' response: Where appropriate, we now highlight when the values listed in the text refer to > 5 inches or > 9 inches throughout RMRS-GTR-422.

Comment #: 313

Line # or Figure #: 406-407

Description of the comment/ issue /question: See R-2 Attachment. It would be good to clarify how this relates to the inventory, future timber harvest levels, and this analysis, i.e. what is the take home message for this section. Is it simply that the mountain pine beetle and harvest operations are both going after the same trees?

Authors' response: Figure 7 in the interim report was removed since it caused confusion. In RMRS-GTR-422, we have added additional information about MPB preference for ponderosa pine and tree size in the MPB section of *Understanding Disturbance and Tree Mortality.*

Comment #: 314

Line # or Figure #: 423-429

Description of the comment/ issue /question: See R-2 Attachment. As mentioned above, I would focus on the second bullet re: sustainable timber harvest estimate as that was the fifth question agreed upon.

Delete the first and third bullet points.

Authors' response: In RMRS-GTR-422, we provided a section titled *Information Need* where we state our objectives that are specific to three questions that guide the section titled *Scenario Outcomes.*

Comment #: 315

Line # or Figure #: 434-435

Description of the comment/ issue /question: See R-2 Attachment. I would clarify here that the analysis was based on the subset of the suitable base that meets the definition of timberland, rather than any land that meets the definition of timberland. Clarify the statement.

Authors' response: In RMRS-GTR-422, we expanded our discussion of land classification including the definitions of suitable timberlands based on the FIA and BHNF in appendix A. We also mentioned throughout the report that these scenarios are based on suitable timberlands.

Comment #: 316

Line # or Figure #: 463

Description of the comment/ issue /question: See R-2 Attachment. Looking at Table 1, I believe this should be 2.7 and 3.1%. Fix language in the text.

Authors' response: Thank you for proofreading. We have fixed the numbers in RMRS-GTR-422.

Comment #: 317

Line # or Figure #: 474-476

Description of the comment/ issue /question: See R-2 Attachment. Suggestion to reword this to simply reference the publication. "In addition, we feel this rate is a good estimate of what might occur in future decades and is similar to other observed mortality rates (van Mantgem et al. 2009)."

Authors' response: The language was revised in RMRS-GTR-422.

Comment #: 318

Line # or Figure #: 482-483, 497

Description of the comment/ issue /question: See R-2 Attachment. Scenario 1 isn't realistic. Given the current standing inventory, it is unrealistic that 3% mortality will last into the future. The mortality rate from 2019 covers the amount of mortality since the last measurement, but the current mortality rate is in fact much lower since the MPB epidemic ended in 2016. Overall, the 3% mortality rate is too high to use going forward, given the MPB epidemic has ended, current stand conditions/structural stage

distribution, and given current management direction/planned BHRL treatments. Delete this scenario or adjust it to use a lower mortality rate.

Authors' response: We changed our approach in RMRS-GTR-422 to the scenario development and increased the number of scenarios from 6 to 60.

The 60 scenarios, in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 319

Line # or Figure #: 516

See R-2 Attachment. I believe the year referenced should be 2028 rather than 2030. This is the year harvest volume is 85,000.

Authors' response: We have revised the scenarios in RMRS-GTR-422 and this comment no longer applies.

Comment #: 320

Line # or Figure #: 517

Description of the comment/ issue /question: See R-2 Attachment. I believe the year referenced should be 2029 rather than 2028. This is the year mortality is 1.04%.

Authors' response: We have revised the scenarios in RMRS-GTR-422 and this comment no longer applies.

Comment #: 321 and 322

Line # or Figure #: 538

See R-2 Attachment. I believe the year referenced should be 2029 rather than 2030. This is the year mortality is 1.04%.

Authors' response: We have revised the scenarios in RMRS-GTR-422 and this comment no longer applies.

Comment #: 323

Line # or Figure #: 563-564

Description of the comment/ issue /question: See R-2 Attachment. Clarify that high standing inventory and harvest levels that match the current forest plan ASQ may or may not be the goal.

Nevertheless, these harvest levels would allow the live sawtimber inventory amounts to increase to 6 million CCF in approximately 60 years and return to the level needed to support ASQ as identified in the current forest plan (181,000 CCF) within a century, if this is the goal. Fix the sentence to reflect what we meant. Is it the goal to increase to 181,000 ccf? Or the goal to increase to 12 million CCF?

Authors' response: This sentence has been removed since we revised our approach to the scenarios in RMRS-GTR-422.

Table 8 provides the standing live volume that is required to maintain 181,000 CCF/yr under various mortality and growth rates.

Comment #: 324

Line # or Figure #: Table 1

Description of the comment/ issue /question: See R-2 Attachment. Table 1 has harvest volumes as estimated with FIA data. I would add a footnote that states that while harvest volumes can be estimated with FIA data, the Timber Information Manager (TIM) and Forest Products Financial System (FPFS) are the systems of record for sold and cut volumes.

Authors' response: In RMRS-GTR-422, we added a footnote to table 4 that states the following: "To ensure consistency in calculations, FIA estimates of harvest levels were reported in the table. The U.S. Forest Service utilizes a series of systems: Timber Information Manager (TIM) and Forest Products Financial System (FPFS) for a more accurate record of sold and cut volume (https://www.fs.fed.us/forestmanagement/products/cut-sold/index.shtml). Note: Sawtimber utilization standards for FIA estimates use a 7-inch top and current utilization on the BHNF use a 6-inch top.

Comment #: 325

Line # or Figure #: Appendix, Scenario 3

Description of the comment/ issue /question: See R-2 Attachment. Scenario 3 header references 2030, but the year harvest volume reaches 85,000 is 2028.

Authors' response: In RMRS-GTR-422, our revised approach to the scenarios has changed the description of the outcomes. Thank you for your proofreading though.

Comment #: 326

Description of the comment/ issue /question: Appendix, Scenario 3

See R-2 Attachment. Scenario 3 header references 2028, but the year the mortality reaches 1.04 is 2029.

Authors' response: In RMRS-GTR-422, our revised approach to the scenarios has changed the description of the outcomes. Thank you for your proofreading though.

Comment #: 327

Description of the comment/ issue /question: Appendix, Scenario 4

See R-2 Attachment. Scenario 4 header references 2030, but the year the mortality reaches 1.04 is 2029.

Authors' response: In RMRS-GTR-422, our revised approach to the scenarios has changed the description of the outcomes. Thank you for your proofreading though.

Comment #: 328

Line # or Figure #: Appendix, Scenario 5

Description of the comment/ issue /question: See R-2 Attachment. Scenario 5 header references 2030, but the year the mortality reaches 1.04 is 2029.

Authors' response: In RMRS-GTR-422, our revised approach to the scenarios has changed the description of the outcomes. Thank you for your proofreading though.

Comment #: 329

Line # or Figure #: Figure 6

Description of the comment/ issue /question: See R-2 Attachment. Suggestion to have harvest bars show as a negative value, like the mortality bars do. fix figure 6 to have harvest also be a negative number to show that it is contributing to removal.

Authors' response: We have revised figure 6 (now figure 11) in RMRS-GTR-422 to show that harvest removals are negative in terms of volume change.

Comment #: 330

Line # or Figure #: 238, 256

Description of the comment/ issue /question: Change statue to statute

Authors' response: Thank you for proofreading. We have fixed the misspelling in RMRS-GTR-422.

Comment #: 331

Line # or Figure #: 312, 330-331

Description of the comment/ issue /question: See R-2 Attachment. sawtimber volumes were computed to a 7-inch top. Black Hills utilization specs go to a 6" top for sawtimber. Volumes in this study should reflect that.

Authors' response: FIA only provided the data for sawtimber at a 7-inch top. We recognize that this adds additional uncertainty to the estimates as we are underestimating sawtimber volume. However, in RMRS-GTR-422 we tried to address this by evaluating the numerous scenarios to provide an envelope of outcomes.

Comment #: 332

Line # or Figure #: 367-69

Description of the comment/ issue /question: See R-2 Attachment. "As a conservative estimate, the 1.04% mortality rate observed by Walters et al. (2013) is reasonable and may reflect that the long-term mortality trend of trees killed in the Black Hills. In addition, it is a good estimate of what might occur in

future decades." - this mortality rate is too high given current management direction/planned treatments under the BHRL decision.

The cited report from Walters, et al., bases mortality on measurements in SD and WY during years when the epidemic was greatly impacting tree mortality (2000-2005 for WY and 2002-2006 for SD). This elevated the mortality rate now used as a long term estimate in this report. During the Black Hills Resilient Landscape (BHRL) analysis, it was identified that over 300,000 acres of the suitable timber base is in a mature (>9" d.b.h) open condition (11-40% crown cover). This is the result of implementing commercial thinning in ponderosa pine stands to a BA of 40-60 square feet/acre across the Forest in suceptible stands during the epidemic. BHRL also proposes thinning up to 250,000 acres of the pre-commercial size classes to reduce suceptability to MPB epidemic populations, using mechanical and prescribed fire applications. Even dense stands surrounded by open conditions have decreased MPB risk. Mitigations for MPB also mitigate effects of climate change and fire hazard ratings through density reduction. The mortality rates should be lower for a longer period based on current conditions and implementation of silvicultural treatments described in BHRL.

Authors' response: We expanded our mortality discussion in RMRS-GTR-422 to highlight the changes through time and broke down the contribution of each mortality category's contribution to the total mortality (see table 1). In the report, we added a section titled *Understanding Disturbance and Tree Mortality* that includes discussions on disturbances that have occurred in the Black Hills. In addition, we included a section that highlights the recent mortality in ponderosa pine forests across the Interior West. We added an element of uncertainty associated with a changing climate (section titled *Changing Climate*) where evidence shows longer fire seasons and increased wildfire activity (which also has already been demonstrated in the Black Hills over the past 20 years). Fuel loadings caused by MPB mortality is expected to increase wildfire hazard. Under the subsection titled *Mortality Rates* within the *Scenario Development* section, we described in detail how we developed the mortality rates we used in the revised scenarios.

We recognize that mortality rates over the past 60 years have varied and we added table 1 to show those differences by mortality agent. We discussed the different mortality agents over time and how they have changed with the endemic and epidemic as well as impacts from wildfire (see section titled *Understanding Disturbance and Tree Mortality*). We acknowledge that the current epidemic is over; however, there are still areas in the Black Hills that were not impacted by MPB and can still support infestation. Furthermore, we placed the Black Hills in the context of other Interior West states that are currently experiencing mortality rates on average of 0.79% due to an increase in wildfire. We discussed this trend in wildfires for the Black Hills and potential impacts of an uncertain climate. In the section titled *Scenario Development,* we provided details and identified the range of mortality rates, growth, and harvest levels (see table 6 for list of scenarios).

Comment #: 333

Line # or Figure #: Scenarios

Description of the comment/ issue /question: See R-2 Attachment. Recommendation to have four scenarios with contrasting sustainable harvest levels and high and low mortality and growth rates and a recommended scenario supported by the best available data. We suggest a constant timber harvest

level be used where the 2021 inventory level is maintained in all planning scenarios to ensure consistency with the National Forest Management Act.

"Recommendation is specifically to have four scenarios - the current scenario 2 that examines the inventory needed to support ASQ of 181,000 CCF. Plus three new scenarios that vary in terms of mortality and growth, and where growth, mortality, and harvest levels are constant, and with the resulting sustainable harvest level. An example of these three scenarios was also sent in via email and they include a 1) low growth, high mortality scenario, 2) a high growth, low mortality scenario, and 3) an average growth, moderate mortality scenario. Other suggested changes are to start the scenarios in 2020 and use a harvest level of 120,000 CCF for the year 2020 since that is a realistic estimate for this year. Follow this with a constant timber harvest level starting in 2021 where the inventory level is maintained.

The example scenarios are provided as a format suggestion (contrasting alternatives). The mortality and growth values included in the examples are simply examples, with potentially different values used as deemed appropriate by research.

At a minimum, a scenario with a lower average mortality rate should be evaluated, given the current stand conditions, low MPB risk, and planned treatments under the BHRL decision."

Authors' response: The 60 scenarios, in RMRS-GTR-422, with a range of rates and harvest levels, should provide the reader with an improved ability to assess sustainability. Instead of a specific growth rate, we used three gross growth rates (2.33%, 2.52%, and 2.73%) in the scenarios. These values were based on the low, average, and high growth rates reported in FIA resource bulletins from the 1960s to 2019. Based on many comments about the scenarios, we changed our approach. Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the section titled *Scenario Development.* These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019. We expanded our discussion in the section titled *Understanding Disturbance and Mortality* to provide context for different mortality rates and we acknowledge the current MPB epidemic has been deemed over; however, the risk for wildfire, weather events, and other disturbances is still plausible.

Comment #: 334

Line # or Figure #: Scenarios

Description of the comment/ issue /question: Description of the comment/ issue /question: See R-2 Attachment. Suggestion to focus the scenarios and discussion on the first 20-25 years given that the data, particular mortality estimates, are more reliable for this shorter time frame and because it matches more closely with the standard planning horizon. Shorten the simulations to 25 years or focus the discussion on the first 20-25 years.

Authors' response: We have now provided scenario outcomes for 5 years, 20 years, and 80 years for readers to assess immediate and future outcomes in RMRS-GTR-422.

Reviewer #19

Comment #: 11

Line # or Figure #: N/A

Description of the comment/ issue /question: This manuscript is a thoughtful and well-presented analysis of current timber stocking in the Black Hills National Forest with respect to the sustainability of current harvest levels. The authors used the best currently available data on stocking, growth and mortality in the Black Hills in their analysis and selected reasonably-based assumptions for growth and mortality in the future growth and yield scenarios they present.

Authors' response: We hope you find RMRS-GTR-422 even better.

Comment #: 12

Line # or Figure #: N/A

Description of the comment/ issue /question: The results of their scenarios are well presented and consider a variety of future growth and harvest schemes. However, several things are abundantly clear to me after studying this paper:

Authors' response: We hope you find RMRS-GTR-422 even better.

Comment #: 13

Description of the comment/ issue /question: Loss of growing stock due to wildfire and mountain pine beetles have made the 181,000,000 CCF Forest Plan annual harvest unsustainable. The Forest Plan needs to be revised to reflect these unforeseen changes.

Authors' response: No change needed. Comment doesn't require editing.

Comment #: 14

Description of the comment/ issue /question: Even though current harvest levels are less than the Forest Plan target, they cannot be sustained without further reducing current levels of stocking into the future.

Authors' response: No change needed. Comment doesn't require editing.

Comment #: 15

Description of the comment/ issue /question: Reducing harvest (and industry capacity) is the only way to maintain a sustainable harvest (and viable forest industry) in the Black Hills in the future, regardless of the management scenario considered in this paper. Not doing so now will inevitably result in the disappearance of a forest industry and the ability to properly manage the forest.

Authors' response: No change needed. Comment doesn't require editing.

Comment #: 16

Description of the comment/ issue /question: Having participated in the thinning studies mentioned in this paper, I applaud the authors for emphasizing the need for early pre-commercial thinning to improve growth rates and increase available stocking for a variety of resource values. Finding the means to do so

has long been needed in the Black Hills and will be even more critical for recovery of growing stock in the future.

Authors' response: No change needed. Comment doesn't require editing.

Reviewer #20

Comment #: 98

Line # or Figure #: 372

Description of the comment/ issue /question: The use of an 0.26 mortality rate would assume that for the next 50 years of a scenario there would be no large fires nor another large MPB epidemic. There is really no reason to believe that.

Reviewer's proposed or suggested change: State why there is no reason to believe that the mortality rate would be that low. The overabundance of young, dense stands (unless dealt with through very ambitious, pre-commercial thinning efforts) will develop into stands at high risk to wildfire and MPB

Authors' response: In RMRS-GTR-422, we have added a section titled *Understanding Disturbance and Tree Mortality* where we provide context for a diversity of mortality rates. From recent FIA reports from across the Interior West, we calculated mortality for the ponderosa pine forest type across all land ownership. Based on that widespread information, the average mortality was 0.79% (table 2) and provides good rationale for mortality rate trends that exceed the 0.16 to 0.26% levels. Furthermore, we expanded our discussion of disturbance history and subsequent mortality, provided a breakdown of the mortality factors (table 1) over time in the Black Hills region, and discussed possible trends with an uncertain climate. All this information provided us with science-based rationale for potential mortality rates. Lastly, we employed a range of mortality rates to provide the reader with different scenario outcomes.

Comment #: 99

Line # or Figure #: 497 to 548

Description of the comment/ issue /question: I don't believe that the higher mortality percentages should be used at the beginning of any of the scenarios. The MPB epidemic is over and that should be reflected in the scenarios. They should use a flat percentage from the start for a number of years unless the scenario predicts for some reason that the mortality will go up over time.

Reviewer's proposed or suggested change: Have each scenario use a flat mortality rate and not one that decreases for the first 5-15 years. Or at least create a scenario where that is the case.

Authors' response: Based on many comments about the scenarios, we changed our approach in RMRS-GTR-422. Please refer to the section titled *Scenario Development.* Instead of a specific mortality rate, we used five mortality rates (0.26%, 0.60%, 1.04%, 1.52%, and 2%) in the scenarios. These values were based on the wide range of mortality rates reported in FIA resource bulletins from the 1960s to 2019.

Comment #: 100

Line # or Figure #: 566

Description of the comment/ issue /question: The greatest long-term threat to a healthy Black Hills National Forest, is the doghair thickets of regeneration across the Forest. This needs to be recognized in the GTR. The FIA data shows that the structural stage 4C stands (which are at high risk to MPB and fire) only make up 10% of the suitable timber base. While that needs to be managed, 10% is not a significant risk, certainly not compared to the thick understories.

Reviewer's proposed or suggested change: State that the dense understories are the greatest threat to the Forest if left untreated. They are or will be at high risk to wildfire and MPB

Authors' response: In RMRS-GTR-422, we have added two sections titled *Moving Forward* and *Management Opportunities.* Both sections refer to both challenges and opportunities; please refer to these sections for details where we added discussion points on the benefits of thinning dense regeneration to reduce fire hazard and to enhance tree growth.