Piquett Creek Project Consideration of Science Submitted by the Public

Members of the Piquett Creek Project interdisciplinary team are considered proficient in their field of study by way of academic achievement, agency training, years of professional experience, and in some cases, certification programs. The following literature and scientific studies were brought forward by the public during scoping. All applicable science was considered. The citations contained in the comment letters were evaluated for applicability to this project proposal, and the findings discussed below.

Aquatics/Fisheries

Malison, R.L., and C.V. Baxter. 2010. The fire pulse: wildfire stimulates flux of aquatic prey to terrestrial habitats driving increases in riparian consumers. Canadian Journal of Fisheries and Aquatic Sciences 67: 570-579. *In ponderosa pine and Douglas-fir forests of Idaho at 5-10 years post-fire, levels of aquatic insects emerging from streams were two and a half times greater in high-intensity fire areas than in unburned mature/old forest, and bats were nearly 5 times more abundant in riparian areas with high-intensity fire than in unburned mature/old forest.*

Sestrich, C.M., T.E. McMahon, and M.K. Young. 2011. Influence of fire on native and nonnative salmonid populations and habitat in a western Montana basin. Transactions of the American Fisheries Society 140: 136-146. *Native Bull and Cutthroat trout tended to increase with higher fire intensity, particularly where debris flows occurred. Nonnative brook trout did not increase.*

Consolidated Response: The Sestrich et al. (2011) paper documented the response of native fish populations (bull trout and westslope cutthroat trout) on the Bitterroot NF following the 2000 fires. The sampling period was from 2002 to 2004, so it only looked at the first 4-years post fire. Since 2004, Bitterroot NF and Montana Fish, Wildlife, and Parks fisheries biologists have continued to periodically monitor the same sites that Sestrich et al. sampled. This monitoring indicates that the longer-term impact of the 2000 fires on native fish populations has been: (1) westslope cutthroat trout populations have remained at strong levels similar to or higher than those reported by Sestrich et al. (2011); but (2) bull trout populations have been declining since at least 2006, and in nearly all of Sestrich et al.'s sampling sites, are in worse shape now than they were in 2004.

There are thought to be two primary reasons for the bull trout decline. The main one is that temperatures are increasing in all streams across the Forest, regardless of their location or management history (wilderness or logged/roaded watersheds). Temperatures have continued to increase since the Sestrich et al. (2011) study concluded in 2004 and continue to be higher in the sites that were burned at high severity than in sites that were unburned or burned at low to moderate severity. So, although high severity burns do create improvements in some habitat features such as large wood, pools, hiding cover complexity, and the availability of macroinvertebrate prey (Malison and Baxter, 2010), these improvements have not been able to override and negate the long-term negative effect of loss of overstory shade cover and continued stream temperature warming. At least for bull trout, temperature appears to trump all other habitat features, and we continue to see bull trout decline as streams

continue to warm along with the warming climate. Related to this warming is an ongoing invasion of brown trout, which are tolerant of warmer water and very good at replacing bull trout. The threat posed by brown trout is something that Sestrich et al. (2011) hinted at in 2002-04 but has gotten worse since then.

To summarize, high severity fire does create more large wood in streams, more pools, more macroinvertebrate food, and better hiding cover. However, in our ongoing climate warming scenario, the decades long loss of overstory shade and its resulting effect on rising stream temperatures appears to be negating these improvements, at least for a thermally sensitive species like bull trout.

Carbon Storage and Climate Change

Abatzogloua, J. T., Williams, A.P., 2016, Impact of anthropogenic climate change on wildfire across western US forests. PNAS https://www.pnas.org/content/pnas/113/42/11770.full.pdf

Response: This paper looks at the factors that might have led to increased fire activity across the western United States in recent decades resulting in widespread forest mortality, carbon emissions, periods of degraded air quality and substantial fire suppression expenditures. They conclude that human increases in temperature and vapor pressure deficit have enhanced fuel aridity across western US forests. That fuel aridity will increasingly promote wildfire potential in the coming decades and pose threats to ecosystems, carbon budgets, human health and fire suppression budgets. They suggest that those threats will collectively encourage the development of a fire-resilient landscape. We agree with these findings and expect fire to be an increasing influence on the landscape as the climate changes. The activities proposed in the Piquett Creek project are designed to increase the landscape resilience to fire and lessen the impacts future fires may have on the area.

Berner, L.T., Law, B.E., Meddens, A.J.H, Hicke, J.A. 2017 Tree mortality from fires, bark beetles, and timber harvest during a hot and dry decade in the western United States (2003–2012) Environ. Res. Lett. 12 065005

Summary: This paper looks at the amount of carbon stored in tree biomass that has been killed by different types of disturbance (harvest, beetles, fire) between 2003-2012 for each state in the western United States. This information was intended to inform states with greenhouse gas (GHG) emission targets how forests can help or impact meeting those targets. Approximate mortality results specific to Montana show the following percentages by mortality type; timber 30%, beetles 50% and fires 20%. This was a period during which high temperatures contributed to severe drought that increased both fire and bark beetle activity relative to recent decades. Tree mortality from bark beetles and fires will likely increase in parts of the regions over the coming decades as anthropogenic GHG emissions drive higher temperatures and increased risk of drought. Efforts to manage natural resources and meet GHG emission targets will all benefit from better understanding of the magnitude, location, and causes of tree mortality.

Response: Results of this study show that beetles and fire are the primary causes of tree mortality in Montana and will likely increase overtime. The purpose and need of the Piquett Creek project is to increase resiliency to insects and disease and wildfire. The project area is not currently experiencing a

beetle outbreak however, 64% of the area is rated as moderate to high risk for future mountain pine beetle mortality and 33% for Douglas-fir beetle mortality. Currently, 54% of the project area is at risk for stand replacing fire. Completing treatments that will reduce the potential for mortality from beetles and fire may help to offset carbon loss from tree mortality. Promoting healthy forests also aligns with one of the recommendations the Montana Climate Change Advisory Committee made to help reduce GHG emissions (MTDEQ, 2007).

Campbell, J.L., Harmon, M.E., Mitchell, S.R., 2011, Can fuel reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and Environment, doi:10.1890/110057. *No evidence that thinning will decrease CO2 emissions in the long or short term; in fact it may be the opposite.*

Response: Campbell et al. addresses the issue of climate change, either through carbon storage or CO2 emissions from logging. The paper concludes that fuel treatments do not have an additional benefit of increasing carbon storage. This project is not a primary contributor of global greenhouse gas emissions nor is it similar to the primary human activities exerting negative pressure on the carbon sink that currently exists in U.S. forests, namely land use conversion. The affected forests will remain forests, not converted to other land uses, and long-term forest services and benefits will be maintained.

DeLuca, T.H., and Aplet, G.H.,2008, Charcoal and carbon storage in forest soils of the Rocky Mountain West:Frontiers in Ecology and the Environment, v. 6, n. 1, p. 18-24, doi:10.1890/070070. *Charcoal deposition over the course of several millennia probably accounts for a substantial proportion of the total soil C pool in fire-maintained forest ecosystems. Forest management processes that interfere with natural fire processes eliminate the formation of this passive form of C.*

Response: DeLuca and Aplet (2008) state, "Timber harvest without prescribed fire may be applied as a forest restoration tool; however, under these conditions, charcoal, as a passive C contribution to the soil system, will be eliminated and will lead to a modest, but long-term loss of C from the forest ecosystem. Conversely, restoration harvests that incorporate prescribed fire will more effectively emulate natural fire events and deposit charcoal across the activity unit." Prescribed fire is proposed to follow all areas receiving commercial and non-commercial vegetation treatments within the Piquett Creek project.

Harmon, M.E., et al., 1996, Modeling carbon stores in Oregon and Washington forest products: 1900-1992: Climatic Change 33: 521-550. *Found that only 23% of carbon harvested during the selected period is currently stored; the rest was emitted to the atmosphere.*

Response: We do not disagree with the findings of Harmon et al. (1996), however, as indicated above the scale of vegetation change as a result of the Piquett Creek project compared to the scale as which carbon storage is modeled would be insignificant.

Harris, N.L., and 6 others, 2016, Attribution of net carbon change by disturbance type across forest lands of the conterminous United States: Carbon Balance Management, v. 11, 24 p. DOI 10.1186/s13021-016-0066-5. *Timber harvest in western forests resulted in 4 times more carbon storage loss than wildfire.*

Response: We do not disagree with the findings of Harris et al. (2016), however, as indicated above the scale of vegetation change as a result of the Piquett Creek project compared to the scale as which carbon storage is modeled would be insignificant.

Law, B.E., and Waring, R.H., 2015, Carbon implications of current and future effects of drought, fire, and management on Pacific Northwest forests: Forest Ecology and Management, v. 355, p. 4-14.

Response: The Law and Waring (2015) conclude that longer rotations between harvests or selection harvests in Pacific Northwest forests would maximize carbon sequestration. Selective harvest that would leave a residual stand is proposed as a potential treatment activity within the Piquett Creek project. Law and Waring (2015) is specific to Oregon and the Pacific Northwest, it is unclear (and not stated by the commenter) the application this research paper has to ponderosa pine and dry Douglas-fir forests or western Montana.

Law, B.E., Hudibug, T.W., Berner, L.T., Kent, J.J., Buotte, P.C., and Harmon, M.E., 2017, Land use strategies to mitigate climate change in carbon-dense temperate forests: PNAS, www.pnas.org/cgi/doi/10.1073/pnas.1720064115. *Logging is Oregon's biggestCO2 polluter, much more so than wildfire.*

Response: Law et al. (2017) conclude that longer rotations between harvests or selection harvests in Pacific Northwest forests would maximize carbon sequestration. Selective harvest that would leave a residual stand is proposed as a potential treatment activity within the Piquett Creek project. Law et al. (2017) is specific to Oregon and the Pacific Northwest, it is unclear (and not stated by the commenter) the application this research paper has to ponderosa pine and dry Douglas-fir forests or western Montana.

LePage, 2019, Logging study reveals huge hidden emissions of the forest industry: New Scientist online, https://www.newscientist.com/article/2215913-logging-study-reveals-huge-hidden-emissions-of-the-forestry-industry/ Reinhardt, E., and Holsinger, L, 2010, Effects of fuel treatments on carbon-disturbance relationships in forests of the northern Rocky Mountains: Forest Ecology and Management, v. 259, p. 1427–1435. *Modeling indicated that fuel treatments decreased fire severity and crown fire occurrence and reduced subsequent wildfire emissions, but did not increase post-wildfire carbon stored on-site. Conversely, untreated stands had greater wildfire emissions but stored more carbon.*

Response: LePage (2019) is specific to North Carolina, it is unclear (and not stated by the commenter) the application this research paper has to ponderosa pine and dry Douglas-fir forests or western Montana.

Segerstrom, C., 2018, Timber is Oregon's biggest carbon polluter: High Country News, May 16, 2018.

Response: Segerstrom (2018) discusses the research in the Law papers and that logging practices in Oregon are the largest contributor to CO2 emissions in the state, more so than wildfires. This paper is specific to logging practices in Oregon, where rotation between harvests is shorter and timber from private lands accounts for 63% of timber produced.

Fire and Fuels

Wildland Urban Interface/Home Ignition

Cohen, J.D. 1999. Reducing the wildland fire threat to homes: Where and how much? PSW-GTR-173. 189-195. [0863]

Summary: This publication focuses on the ignitability of structures during wildfire and proposes recommendations on reducing potential loss. The research concludes that home losses from direct flames can be reduced by focusing mitigation efforts on the structure and its immediate surroundings. It also finds that the structures' materials, design and surrounding flammables determine the potential for a home to ignite during a wildfire. Cohen also recommends that in order to improve the effectiveness of wildland fuel reduction in relation to home ignition, vegetation management needs to reduce firebrand production from torching which requires extending vegetation management out several kilometers away from homes.

Cohen, J.D. 2000. What is the wildland fire threat to homes? Presented as the Thompson Memorial Lecture, School of Forestry, Northern Arizona University, Flagstaff, AZ; April 10, 2000. [http://www.nps.gov/fire/download/pub_pub_wildlandfirethreat.pdf [0502]

Summary: This publication focuses on the ignitability of structures during wildfire and proposes recommendations on reducing potential loss. The research concludes that home losses from direct flames can be reduced by focusing mitigation efforts on the structure and its immediate surroundings. It also finds that the structures' materials, design and surrounding flammables determine the potential for a home to ignite during a wildfire. Cohen also recommends that in order to improve the effectiveness of wildland fuel reduction in relation to home ignition, vegetation management needs to reduce firebrand production from torching which requires extending vegetation management out several kilometers away from homes.

Cohen, J.D. 2002. Wildland-urban fire: A different Approach. [1611] [http://www.firelab.org/]

Summary: This publication focuses on the ignitability of structures during wildfire and acknowledges that fire is an intrinsic ecological process in nearly all North American ecosystems. It focuses on improving residential compatibility with wildland fire rather than preventing fire encroachment on the community. Before the wildfire, the wildland-urban fire specialist uses home ignition expertise to identify vulnerable residential areas and facilitate community efforts to reduce home ignitability. During wildfires, the specialists work with homeowners and multi-agency wildland-urban fire protection teams to identify and implement effective actions for reducing home destruction during wildfires.

Cohen, J.D. 2003a. An examination of the Summerhaven, Arizona home destruction related to the local wildland fire behavior during the June 2003 Aspen Fire. [1715] http://www.tucsonfirefoundation.com/wp-content/uploads/2012/07/2003-Summerhaven-Ho-Dest.pdf

Summary: This publication examines the home destruction in an Arizona subdivision (Summerhaven) that occurred in 2003 during the Aspen Fire. The evidence revealed that the wildfire in the Summerhaven area largely spread as a surface fire not as a high intensity crown fire. The differences in the direct flame and firebrand exposures related to the home characteristics resulted in whether a home survived or not. Also found that a structure may ignite directly from firebrands that have come from an intense wildland fire at over ½ mile away, but these ignitions are dependent on the materials and design of the structure.

Cohen, J.D. 2003b. Structure ignition assessment model (SIAM). USDA Forest Service General Technical Report PSW-GTR-158, 1995. An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15–17, 1994,Walnut Creek, CA. [1716]
[http://www.fs.fed.us/psw/publications/documents/psw_gtr158/psw_gtr158_05_cohen.pdf]

Summary: This publication discusses the Structure Ignition Assessment Model (SIAM) which uses an analytical approach that relates the potential for sustained structure ignitions to the location and characteristics of adjacent fires and the structure's materials and design. Initial SIAM results indicate that the flames of burning vegetation are not greatly effective in creating sustained ignitions. This suggests that firebrands and adjacent burning structures are significant causes of structure ignitions.

Cohen, J.D. 2003c. Thoughts on the wildland-urban interface fire problem. Published in Wildfire Magazine and International Journal of Wildland Fire.
http://www.nps.gov/fire/download/pub_pub_wildurbaninterface.pdf

Summary: This magazine article provides historical context to how fire suppression policies have created the current fuels and vegetation conditions on National Forests that can lead to high intensity fire behavior. Discussion focuses on how WUI fire disasters are primarily a home ignition and loss problem and how that can be prevented by creating ignition resistant homes. Contends that national fire policies focus on a suppression approach to control fires away from structures to in order to minimize WUI fire disasters without consideration for home ignition potential.

Cohen, J.D. and J. Saveland. 1997. Structure ignition assessment can help reduce fire damages in the WUI. [1717] https://www.firelab.org/

Summary: This publication discusses the Structure Ignition Assessment Model (SIAM) which uses an analytical approach that relates the potential for sustained structure ignitions to the location and characteristics of adjacent fires and the structure's materials and design. Modeling suggest that WUI fire loss mitigation should concentrate on the residence and its immediate surroundings.

Consolidated Response to Cohen's Research.

Response: Preventing negative impacts to our communities and the loss of homes from wildfire is important, however, only treating the home ignition zone will not reduce firebrand production from torching nor will it meet the stated purpose of and need of the Piquett Creek project. It is well understood and supported that the immediate area surrounding a home and the characteristics of the building material are potentially the most critical elements in determining its survivability. The Forest Service encourages homeowners to do their part in making their homes fire safe, however, hardening structures on private land is beyond the scope and scale of this project. The Bitterroot National Forest continues to work with our local fire districts and the Bitterroot RC&D to promote the FIREWISE program to local landowners in order to create homes and communities that are resilient to wildfire.

While Cohen's research has shown individual home-by-home treatments can help reduce the risk of loss of individual homes, relying solely on such treatments would forego strategic opportunities for reducing fire behavior and controlling fires within the wildland urban interface area prior to fire impacting structures. Additionally, reducing fire behavior and the potential for torching within the WUI will also reduce the potential for lofted firebrands which Cohen has identified as a principle ignition factor for structures. Highly ignitable homes can ignite during a wildland fire without a fire spreading near the

structure. Firebrands that result in ignitions can originate from wildland fires that are a distance of 1 kilometer (0.6 miles) or more (Cohen 2000).

Although homes in the path of a wildfire are perhaps the most immediately recognized value at risk, research has determined that treatments need to go beyond the home ignition zone for other resource values (Graham 2004). While changing fire behavior in the WUI to improve firefighter and public safety, protect values and increase probabilities of success during suppression are important outcomes from the proposed treatments, increasing landscape diversity, resilience to fire along with preventing the loss of key ecosystem components from fire effects that are predicted to be outside of historic characteristics for low/mixed fire regimes are just as important results.

Kramer, H., et al., 2019, High wildfire damage in interface communities in California: International Journal of Wildland Fire, 28, 641–650, https://doi.org/10.1071/WF18108

Summary: This paper examined wildfire damages among urban, rural and WUI (intermix and interface) areas for three decades in California (1985-2013). Research found that interface WUI accounted for 50% of the homes destroyed by wildfire, whereas intermix WUI accounted for 32%. The rate of destruction in rural areas was also high. Buildings in non-WUI, rural areas with wildland vegetation certainly remain vulnerable to wildfires as evidenced by this high overall destruction rate (see also Kramer et al. 2018). The paper recommends improving the fire behavior science and modeling predictions for non-wildland vegetation, buildings, propane tanks, wood pile and vehicles to better understand how fire moves through the interface WUI. They also acknowledge the importance that building materials and defensible space in the home ignition zone play in structure survivability.

Response: The WUI within and adjacent to the Piquett Creek project would be considered intermix based on the density of structures and the presence of continuous wildland fuels. The fuels, fire behavior and presence of interface WUI that are found in California are not representative of the Piquett Creek project area. As the paper references, homes in intermix and rural areas surrounded by wildland fuels remain vulnerable to loss from wildfire. Activities that reduce potential fire behavior and sources of ignition from embers will help to reduce impacts to the intermix WUI.

Fire Effects & Beetles

Bradley, C. M., C. T. Hanson, and D. A. DellaSala. 2016. Does increased forest protection correspond to higher fire severity in frequent-fire forests of the western United States? Ecosphere 7(10):e01492. 10.1002/ecs2.1492. *Forests with the most active management produce the highest severity wildfires.*

Summary: This paper examined whether areas of the western United States with increased protection status (wilderness) experienced higher fire severity due to restrictions on active forest management. The study looked at 1500 fires affecting 9.5 million hectares between 1984 and 2014 in pine (*Pinus ponderosa, Pinus jeffreyi*) and mixed-conifer forests of western United States. Findings conclude that areas with the highest levels of protection from logging tended to burn the least severely. The authors recommend allowing more wildfires to burn under safe conditions can be an effective restoration tool for increasing landscape diversity. The researchers also acknowledge they could not rule out that low-intensity management could decrease the occurrence high-severity fires.

Response: We agree with the recommendation that when conditions are favorable wildfire can be an effective tool in managing the landscape. Since 1972, the West Fork Ranger District has managed

wildfires within the Selway-Bitterroot and Frank Church River of No Return wilderness to allow them to play their natural role in the ecosystem. Historically these fires have been managed under more moderate conditions than what the majority of the wildfires outside of wilderness tend to burn under. Not all fires in wilderness are allowed to burn if conditions are outside of acceptable parameters, thus limiting a number of fires that would have burned at higher severities. Wildfires outside of wilderness are suppressed due to forest plan direction, the proximity to values and the expected fire behavior based on current vegetation and fuel conditions. Wildfires that escape initial attack outside of wilderness areas tend to burn under very high or extreme conditions with high intensities that likely lead to more high severity. Regardless of the protection status, wildfires are burning under much different fuel moistures and weather conditions that are likely causing the differences in fire severities.

The Piquett Creek project does not have any protected lands within the project area nor does it contend that protected areas burn at higher severities. A desired outcome of implementing activities proposed by this project is to lower fire severities in low severity regimes, increase the ability to utilize fire (wildfire or prescribed) on the landscape to maintain natural processes and landscape diversity. Until the risk of negative impacts from fire on our communities can be reduced, wildfires outside of wilderness will continue to have an aggressive suppression approach. Changes to the Bitterroot Forest Land Management Plan and the corresponding fire management responses for each management area, are outside of the scope and scale of this project.

Donato, D.C., B.J. Harvey, W.H. Romme, M. Simard, and M.G. Turner. 2013. Bark beetle effects on fuel profiles across a range of stand structures in Douglas-fir forests of Greater Yellowstone. Ecological Applications 23: 3-20. *Fire potential is less, particularly for crown fires, after Doug Fir bark beetle mortality. Formerly dense DF forests became more open parklands, which is one of your goals.*

Summary: This paper examined the effects of Douglas-fir bark beetle mortality on fuel profiles within Yellowstone National Park. The study found evidence that the effects of bark beetle outbreak on fuel profiles in lower montane forests differ from those in higher elevation forests with stand replacing fire regimes and that changes to the fuel profile were less in areas with relatively low tree density and canopy biomass to begin with. Thus, any management of fuels in post-outbreak stands may be better prioritized for denser stands in which crown fuels may still have a degree of continuity, and coarse woody fuels are more abundant. Conclusions highlight the importance of evaluating outbreak effects in the context of the wide structural variation inherent to many forest types in the absence of beetle disturbance. Specific to the management of wildland fuels, this finding suggests that bark beetle outbreaks can be approached as but one of many influences structuring fuel profiles, and that treatments in beetle-affected landscapes could continue to address a variety of objectives rather than focusing singularly on beetle impacts.

Response: The Piquett Creek project is not currently experiencing high levels of tree mortality from bark beetles nor do the proposed activities focus solely on reducing fuels created from beetle mortality. The findings of this paper are in agreement with the purpose and need and proposed action of the Piquett Creek project.

Hart, S.J., Schoennagel, T., Veblen, T.T., and Chapman, T.B., 2014, Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks: Proceedings of the National Academy

of Sciences (PNAS), v. 112, n. 14. *Trees killed by mountain pine beetles have had no effect on the areas subsequent wildfires have burned.*

Summary: This paper examines the effect of mountain pine beetle and wildfire activity and whether or not the area burned increased during extreme fire seasons. They conclude that both mountain beetle infestation and fire activity have each independently increased due to recent warming and the area burned in the western United States is not in direct response to beetle activity. This study was conducted at a macroscale across the western United States and they acknowledge that the effects of beetle outbreaks at the stand scale on other measures of fire behavior, most importantly, fire intensity and crowning behavior, may be important and clearly warrant caution from a fire-fighter safety perspective. They also note that under moderate burning conditions, stand-scale fire behavior models predict that MBP alterations to fuel complexes result in increased fire severity.

Response: The purpose and need of the Piquett Creek project is to increase resiliency to insects and disease and wildfire. The project area is not currently experiencing a mountain pine beetle outbreak. There is no indication that the project area is more likely to burn because of beetle mortality.

Kulakowski,D., Daniel Jarvis, D., 2011, The influence of mountain pine beetle outbreaks and drought on severe wildfires in northwestern Colorado and southern Wyoming: A look at the past century: Forest Ecology and Management, v. 262, p. 1686–1696. *Found no detectable increase in fire severity following MPB mortality in lodgepole forests. Climate appears to be a much more important factor in fire severity than fuels.*

Summary: This paper discusses the potential for reduced risk of active crown fire 5 to 60 years after a mountain pine beetle outbreak in lodgepole pine forests located in Colorado. This study suggests that over the past century drought has been more important than MPB outbreaks in determining the occurrence of severe fires in lodgepole pine forests of northwestern Colorado and adjacent areas of southern Wyoming. Stands that were burned in high-severity fires were no more likely to have been affected by outbreaks than nearby stands that did not burn. However, years during which fires occurred were significantly drier (based both on PDSI and AET) than years during which fires did not occur.

The most likely explanation for why severe fires are not more strongly associated with MPB outbreaks than would be expected by chance is twofold: First of all, the effect of outbreaks in reducing foliar moisture content is outweighed by reductions in canopy bulk density, which has a net effect of reducing fire hazard (Simard et al., 2011). Thus, although the canopy of affected stands is drier immediately after outbreaks due to the abundance of dead trees, no increase in fire hazard is observed because the killed trees rapidly lose their needles and effectively reduce canopy bulk density. Second of all, given the importance of infrequent but extreme drought to fires in lodgepole pine forests (Schoennagel et al., 2007), it appears that the abundance of live versus dead fuels is not generally limiting to the occurrence of severe fires

Response: Depending on the intensity and levels of mortality, there may be a reduction to canopy bulk density (CBD) after dead needles fall from the trees. However, before these changes to CBD occur, research results have empirically demonstrated that the needles of attacked and red trees are more easily ignited than those of healthy trees and may thus pose a greater crown fire risk, as long as the physical structure of the tree remains the same (Jolly et al., 2012a). “In a replicated laboratory study,

scientists with the Rocky Mountain Research Station determined that the greater flammability of red needles is due to their lower foliar moisture and altered chemistry. Ignition rates are about three times faster for red needles than healthy green needles (13 vs. 35 seconds) (Jolly et al. 2012a)." (Matonis et al, 2014). A site specific example of increased fire behavior during the red stage occurred during "the 2011 Saddle Complex Fire which made a sustained crown fire run of 17,000 acres along the Montana-Idaho border in a relatively short time, mostly through beetle-kill fuels. Spotting distances were likely greater than 1 mile (Matt Jolly, USDA Forest Service, pers. obs.)." (Matonis et al, 2014).

The potential for active crown fire may be reduced during the grey stage, however, few researchers have explored fire behavior in gray-stage forests and forests with fallen snags. Fire managers in Canada reported that standing gray-stage trees shed bark that could generate embers and increase spot fire occurrence, potentially as far as a half-mile away. "Research also suggests that fire hazards and behavior will change after the gray-stage as snags drop to the ground. Collins and others (2012) estimated that windthrown snags will cause a >5-fold increase in the coarse surface fuels in beetle-killed stands with no fuels reduction treatment. Wind speeds are likely to increase throughout the forest, fanning fast fires through accumulations of dry fuels (Linn et. al 2013). A higher prevalence of open canopies and coarse surface fuel loads are likely to increase surface fireline intensities. These changes could facilitate active crown fires at lower wind speeds across all moisture scenarios in gray-stage or dead-and-downed stands, even 30 years after an MPB attack (Schoennagel and others 2012). Falling snags and jack-straw logs are serious hazards for firefighters. In addition, fire line production rates drop when more logs need cutting (Page 2013). Fires in these forests may grow exceptionally large due to an unwillingness to put firefighters at risk." (Matonis et al. 2014)

We agree that climate is an important factor in fire severity in lodgepole pine forests and that during dry fire seasons all fuels are readily available to burn regardless if they have been impacted by mountain pine beetle mortality. Lodgepole pine is a relatively short lived tree species that depends on stand replacing high severity fire to regenerate. These fire effects are an expected outcome as areas dominated by lodgepole pine reach conditions typical of their ecological climax. It is not suggested that mountain pine beetle mortality is solely causing this type of fire behavior and severity.

The purpose and need of the Piquett Creek project is to improve landscape resilience to disturbances (such as fire, insects and diseases) by diversifying forest structure and composition and reducing fuels. By reducing the likelihood of widespread future mountain pine beetle mortality in this area, the project will eliminate some of the potential risks and uncertainty of the effects beetles have on fire behavior. The Piquett Creek Project is not currently experiencing a mountain pine beetle outbreak and lodgepole pine only comprises 4% of the vegetation cover type across the project area. For these reasons the findings of this research are not applicable to the Piquett Creek project.

Meigs, G. W., J. L. Campbell, H. S. J. Zald, J. D. Bailey, D. C. Shaw, and R. E. Kennedy. 2015. Does wildfire likelihood increase following insect outbreaks in conifer forests? Ecosphere v. 6(7), article 118, 24 p. *Wildfire likelihood does not increase in insect-killed conifer forests.*

Summary: This is an article that looks at whether insect outbreaks have an effect on increasing the likelihood of wildfires in Oregon and Washington. Their central finding was that wildfire likelihood does not consistently increase or decrease in areas affected by recent insect outbreaks. Despite their finding they make several recommendations. They acknowledge that MPB, WSB, and wildfire will continue to

influence PNW forests, and it may be efficient to focus on their individual forest health impacts more than their interactions. Additionally, because these disturbances are not distributed evenly across space and time, it also makes sense to prioritize management activities on specific landscapes with higher disturbance impacts and/or more valuable ecosystem services. Second, when and where wildfires do occur in recent or ongoing insect outbreaks, fire behavior and effects may change (e.g., higher rate of spread or severity, fire management will likely be more challenging, and compounding disturbance effects must be addressed. They acknowledge that both MPB and WSB are native to PNW forests and likely contribute to the pyrodiversity inherent to mixed-severity fire regimes. Just because these insects may not represent a regional forest health crisis, there are likely higher priorities for ecosystem restoration programs, such as fuel and fire dynamics at the wildland-urban interface. Lastly, forests will continue to burn whether or not there was prior insect activity and known fire drivers like fuel accumulation and vegetation stress likely will play a more important role in a warmer, potentially drier future.

Response: The Piquett Creek project does not contend that wildfires are more likely to occur because of insect outbreaks. By improving landscape resilience to disturbances (such as fire, insects and diseases) by diversifying forest structure and composition and reducing fuels, the Piquett Creek project is in line with the recommendations of this article.

Meigs, G.W., J.D. Zald, H.S. Campbell, W.S. Keeton, and R.E. Kennedy, 2016, Do insect outbreaks reduce the severity of subsequent forest fires? Environ. Research Letters 11, 045008, doi:10.1088/1748-9326/11/4/045008. *Both WPB and MPB mortality decrease the severity of subsequent fire.*

Summary: This is an article that looks at whether insect outbreaks have an effect on the severity of subsequent wildfires in Oregon and Washington. Results of this broad scale study indicate that insects generally reduce the severity of subsequent wildfires. Specific effects vary with insect type and timing, but both insects decrease the abundance of live vegetation susceptible to wildfire at multiple time lags. The continuing decline in post-beetle burn severity indicates that the thinning effect may persist until vegetation and fuel distributions recover to pre-insect conditions. Because there were relatively few fire events within the first few years following mountain pine beetle (MPB) outbreak in our census, future studies should continue to investigate the transient yet highly flammable red stage of outbreak (Jolly et al 2012a). In the case of western Spruce-budworm (WSB) defoliation, lower initial burn severity is consistent with reduced potential fire behavior and effects due to fine-scale canopy thinning and mortality dynamics (Cohn et al 2014). The relatively rapid increase of the budworm-fire coefficient with time indicates that the thinning effect on fuel profiles is less persistent for the defoliator (WSB) than for the bark beetle (MPB).

The article acknowledges that because their census uses remotely sensed relative spectral change (RdNBR) as a proxy for fire effects, they cannot directly address causal relationships, fine-scale ecological impacts and responses (e.g., soil heating, tree regeneration), fire behavior (e.g., fire intensity, crowning), or operational fire management (e.g., firefighter safety, suppression tactics). Although our regional census reveals negative insect effects on burn severity across a range of conditions that has not been assessed to date, numerous uncertainties and research questions remain, particularly regarding the

mechanistic linkages among insects, fuels, and other known drivers of fire behavior and effects. Specifically, our inference is limited to the locations and years captured by the available spatial datasets, and future studies could investigate insect– fire severity relationships over broader spatiotemporal scales.

Response: Due to the scale and lack of site specific information on casual relationships it is difficult to apply this information to the project scale. The Piquett Creek project does not contend that wildfires are likely to burn more severely because of insect outbreaks. They do, however, have effects on fire behavior as this paper and other research have acknowledged. Additionally, the project area is not currently experiencing a mountain pine beetle outbreak although areas are currently at high risk to future activity. Local observations of fire behavior in areas impacted by western spruce bud-worm indicate increased potential for torching due to low live foliar moisture caused by stress. The 2018 Reynolds Lake Fire (on the southern end of the West Fork Ranger District) quickly transitioned into the crowns under moderate early season conditions.

Nacify, C., Sala, A., Keeling, E.G., Graham, J., Deluca, T.H., 2010, Interactive effects of historical logging and fire exclusion on ponderosa pine forest structure in the northern Rockies Ecological Applications, 20(7), 2010, pp. 1851–1864. *" Fire-excluded ponderosa pine forests of the northern Rocky Mountains logged prior to 1960 have much higher average stand density, greater homogeneity of stand structure, more standing dead trees and increased abundance of fire-intolerant trees than paired fire-excluded, unlogged counterparts. In other words, logging increases fuel loads and produces the densest forest over the long term.*

Summary: This paper discusses the effects of logging and fire exclusion in the northern Rocky Mountains. The conclusion of this paper shows that forests that were logged and had fire suppression are denser, less diverse, and less fire tolerant than similar unlogged and fire suppressed stands. The removal of large fire tolerant trees and lack of follow up stand improvement activities has created conditions that are more prone to stand replacing fires. The authors emphasize that forest health treatments should focus on stands that were previously logged, located near communities and have existing road infrastructure. Stands that are previously unlogged and fire-excluded may not require as of intense management prescriptions.

Response: The majority of stands proposed for treatment in the Piquett Creek project have had varying levels of harvest at some point in the past and are located within the WUI where fuels reduction is one of the primary goals. Treatments will be designed to promote fire tolerant species, retain the largest healthy trees, reduce stand densities, increase canopy base heights, diversify stand structure and promote landscape diversity. Opportunities to use less intensive management prescriptions to meet the desired conditions such as prescribed fire, will be evaluated for stands that are previously unlogged and fire-excluded.

Simard, M., Reese, W.H., Griffin, J.M., Turner, M.G., 2011, Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? Ecological Monographs, 81(1), 2011, p. 3–24. *MPB outbreaks in Lodgepole Pine reduce the likelihood of crown fires.*

Summary: The results of the article suggest that thinning of lodgepole pine canopies in the Greater Yellowstone area from mountain pine beetle mortality may reduce the probability of active crown fire in

the short term. The paper later discusses the effects for crown fire are linked to canopy bulk density. "The primary driver of crowning is canopy bulk density (Van Wagner 1977), and post-outbreak reduction of canopy fuels is the most likely mechanism of reduced probability of active crown fire in both red and gray-stage sites." Results also showed that predicted fire behavior in the decades that followed the outbreak (25–35 years post-outbreak) was qualitatively different than at the early stages of the outbreak. Passive crown fires were predicted to be the norm in the 25- and 35-year post-outbreak stands because post-disturbance release of understory saplings provided ladder fuels that greatly reduced canopy base height.

Response: In a response to this research, Jolly et al. 2012b) concluded that Simard et al. (SRGT) failed to capture critical surface and crown fuel changes as an MPB attack progresses through a given stand. That SRGT used a fire behavior modeling framework that has no mechanism for considering highly heterogeneous fuels, omission of critical canopy and surface fuel changes in stands attacked by MPB, and potential increases in the inherent variability associated with fuels sampling in general and along a chronosequence, led to the predicted reduction in the crown fire potential in red-needle stands under the moderate conditions reported by SRGT. As Jolly et al. demonstrated in their response, if SRGT had chosen estimates of surface and canopy fuel inputs that better described stands during the early stages of a MPB attack, inevitably they would have found an increase in predicted crown fire potential in almost all cases, particularly during the first three years after an attack. There is not yet a consensus among researchers regarding the nature and magnitude of these effects (Jenkins et al. 2008).

Depending on the intensity and levels of mortality, there may be a reduction to canopy bulk density (CBD) after dead needles fall from the trees. However, before these changes to CBD occur, research results have empirically demonstrated that the needles of attacked and red trees are more easily ignited than those of healthy trees and may thus pose a greater crown fire risk, as long as the physical structure of the tree remains the same (Jolly et al., 2012a). "In a replicated laboratory study, scientists with the Rocky Mountain Research Station determined that the greater flammability of red needles is due to their lower foliar moisture and altered chemistry. Ignition rates are about three times faster for red needles than healthy green needles (13 vs. 35 seconds) (Jolly et al. 2012a)." (Matonis et al, 2014). A site specific example of increased fire behavior during the red stage occurred during "the 2011 Saddle Complex Fire which made a sustained crown fire run of 17,000 acres along the Montana-Idaho border in a relatively short time, mostly through beetle-kill fuels. Spotting distances were likely greater than 1 mile (Matt Jolly, USDA Forest Service, pers. obs.)." (Matonis et al, 2014).

The potential for active crown fire may be reduced during the grey stage, however, few researchers have explored fire behavior in gray-stage forests and forests with fallen snags. Fire managers in Canada reported that standing gray-stage trees shed bark that could generate embers and increase spot fire occurrence, potentially as far as a half-mile away. "Research also suggests that fire hazards and behavior will change after the gray-stage as snags drop to the ground. Collins and others (2012) estimated that windthrown snags will cause a >5-fold increase in the coarse surface fuels in beetle-killed stands with no fuels reduction treatment. Wind speeds are likely to increase throughout the forest, fanning fast fires through accumulations of dry fuels (Linn et. al 2013). A higher prevalence of open canopies and coarse surface fuel loads are likely to increase surface fireline intensities. These changes could facilitate active crown fires at lower wind speeds across all moisture scenarios in gray-stage or dead-and-downed stands, even 30 years after an MPB attack (Schoennagel and others 2012). Falling

snags and jack-straw logs are serious hazards for firefighters. In addition, fire line production rates drop when more logs need cutting (Page 2013). Fires in these forests may grow exceptionally large due to an unwillingness to put firefighters at risk." (Matonis et al. 2014)

The purpose and need of the Piquett Creek project is to improve landscape resilience to disturbances (such as fire, insects and diseases) by diversifying forest structure and composition and reducing fuels. Reducing the likelihood of widespread future mountain pine beetle mortality in this area, the project will eliminate some of the potential risks and uncertainty of the effects beetles have on fire behavior. The Piquett Creek project is not currently experiencing a mountain pine beetle outbreak and lodgepole pine only comprises 4% of the vegetation cover type across the project area. For these reasons the findings of this research are not applicable to the Piquett Creek project.

Fire Ecology & Fire Regimes

Baker WL (2017) Restoring and managing low-severity fire in dry-forest landscapes of the western USA. PLoS ONE 12(2): e0172288. https://doi.org/10.1371/journal.pone.0172288. *Frequent low severity fire rates have been overestimated in dry forests, meaning that understory shrubs and small trees could fully recover between low severity fires. Therefore, less restoration treatment (thinning) is needed before reintroduction of fire.*

Summary: Baker and Hanson (2017) examined early timber inventories of large forest landscapes in the Central and Southern Sierra Nevada in California and the eastern slopes and foothills of the Cascade Range in Oregon to look at historical conditions and processes.

Response: In a review of that work, (Hagmann, 2018) concluded that numerous errors of fact and interpretation limit the usefulness of this Baker and Hanson contribution to a better understanding of historical forest conditions and the processes that structured them. Furthermore, previous publications have also documented errors in methodology or misrepresentation of the work of others in papers published by Baker and/or Hanson (for details, see Brown et al. 2008, Safford et al. 2008, Spies et al. 2010, Fule et al. 2014, Safford et al. 2015, Collins et al. 2016, Stevens et al. 2016, Hagmann et al. 2017, Levine et al. 2017, Miller and Safford 2017, O'Connor et al. 2017).

Baker, W.L., and Ehle, D., 2001, Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States: Canadian Journal of Forest Research. V. 31, p. 1205–1226. DOI: 10.1139/cjfr-31-7-1205. *Examines the biases in fire scar studies and finds that average fire return interval is much longer than previously thought.*

Response: Baker and Ehle 2001 acknowledge that surface fires were clearly an important process in these forests, and there is also ample evidence that fires have been excluded. They also state that exclusion of surface fires undoubtedly has altered forest structure since surface fires readily kill young trees. (Baker & Ehle, 2001)

Baker, W.L., T.T. Veblen, and Sherriff, R.L. 2007. Fire, fuels and restoration of ponderosa pine Douglas-fir forests in the Rocky Mountains, USA. Journal of Biogeography, 34: 251-269. *"Exclusion of fire has not clearly and uniformly increased fuels or shifted the fire type from low- to high-severity fires. However, logging and livestock grazing have increased tree densities and risk of high-severity fires in some areas. Restoration is likely to be most effective which seeks to (1) restore variability of fire, (2)*

reverse changes brought about by livestock grazing and logging, 3) ensure that degradation is not repeated."

Response: Baker et al. 2007 examines fire return intervals in in dry ponderosa pine and Douglas-fir ecosystems and the effects of fire exclusion to these systems. The paper acknowledges there is still a need for restoration in these ecosystems and depending on the current condition of the areas prescribed for treatment, options could include a more passive, prescribed fire only option or active options, such as thinning and re-introduction of fire. This is consistent with our approach for treatment implementation in the Piquett Creek project.

DellaSala, D.A.; Hanson, C.T. Are Wildland Fires Increasing Large Patches of Complex Early Seral Forest Habitat?* Diversity *2019,* 11*, 157.

Summary: DellaSala et al. 2019 used GIS databases for vegetation and fire severity to investigate trends in large complex early seral forest (CESF) patches in frequent-fire forests of the western USA for time periods between 1984-2015. They found no significant trend in the size of large CESF patches although there was a significant trend in the combined total area of CESF patches in each year. The authors point out that areas of CESF play an important role in providing a unique ecological community. The findings also highlight that large CESF patches are extremely infrequent at landscape scales in ponderosa pine and mixed-conifer forests of the western US. The authors recommend that land managers focus limited resources on community fire safety and creating defensible space for homes as a means for coexistence with wildfire. They also recommend managing wildfire under safe conditions to achieve a myriad of ecosystem benefits.

Response: We acknowledge the importance of landscape diversity and the benefits patches of CESF have on the landscape both ecologically and by providing habitat for certain species. We don't propose to remove CESF patches from the landscape or to conduct post fire salvage. As the findings suggest, large patches of CESF were not common in ponderosa pine or mixed conifer forests which comprise 93% of the forest type in the project area. Project activities are designed to reduce fire behavior and crown fire activity, but this will not occur on every acre in the project area. Untreated areas that experience fire in the future or some areas treated with prescribed fire are likely to result in the creation of patches CESF that will provide those benefits to the project area. Additionally, areas adjacent to the Piquett Creek project experienced mixed and high severity wildfire in 2000 and 2007 that created various size patches of CESF that add to overall diversity of the entire landscape.

As recommended by this paper, proposed fuels reduction activities are focused adjacent to homes within the WUI that will increase community resilience to wildfire. Achieving the desired post treatment conditions will help improve opportunities for suppression and provide for public safety. Additionally, a desired outcome of implementing activities proposed by this project is to increase the ability to utilize fire (wildfire or prescribed) on the landscape to maintain natural processes and landscape diversity. Improving the vegetation and fuel conditions within low severity fire regimes and reducing potential fire behavior within the WUI will reduce the potential risk for negative effects from wildfires on onsite and adjacent values. This will increase the decision space and management opportunities for future wildfires in the area.

Dellasala, D.A., Ingalsbee, T., and Hanson C.T, Everything you wanted to know about wildland fires in forests but were afraid to ask: Lessons learned, ways forward:

https://forestlegacies.org/images/projects/wildfire-report-2018.pdf *Comprehensive summary of historical wildfire compared to modern conditions, ecological benefits of wildfire, best practices for home protection.*

Summary: This paper addresses a number of issues and its key findings conclude that large wildfires lead to higher levels of biodiversity, today's wildfires are driven by climate change, human-caused ignitions, and forest type conversion, post-fire logging is damaging to forests and aquatic ecosystems, thinning small trees and prescribed burning can lower fire intensity (but is nuanced), and a number of new strategies are needed to address the WUI.

Response: The Piquett Creek project was designed with several goals, none of which include post-fire logging or forest type conversion. Human caused ignitions of wildfires are very low on National Forest and private lands within the West Fork Ranger District with 94% of fires originating from lightning. Treatments are planned to improve resilience to insects, disease and fire while considering changing conditions from climate. Changes to WUI regulations or fire suppression policies are outside of the scope of this project. However, a desired outcome of implementing activities proposed by this project is to increase the ability to utilize fire (wildfire or prescribed) on the landscape to maintain natural processes and landscape diversity.

Hanson, C.T, Sherriff, R.L., Hutto, R.L., DellaSala, D.A., Veblen, T.T and Baker, W.L. 2015 The Ecological Importance of Mixed-Severity Fires: Nature's Phoenix. Elsevier Inc.

Summary: This book that looks at the ecological importance of mixed-severity fire on the landscape. They conclude that historical structure and fire regimes in mixed conifer and ponderosa pine forests of western North America were far more variable than current management regimes assume, and mixed – and high severity fires are a natural and ecologically beneficial part of many forests. They recommend a shift in policies that would allow more mixed-high severity fire in the wildlands away from homes, while focusing on fuel reduction and fire suppression activities adjacent to homes to provide for public safety.

Response: Changes in fire policy nationally or at the forest level are outside of the scope of this project, however, current policy is not necessarily limiting the ability to have mixed severity fire on the landscape where appropriate. The current vegetation and fuel conditions within low severity fire regimes, continuity of fuels adjacent to values that limit fire management opportunities and the risk of negative effects to values are the primary limiting factors. We recognize that mixed and stand replacing fire is a natural disturbance process in some forest types found in the Piquett Creek project and on the Bitterroot NF. We desire to have mixed severity fire as part of those systems where appropriate when negative impacts to other onsite and adjacent values can be mitigated.

Mixed and stand replacing fire was historically typical in areas identified as Fire Regimes III-V. These regimes only comprise 10% of the project area. Ponderosa pine and dry Douglas-fir comprise 93% of the forest vegetation within the Piquett Creek project. Local research efforts suggest that historically, fires in these forest types would have burned frequently and generally at low to moderate intensities. Variability in fire intensities likely depended on fuel continuity and weather conditions which resulted in mosaic burn patterns and landscape diversity. A comprehensive literature review conducted by the Fire Effects Information System (FEIS) of wildland fire interactions with ponderosa pine communities within the Northern Rockies shows that low to moderate surface fire typically burned every 6-13 years. (Fryer, 2016). These findings are similar to the site specific results Arno found on the Bitterroot NF (Arno, 1976,

1983) as well as others (Barrett et al. 1997; Arno et al. 1995; Agee 1993; Fischer and Bradley 1987; Arno and Gruell 1986; Habeck 1976; Habeck and Mutch 1973; and Leiberg, 1899).

As recommended by this book, proposed fuels reduction activities are focused adjacent to home within the WUI. Achieving the desired post treatment conditions will help improve opportunities for suppression and provide for public safety. Additionally, a desired outcome of implementing activities proposed by this project is to increase the ability to utilize fire (wildfire or prescribed) on the landscape to maintain natural processes and landscape diversity. Improving the vegetation and fuel conditions within low severity fire regimes and reducing potential fire behavior within the WUI will reduce the potential risk for negative effects from wildfires on onsite and adjacent values. This will increase the decision space and management opportunities for future wildfires in the area.

Hessburg, P.F., et al., 2015, Restoring fire-prone Inland Pacific landscapes: seven core principles: Landscape Ecology, v. 30, p, 1805–1835. DOI 10.1007/s10980-015-0218-0

Summary: This paper finds that historical forests were spatially heterogeneous at multiple scales. Heterogeneity was the result of variability and interactions among native ecological patterns and processes, including successional and disturbance processes regulated by climatic and topographic drivers. They recommend attention on landscape-level prescriptions as foundational to restoration planning and execution and recommend that landscape prescriptions are needed at three levels; Large-scale, Local landscape and patch-level.

Response: The Piquett Creek project would be considered the local landscape level which recommends identifying treatments to restore ecoregional patterns and processes for multiple resources. Local landscape prescriptions provide guidance about how to arrange different successional patches across the topographic template, the target patch size distributions and how to protect and increase the abundance of legacy trees. Articulating how silvicultural treatments, prescribed fire and wildfire can work together to restore disturbance regimes will be necessary for a successful local landscape prescription. Local prescriptions should also look at terrestrial and aquatic habitat and road system restoration opportunities.

The Piquett Creek project is following the recommendations of this publication. Historical disturbance regimes, species composition, patch and pattern are all being used to identify the desired landscape conditions in which specific treatment activities will be identified and implemented. Additionally, the BMP work identified is specifically intended to address current aquatic habitat impacts and road system upgrades.

Odion D.C., Hanson C.T., Arsenault A., Baker W.L., DellaSala D.A., Hutto R.L., Klenner W., Moritz M.A., Sherriff R.L., Veblen T.T., Williams M.A. 2014. Examining historical and current mixed-severity fire regimes in ponderosa pine and mixed-conifer forests of western North America. PLoS ONE 9: e87852.
"Our findings suggest that ecological management goals that incorporate successional diversity created by fire may support characteristic biodiversity, whereas current attempts to ''restore'' forests to open, low-severity fire conditions may not align with historical reference conditions in most ponderosa pine and mixed-conifer forests of western North America."

Summary: This paper uses Forest Inventory Analysis (FIA) plots across the western United States to compiled landscape-scale evidence of historical fire severity patterns in the ponderosa pine and mixed-

conifer forests. Consensus from this evidence is that the traditional reference conditions of low-severity fire regimes are inaccurate for most forests of western North America. This paper recommends a variety of management practices to restore resilience to stands and landscapes including providing for open stands, age class diversity, and retention of fire-tolerant trees through a variety of mechanical and prescribed burning treatments.

Response: Both Collins et al. 2016 and Stevens et al. 2016 identified concerns over the approaches used in this paper and the findings that low severity fire regimes classifications are inaccurate for most forests of the western United States. These concerns by the science community and the availability of site specific data about fire regimes in the Northern Rockies raises uncertainty about the findings of this paper and its applicability to this project. A comprehensive literature review conducted by the Fire Effects Information System (FEIS) of wildland fire interactions with ponderosa pine communities within the Northern Rockies shows that low to moderate surface fire typically burned every 6-13 years. (Fryer, 2016). These findings are similar to the site specific results Arno found on the Bitterroot NF (Arno, 1976, 1983) as well as others (Barrett et al. 1997; Arno et al. 1995; Agee 1993; Fischer and Bradley 1987; Arno and Gruell 1986; Habeck 1976; Habeck and Mutch 1973; and Leiberg, 1899). We recognize that mixed and stand replacing fire is a natural disturbance process in some forest types found in the Piquett Creek project and on the Bitterroot NF. We desire to have fire as part of those systems where appropriate when negative impacts to other onsite and adjacent values can be mitigated. Mixed and stand replacing fire was historically typical in areas identified as Fire Regimes III-V which only comprise 10% of the project area.

Project-wide conditions in the Piquett Creek project area will allow for a range of successional diversity following implementation. Treatments are not intended to convert every square inch of the project area to an open forest. The proposed vegetation management activities will treat approximately 52 percent of the area, helping create a landscape with a diversity of stand conditions in various successional stages.

Swetnam, T.W., and Baisan, C.H., 1996, Historical Fire Regime Patterns in the Southwestern United States Since AD 1700, in CD Allen (ed), Fire Effects in Southwestern Forest: Proceedings of the 2nd La Mesa Fire Symposium, p. 11-32: USDA Forest Service, Rocky Mountain Research Station, General Technical Report RM-GTR-286. *Elevation and forest type were often weak determinants of fire frequency. Some of the variations in fire interval distributions between similar elevation or forest types were probably due to unique site characteristics, such as landscape connectivity (Le., ability of fires to spread into the sites), and land-use history. Differences in the sizes of sampled areas and fire-scar collections among the sites also limit ability to compare and interpret fire interval summary statistics.*

Summary: This paper is a review of some of the facts that have been learned from intensive fire history studies in Southwestern ponderosa pine and mixed conifer forests. The goal of this review and summary to document and understand the natural range of variability of fire regimes across multiple temporal and spatial scales, and to use this knowledge to guide and support ecosystem management programs. They conclude that pre-1900 fire regimes of the Southwestern U.S. varied greatly in time and space. Some patterns of fire regime variation were evident across gradients of elevation and forest type, such as a decrease in frequency from low to high elevations and from drier ponderosa pine to wetter mixed-conifer forests. However, they also conclude additional fire history reconstructions are needed in low elevation woodlands and high elevation mixed conifer to evaluate intersite variations as well as

historical fire spread patterns and relative fire extent across the landscape. It is expected that as additional information and understanding is gained that other landscape attributes (e.g., slope, aspect, landscape connectivity, etc.) will have greater or lesser importance in different instances. Finally, they conclude that climatic variations, specifically drought fluctuations, were important in determining temporal and spatial patterns of fire occurrence across time scales of years to centuries and spatial scales from forest stands to the region.

Response: The information provided in this paper is site specific to the southwestern United States. We agree with the conclusions that drought fluctuations likely played a role in fine fuel accumulations and determining the extent to which fire spread across the landscape. We also agree with the suggestion that fuel/landscape connectivity and topographic variables can affect the frequency and ability in which fire spreads across the landscape. The conclusion that fire frequency generally decreases with elevation is similar to our understanding of fire regimes on the Bitterroot and what was found by Arno's research (Arno, 1976, 1983) as well as others (Barrett et al. 1997; Arno et al. 1995; Agee 1993; Fischer and Bradley 1987; Arno and Gruell 1986; Habeck 1976; Habeck and Mutch 1973; and Leiberg, 1899).

Swetnam, T.W., Allen, C.D., and Betancourt, J.L., 1999, Applied historical ecology: Using the past to manage for the future: Ecological Application is, v. 9(4), p. 1189-1206. *Found that weather has been more important than fuels in driving fires in southwestern forests.*

Response: This paper discusses how historical ecology can be used to help guide the management of ecosystems. That using historical perspectives can increase the understanding of the dynamic nature of landscapes and provide a frame of reference for assessing modern patterns and processes. The research is focused on the southwestern United States but the methods they describe can be applied to other areas. They provide examples of using historical maps, repeat aerial photos and fire scar data to provide historical information and context to landscape changes and inform management decisions. The use of historical aerial photos and fire scar data collected in the 1970's by Arno are already being used to help inform existing and desired conditions within the Piquett Creek project.

The research mentions that based on findings in the fire scar data, increased regional burning in the southwest corresponded with previous El Nino events that produced increased fine fuel growth due to abundant moisture availability and cooler conditions. These cool wet periods were then followed by La Nina events that created moisture deficits and extreme burning conditions with an abundance of fine fuels that supported large fire growth. They suggest that the inverse may apply to the Northern Rockies and that large fire years correspond with El Nino that have been proceeded by La Nina moisture and increased vegetation growth. There has been a correlation with this pattern in the past although above normal summer temperatures and lack of moisture are major influences on large fire years in the Northern Rockies. These factors have occurred outside of El Nino years.

Williams, M.A., W.L. Baker. 2012b. Comparison of the higher-severity fire regime in historical (A.D. 1800s) and modern (A.D. 1984-2009) montane forests across 624,156 ha of the Colorado Front Range. Ecosystems 15: 832-847. *Recent high severity fires in Ponderosa-Doug Fir forests in Colorado are not outside historical (1800s) averages.*

Response: This paper uses General Land Office records from Arizona, Colorado and Oregon to reconstruct dry western US Forests of the late 19th century to infer past fire regimes had substantial moderate and high severity burning. Multiple publications have documented errors in methodology or

misrepresentation of the work of others in papers published by Baker and/or Hanson (for details, see Brown et al. 2008, Safford et al. 2008, Spies et al. 2010, Fule et al. 2014, Safford et al. 2015, Collins et al. 2016, Stevens et al. 2016, Hagmann et al. 2017, Levine et al. 2017, Miller and Safford 2017, O'Connor et al. 2017).

Zald, S.J., and Dunn, C.J., 2018, Severe fire weather and intensive forest management increase fire severity in a multi-ownership landscape: Ecological Applications, v. 28 (4), p. 1068–1080. *Found that "daily fire weather was the most important predictor of fire severity, followed by stand age and ownership, followed by topographic features. Estimates of pre-fire forest biomass were not an important predictor of fire severity". Demonstrated that managed forests burn more severely and that fuels are not an important factor.*

Response: This research looked at different forest management practices and their influence on fire severity during the 2013 Douglas Complex in southwestern Oregon. They chose the location based on the checkerboard of ownership which consisted of federal and private timberlands and the prevalence of previous intensive management. Findings suggest that the large areas of continuous, high biomass plantations on industrial timberlands burned at higher severity than areas of public land that were dominated by more variable, older forests. They recommend looking for alternative management strategies in these plantations to increase age, size and spatial heterogeneity to reduce fire severity. Zald and Dunn's conclusions are specific to intensively-managed industrial timberland plantations in the Pacific Northwest, these conditions do not represent those found within the project area. We support promoting treatments in plantations that are designed to promote fire tolerant species, retain the largest healthy trees, reduce stand densities, increase canopy base heights, diversify stand structure and promote landscape diversity.

Silviculture

Bailey, J.K., Deckert, R., Scheitzer, J.A., Rehill, B.J., Lindroth, R.L., Gehring, C., and Whitham, T.G., 2005, Host plant genetics affect hidden ecological players: links among Populus, condensed tannins, and fungal endophyte infection: Canadian Journal of Botany, v. 83, p. 356–361 (2005) doi: 10.1139/B05-008. *Genetic differences in Cottonwoods that cannot be visually determined have profound effects on the forest ecosystem.*

Response: Bailey et al. 2005 is specific to cottonwood trees, which are found in limited quantities within the project area. Cottonwood trees are not being treated by proposed activities.

Carswell, C., 2016, Genetic research lays foundation for bold conservation strategies: High Country News, June 8, 2016. *Pinyon pines susceptible to moths turn out to be the most drought resistant and survive over healthy appearing ones.*

Response: Carswell 2016 is specific to Pinyon pines, a species not found within the Northern Rockies or Piquett Creek project area.

Hadfield, J.S., Mathiason, R.L., and Hawksworth, F.G., 2000, Douglas-fir Dwarf Mistletoe: Forest Insect and Disease Leaflet 54, USDA-FS, 10 p. *Your own USFS pamphlet states "it is a pest only where it*

interferes with management objectives, such as timber production". In other areas, it is important for wildlife habitat. It also states that spread rates are faster in open stands than dense stands.

Response: The objective of this project is not to entirely remove Douglas-fir dwarf mistletoe at the landscape scale. The Piquett Creek project proposes management activities to help manage mistletoe in the project area, however, the project does not intend to fully eradicate mistletoe from the project area. Treatments are intended to reduce mistletoe spread in selected units to improve growth and vigor of residual trees as well as reduce the potential for passive crown fire caused by flammable brooms. Many acres of the project area contain mistletoe that will remain untreated and will continue to provide benefits to wildlife.

Hoffman, J.T., 2004, Management of Dwarf Mistletoe, 2004, USDA-FS https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187427.pdf *Gives strategies for management when commercial timber production is the goal.*

Response: Hoffman 2004 include regeneration operations, pre-commercial thinning, commercial thinning, chemical control and prescribed fire. Except for chemical control, all other strategies are proposed for the Piquett Creek project. The Piquett Creek project proposes management activities to help manage mistletoe in the project area, however, the project does not intend to fully eradicate mistletoe from the project area. Treatments are intended to reduce mistletoe spread in selected units to improve growth and vigor of residual trees as well as reduce the potential for passive crown fire caused by flammable brooms. Many acres of the project area contain mistletoe that will remain untreated and will continue to provide benefits to wildlife.

Keim, B., 2019, Western forests could adapt to pine beetles, but people won't let them: Anthropocene Magazine online, www.anthropocenemagazine.org/2018/10/pine-beetle-resilience/

Response: This is a magazine article summarizing a study located on the Beaverhead National Forest that was conducted by Diana Six, a forest entomologist from the University of Montana. The study examined the genetic signatures of surviving lodgepole and whitebark pine following recent high mortality mountain pine beetle outbreaks. Refer to Six et al. 2018 for more detailed information.

Lodgepole pine only comprises 4% of the vegetation cover type across the project area. Some of these areas experienced mortality during previous mountain pine beetle outbreaks. Individual trees selected to be retained will be selected on various criteria based on the best available science for resilience, site specific conditions and desired conditions. The findings of this research will be considered during prescription development in areas that contain surviving lodgepole pine.

McNulty, S.G., Boggs, J.L. Sun, Ge. 2014. The rise of the mediocre forest: why chronically stressed trees may better survive extreme episodic climate variability. New Forests (2014) 45:403-415. *Finds that the healthy looking trees are not the ones that best survive climate change due to slower growth and higher root to foliage ratios. You cannot select for adaptive trees; only nature can do that.*

Summary: This paper hypothesizes that as the duration, severity and interaction of stress becomes more pronounced under increasing climate variability, seemingly less healthy, chronically stressed trees could begin to survive environmental stress better than their traditionally considered healthy, non-chronically

stressed tree counterparts. They further hypothesize that this shift in survivorship will be attributed to tree response to increasingly extreme climate variability at levels not previously observed in recorded history. Information from two case studies was used to support this hypothesizes. The first focused on red spruce in New England, a species that was historically in decline and is now growing at record rates. As stated in the publication, "Perhaps the previous decades of tree mortality may have increased current resources availability and were at least partially responsible for the current growth increases across the region". The second focused on tree species and plantation forestry in the southeastern United States were tree species are far less accustomed to resource limitations as those found in the arid west. They acknowledge that forest management may be useful in reducing ecosystem stress while maintaining high quality forests. They also recommend that forest managers may want to reduce the demand on the water resources base by maintaining forest stocking level below what would be considered optimal for timber production through heavier, more frequent thinning.

Response: The findings of this paper are hypothetical, and recommendations are primarily focused on minimizing impacts to timber production plantations. There is no clear cause and effect to this study. Adaptive management will continue to be important. Implementing the proposed vegetation management activities will reduce competitive stress, increase water availability and maintain high quality forests as the authors recommend. Individual trees selected to be retained in the project area will be selected on various criteria based on the best available science for resilience, site specific conditions and desired conditions.

Six, D.L., Vergobbi, C. and Cutter, M., 2018, Are survivors different? Genetic-based selection of trees by mountain pine beetle during a climate-change-driven outbreak in a high-elevation pine forest: Plant Science, Plant Sci., 23 July 2018 \| https://doi.org/10.3389/fpls.2018.00993 *Genetic differences that cannot be determined visually determine the variable susceptibility to bark beetles in lodgepole pine.*

Response: Six et al. 2018 documents a study conducted on the Beaverhead National Forest that examined the genetic signatures of surviving lodgepole and whitebark pine following high levels of mortality during a recent mountain pine beetle outbreak. Results indicate that during outbreaks, beetle choice may result in strong selection for trees with greater resistance to attack. Findings suggest that survivorship is genetically based and, thus, heritable. If these trees are genetically different than those selected and killed by the beetles as our study suggests, these trees may aid in in-situ adaptation and persistence. They recommend that retaining surviving trees as a primary seed source, rather than removing them during salvage operations could support in-situ adaptation.

Lodgepole pine only comprises 4% of the vegetation cover type across the project area. Some of these areas experienced mortality during previous mountain pine beetle outbreaks. Individual trees selected to be retained will be selected on various criteria based on the best available science for resilience, site specific conditions and desired conditions. The findings of this research will be considered during prescription development in areas that contain surviving lodgepole pine.

Six, D.L., Biber, E., and Long, E., 2014, Management for Mountain Pine Beetle Outbreak Suppression: Does Relevant Science Support Current Policy? Forests, v. 5, p. 103-133, doi:10.3390/f5010103. *Thinning results in less live trees afterwards than just letting MPB go their course. You may actually be selecting the wrong (genetically less resistant) trees by thinning.*

Response: Six et al. 2014 address interest in forest management conducted by the USFS in response to bark beetle infestations occurring at that time. The paper raised questions regarding treatment efficacy of projects implemented for direct and indirect control of Mountain Pine Beetle (MPB). The points in the article argue against indiscriminate applications of direct and indirect MPB control treatments to halt severe and widespread MPB infestations. Points were also raised about the extensive application and efficacy of direct and indirect control treatments. While the issues discussed in the paper are appropriate, some of the conclusions are not applicable to conventional management strategies implemented by the USFS. This is primarily because USFS treatments are not implemented to stop ongoing MPB infestations that are sever and widespread. Rather, USFS indirect control treatments are implemented prior to severe infestations to enhance tree survival and resilience to multiple disturbances. USFS direct control treatments are implemented as only one component of an integrated pest management strategy to provide short-term protection for high value trees.

The Piquett Creek project is applying indirect control treatments designed to enhance tree survival to meet integrated resource objectives and promote forest resilience to multiple disturbances. A patchwork of treatments is chosen to increase heterogeneity and reducing continuous host conditions. Treatments are designed to reduce stand density and promote age-class, structure, and species diversity to reduce conditions susceptible to MPB infestations.

Sthultz, C.M., Gehring, C.A., and Whitam, Deadly combination of genes and drought: increased mortality of herbivore-resistant trees in a foundation species: Global Change Biology, v. 15, 1949–1961, doi: 10.1111/j.1365-2486.2009.01901.x *The least vigorous pinyon pines, with their growth slowed by moth caterpillars, had much greater survival rates during drought than the healthy-appearing trees.*

Response: Sthultz et al. 2009 is specific to Pinyon pines, a species not found within the Northern Rockies or Piquett Creek project area.

Watson, D., Herring, M., (2012). Mistletoe as a keystone resource: An experimental test. Proceedings. Biological sciences / The Royal Society. 279. 3853-60. 10.1098/rspb.2012.0856. *Mistletoe is an important part of the forest ecosystem, providing many benefits that are not entirely known yet.*

Summary: This paper presents findings from a study in southeastern New South Wales, Australia that looked at the impacts to species richness of birds following the removal of mistletoe. The found that 3 years after treatments completely removed mistletoe total species richness of birds and woodland-dependent residents was reduced. The vegetation in the study was classified as Dry Foothill Forest or Grassy Box Woodland, neither of which are similar to the vegetation found within this project area.

Response: Fire suppression and some past management practices (high grading and selective cutting) have increased the abundance and distribution of dwarf mistletoe. In addition to impacts on tree vigor, Dwarf mistletoe infestations can increase wildfire risk, especially in Douglas-fir, when large brooms filled with small twigs and dead needles in the lower portions (PF-SILV-001). The Piquett Creek project proposes management activities to help manage mistletoe in the project area, however, the project does not intend to fully eradicate mistletoe from the project area. Treatments are intended to reduce mistletoe spread in selected units to improve growth and vigor of residual trees as well as reduce the

potential for passive crown fire caused by flammable brooms. Many acres of the project area contain mistletoe that will remain untreated and will continue to provide benefits to wildlife.

Wildlife

Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041–1058.

Summary: Hutto (1995) surveyed recently burned areas in western Montana and northern Wyoming and determined that 15 bird species are generally more abundant in early post-fire communities than in any other major cover type occurring in the northern Rockies. He also stated that one species, the black-backed woodpecker, seems nearly restricted in its habitat distribution to standing dead forests created by stand-replacement fires. Hutto recommends that public land managers "leave an adequate amount of standing, dead trees after a fire because of the species that depend on that forest element."

Response: The Piquett Creek project is not a post-fire salvage logging project and does not proposed to cut burned, dead trees. No suitable habitat for black-backed woodpeckers is currently present within the project area. (PF-WILD-001) Some habitat may be created from tree mortality caused during prescribed fire implementation.

Irwin, L.L, Riggs, R.A., Verschuyl, J.P. 2018. Reconciling wildlife conservation to forest restoration in moist mixed-conifer forests of the inland northwest: A synthesis. Forest Ecology and Management 424 (2018) 288-311.

Summary: Irwin et al. 2018 is a synthesis paper that evaluates recent research on a number of different avian and mammalian species and impacts of silvicultural practices in moist, mixed conifer (MMC) forest of the inland northwest including western Montana. The authors contend that most of the species reviewed are likely to respond positively to restoration, and that a wide array of extant silvicultural methods can be used, provided that large snags and acceptable levels of coarse woody debris are recruited or retained. Irwin et al. also suggests that thinning followed by routine prescribed burning will be problematic for some wildlife species; and that knowledge of wildlife responses to variation in the size distribution of disturbance patches is limited, as is knowledge of wildlife population responses to intentional forestry. General conclusions from this paper are that wildlife biologists and silviculturists need to be attuned to the resource concerns and needs of a variety of wildlife species. In addition, restoration or forest practices in MMC forests for climate change adaptations should focus for wildlife on restoring backbone structures and large, old, early- to mid-seral, shade-intolerant tree (LOEST) species, and to intensity stocking control across larger landscapes and temporal scales.

Response: Some of this literature is pertinent and applicable to the Piquett project, some is not. The species reviewed for potential effects from silvicultural practice are based on state's "strategy" species, which in most cases closely align with Forest Service Sensitive Species, but some do not. Forest Plan standards and design features included in the project with respect to old growth standards and coarse woody debris standards are specifically designed with a multitude of wildlife species in mind. The project wildlife biologist and silviculturist work together to ensure that certain applicable standards are met and take wildlife into consideration. In addition, large snags, snag densities, and wildlife trees are retained to meet standards. The Piquett project is designed to create and contribute to a landscape

mosaic that is present over a landscape scale from both natural and man-made disturbance. The project area is near the Rombo Fire from 2007, there are tree terraces remnant from forestry practices of decades ago, and patches of insect and diseased trees exist across the landscape. All of these factors combined with the project design features and larger landscape context contribute to a number of different habitat types, opening, structural stages, and important wildlife features that adequately capture the pertinent points in this research.

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