DOCUMENTATION OF CHANGES IN MODELED FUTURE VEGETATION CONDITIONS BETWEEN DRAFT AND FINAL EIS

I. Introduction

This document summarizes the differences in future modeled results for disturbances and vegetation conditions between the Draft and Final EIS, occurring due to updates of the SIMPPLLE model. In the process of conducting the vegetation modeling for the Draft EIS and analyzing future expected outputs from the SIMPPLLE model, it became increasingly clear to the vegetation, fire and insect and disease specialists that the model was not correctly portraying the future anticipated activity and patterns of certain disturbance processes. In particular, activity and responses of Douglas-fir beetle and spruce beetle were being substantially overestimated (which was noted in the DEIS); western spruce budworm and root disease were likely underestimated. Potential amount of future fire was believed to be underestimated, in light of expected climate changes and potential effects on fire disturbance processes. Though it is understood that models can never be perfect, and that future amounts and patterns of disturbances have a high degree of uncertainty, we felt it was important to adjust model assumptions to correct some of these issues, because these disturbances strongly influence vegetation conditions. Changes in the Douglas-fir beetle and spruce beetle, and changes in the fire assumptions in the SIMPPLLE model were completed.

In addition, further correlation of the SIMPPLLE VMap vegetation input database with FIA data for large/very large forest size class and for species presence occurred between the Draft and Final EIS. These changes improved the comparison and interpretation of both NRV and future vegetation projections against current condition. Refer to exhibit 00255 for details on all the model updates.

II. Changes in projected future disturbance amounts and patterns over the five decade model period

A. Fire disturbances

For the FEIS, the SIMPPLLE model was re-run incorporating a low, moderate and high level of expected fire into the future, with the high level designed to approximate a potential maximum amount of fire as estimated from the natural range of variation (NRV) analysis. As before, 30 runs were made, only this time to evaluate what a more complete range in conditions might occur under different climate scenerios – 10 runs were modeled under the dry climate assumption; 10 were modeled under the wet climate assumption; and 10 were modeled under a normal climate assumption. Figure 1 displays the outputs from the original modeling completed in the DEIS, and figure 2 displays these outputs for the updated FEIS model. All runs reflect the same fire suppression strategy across all five decades that was developed for the original analysis (see exhibit 00255).

Figure 1. Percent and acres of Flathead NF lands experiencing fire activity, as modeled with SIMPPLLE five decades into the future for the **Draft EIS** (displayed as the average of all 4 alternatives)**.**

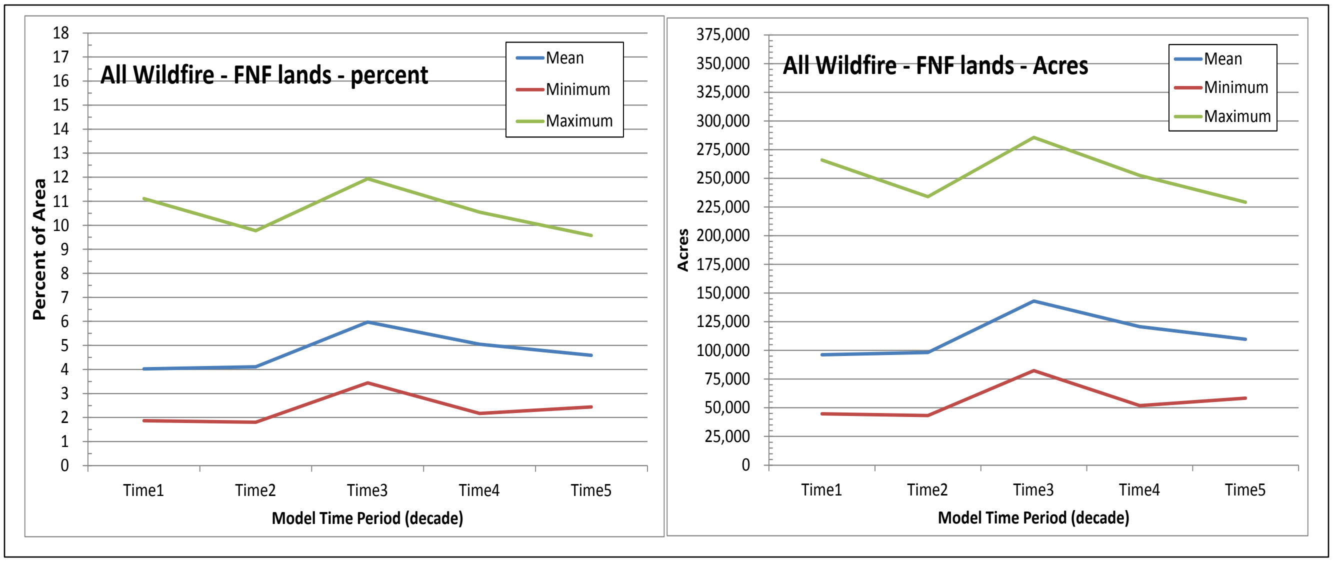
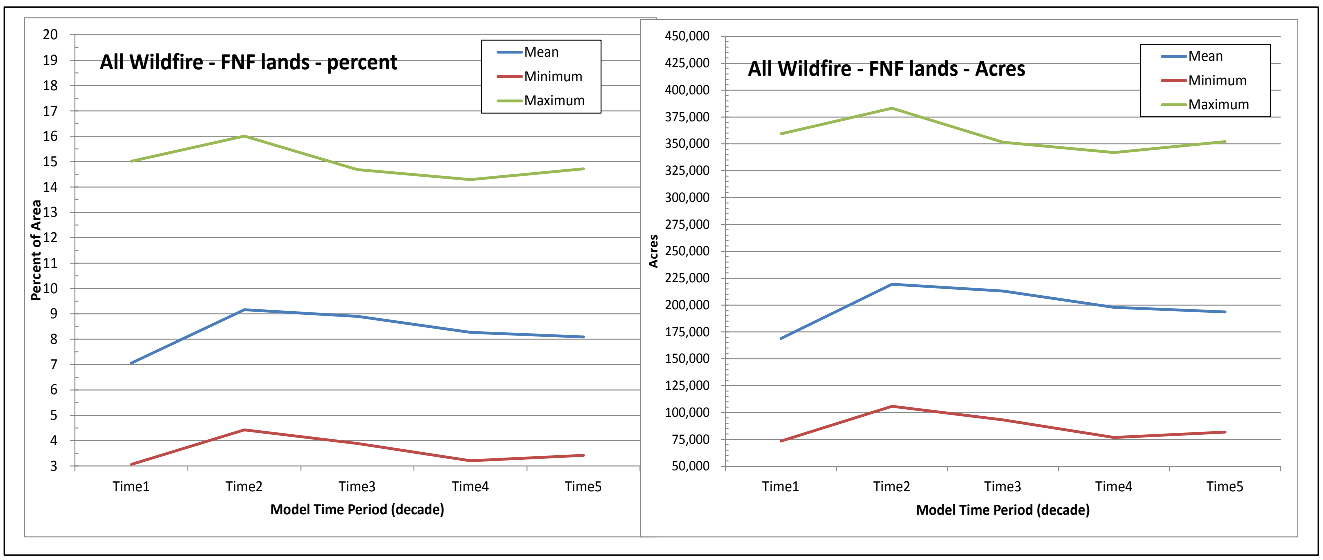


Figure 2. Percent and acres of Flathead NF lands experiencing fire activity, as modeled with SIMPPLLE five decades into the future for the **Final EIS** (displayed as the average of all 4 alternatives).



General distribution of fires was similar between the original DEIS modeling and the updated FEIS modeling, with 65-70% of fire acres located within designated and recommended wilderness areas. The pattern (increase/decrease in any one decade) in the amount of fire over the five decade model period is also similar, with both showing a general rise in fire acres across the first 2 to 3 decades, followed by a general decrease in the last couple decades. There were differences, however, in the overall acres and severity of projected fire between the original and updated model, as displayed in figures 1 and 2 and described below:

1. The maximum amount of fire both in any one decade and the average value per decade is greater in the updated modeling.

In the original model (DEIS), the range in acres of fire over the five decades went from a low of about 50,000 acres in the lowest decade to a high of about 285,000 acres in the highest decade. In the updated model used in the FEIS, the lowest amount of fire in any one decade is about 75,000 acres. The highest level of fire that is achieved in the updated model is about 380,000 acres in decade 2. This maximum modeled amount is a little more than the amount of fire the Forest actually experienced in the decade 2000 to 2009 (which was about 330,000 acres). The average amount of fire per decade over the five decade period is about 115,000 acres per decade in the original DEIS modeling and 194,000 acres per decade in the updated model for the FEIS.

2. The overall amount of fire over the five decade model period is greater in the updated modeling.

   The total amount of fire experienced over all five decades is about 590,000 acres in the DEIS modeling and 990,000 acres in the updated model for the FEIS.

3. The proportion of stand replacement fire vs mixed severity (more moderate severity) fire is greater in the updated modeling.

   In both the modeling efforts, stand replacement fire is by far the most common type over the five decade period. However, the updated FEIS model projects nearly all fires to be stand replacement, about 99% of the total over the five decades. The original DEIS modeling predicted about 88% of the fires as stand replacement, with the remaining amount mostly mixed (moderate) severity.

B. Insect disturbances

Adjustments to the model logic and assumptions related to Douglas-fir beetle and spruce beetle activity were made to the SIMPPLLE model, to address what was determined by the USFS R1 Entomologist to be a greatly overestimated level of activity of these insects in the model across the Flathead NF landscape (see attachment 1 of this exhibit). Figure 3 displays the original model results used in the DEIS for activity of these two beetles five decades into the future. Figures 4 and 5 display the updated model results.

Figure 3. Acres of Flathead NF lands experiencing Douglas-fir and spruce beetle activity as modeled with SIMPPLLE five decades into the future for the **Draft EIS**.

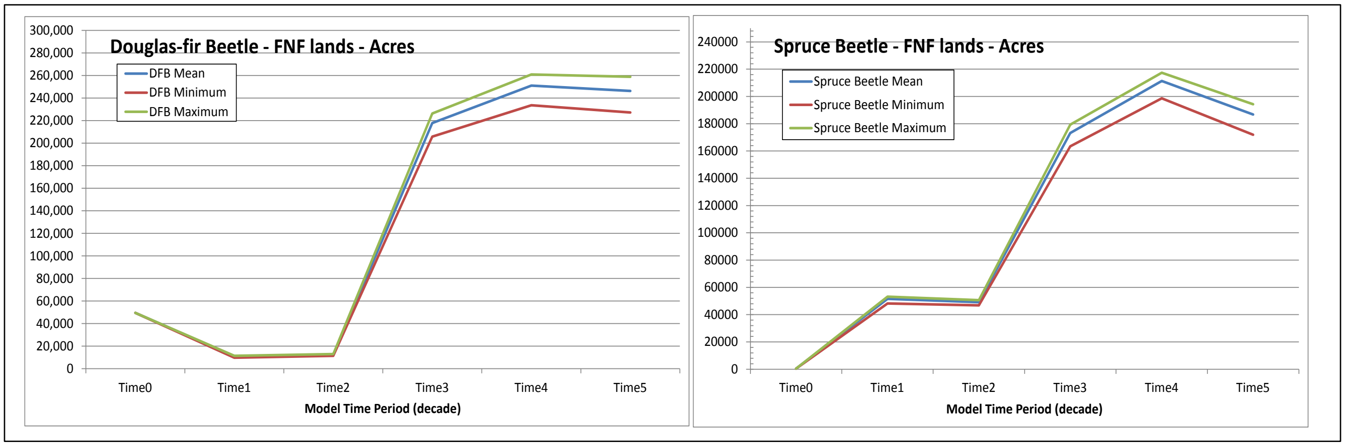


Figure 4. Percent and acres of Flathead NF lands experiencing Douglas-fir beetle activity as modeled with SIMPPLLE five decades into the future for the **Final EIS**.

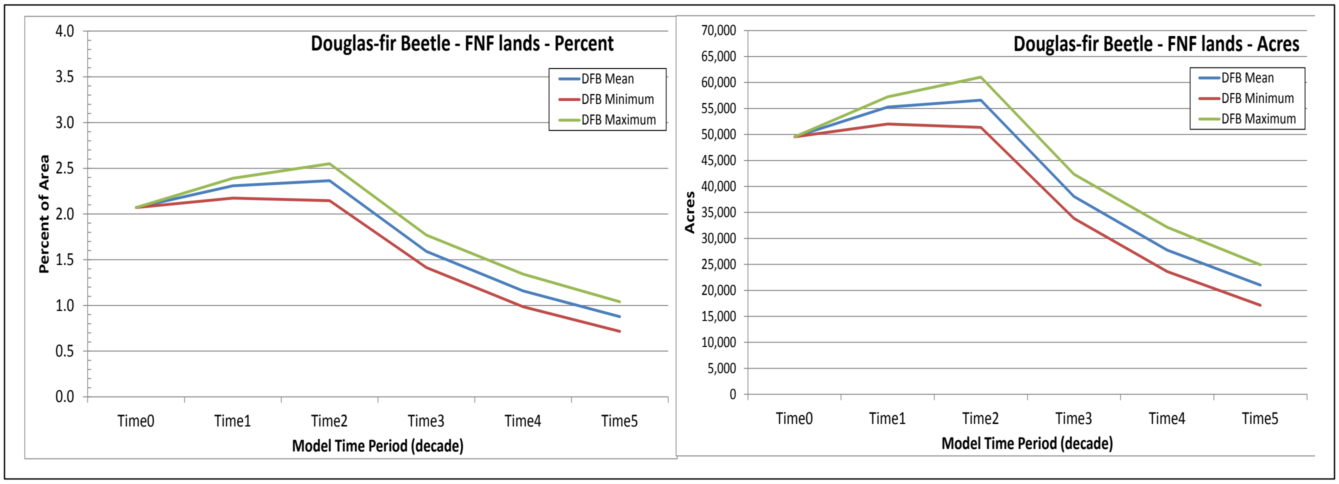
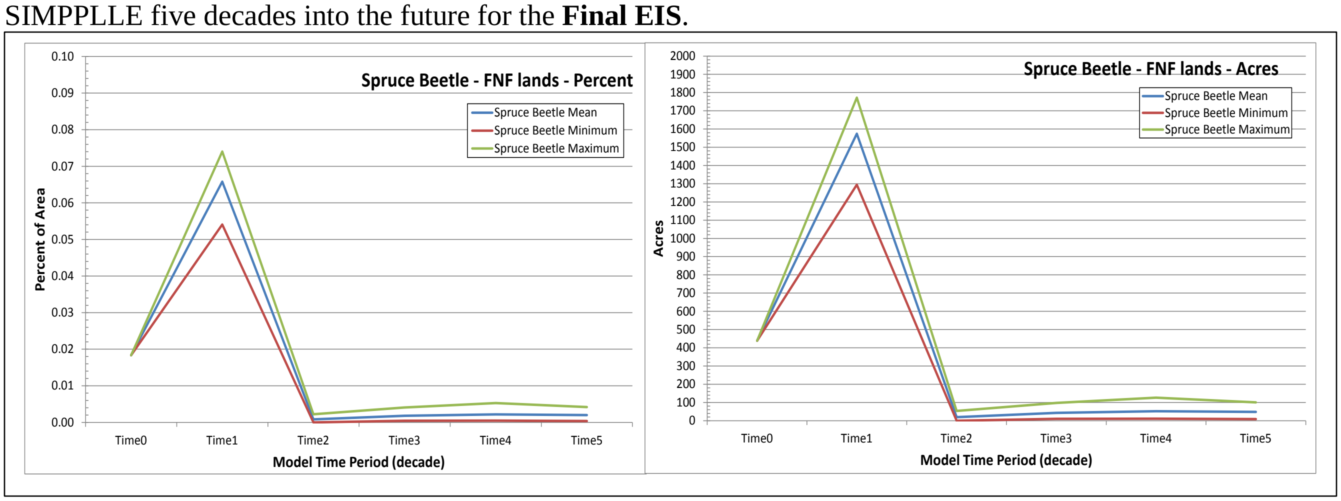


Figure 5. Percent and acres of Flathead NF lands experiencing Spruce beetle activity as modeled with SIMPPLLE five decades into the future for the **Final EIS**.



As evident in the figures above, the model corrections resulted in substantial change in the estimated intensity and pattern of Douglas-fir and spruce beetle activity across the Flathead. The updated model is believed to portray more appropriately what might be expected for these disturbances, given an understanding of both past patterns on the Flathead NF and the relationship of beetle activity with climate and changing vegetation conditions that may occur in the future (see attachment 1).

In the updated model, average acres per decade infested by Douglas-fir beetle across the five decade model period is about 40,000 acres in the updated FEIS model, but nearly four times that amount (about 150,000 acres) in the original DEIS modeling outputs. This results in a total average amount across the five decades of about 200,000 acres in the updated FEIS model, compared to about 740,000 acres in the DEIS model. Patterns of beetle activity also vary between the two modeling efforts. In the updated model results, Douglas-fir beetle activity forestwide remains about the same or a little higher than existing amount for about 2 decades, peaking at about 60,000 acres, then drops gradually but rather steeply in decades 3 through 5 to a low of about 20,000 acres. In the original DEIS modeling, Douglas-fir beetle first drops down to a low of about 10,000 acres forestwide in decade 2, then rises very steeply to a high of about 260,000 acres in decades 4 and 5.

Spruce beetle reflects more dramatic differences in the updated model, changing from an average of about 134,000 acres per decade across the model period in the original DEIS model to less than 500 acres on average in the updated model. This results in a total average amount across the five decades of about 2000 acres in the updated FEIS model, compared to about 670,000 acres in the DEIS model. Maximum level of spruce beetle activity projected to occur in any particular decade was about 220,000 acres in the DEIS model, compared to about 1000 acres in the updated FEIS model. The updated model may underestimate spruce beetle activity somewhat, but it is still believed to be far closer to expected impacts of spruce beetle in the Flathead Forest ecosystems in the short term (the next five decades) compared the original model (see attachment 1).

Western spruce budworm was also believed to be not functioning in the model as would be expected over the next five decades. However, the model parameters for this insect are hard-wired into the model and were not able to be adjusted for the final. Therefore, this disturbance was "turned off" instead, and analysis of potential effects will be addressed outside the model environment.

Root disease model parameters remain the same between the DEIS and FEIS, though the pathologist suspects model outputs greatly under estimate both the present and potential root disease activity (see attachment 1). However, if one assumes that the impacts that are modeled in SIMPPLLE reflect only the areas experiencing severe root disease impacts, it may be closer to the level of severe root disease impacts that would be expected forestwide.

Mountain pine beetle model parameters remain the same between the DEIS and FEIS, because entomologists believed model outputs generally fell within the realm of what might be expected activity levels in the future. Model outputs are thus similar between the DEIS and FEIS modeling, indicating an average of about 108,000 acres per decade for the FEIS analysis and 116,000 acres per decade for the DEIS analysis.

Graphs showing acre and percent outputs for all disturbances as modeled across five decades for the Final EIS can be found in exhibit 00262 of the planning record.

III. Changes in projected vegetation conditions over the five decade model period

Changes in the amounts and patterns of future fire, Douglas-fir beetle and spruce beetle activity would be expected to affect and change vegetation conditions and trends as compared to current conditions. This section summarizes the substantive changes in modeled vegetation results between the Draft and Final EIS resulting from the SIMPPLLE model modifications described above. The graphs showing the vegetation conditions at the end of the model period (decade 5), that also display the desired condition and the existing condition, are included in appendix 2 (Vegetation and Timber Analysis Process) of the Final EIS. The Draft EIS contains this same set of graphs, except display results from the original SIMPPLLE model parameters used in the DEIS. These graphs can be referenced for comparison, if desired.

A. All modeled vegetation attributes

Nearly all of the modeled vegetation attributes (dominance type, species presence, size classes, canopy cover) exhibited greater variability in acres/percent across the five decade period in the FEIS analysis, resulting in a wider range in potential vegetation condition (e.g., minimum and maximum expected proportions) at the end of the model period (the 5th decade). This is likely due to the greater variability in future fire activity that has been reflected through the model modifications.

B. Species composition

The decrease in activity of Douglas-fir and spruce beetle in the model would be expected to favor retention of Douglas-fir and spruce across the Flathead, and in general this is the case. The differences between DEIS and FEIS results in Douglas-fir conditions are relatively minor, though spruce shows markedly different results from the DEIS analysis.

Both Douglas-fir and subalpine fir/spruce dominance types show an upward trend in the FEIS, as they did in the DEIS, though the rate of increase is somewhat higher than in the DEIS for the DF dominance type. Trends in the Douglas-fir presence in the FEIS is similar to those in the DEIS, though the rate of change is sometimes less (e.g., DF still trends down in the warm dry PVT, but does not get as low as in the FEIS; DF is maintained near current condition in the cool moist PVT, vs a slight decrease in the DEIS). Spruce presence has considerably different results in the FEIS, with trends upward forestwide and in all PVTs where it is present, as compared to downward trends in the DEIS.

The model changes related to fire modeling could potentially affect outputs for all conifer species. Comparing the original model results in the DEIS to the updated modeling in the FEIS, the trends and conditions are the same over time for the more shade intolerant early/mid successional species of ponderosa pine, western larch, whitebark pine, lodgepole pine and western white pine. These species generally could be expected to respond well to fire, and model results indicate they at the least maintain and sometimes increase their presence forestwide both in the DEIS and FEIS results. The response of these species is more variable within the PVTs, where they sometimes show a decrease by the 5^{th} decade, sometimes an increase, sometimes stay at about the same level. Though the rate of change may vary a bit, trends in the FEIS modeling are the same as in the original DEIS modeling for all except western white pine on the cool moist PVT (it trends up in the FEIS modeling, down in the DEIS modeling). Also, ponderosa pine on the warm moist PVT does not show any presence in the FEIS, though in the DEIS it was present at low proportions. This difference is due to some additional refinements of both the SIMPPLLE VMap input data set and how FIA data was reported out (see exhibit 00259).

The shade tolerant species show more variation than other species in model results between the DEIS and FEIS. Spruce changes the most, with upward trends and greater proportions as described above, due to the major decrease in spruce beetle activity in the updated model. Subalpine fir presence trends upward across most of the forest, compared to a downward trend forestwide and in the cool moist and cold PVTs. Fire would remove subalpine fir from the stand, reverting it back to early/mid successional species in most cases (such as Douglas-fir, lodgepole pine and larch). The increasing distribution (presence) of subalpine fir across the landscape over the next five decades, coupled with the fairly static and/or downward trends in presence of lodgepole, larch, Douglas-fir and whitebark pine in some PVTs, suggests that the increased amount of fire in the updated model is insufficient to counter the expanding distribution and dominance of subalpine fir across the landscape as the forests advance into later successional stages over time. The coarse nature of the model may not capture other disturbance factors that would affect and maybe reduce amount of subalpine fir, such as certain insects and pathogens (e.g. western spruce budworm, root disease).

The dominance and presence of grand fir and western red cedar, the shade tolerant later successional species that occur on the warm moist PVT, do not change dramatically from present conditions in the updated model, compared to some increase (especially for cedar) in the DEIS model. Fire, as well as the lower amount of Douglas-fir beetle, is likely influencing this change by both retaining the early/mid successional species (e.g. Douglas-fir) and by the mortality of grand fir and cedar by fire.

C. Forest size class

Increase in amount of fire in the updated model could be expected to influence forest size class distribution when compared to the DEIS results. Stand replacement fires would create seedling/sapling forest size class from previous areas of small, medium, large and very large size classes. The decrease in both Douglas-fir beetle and spruce beetle could be expected to influence size classes, because these beetles remove (kill) the largest trees and, as modeled, could potentially decrease proportion of large and very large forest size class as well as forest density (canopy cover) for a period of time. Also, the refinements made to the SIMPPLLE VMap database between the DEIS and FEIS, specifically those related to the mapping of the very large tree size class, caused some changes in forest size class relationships in the FEIS.

There is an upward trend in large size class and a downward trend in the very large size class forestwide both in the original DEIS modeling and in the updated FEIS model. However, for the large tree size class the trend upward is substantially steeper in the FEIS, achieving up to 20% greater proportion forestwide as compared to the DEIS. The very large size class is better retained in the FEIS and shows less decrease forestwide, where it ranges from slightly above current amounts to at most dropping about 2% forestwide. This is compared to a 3 to 5% decrease in the DEIS.

In all PVTs except the warm dry, the same patterns occur as seen at the forestwide scale, with similar trends between the DEIS and FEIS modeling, but with different rates/degree of change over time. The large size class shows a much larger increase over time in the FEIS, and the very large size class shows less decrease (and in the case of warm moist PVT a greater increase). In the warm dry PVT, the large size class shows a strong increase in the FEIS modeling, compared to a decrease in the DEIS. The very large size class shows and increase in both DEIS and FEIS, though the increase is less pronounced in the updated FEIS modeling.

One of the most notable differences in the updated model results is in the relationship between the medium, large and very large tree size classes compared to the DEIS. In general, in the FEIS modeling there is a distinct and strong increase in the large size class (and very large size class to a lesser degree), which appears to result from both the reduced loss of large and very large trees to Douglas-fir and spruce beetle, and to the effects of natural succession as stands grow into large size classes. The increases in the larger size classes are associated with a substantial decrease in the medium size class, and in the warm dry PVT, the medium size class decreases to nearly zero at decade 5. This is obviously not a true reflection of reality. This pattern and relationship of size classes is, to a large degree, a peculiarity of the modeling process, reflecting assumptions associated with natural succession, the variation in number of decades a polygon remains within a particular size class before it abruptly shifts into the next size class. In reality, forest size classes, growth rates, and the rate of progression of stands into the next class is highly variable depending on species composition, stand densities, site specific conditions and a host of other factors. Change occurs across a continuum. To appropriately interpret these results it should be assumed that some of the large forest size class is actually more in a medium size class. It is also more useful to focus on the overall shifts in size class patterns that appear to have occurred as a result of more appropriate modeling of disturbance processes in the updated model. These changes clearly resulted in a shift to larger size classes across the Forest, due to the decrease in loss of large trees to DF and Spruce beetles. This preserved the large and very large tree size classes rather than bumping them back to the medium size class after beetle infestation. The increase in amount of fire does not appear to be sufficient to fully over-ride this effect, and there seems to still be large areas of forest able to advance, through natural succession, into the larger size classes, at least over the next 50 years. The effects of increased fire are evident, though, with the higher modeled amount and increased trends of seedling/sapling forest in the FEIS, both forestwide and within PVTs.

D. Forest canopy cover

The decrease in Douglas-fir and spruce beetle activity in the FEIS modeling results in retention of more moderate and high density stands and less of the low density stands, because density is not reduced by tree mortality. Though there is still a decrease in high density forests across all but the cold PVT, the trend tends to be much less steep in the FEIS than in the DEIS. Forestwide, the low density forests show a decrease, compared to an increase in the DEIS. Very low canopy cover class shows an increasing trend in all PVTs both in the FEIS and DEIS. Fire appears to be the primary agent maintaining this low density class, and they are probably mostly seedling/sapling forests. The trend in all canopy cover classes in the warm moist, warm dry and cold PVTs are about the same in the FEIS as in the DEIS, though the degree of change tends to be much less in the FEIS. The trend in canopy cover classes in the cool moist PVT are the same except for the low density forests, which show a decrease in the FEIS vs an increase in the DEIS.

Attachment 1-Reports from Entomologist and Pathologist

November 2016
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Differences between the Draft and Final EIS for the Flathead Forest Plan Revision related to the Impacts of Forest Insect Included in the SIMPPLLE Model

Forest Entomologists (Forest Health Protection) based in Missoula, Montana, reviewed the output for insect activity that were included in the SIMPPLLE model and disclosed in the vegetation section of the Draft EIS (published May 2016). The draft EIS had acknowledged that for some insects the patterns and intensity of infestation the model projected into the future was inconsistent with expectations of how these organisms would function at the landscape scale. Based on past experience and knowledge of Forest Entomologists, and data from the Annual Aerial Detection Survey, some of the model assumptions related to the impacts of several insects on vegetation were adjusted for the analysis disclosed in the Final EIS. The additional or new assumptions are responsible for the differences found between the draft and final EIS for impacts of insects on vegetation. This document provides information on what changes were made in the model and why. For more detailed information on the insects and their relationship to forest conditions, see the *Vegetation-Terrestrial Ecosystems* section in the EIS, under the descriptions of *Forest Insects and Diseases*.

Douglas-fir Beetle

Several adjustments were made to Douglas-fir beetle (DFB) (*Dendroctonus pseudotsugae)* sub-model that are reflected in the output between the draft and final EIS. DFB activity declines over a 50-year period in the final EIS versus increasing over a 50-year time period in the Draft EIS primarily due to the following assumptions. The first new assumption was that there has to be a disturbance in a stand to initiate a DFB outbreak. The second assumption was that a stand adjacent to another stand that was experiencing a DFB outbreak was more likely to experience a DFB outbreak too. However, once an outbreak occurred in any one stand, a subsequent outbreak could not occur in the same stand for another 120 years.

1) **DFB Outbreaks are Initiated by Disturbances**
A trigger or disturbance is usually necessary to start a DFB outbreak. This is usually fire (especially lower severity fire that does not severely burn the boles of the trees) or windstorms that results in large numbers of downed trees. In windthrown trees, DFB tend to concentrate their attacks on the shaded underside of the downed trees rather than the tops, because of their aversion to the high temperatures (Vite and Rudinsky 1957). When weakened-susceptible trees become abundant across the landscape DFB can build up, rapidly killing weakened trees, and then spread to adjacent green trees and stands (Schmitz and Gibson 1996). DFB maintains itself at endemic populations in trees that are damaged by wind and fire, and in trees that are infected by root disease or are severely defoliated by spruce budworm.

2) **DFB can Move into Adjacent Stands during an Outbreak**
Outbreaks of DFB typically last 2-4 years, however, a drought can extend the outbreak for several more years. Large trees are needed for the development of an outbreak but stand density is what drives the

amount of mortality that will occur during the outbreak (Negron et al. 1999). Beetles tend to stay in a stand until most of the larger, susceptible trees are killed. Beetles also emigrate to surrounding susceptible trees and stands that are usually within a 3-mile radius (Withrow et al. 2013), despite having the capability to fly much further distances. Outbreaks tend to subside once there are no longer susceptible trees. Beetle populations can build up in damaged or weakened trees and attack green, more vigorous, trees and stands for a year or two. Climate conditions or a depletion of susceptible host material can reduce the extent of an outbreak. Management practices that aim to increase individual and stand vigor and health, such as thinning, can also serve to limit the extent of an outbreak.

3) How Changing Forest Vegetation can Reduce Impacts from DFB

Larger diameter trees (i.e., greater than 15 inches d.b.h.) are most susceptible to DFB. A DFB outbreak can remove most or all of the larger trees within a stand, as well as many of the smaller diameter trees, depending on the intensity of the outbreak. It can take many decades before trees within the stand are large enough and abundant enough to support another outbreak. Larger trees growing in thinned stands are less susceptible to beetle attacks than larger trees within dense stands. Thinning reduces inter-competition between trees and improves individual tree vigor, allowing trees to pitch-out attacking beetles. This is referred to as an unsuccessful beetle attack. Also, in unthinned stands the dense overstory and understory vegetation cause a reduction in air movement, resulting in enhanced pheromone saturation and communication of mating and aggregating beetles. Though low or moderate severity fire may increase forest or tree vulnerability to DFB attack, high severity fire can reduce vulnerability by severely burning the boles of the trees and making them less able to support DFB breeding activity and population buildup.

Spruce Beetle

Several adjustments were made to the spruce beetle (SB) (*Dendroctonus rufipennis)* sub-model that are reflected in the output between the draft and final EIS. SB activity increase initially in the Final EIS and then drops sharply and remains at low levels, versus in the Draft EIS SB activity gradually increases to fairly high levels over a 50-year model run, primarily due to the following additional assumptions. The first new assumption is that there is a 60-year or longer minimum time period between outbreaks in a stand (Veblen et al. 1994). The second assumption is that the probability of an outbreak in any given stand is reduced because most of the moderate and high hazard stands on the Flathead National Forest have had a SB outbreak within the past 100 years.

1. Length of Time between SB Outbreaks

SB occurs mostly at endemic levels across the Flathead NF landscape in spruce trees with root-disease, weakened trees or in down trees. SB activity increases from endemic to epidemic levels when substantial numbers of mature host trees occur on a site following disturbance, such as windthrow or landslides. Drought can also precipitate an outbreak of SB and/or extend it, resulting in more trees killed during an outbreak. Usually, there are long periods of time between SB outbreaks in an area, because during an outbreak between 60 and 90% of mature spruce are typically killed (DeRose and Long 2006).

2. Expanses of Spruce Stands that are Highly Susceptible to SB Outbreak are found Infrequently on the Flathead NF and the Northern Region

The most recent SB outbreak on the Flathead and Kootenai NFs occurred between 1982 and 1984 when more than 20,000 spruce trees were killed on approximately 30,000 acres. During most years only small groups and individual trees are killed by SB. Frequently following fire, such as the Little Wolf (1994) and

Brush Creek (2007) fires, SB activity increases in response to the availability of fire-injured trees. Low or moderate severity fires may increase chance of a SB outbreak, but high severity fire that severely burns the bole of the spruce trees is not conducive to SB population buildup. In any given year, windstorms can cause spruce blowdown on the Flathead NF and subsequently be infested by SB. High hazard stands have the following characteristics: they contain large spruce trees (d.b.h is greater than 16 inches); in densely stocked stand conditions (basal area exceeds 150 square feet per acre); have a high proportion of spruce in the stand (>65%). These types of stands typically occur as discontinuous patches or stringers along drainage bottoms and moist slopes and basins, with extensive areas of high hazard stands not widely common across the landscape. Spruce on the Flathead NF frequently occurs in mixed species stands, usually with subalpine fir.

Western Spruce Budworm

Western spruce budworm (SBW) (*Choristoneura freeman)* was included in the model for the draft EIS, but was not portraying future impacts appropriately. The amount of area affected by SBW in the model is believed to be less than expectations, considering possible climate changes and vegetation types in the future. The logic for this insect is “hard wired” in the SIMPPLLE model, and the only choices we had were to turn that logic on or off, or to expend a great deal of time and effort to rewire the logic within the model. The choice was made to turn off the logic for SBW, and discuss it in a more qualitative, narrative manner in the effects analysis in the final EIS. The reason for this decision is discussed below.

Western spruce budworm is a native insect that feeds on the foliage of Douglas-fir, true-firs, spruce, hemlock and occasionally on western larch and pines. Most of the time this native insect co-exists with our fir forest types at endemic or low population levels. Occasionally there are outbreaks of SBW following periods of dry, warm weather and when multi-storied, continuous susceptible forested stands occur across the landscape. Outbreaks of this insect may also predispose host trees to subsequent infestations by other insects and pathogens such as DFB (Alfaro et al. 1982). It is often the influence of these other infestations that result in the greatest mortality or changes in forest conditions.

The beginning and end of outbreaks are often synchronized across large areas of forestlands. Weather can significantly affect insect population dynamics. SBW outbreaks tend to occur towards the end of a drought. Flowers et al. (2014) suggested that future changes in SBW outbreak dynamics will be determined by a combination of changing climate, interactions with other disturbance agents, and changing forest composition and structure.

On the Flathead NF, there have been several budworm outbreaks during the past century. In some localized areas, susceptible forests have experienced heavy defoliation by budworm over multiple years (including the most recent outbreak occurring over the past 10 years). Budworm activity increases in forests that are multi-storied Douglas-fir and true-fir dominated stands. Extended periods of defoliation from budworm can result in growth loss, top-kill, branch dieback, increased susceptibility to bark beetles and even tree mortality of susceptible species. Past and current wildfire suppression and management practices have sometimes resulted in an abundance of Douglas-fir and true-fir dominated forests across the forest.

The impacts of SBW are the most significant in dry, Douglas-fir stands such as those of south-facing slopes. On the Flathead NF Douglas-fir often occurs in mixed stands across a variety of habitat types. In mixed forest stands or on moist sites, impacts from SBW are usually limited to growth loss and sometime top-kill. Budworm outbreaks on the Flathead NF may increase in their duration and severity in the future. This may be in response to an increase in more favorable susceptible forests and a warmer and/or dryer climate. We may see increased tree mortality directly from SBW activity across all size classes on the Flathead, especially on the dry-forest types.

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Review of Root Disease SIMPPLLE Modeled Outputs for Flathead NF

Heidi Trechsel (Flathead National Forest (FNF) Silviculturist and Vegetation Specialist for the Forest Plan Revision Team) and Eric Henderson (Regional Analyst) provided me with SIMPPLLE Model root disease outputs in the form of two charts (Figures 1&2). In addition, Heidi sent vegetation and climatic information that supports the root disease outputs. I was not involved in providing input into the modelling efforts. The following paragraphs describe my opinion in regards to whether or not the charts represent a reasonable depiction of root disease of the last 1,050 years (Figure 1) and expectation for root disease progression over the next five decades (Figure 2). The best available science for current root disease status and hazard on the Flathead National Forest is described by Lockman et al. (2016).

Figure 1 shows natural range of variation for root disease activity as modeled over the past 105 decades with the SIMPPLLE model.

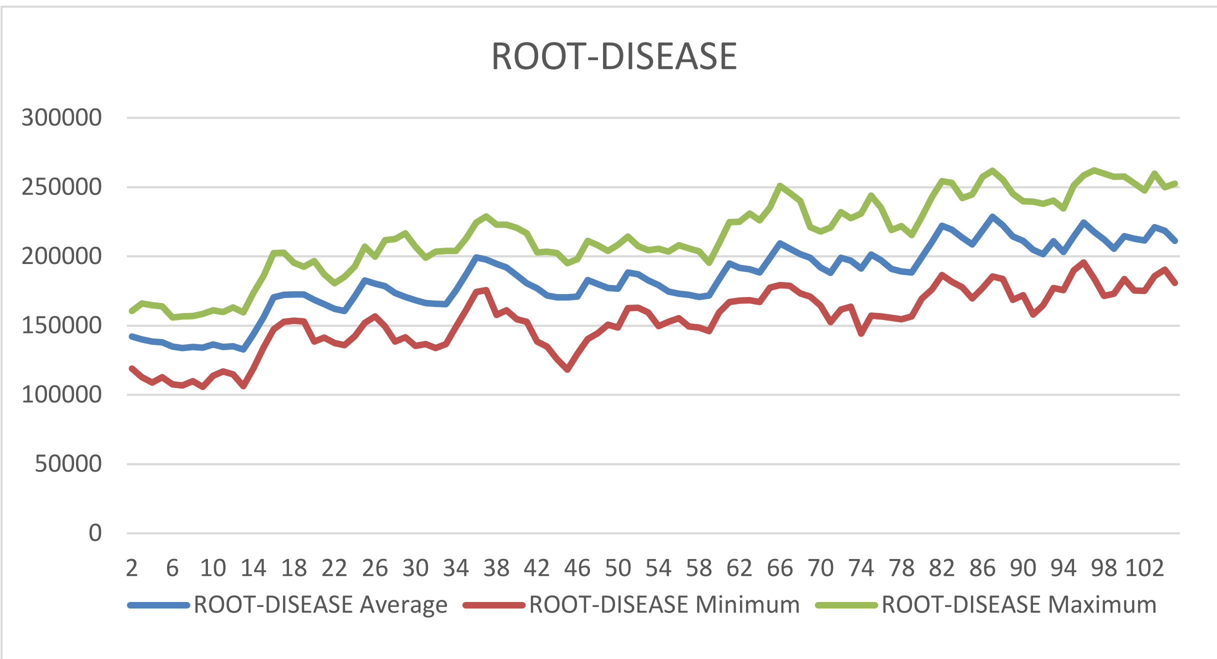

Figure 1. Natural Range of Variation for root disease over last 1,050 years as modeled through SIMPPLLE. Acres affected on y-axis; decades on x-axis, with 1050 years ago farthest to the left.

Current root disease levels that were input into the SIMPPLLE model are not shown on the graph, but were estimated at about 20,000 acres - which is far too low and do not accurately reflect current estimated levels of root disease as published in Lockman and others (2016), and displayed in figure 2. If this graph were to represent all acres with root disease (low, moderate or high severity), the levels should be increased by a factor of 5 since as indicated in figure 2, there is over one million acres believed to currently have root disease on the Flathead National Forest (Lockman et al. 2016). However, it is more likely that the model assumptions for root disease reflect a moderate and high severity of root disease, where more notable changes in forest conditions would occur. If this were the case, the levels of root disease in the NRV analysis might be increased by 2 to 3 times to more appropriately reflect root disease impacts over time.

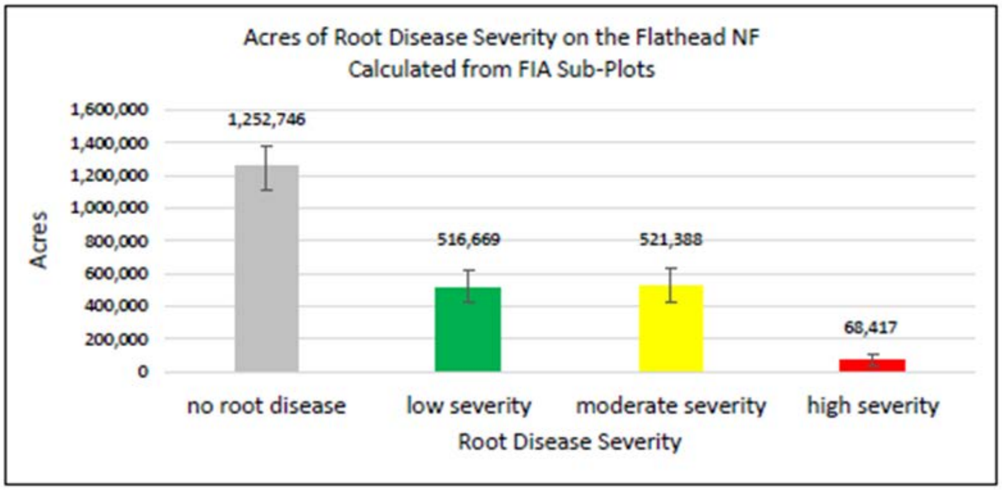

Figure 2. Acres of high, moderate, low and no severity for root disease forestwide on the Flathead National Forest.

In addition, Figure 1 shows that SIMPPLLE estimates root disease infested acres have increased by about 50% over the past 1,050 years on the FNF. Habitat type group and forest type are significant factors in succession functions of root diseases (Hagle et. al. 2000). Lockman et al. (2016) show that abgr3, abla1, abla2, and/or abla3 potential vegetation types (PVTs) have high root disease severity in some locations on the FNF and these PVTs as well as abgr2, psme2, and/or thpl1 have potential for high hazard to root disease. Most important root diseases in northwestern Montana affect the following conifer species in decreasing order: Douglas-fir, true firs, spruce, pine, larch (Hagle 2004) Power et al. (2006) shows that there were substantial shifts in proportion of forest to grassland over the last 3,800 years around Foy Lake near Kalispell and changes in conifer species composition based on pollen analysis. Of particular interest to root disease estimations would be changes in amounts of Douglas-fir and true firs. Douglas-fir/larch pollen proportion changed from 3800-2125 BP (before present) of 5% to 8 – 27% (2125 – 750 BP), to 14- 18% (750 – 75 BP) and decreased from 10% to 4% over the last 200 years presumably due to Euro-American settlement (Power et al. 2006). An increase in acreage of root disease can be expected with an increase in acreage of highly susceptible species that would only be expected to decline as infected acres were converted back into grassland or less susceptible forest. Based on the pollen data, there was an increase in Douglas-fir sometime between 2,000 and 1,000 years BP and those numbers did not drop dramatically until about 200 years or so BP.

In summary, the general trend of increased root disease over the last 1,050 years as identified in the SIMPPLLE model seems reasonable; however, the beginning and ending acreages are likely underestimated.

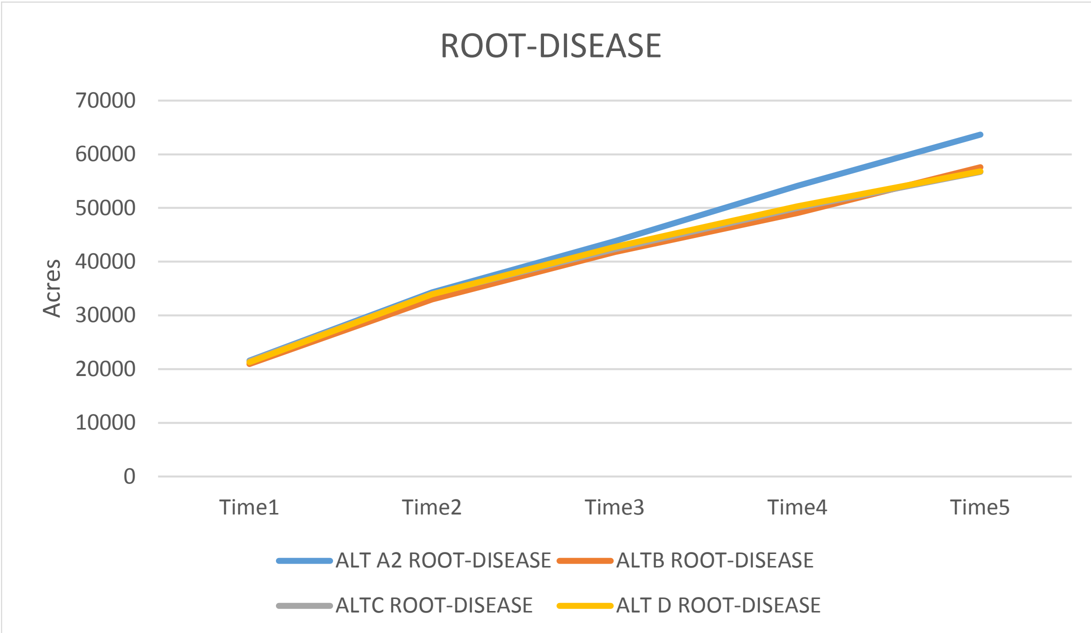

Figure 3. Future root disease increase on the FNF as modeled by SIMPPLLE over the next five decades.

Figure 3 shows the SIMPPLLE Model estimates about 20,000 acres of root disease after 10 years from current time. That acreage then doubles about every 20 years for approximately 60,000 acres of root disease after 50 years. As mentioned above, the current acres of root disease activity on the Flathead is too low in the model, if it is meant to reflect levels of high severity root disease (see figure 2). Given this, the end number at time 5 seems more reasonable for estimated **current levels of 'high severity' root disease** where 50% or more of the canopy is lost due to root disease (Lockman et al. 2016), but would grossly underestimate total acres of root disease which is estimated to total more than one million acres. Lockman et al. (2016) estimates that about 47% of Flathead NF acres are currently infested with root disease and that 82% has some level of hazard (capable of carrying root disease); therefore, the capacity for root disease to increase with current forest acreage is limited to less than doubling over any period of time.

There are many factors involved in determining spread of root disease. It would be incredibly difficult to make a reasonable estimate of spread since we don't know where and how large root diseased patches are on the Forest and if patch sizes are predominantly limited by habitat (already to edge of most susceptible species or even edge of forest) or if they can be expected to continue to spread due to adjacency to susceptible forest. With that said, a more attainable estimate may be the amount of currently infected (estimated) area that will move from a low level of infection (with up to 10% canopy loss) to a moderate level of infection (with 10% to 50% canopy loss) and a moderate level infection to a high level of infection with more than 50% canopy loss over 10 or 20 year increments.

There is great capacity for root disease to move from a moderate level of severity to high severity on the Flathead NF (Lockman et al. 2016). Hagle et al. (2016) completed an analysis of root disease plots monitored over 22 years on the Clearwater National Forest and found that root disease severity class increased "roughly one severity class…per decade.” This study found that root disease-caused mortality tended to be greater on the wetter habitat types. Since the FNF has a greater proportion of drier PVTs, a slower transition to higher PVTs may be expected, but data has not been analyzed to date to validate this assumption. Lockman et al. (2016) shows that there are over 500,000 acres in the moderate (root disease rating 3 to 5) severity class. If these acres were to increase in root disease severity by 0.5 per decade (half the rate identified in Hagle et al. (2016) for Clearwater NF plots), more than half of these acres could be expected to be severely affected (50% or more mortality) within the 50 year projection period. Therefore, it is conceivable that there could be a 3-fold, or greater, increase in severe root disease in the next 50 years as shown in Figure 2.

In summary, although any estimation of past and future trends in root disease can only be done with tenuous assumptions, both Figures 1 and 3 appear to greatly underestimate amount number of acres impacted by root disease historically and projected over the next five decades, as estimated using best available science at this time (Lockman et al. 2016). However, the general trends identified in these graphs seem reasonable. Current root disease acreage and severity should be based on estimated provided by Lockman et al. (2016).

References:

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