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## Bark Beetles (Scolytidae) in Eastern Oregon and Washington

### Abstract

Bark beetles are well described in terms of life history and general ecology for the six beetle species of concern in eastern Oregon and Washington: Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins; mountain pine beetle, *D. ponderosae* Hopkins; western pine beetle, *D. brevicornis* LeConte; spruce beetle, *D. rufipennis* (Kirby); fir engraver, *Scolytus ventralis* LeConte; and, pine engraver, *Ips pini* (Say). Many interactions between bark beetles and other agents and resources have been described. Wildfire, windstorms, disease, other insects, and land management practices can weaken trees and attract bark beetles that become locally epidemic. At low population levels, beetles perform useful functions by creating habitat and forage for many organisms, but outbreaks can cause extensive tree mortality and increase risk of wildfire. Natural control agents such as birds, predatory beetles, parasitoids, and parasites, have been studied, but have not been employed operationally in management strategies. While semiochemical-baited traps provide information about population fluctuations locally, large area monitoring relies primarily on aerial surveillance. Stand susceptibility, hazard, or risk-rating systems exist for most of these species, and infestation growth or damage models are available for a few. In most cases, pesticide sprays, attractants and anti-aggregants, and trap-tree techniques have been useful in specific applications. Anti-aggregants have been proven useful in large-scale operations for Douglas-fir beetle. Salvage or sanitation of infested, wind- or fire-damaged trees can prevent population build-ups if done promptly. Integration of these methods along with prescribed fire and tree thinning has been recommended. Decision-support tools are becoming more prevalent but each requires validation for different geographic variants.

### Introduction

A large number of bark and wood-boring beetles occur in the mixed-conifer forests of eastern Oregon and Washington (Furniss and Carolin 1977). Arguably the most important are those beetles in the family Scolytidae that can attack and kill apparently healthy host trees, and are capable of reaching population levels that result in extensive infestations and tree mortality. This group includes four species of *Dendroctonus* known for periodic outbreaks: Douglas-fir beetle (DFB), *Dendroctonus pseudotsugae* Hopkins, which attacks Douglas-fir (*Pseudotsuga menziesii*); mountain pine beetle (MPB), *D. ponderosae* Hopkins, which attacks numerous species of pine, particularly ponderosa and lodgepole pine (*Pinus ponderosa* [pp] and *P. contorta* [lp]); western pine beetle (WPB), *D. brevicornis* LeConte, which also attacks ponderosa pine; and spruce beetle (SB), *D. rufipennis*, which attacks several species of spruce, but principally Engelmann spruce (*Picea engelmannii*) in this area. Also of concern under conditions of stress such as from defoliation or drought is the fir engraver (SV), *Scolytus ventralis* LeConte, which is primarily a threat to the true

firs, principally grand fir (*Abies grandis*) in this area. The pine engraver (IP), *Ips pini* (Say), can be found on several species of pine, especially lodgepole and ponderosa, prefers green slash or severely stressed trees, and is a threat to sapling and pole-size trees in recently thinned stands.

In 1991, the Blue Mountain Forests (Umatilla, Malheur, and Wallowa-Whitman National Forests) prepared a comprehensive review of forest health issues in northeast Oregon and southeast Washington in the Blue Mountains Forest Health Report: New Perspectives in Forest Health (Gast et al. 1991). In that compendium can be found detailed descriptions of the major forest insects, including the bark beetles listed above, that affect resources in the Blue Mountains. For each of these beetles is information pertinent to the Blue Mountains and applicable to much of eastern Oregon and Washington on host and community, biology, historical trends, stand conditions under which they occur, occurrence, suppression of outbreaks, effects on resources, hazard- or risk-rating methods, population dynamics or damage simulation models, and pest management options or recommendations, as well as literature citations.

Similarly, in *Search for A Solution*, Jaindl and Quigley (1996) summarize existing knowledge and identify gaps in our knowledge relative to key issues for addressing ecosystem health in the Blue Mountains. In their contributed chapter on "Insects and disease factors in the Blue Mountains," Filip et al. (1996) more generally discussed research on bark beetles in unmanaged forests, natural enemies, implications of wildfire and drought, effects of forest practices, and monitoring techniques, and provided literature citations. For the purpose of this synthesis, in part because the first of these publications is now out of print and also is nearly a decade old, some of the same literature will be cited along with new information and advances that pertain to management options for bark beetles at multiple scales in east-side forests of Oregon and Washington. This synthesis is not intended to provide an exhaustive literature review, but rather to provide a brief overview of the effects of bark beetles, monitoring/risk rating, treatment practices, effects of treatments, and decision support tools applicable to eastern Oregon and Washington. In many cases, because studies or reports are specific to a beetle species or host type, as well as locality, multiple example references are provided and attributed to beetle species (and host type, if pertinent).

### Effects of Bark Beetles

The basic life histories of these beetles are well known and documented in numerous sources (e.g., Furniss and Carolin 1977; Sartwell et al. 1971; Livingston 1979 [IP]; Ferrell 1986, Berryman and Ferrell 1988 [SV]; Bedard 1950, Schmitz and Gibson 1996 [DFB]; Holsten et al. 1999 [SB]; Miller and Keen 1960, DeMars and Roettgering 1982 [WPB]; Amman et al. 1985, Raffa 1988 [MPB]). Spruce beetle exhibits perhaps the most unique life history of this group, in that it can vary from a 1- to 3-yr life cycle depending on conditions (Schmid and Frye 1977). Annotated bibliographies have been compiled for DFB (Furniss 1979), MPB (Lessard et al. 1986), and SB (Linton and Safranyik 1987) and a searchable bibliography for SB is included in SBexpert ([www.fsl.orst.edu/usfs/sbexpert](http://www.fsl.orst.edu/usfs/sbexpert)). Most of these beetles, particularly the *Dendroctonus* species, prefer mature hosts, and at endemic levels, typically infest weakened or wounded trees. These levels of beetle populations occur over the larger

forested landscape most of the time. There are large communities of organisms that depend on disturbance in general and on bark beetles in particular for habitat and forage. These include extensive lists of predators and parasites of the beetles themselves, as well as a vast array of vertebrates, invertebrates, and microbes associated with snags and coarse woody debris created by beetle-caused mortality. The conservation and exploitation of bark beetle natural enemies, native and introduced, in control programs has received considerable attention (e.g., Miller et al. 1987, Kulhavy and Miller 1989, and reviewed in Bellows et al. 1998 and Fluxa et al. 1998); however, to date, manipulating these agents for control of bark beetles has not been used operationally. Most notable among the natural enemies are birds such as woodpeckers and gleaners (Steeger et al. 1998), predatory beetles that feed on both larval and adult bark beetles, hymenopteran and dipteran parasitoids that attack immature stages under the bark, and entomopathogenic nematodes (Bellows et al. 1998, Fluxa et al. 1998). Interestingly, while the extent of mortality caused by birds has been quantified or at the minimum recorded for most bark beetles, there is no record of predation by birds on DFB. Each of these bark beetles is also associated with an array of microbial organisms, some of which are pathogenic to the host tree including stain fungi (e.g., Whitney 1982, Schowalter and Filip 1993).

Certain disturbance events like wildfire (e.g., Furniss 1965 [DFB]; Gara 1988, Rasmussen et al. 1996 [MPB]; McCullough et al. 1998), windstorms (e.g., Johnson et al. 1959, Johnson and Pettinger 1961 [DFB]; Struble 1948 [WPB]; Schmid 1981 [SB]; Scott and Schmitt 1998 [SB, DFB, MPB, WPB, IP]), other insects (e.g., Wright et al. 1984 [DFB, SV], Fredericks and Jenkins 1988 [DFB]), or disease (e.g., Lane and Goheen 1979 [DFB], Hertert et al. 1975 [SV]), and land management practices (e.g., Lejeune et al. 1961, Furniss et al. 1979 [DFB], Dolph 1965 [IP], Mitchell and Martin 1980 [MPB, WPB, IP]) often result in direct tree mortality, or may weaken trees to the extent that they attract large numbers of bark beetles that then become locally epidemic. Rapid buildup of these populations may lead to spread of the outbreak to nearby areas if left unchecked. In outbreak conditions, infestations can grow over several years to consume large acreages of mature host trees (e.g., reviewed in Gast et al. 1991). Outbreaks can influence attainment

of resource objectives and composition of forested lands (Eaton 1941, Heath and Alfaro 1990 [MPB], Veblen et al. 1991 [SB]). Large outbreaks of bark beetles may disrupt natural resource management objectives over broad landscapes (e.g., Keen 1950 [MPB, WPB, IP], Fitzgerald 1954 [SB], Cornelius 1955 [DFB]). When this happens, forest health and associated social and economic values are threatened. Infestations result in loss of productivity, losses of traditional and non-traditional forest products, as well as loss of old-growth habitat (e.g., Schmid and Amman 1992), and add a significant fuel component to the landscape. Bark beetle outbreaks can set the stage for subsequent disturbance events such as fire (e.g., Geiszler et al. 1980, Parker and Stipe 1993 [MPB]). Outbreaks along stream reaches can have effects on stream flow (e.g., Love 1955, Bethlahmy 1974, 1975 [SB]) and temperature from loss of shading. Outbreaks and associated management activities can affect wildlife habitat (Light and Burbridge 1985). On the other hand, endemic levels of bark beetles, along with other insects and diseases, provide a beneficial process by which the recruitment of new snags, and eventually coarse woody debris, can occur in the forest (e.g., Hinds et al. 1965 [SB], Schmid et al. 1985 [pp/MPB], Mitchell and Preisler 1998 [lp/MPB]). Historically, in unmanaged forests, bark beetle infestations have set the stage for successional processes to begin, resulting in a mosaic forest landscape of variable age (Filip et al. 1996; Lindgren and Lewis 1997 [SB]).

### Monitoring and Risk Rating

Although semiochemical-baited traps can provide information about population fluctuations at the local level, detection of incipient infestations and subsequent monitoring is primarily done through aerial surveys and, in some cases, ground checking (e.g., USDA FS 2000). In contrast to the use of pheromones in defoliator systems, such as with the tussock moth early warning system (Daterman 1978, Daterman et al. 1979), or in southern pine beetle (Billings 1985), no similar large area monitoring system that can enhance the development of forecasting or predictive tools exists for the bark beetles of western conifer forests. However, infestation growth or damage models have been developed (e.g., Cameron et al. 1990, Thompson 1991 [MPB]; Marsden et al. 1994 [DFB]) for a few species. Typically, by the time an infestation

becomes large enough to detect by aerial survey, a number of trees have been killed, and, if conditions are appropriate, a relatively large area may be involved in the infestation. In addition to the occurrence of one or more disturbance events (e.g., windthrow, fire, defoliation), appropriate conditions include availability of susceptible hosts. Stand susceptibility or hazard (e.g., Furniss et al. 1981, Weatherby and Thier 1993 [DFB]; Stevens et al. 1980 [pp/MPB], Dolph 1983 [lp/pp MPB], Schmid et al. 1994 [pp/MPB]; Keen 1936, Miller and Keen 1960, Smith et al. 1981 [WPB]; Schmid and Frye 1976 [SB]; Moore et al. 1978 [SV]), or risk rating systems (e.g., Shore and Safranyik 1992 [lp/MPB]; Schmitt and Scott 1997) have been developed for several bark beetle species at the stand to sub-watershed level, although none has apparently been developed specifically for *I. pini*. Scott et al. (1998) have developed a watershed analysis risk calculator (UPEST) for insects and disease including the predominant bark beetle species of eastside Oregon and Washington. Through the east-side assessment of historical and current conditions, the role and hazard of insects across the forested landscape has been evaluated (Hessburg et al. 1994, Lehmkuhl et al. 1994). Discussions of the role of historical range of variability (HVR) of insects are limited, but are important for understanding when and how they function as natural disturbance agents in forest ecosystems (Hessburg et al. 1994, Schmid and Mata 1996, Scott 1996).

### Treatment Practices

Treatment tactics and strategies for bark beetle control range from traditional silvicultural practices (e.g., Patterson 1992 [DFB]; Amman and Logan 1998 [MPB]), such as thinning and prescribed fire aimed at improving the overall health of the stand and risk reduction, to so-called direct or remedial control methods (e.g., Miller and Keen 1960, Smith 1990 [WPB], Sartwell and Dolph 1976 [pp/MPB], Werner et al. 1983, Werner and Holsten 1992 [SB]), to landscape-level semiochemical-based tactics (Ross and Daterman 1997a [DFB]), as well as the integration of these tactics into management strategies (Ross and Daterman 1997b [DFB]). For high-value trees, especially those in recreation areas and residential areas at the urban-wildland interface, the protection of individual trees from attack by bark beetles has proven effective for one to several years

with the use of certain pesticides (e.g., Werner et al. 1986 [SB], Haverty et al. 1998 [MPB, WPB]). A good discussion of various field methods and their value at different stages of infestation development is provided in Scott and Schmitt (1998). Prompt salvage or sanitation (Gast et al. 1991) of currently infested, wind- or fire-damaged trees can forestall population build-up. Removal of this material from one season to the next can prevent the emergence of the new generation the following year. Once populations build or the area of damage includes large numbers of hosts, salvage becomes less feasible or constrained with other resource concerns to balance.

Other control tactics involve use of felled- or baited-trap trees, to which specific bark beetles are attracted, and subsequently the trees are removed (e.g., Schmitz and Gibson 1996 [DFB]; Borden et al. 1986 [MPB]; Gibson 1984, Scott 1990 [SB]; Thier and Donnelly 1994 [WPB]; Gast et al. 1991). These tactics are most effective when infestation levels are low, and when timely removal of infested material is assured. At stand and larger scales, the use of both attractant and repellent semiochemicals have been tested. The use of mass removal or suppression trapping with attractant-baited traps has been shown to draw down the number of beetles over infested areas (e.g., Ross and Daterman 1997a [DFB], Bedard and Wood 1981 [WPB], Borden and Lacy 1985 [MPB]). The use of host-produced repellents (Hobson 1995), green leaf volatiles (Poland et al. 1998 [SB, WPB]; Wilson et al. [MPB] 1996), and anti-aggregant pheromones of several bark beetle species (Shea et al. 1992 [Ip/MPB]; Ross and Daterman 1994, 1995b [DFB]; Lindgren et al. 1989, Thier and Munson 1993 [SB]) as tools in suppression have been investigated. The DFB anti-aggregant (MCH) has been used with consistently good results as an area protectant (Ross and Daterman 1994, 1995b). The combination of silvicultural and semiochemical-based tactics for management of DFB is currently being used operationally at the watershed level (Ross and Daterman 1997b).

### Effects of Treatments

Effects of treatments for protection from or mitigation of bark beetle infestation are not insignificant. Salvage or sanitation, like any other form of harvesting results in site disturbance and ex-

tensive road use, but at the same time reduces fuel. The use of pesticides, although limited to relatively small areas, has inherent undesirable non-target effects (e.g., Werner et al. 1983 [SB]). Although more species-specific, the use of trap trees or suppression trapping can result in removal of arthropod natural enemies that are also attracted to the traps (e.g., Ross and Daterman 1995a [DFB]). Modifications of the semiochemical attractant components have been proposed to reduce natural enemy captures (e.g., Aukema et al. 2000 [IP]). Certain organisms, such as cavity-nesting birds, are dependent on the snags and woody debris created by disturbance agents such as bark beetles (Saab and Dudley 1998, Bull 1983 [Ip/pp MPB]). Semiochemicals can be used selectively to create wildlife habitat (e.g., Ross and Niwa 1997 [DFB]), or preserve scarce and high-risk habitat in the short term (Daterman 1994).

### Decision-Support Tools

Significant progress has been made over the last decade in the development of mid- or broad-scale decision-support tools for managing multiple pests, although there are some limitations in the ability to apply these tools across beetle-host systems and from area to area. For example, the UPEST watershed risk analysis program includes four different rating systems for MPB, two for each primary host type (Scott et al. 1998). Models for DFB (Marsden et al. 1994) and for MPB (Cole and McGregor 1983) effects have been constructed and linked as pest extensions to a stand prognosis model (Forest Vegetation Simulator, FVS) (Wyckoff et al. 1982). In the FVS system, landscapes are simulated by using representative tree or stand lists and calibrated to specific geographic areas or variants, including those of the east side such as the Blue Mountains and East Cascades variants. With adaptations for the area (changing default parameters for the pest extensions and FVS variant), FVS has formed the basis for simulation modeling efforts for multiple pest (e.g., bark beetles, defoliators, and root diseases) assessments and scenarios for planning (e.g., Eager and Angwin 1997, Roberts and Weatherby 1997). A spatially explicit model (Westwide Pine Beetle Model, WPBM) has been developed to project effects of three pine beetle species (MPB, WPB, IP) in FVS simulations (e.g., Beukema et al. 1997). A comprehensive knowledge-based system,

SBexpert, has been developed for management of spruce beetle in Alaska (Reynolds et al. 1994; www.fsl.orst.edu/usfs/sbexpert). For multiple resource management in lodgepole pine-dominated forests, a decision framework for integrated management for MPB has been developed (McGregor and Cole 1985). Additionally, for Blue Mountains and east-side forests, guidelines have been developed for catastrophic stand conditions (Schmitt and Scott 1993 [DFB]), and for effects on trees during prescribed landscape burns relative to entomological concerns (Scott et al. 1996 [DFB]).

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- In recent work (Hessburg et al. 1999), assessing landscape vulnerability relative to disturbance by insects and pathogens, methods are described that can be used in landscapes or watersheds to evaluate or monitor change in vegetation vulnerability to these disturbances, and in planning processes.

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## Note

This special issue of *Northwest Science* is a set of papers reviewing the state of knowledge about disturbance processes in eastern Oregon and Washington, related management practices, and effects on key management issues.