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Effectiveness of Direct and Indirect Mountain Pine Beetle Control Treatments as Implemented by the USDA Forest Service

White Paper

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Executive Summary

An article recently published by Six et al. (2014) in the journal *Forests* has raised public interest in forest management conducted by the USDA Forest Service (USFS) in response to recent bark beetle infestations. This *Forests* article raised questions regarding treatment efficacy of projects implemented for the direct and indirect control of mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB) infestations. USFS personnel have received comments from various groups inquiring about the widespread implementation and efficacy of these treatments.

This white paper is written for an internal USFS audience to provide science-based justification for management implemented to reduce negative impacts caused by MPBs. To facilitate a USFS response, it is necessary to differentiate between levels of mortality, or severity, of a given MPB infestation and define other terms provided in Appendix A.

Overall, the intent of the *Forests* article was to dispel misconceptions within the public policy arena that may have contributed to recent federal legislation. The points presented 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 within the *Forests* article 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 severe 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 (IPM) strategy to provide short-term protection for high-value trees.

Best-available science and the project monitoring by USFS professionals indicate direct and indirect control treatments can reduce future MPB-caused tree mortality, and augment other resource benefits, when they are applied properly at appropriate spatial scales.

USFS Response to Recent Mountain Pine Beetle Infestations

- The primary USFS management response to recent, severe MPB infestations has been to mitigate public safety issues resulting from beetle-caused tree mortality
- Specific areas have resource objectives that may call for treatments to minimize MPB-caused tree mortality and promote tree survival

The *Forests* article reported that hundreds of millions of dollars have been spent on widespread direct control activities to suppress severe MPB infestations by the U.S. and Canadian governments. While landscape-scale direct control treatments have been implemented in Canada, this is not the management strategy deployed within the U.S. and only limited funding has been spent on direct control to reduce MPB populations. For example, of the average $6.6 million per year spent for fiscal years (FY) 2009-2013 for MPB projects through the Forest Health Protection (FHP) program, only 10% was used for direct control treatments to reduce MPB populations (Forest Health Accomplishments Database).

The USFS response to recent bark beetle activity within the western U.S., including MPB infestations, is outlined within the Western Bark Beetle Strategy (WBBS) (USFS 2011). This strategy does not include directives to stop severe and widespread MPB infestations with direct control. Rather, USFS priorities are to provide for public safety, restore ecological function, and increase resilience to multiple disturbances. Public safety is the foremost priority and much of the funding, such as 86% of the $99.1 million identified within the FY11 USFS Program Direction for the WBBS, was directed to fell and/or remove beetle-killed trees within high-use administrative sites, campgrounds, and travel corridors (USFS 2011).

The extensive efforts spent to address public safety issues illustrate how MPB-caused tree mortality can conflict with short and long-term resource objectives. Objectives that often call for minimizing levels of tree mortality, or provide for those resource benefits that depend on tree survival, include maintaining fish and wildlife habitat, watershed function, recreational opportunities, aesthetics, timber values, and fuel complexes at acceptable levels. MPB direct and indirect control treatments are implemented where limiting tree mortality is required to achieve resource objectives.

Direct Control: Beetle Suppression

- Direct control suppression treatments are designed to caused short-term reductions in MPB populations to enhance high-value tree survival within a project area
- Direct control treatments are implemented at limited spatial scales as part of an IPM strategy to protect high-value areas
- Efficacy of direct control depends on resource objectives and the ability to detect and treat sufficient numbers of MPB-infested trees within a treatment area

The definition of direct control varies and within this paper is limited to activities that suppress MPB populations by killing or removing them from a treatment area (Carroll et al. 2006). Examples of direct control include the sanitation removal of infested trees and treatments that cause MPB mortality such as debarking, chipping, or burning infested trees (Samman and Logan 2000; Nelson et al. 2006).

The main objective for MPB direct control treatments implemented by the USFS is to reduce MPB populations and subsequent tree mortality within a project area to meet integrated resource objectives. Direct control is typically implemented at small spatial scales that are limited to high-value areas. Treatments are conducted within an overall IPM strategy that often aims to slow the buildup of MPB populations until other management (e.g. vegetation, pheromone, and/or insecticide treatments) can be implemented (McGregor and Cole 1985; Samman and Logan 2000; Fettig et al. 2014).

Direct control treatments intended to stop severe MPB infestations at a landscape-level are not likely to succeed. This is because the capacity to successfully detect and treat enough infested trees can be problematic, beetles can migrate from nearby infested areas, and treatments do not alter vegetative conditions susceptible to subsequent MPB infestations (Trzcinski and Reid 2008; Fettig et al. 2014). Four studies recently evaluated the effectiveness of direct control treatments during severe MPB infestations in British Columbia and Alberta, Canada (Nelson et al. 2006; Trzcinski and Reid 2008; Wulder et al. 2009; Coggins et al. 2011). These studies indicate treatments will not stop a severe MPB infestation but can reduce year-to-year tree mortality and slow the rate of MPB-caused mortality within a treatment area.

Best-available science and project monitoring by USFS professionals indicate direct control treatments, as implemented by the USFS, can effectively cause short-term reductions in tree mortality when properly applied. However, additional indirect control treatments may be required to increase stand resiliency to MPBs so that long-term, integrated resource objectives can be achieved.

Indirect Control: Vegetation Treatments

- Indirect control treatments are often designed to enhance tree survival to meet integrated resource objectives and promote forest resilience to multiple disturbances
- Thinning and regeneration treatments that are designed to reduce stand density and promote age-class, structure, and species diversity can reduce conditions susceptible to MPB infestations

- Efficacy of indirect control depends on resource objectives, treatment prescriptions, and the spatial scale of implementation

Forest composition, age and size-class structure, and periods of favorable weather are the primary factors influencing host susceptibility and the severity of a MPB infestation (Taylor et al. 2006). Indirect control treatments are designed to enhance stand resilience to multiple disturbances (e.g. insects, diseases, wildfire, drought, and others). These treatments are considered beneficial under a dynamic and changing climate as they enhance diversity (Gillette et al. 2014) (Appendix B: Photo 1). Thinning, or partial cutting, reduces stand density to reallocate growing space, increase residual tree vigor, and change microclimate within treated areas (Oliver and Larson 1996; Helms 1998; Amman and Logan 1998). Regeneration treatments (e.g. clearcutting, seed/shelterwood cutting, and wildland/prescribed fire) can be used to promote a mosaic of forest ages and structure across a landscape to reduce host tree susceptibility and the impact of MPB infestations (Whitehead and Russo 2005; Taylor et al. 2006; Fettig et al. 2014).

The most common indirect control treatment implemented by the USFS is thinning. Best-available science indicates thinning can reduce MPB-caused tree mortality, and promote residual tree survival, within ponderosa pine and lodgepole pine forests. Further details can be found in the comprehensive reviews presented in Fettig et al. (2007 and 2014).

Thinning treatments do not ensure all residual trees within a treated area will survive a severe MPB infestation. Treatments that are small in spatial extent and adjacent to, or within, landscapes composed of continuous, susceptible pine forests may experience high levels of tree mortality during a severe MPB infestation. However, long-term studies indicate thinning can reduce MPB-caused tree mortality when treatments exceed 10 acres in spatial extent (Schmid and Mata 2005; Whitehead and Russo 2005; Whitehead et al. 2007). Authors of these studies conclude thinning benefits are greatest when implemented as part of a comprehensive, landscape-scale management strategy. Project monitoring by USFS professionals also indicates thinning treatments can be effective at reducing MPB-caused tree mortality when implemented properly at appropriate spatial scales (Appendix B: Photos #2-4).

Ponderosa pine forests

Thinning can significantly reduce MPB-caused tree mortality, and provide for other resource benefits (e.g. fuels, watershed function, etc.), in ponderosa pine forests exposed to various MPB infestation levels when appropriate residual stocking or inter-tree spacings are achieved (Hall and Davies 1968; Sartwell and Dolph 1976; McCambridge and Stevens 1982; Cole and McGregor, 1988; Fiddler et al. 1989; Cochran and Barrett 1993; Cochran and Barrett 1998; Schmid and Mata 2005; Schmid et al. 2007; Egan et al. 2010). Other studies indirectly provide evidence that thinning can reduce MPB-caused tree mortality by finding higher mortality levels are often associated with increases in stand density (Sartwell and Stevens 1975; Cole and McGregor 1988; Fiddler et al. 1989; Oliver and Uzoh 1997; Amman and Logan 1998; Negrón and Popp 2004; Negrón et al. 2008).

Thinning treatments can reduce MPB-caused tree mortality within ponderosa pine forests during a severe infestation (Appendix B: Photos 2-3). Ten experimental plot clusters were established throughout the Black Hills of South Dakota from 1985-1991 to test efficacy of thinning to reduce stand susceptibility to MPB infestations (Schmid and Mata 2005). Results from nearly 20 years of monitoring these plots, after exposure to moderate and severe MPB infestations, indicate thinning reduced MPB-caused tree mortality when sufficient residual stocking levels of 60 ft^2/acre of basal area (BA) were achieved (Schmid and Mata 2005; Schmid et al. 2007). Researchers also found significant edge-effect, caused by surrounding landscapes of susceptible pine forests, can reduce efficacy when treated areas are $\leq$ 10 acres in spatial extent and a severe MPB infestation occurs (Schmid and Mata 2005; Schmid et al. 2007).

Klener and Aresenault (2009) conducted a landscape survey in British Columbia following a widespread and severe MPB infestation in ponderosa pine forests. Their surveys found high levels of ponderosa pine mortality occurred across all stocking levels; however, there was an overall trend where the rate of tree mortality increased with increasing stand basal area in the two diameter classes examined ($\leq$ 11.8 inches and > 11.8 inches). Similarly, Randall et al. (2011a) reported during a severe MPB infestation within central Montana that the rate of ponderosa pine mortality varied by hazard ratings (defined in Randall et al. 2011b) that were based on stocking levels, species composition, and stem diameter. Furthermore, their results indicated that plots with low hazard ratings averaged ≈ 10% BA mortality, those with moderate ratings averaged ≈ 30% BA mortality, and those with the highest ratings, including those with the greatest stocking levels, averaged ≈ 60% BA mortality.

Lodgepole pine forests

Regeneration and thinning treatments that create a mosaic of ages, sizes, structures, and species compositions across a landscape can reduce the severity of future MPB infestations (Safranyik et al. 1974; Amman 1976; Bollenbacher and Gibson 1986; Shore and Safranyik 1992; Whitehead and Russo 2005). Younger, small-diameter trees < 7" DBH are not quality host for MPB reproduction and cannot support large population amplifications (Safranyik 1968; Safranyik and Carroll 2006). Thus, overall forest resilience to multiple disturbances can be increased when younger trees are a substantial component of the landscape (Taylor et al. 2006; Appendix B Photo #1). Thinning treatments can reduce susceptibility to MPBs while meeting integrated resource objectives (e.g. wildlife, watershed function, etc.) that depend on retention and survival of a mature forest component.

Thinning in lodgepole pine stands can be effective in reducing MPB-caused tree mortality relative to unthinned areas. Studies in Colorado (Cahill 1978), Montana (McGregor et al. 1987), Wyoming (Amman et al. 1988), and British Columbia (Whitehead and Russo 2005) all found that thinned lodgepole pine forests experienced significantly less tree mortality compared to adjacent, unthinned areas. These studies indicate treatments that maintained 80-100 ft^2/acre of BA stocking levels, or those that leave $\geq$ 13 feet spacing between residual trees, can reduce MPB-caused mortality. Unthinned patches or leave strips within thinned areas can be colonized by MPBSs and contribute to further tree mortality (Gibson 1988; Whitehead & Russo 2005).

Thinning may reduce MPB-caused tree mortality within lodgepole pine stands even during a severe MPB infestation when landscape-scale strategies are implemented (Appendix B Photo #4). In British Columbia, Whitehead and Russo (2005) surveyed mortality levels that occurred within five, paired thinned and unthinned units that ranged from 1.2 to 19 acres in size. MPB-caused tree mortality was reduced ≈ 5-fold in the four thinned units, as compared to adjacent unthinned units, after being challenged with moderate MPB infestations. In the single area challenged with a severe MPB infestation, "unacceptable" mortality occurred based on British Columbia timber harvest objectives. However, this failure was attributed to the limited, 3.7-acre spatial scale of the treatment area (Whitehead 2010). In a separate retrospective study, Whitehead et al. (2007) surveyed 10 stands within British Columbia where thinned areas were 10-40 acres in size. They found thinning at this spatial scale prevented MPB infestation development and tree mortality, after being challenged by moderate and severe MPB infestations from adjacent areas, for those stands that had sufficient inter-tree spacing. Conclusions from both British Columbia studies indicate thinning mature lodgepole pine can reduce susceptibility to MPB infestations. However, authors emphasize treatments should be considered as part of a landscape, rather than stand-level, management strategy to be effective during a severe and widespread MPB infestation (Whitehead and Russo 2005; Whitehead et al. 2007; Whitehead 2010).

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Appendix A: Definitions

The term **outbreak**, in reference to mountain pine beetles (MPB), can have various meanings to the general public. For the purposes of this paper, a MPB outbreak refers to those populations that reach injuriously high levels as defined by an epidemic within USDA & USDI (2004). The term outbreak is synonymous with **infestation**.

The severity of a MPB infestation can influence the effectiveness and/or capacity to conduct MPB control treatments. The severity of an infestation is a proxy for bark beetle population pressure that is often reported within scientific literature assessing direct and indirect control treatments as actual beetle population levels cannot be readily determined. Differentiating between infestation severities is important as population pressures that challenge treated areas can vary from one MPB infestation to the next.

The **severity of mortality** represents the percent of MPB-killed trees (total killed trees / total trees) within the spatial boundaries of a given MPB infestation (Van Sickle et al. 2001; Taylor et al. 2006). The severity of a MPB infestation is described by the following mortality thresholds: a low-severity infestation has < 10% mortality, a moderate infestation has 10-30% mortality, and a severe infestation has > 30% mortality within the spatial perimeter of an infestation (Figure 1).

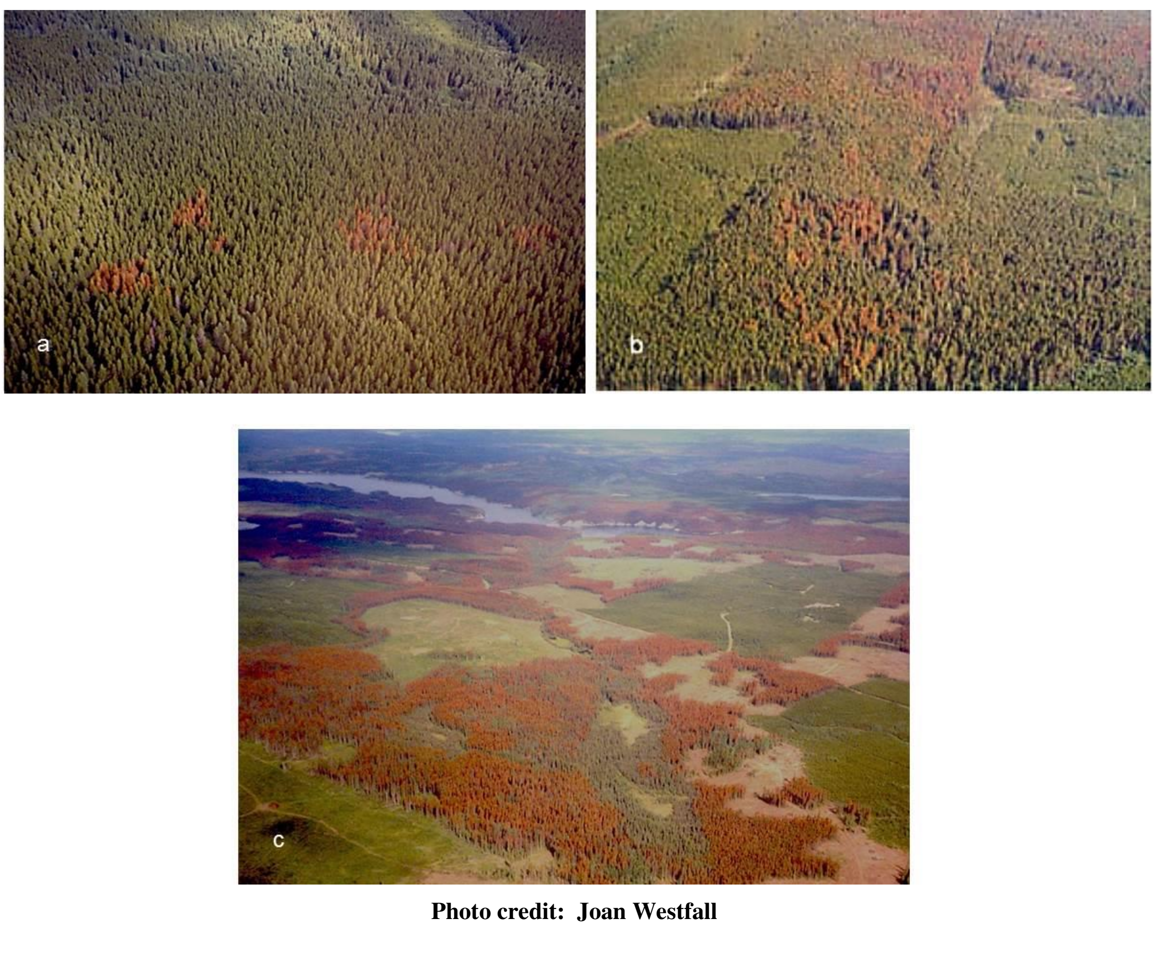

Photo credit: Joan Westfall

Figure 1. Examples of a) low, b) moderate and c) severe mountain pine beetle infestations. This figure was duplicated from Taylor et al. (2006) with permission of the Canadian Forest Service.

Appendix B: Photos

Photo credit: Brian Howell

Photo #1. Age-class diversity within lodgepole pine forested area on the Medicine Bow-Routt National Forest following regeneration treatments in Colorado. Severe MPB infestations occurred in mature lodgepole pines in mid-2000s while the younger pine cohort was resilient to MPBs and other disturbances.

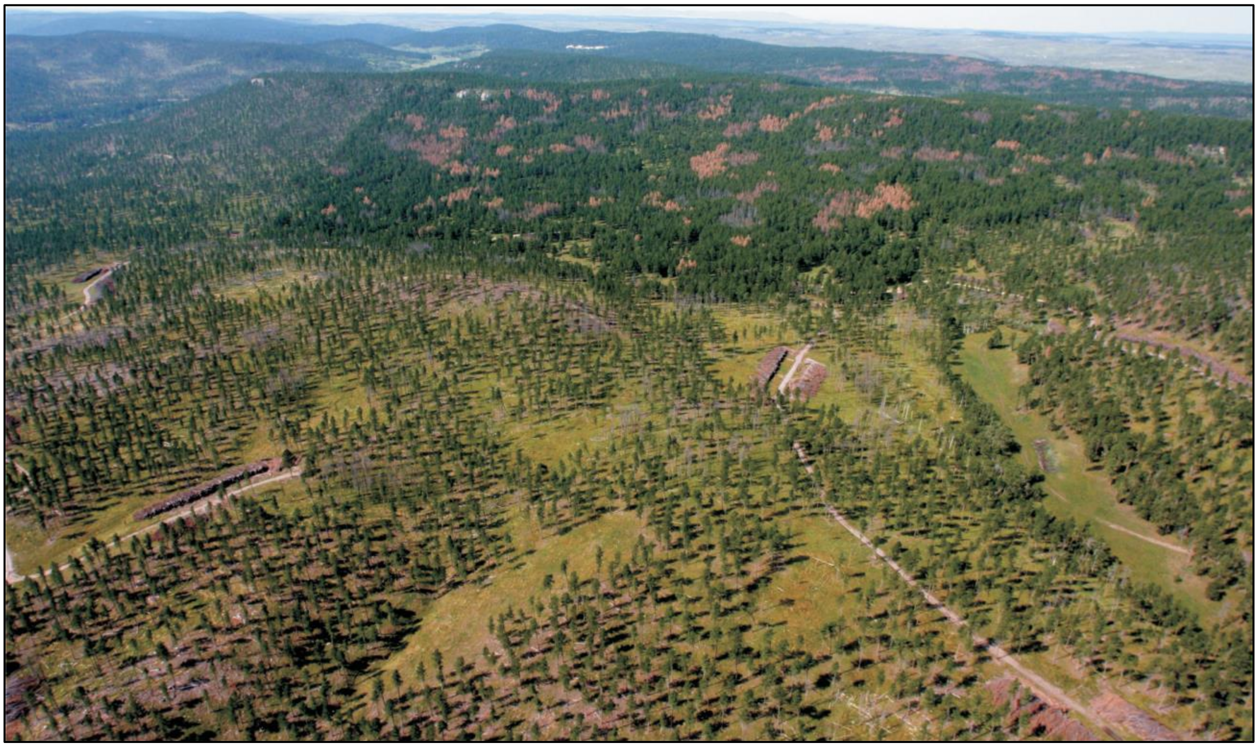

Photo credit: USDA Forest Service, Black Hills National Forest

Photo #2. Thinned ponderosa pine stands within the Bugtown project area of the Black Hills National Forest in South Dakota. Thinned areas had minimal MPB-caused mortality and high residual vegetation survival after exposure to severe MPB infestations while adjacent, unthinned areas had severe tree mortality.

Photo credit: Nancy Sturdevant

Photo #3. Thinned and unthinned ponderosa pine stands within the Jimtown project on the Helena National Forest in Montana. Approximately 300 acres of ponderosa pine forests were thinned with integrated resource objectives of hazardous fuels reduction and restoring open-grown ponderosa pine to promote resilience to multiple disturbances. A severe MPB infestation occurred post-treatment causing minimal mortality within thinned locations and severe levels of mortality within adjacent, unthinned areas.

Photo credit: Keith Konan

Photo #4. Thinned and unthinned lodgepole pine forested areas within the Pierce Lake project on the Flathead National Forest in Montana. Approximately 350 acres of mature lodgepole pine forests were thinned to 15-18 foot residual spacings across four units to enhance resilience to MPB infestations and catastrophic wildfire. A severe MPB infestation occurred following treatment causing minimal mortality within thinned locations and severe mortality within adjacent, unthinned areas.