TESTIMONY OF

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MOUNTAIN PINE BEETLE: STRATEGIES FOR PROTECTING THE WEST

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My name is Peter Kolb, and I am the Montana State University Extension Forestry Specialist and an Associate Professor of Forest Ecology and Management at the University of Montana College of Forestry and Conservation. I'm here today speaking on behalf of the Society of American Foresters (SAF), an organization of over 15,000 forest managers, researchers, and educators. I've been a SAF member for 27 years.

I am here today to offer you my testimony with regard to the bark beetle situation across western forests with specific reference to the conditions across the Montana with which I am most familiar. My perspective is not that of an entomologist, but that of a forest ecologist and management specialist whose main work objective is to help implement the results and conclusion of scientific research into practical working applications. I work in both academic circles as an applied researcher and educator, and in the forest practitioners' realm, which gives me the opportunity not only to conduct relevant research, but to examine the effects of forestry applications. Just three days ago I returned from a week of working with family landowners and the Cree and Chippewa tribes of central Montana where we examined the forest conditions there and the effectiveness of various forest practices in combating a mountain pine beetle outbreak in the Bearpaw Mountains.

Bark Beetles

The bark beetle outbreak we are experiencing across the entire western portion of North America is the result of multiple ecological factors converging at the same time. Its occurrence is not a surprise for foresters across western forests as the current expansiveness of bark beetle activity has been building for many years. Bark beetles such as mountain pine beetles, one of the main culprits in the current outbreaks, have been extensively studied since the mid 1970s. Its life cycle and ecology are very well understood. It has been a natural part of western forests for millennia and its population cycles are fairly predictable. Under what we would characterize the average forest and climatic conditions of the past century it exists as a chronic population within pine forests, colonizing and killing trees that are unable or incapable of defending themselves due to a variety of physiological, genetic or environmental factors. It may be considered analogous to wolves circling a herd of caribou, culling out the weak, unfit and injured. As with any species, bark beetles have numerous pests and predators themselves including a variety of predatory beetles, wasps, nematodes, mites, fungal diseases, and larger predators such as bark gleaning birds and woodpeckers. Depending on the populations of these predators and pests, chronic bark beetle populations might be kept in check.

Perhaps one of the most important factors affecting bark beetle populations is climate. Typically higher elevation and northern latitude forests experience extreme cold periods where air temperatures hover at minus 30-40°F for several or more weeks in winter. Under such temperatures overwintering beetles or larvae experience significant mortality. Similarly, cool moist summers can inhibit beetle activity and larval development and increase the effects of fungal pathogens. When climatic conditions cycle into warmer and drier trends, beetle populations are favored with less winter mortality and faster and better reproductive cycles. Across higher elevation lodgepole pine forests in Montana for example, mountain pine beetles rarely have been able to expand into larger populations in the past 100 years because of extremely cold winter temperatures. Also, short summers have only allowed the beetles to typically have one reproductive cycle. When warmer winters, earlier springs and resulting longer summers prevail, bark beetle populations gain an advantage. Under longer summer scenarios, such as we experienced across Montana for the past decade, mountain pine beetles may start to achieve two regeneration cycles. Two bark beetles produce an average of 80 offspring on one reproductive cycle. With a second cycle the first generation then can produce 3,200 offspring by the end of summer. Milder winters then allow most overwintering beetles to survive, which means in the second summer the overwintering beetles can produce 128,000 offspring in the first reproductive cycle and 5,120,000 offspring in the second cycle.

An equally important factor that influences bark beetle populations is the availability of suitable host trees. Each bark beetle species has adaptations that allow it to attack and reproduce best in specific tree species, and when those trees are in a certain size and age range. The greater the suitable host tree number, the greater the potential food source and thus the larger the population of bark beetles that can develop. Likewise, the greater the percentage of host trees that are similar in age and size, the greater the probability of bark beetles successfully attacking and colonizing them at the same time.

A landscape such as Yellowstone National Park, that had a large acreage burn catastrophically in 1988, will develop an even aged forest of fire adapted lodgepole pine that are all similar in size equivalent in expansiveness as the area of disturbance. When these trees reach 90-100 years of age, they will mostly become suitable host trees at the same time that under the right climatic conditions can allow an epidemic of bark beetles to develop once again. The epidemic will then persist as long as there are host trees within flying distance of beetles and the climate remains favorable. The same is true, for example, of Colorado and Wyoming’s lodgepole pine forests. By and large, these forests are mature, even age forests of lodgepole pine stressed by drought and high densities of trees combined with warmer temperatures that foster mountain pine beetle population explosion.

Since native tree species and their pests have coevolved, trees have natural defense mechanisms against herbivore attacks. Most conifers, the prevalent category of trees in the western United States, produce pitch, which is a viscous liquid and toxic defensive compound (not to be confused with sap, which is the water and nutrient conducting liquid within a tree) and if present in adequate amounts can be used to kill bark intruders such as bark beetles as well as seal off tree wounds. Likewise secondary metabolite products such as terpene and phenolic compounds can be produced as toxic countermeasures to insect or disease attack. The forest products industry processes these very materials out of harvested wood to produce a variety of chemicals we use in our everyday lives as disinfectants, preservatives and even products such as arabinogalactan that is thought to enhance human immune systems. The production of these defense mechanisms, however, only occurs in adequate quantities when a tree has the resources needed to grow well, such as enough sunlight, water and nutrients. Stress brought on by drought periods, mechanical injury, or excessive competition with neighboring trees results in a weakened tree defense capability (Hermes and Matson 1992). The energy allocation within a tree is thought to be prioritized first on maintenance respiration (keeping its cell structure alive), next in adding new growth, and only then in producing defense mechanisms. Thus weakened trees become the natural targets for pests such as bark beetles.

Mature forests with dense canopies have the additive effects of transpiring more water than forests of younger trees with less needle area, and intercepting rainfall and snowfall in their dense canopies that evaporates back into the atmosphere before having a chance to enter the soil where trees can absorb it. The additive impacts of greater water and energy production requirements, less soil water recharge, and limited space for photosynthetic (needle) area leads to significantly weakened trees. At this point the trees in this condition represent a large food source without any defenses, the perfect target for bark beetles and a host of other tree pests and pathogens.

When mild winters, early springs and longer summers, perfect conditions for bark beetle survival and reproduction, are combined with a landscape covered with a disproportionately large population of mature preferred host trees, that are suffering from the stress of overcrowding coupled with drought brought on by the warmer winters and longer summers, the conditions for a perfect bark beetle storm arise. If the climatic conditions that favor bark beetles persist, this storm will last as long as there are host trees available to eat. When epidemic populations develop, trees that originally exhibited resistance to pest attack can succumb to the sheer number of successive attacks. It is not uncommon to find trees that have resisted and survived the first year of a bark beetle attack only to be successfully colonized in the second or third year of an outbreak. This may be a significantly undesirable impact of a forest pest epidemic as the trees exhibiting superior survival abilities and possibly genetically desirable characteristics as the potential seed sources of the future forest are also lost. Local seed sources have their limits, especially when trying to restore ecosystems across broad geographic scales. Diverse seed sources are relevant to restoring vegetation that is resilient, ecologically competent and possesses the evolutionary potential required to meet changing and challenging environments (Broadhurst et al 2008). This can reduce the overall genetic diversity within a population, weaken the robustness and health of a species, and reduce the ability of the species to adapt to new environmental conditions such as may be the case with global climate change. Genetic variation within populations of tree species is a substantial component of biodiversity and appears to be a significant prerequisite for the survival and persistence of forest ecosystems, particularly under heterogeneous and changing environmental conditions. Inbreeding results in weaker individual trees with less stress resistance (Müller-Stark et al 2005).

As long as forests have been a primary provider of resources for human populations, tree damaging agents have been considered unwelcome. Scientific understanding of how forest ecosystems function has progressed to the point in the recent half century to where we understand and appreciate that most organisms perform an important function in keeping forests healthy and in a sense, push species to continue to evolve. Bark beetles are no different and not only continue to help select for genetically strong individuals, but also create habitat and provide food sources or multiple other organisms. As such it would be unwise to eradicate bark beetles and other natural organisms that interfere with our immediate needs from the forest. At some point, however, an organism may reach a tipping point where it gains an unfair advantage against another organism. The result is that the disadvantaged species goes extinct or is pushed onto a small fraction of its former distribution.

German Forests

Across central Europe forests have been harvested intensively and continually for over 2000 years. Many countries there, notably Sweden, Germany, Austria, France and Switzerland have developed forest management practices that maintain forest productivity, biodiversity, scenic and recreational beauty, and that have greatly limited catastrophic disturbances including bark beetle outbreaks.

As an example, the country of Germany has roughly the equivalent land area and forested area as Montana. A greater oceanic effect provides for a slightly milder climate and more evenly distributed annual precipitation. Tree growth rates can be twice as high there as in Montana. Whereas Montana has approximately 950,000 permanent residents, Germany has 83 million residents. Hiking and nature appreciation is a national pastime, and a large proportion of German forests have a primary nature reserve or biodiversity protection designation. Important to note is that forest management including tree harvesting is not viewed as a barrier to such objectives, but rather a tool to help achieve desired conditions for rare and endangered species and recreational quality. Wood has also been identified as a primary mechanism of reducing atmospheric carbon emissions and global warming as it sequesters large amounts of carbon in living trees, wood products, and offsets fossil fuel consumption when used as a primary building material and source of energy. It is a highly valued product in the European carbon cap and trade system. According to the European Forestry Institute, "When wood products are used instead of non renewable materials such as steel or plastics, the carbon is sequestered longer before it is released back into the atmosphere.

On an annual basis Germany harvests 12.6 billion board-feet equivalent of wood, Montana over the past decade has annually harvested an average of 750 million board-feet, most of which has come from private lands, not federal lands even though the later accounts for 67% of the Montana forest land base. To put this in perspective, the height of the timber harvest from national forests was roughly 12 billion board-feet in the 1980s. Now the entire harvest off of national forests is roughly two billion board-feet. For Montana, as many other western states, the repercussions have been devastating to the wood products industry, forestry and logging professions.

Bark beetles are a common problem in all forests in Germany for the most prevalent tree species, yet in the past decades bark beetle epidemics have not occurred, mainly because they have been prevented. The one exception is in the Bavarian National Park, were forest management was excluded as the purpose of the park was for nature to run its course without human interference, and for the dominating native pure spruce forest to grow into ancient old growth character. In the late 1990's a spruce bark beetle population started to build in this forest. In the past decade it has killed 80% of the trees across 60% of the park and is expected to decimate the rest in the next five years. This past year, the Bavarian government agreed to allow foresters to start implementing measures to attempt to control the epidemic as it is now spilling out of the park onto private forested lands. The measures being used, which are successfully used to prevent outbreaks across the rest of the nation are: 1) remove beetle infested trees before the brood hatches out of it, 2) bait and trap beetles, 3) manage surrounding spruce forests with thinning applications to enhance tree vigor and natural resistance, 4) increase non-host tree species diversity in forests around the park to limit beetle food sources, 5) divert planned harvests of green trees to harvesting of beetle infected or killed trees instead, 6) pursue research into other methods for controlling bark beetle outbreaks, 7) manage for tree species that are calculated to be adapted for future (warmer) climate scenarios.

Management Solutions for the US?

Can these management tactics also work for forest across the western United States? Our understanding of tree and beetle biology for our afflicted areas and species, as well as experiential knowledge certainly matches what German foresters have to work with. Multiple studies have shown that thinning forest stands to alleviate the impacts of light and water competition on tree vigor while leaving what appear to be the best trees results in less successful bark beetle attacks (Schmid et al. 2007). It has also been postulated that the greater heating from sunlight increases stress on bark beetles as they seek out trees. Increasing the diversity of tree species in forests that are primarily monocultures, such as the situation we see in Wyoming and Colorado with lodgepole pine, thus reducing contiguous host tree availability also makes for a more difficult environment for bark beetles, and reduces the ability of epidemics to develop. Similarly, decreasing the size of similar tree age and size patches of host trees will have the same effect as increasing species diversity, as younger age trees are not suitable host trees for most of the most prevalent tree killing bark beetle species. Finally, using harvest trees to trap beetles into, and then processing those trees thereby destroying the brood, combined with the use of synthesized aggregation and anti-aggregation pheromones (attractants and repellents) to manipulate and control populations of beetles. All of these tactics have been used with documented success in western forests. They do require the skill and expertise of forest managers and forest entomologists, as well as a skilled and modern logging workforce. They also require a funding mechanism as the extensiveness of bark beetle mortality and risk is enormous (Figure 1). As a side note, we are quickly losing our skilled logging workforce in Montana (and across the West). Without this workforce and infrastructure to take these materials, we'll lose our ability manage forests.

Another issue is what to do with the significant volume of already dead trees. In Germany much of the beetle infested or killed wood is harvested. Fifty percent of the more than four billion board-feet equivalent annual harvest in the German state of Bavaria, a forested land base of slightly more than 6 million acres, is salvage and sanitation harvest of dead and dying trees. This is all accomplished in a taxable profit generating free market system. What is suitable goes to sawmills and much of the rest is utilized for electricity, steam and home heating (Figure 2) with one third of all households heating with wood. Wood is rated as a renewable biomass source and replaces an equivalent of 396 million gallons of heating oil per year in Bavaria alone. Across the western United States, such utilization also occurs at a small scale in the form of rural home heating and cogeneration "hog-fuel" of some wood products industries. For Montana the calculated home heating oil replacement for national forest private firewood cutting permits is 3.1 million gallons. Several small wood burning school heating systems have been installed in recent years, and several of the few remaining sawmills are considering investing in wood generated power plants as the heat by-product of a wood-to-energy plant can be used heat the dry kilns of the sawmills, thereby increasing the efficiency and output of such a facility. One of the major barriers for such investments remains the availability of wood raw materials where 67 percent of the forested land base, bark beetles and all, is under federal management.

Forests suffering from large scale bark beetle outbreaks accumulate significant amounts of dead wood. Mountain pine beetle killed trees of ponderosa and lodgepole pine typically topple over within 2-10 years, creating large fuel loading for wildfires. Such heavy fuel accumulations represent challenging wildfire control scenarios, and if the larger diameter stem material dries out sufficiently, as has occurred frequently in the past decade, wildfire severity and intensity is greatly increased, which can result in mortality of beetle surviving trees and their seed source. Such scenarios can further decrease the genetic diversity of forests, particularly during a time when such diversity may be needed to help forests adapt to projected climatic change. Fuel management addresses directly the root of the wildfire problem and when properly designed and implemented increases the effective weather threshold for effective fire control, which is even more relevant in a climate change scenario (Rigolot et al. 2009).

Conserving tree species across their historical range with densities fitting the definition of "forest" both in the short term (next 50 years) and long term (next 50-200 years), that are capable of naturally regenerating and conserving their gene pool will be challenging if the predictions of climate change are realized. In addition, the characteristics and values associated with those forests have a greater probability of being conserved with active forest management than if left to what are deemed "natural" processes and consequences. "Active management" is defined here as the process where forests are inventoried within a reasonable scale for their biological and physical properties, that this knowledge is used to plan and implement landscape activities that provide for greater tree survival and natural regeneration when exposed to significant changes in temperature, precipitation and associated disturbances (wildfires, insects and diseases), and that all management options ranging from benign neglect to commercial tree harvesting are utilized. A thus managed forested landscape would consist of a mosaic of "wilderness" and "old-growth" patches as well as areas with harvests designed to promote tree vigor (thinning) and species and age class diversity (seed tree, shelterwood, patch cutting). In Montana, most Native American tribes have already adopted this management style on their reservation lands. Both the confederated Salish and Kootenai tribes (Flathead reservation) and Chippewa and Cree tribes (Rocky

Boy reservation) are using active forest management as well as rapid salvage and sanitation harvesting to stem bark beetle epidemics and reduce the probability of catastrophic wildfire effects in their forests.

Forest ecosystems are an important part of the global carbon cycle since they are estimated to sequester and store approximately 80% of the aboveground terrestrial carbon (Waring and Running 1998) which equates to estimates from 380 to 458 Pg of total global stored biologically based carbon (1 petagram = 1 gram x 10^{15} or about 1,100,000,000 tons). These estimates have put forests and their management into the forefront of anthropogenic caused global climate change debates as they may be one of the most efficient and effective mechanisms for offsetting the most common human caused source of atmospheric carbon dioxide: fossil fuel consumption that emits an estimated global rate of 5.5 Pg of carbon per year (Waring and Running 1998). The European Community has instigated policy that offers financial support for afforestation of agricultural lands and silvicultural actions that may increase carbon sequestration (FAO 2009).

Larger disturbance such as a wildfire can kill many trees, thereby releasing the stored carbon quickly through wood combustion or slowly by killing the tree and thus releasing carbon through the slower decomposition process. Wildfires release an instant pulse of carbon and then changes the albedo of the land surface that allows for a much greater absorption of solar energy that may last decades in boreal forests (Running 2008). A young forest that may develop in the burned area over the next 100-300 years recaptures the carbon again leading to the concept that forests are actually "carbon neutral" in the long term. However, if forest's natural cycles are altered, their overall contribution to atmospheric carbon-dioxide also changes. Enhanced growing conditions resulting from factors such as increased precipitation, milder or shorter winters, fewer pests and pathogens, faster growing or longer lived species to name a few all can lead to greater carbon sequestration and carbon storage. Alternatively, conditions such as less precipitation, greater drought periods, uncharacteristic summer and winter temperatures, unusual wind events, and increased pest, pathogen and wildfire occurrence can result in lower rates of tree carbon sequestration, and the loss of total forested area and the release of large amounts of wood sequestered carbon into the atmosphere. The global carbon cycle can be converted into atmospheric carbon dioxide, a primary greenhouse gas when trees burn or decay, or atmospheric carbon can be sequestered when trees grow and produce wood. As part of the IPCCs 4th assessment, seven general circulation model simulations unanimously project an increase in June through August temperatures of 2 to 5 ºC by 2040 to 2069. Wildfire burn areas in Canada and the western United States are expected to increase by 74 to 118%. Wildfires add an estimated 3.5 x 10 15 g atmospheric carbon each year equivalent to 40% of annual fossil fuel emissions (Running 2006). Forests thus represent both a potential source of atmospheric carbon dioxide if they are degraded, or the most efficient land based sink with a large capacity to absorb atmospheric carbon dioxide when trees are rapidly growing.

Opinions vary and range from those that advocate active forest management to enhance forest's resilience to bark beetle epidemics, wildfires and ability to adapt as well as increase atmospheric carbon dioxide sequestration rates and fixed carbon storage capacity to those that feel active management of forests causes a net carbon storage loss as well as less carbon sequestration capacity and overall harm to forest function and integrity. As with all complex natural resource issues, there are valid arguments based on site specific and single species research that can be made to support both sides of the issue. As a forest practitioner with now 29 years of applied experience caring for trees and managing forests as well as extensive academic and scientific training and work on the ecology of Northern Rockies forest ecosystems, it is my opinion that active forest management and the use of wood-based renewable bioenergy applied in appropriate locations using both the academic and practical knowledge and experience currently available, will most likely result in greater forest resilience to large landscape level disturbances that are both within and outside of the historic range of variability. This will also maintain or increase most forest ecosystems ability to store and sequester atmospheric carbon dioxide.

Figure 1 Source: Gannon and Sontag 2008, Meyer 2005.

Acres Burned

Year	Acres
2000	1,160,145
2001	146,819
2002	110,309
2003	736,809
2004	18,445
2005	103,294
2006	1,047,118
2007	778,079
2008	123,943
Total:	**4,224,961**

Acres severely affected by bark beetles

Year	Acres
2000	103,920
2001	223,892
2002	450,134
2003	493,785
2004	730,782
2005	1,213,602
2006	1,000,289
2007	948,517
Total:	**5,164,921**

(Source: Montana Department of Natural Resources and Conservation 2007)

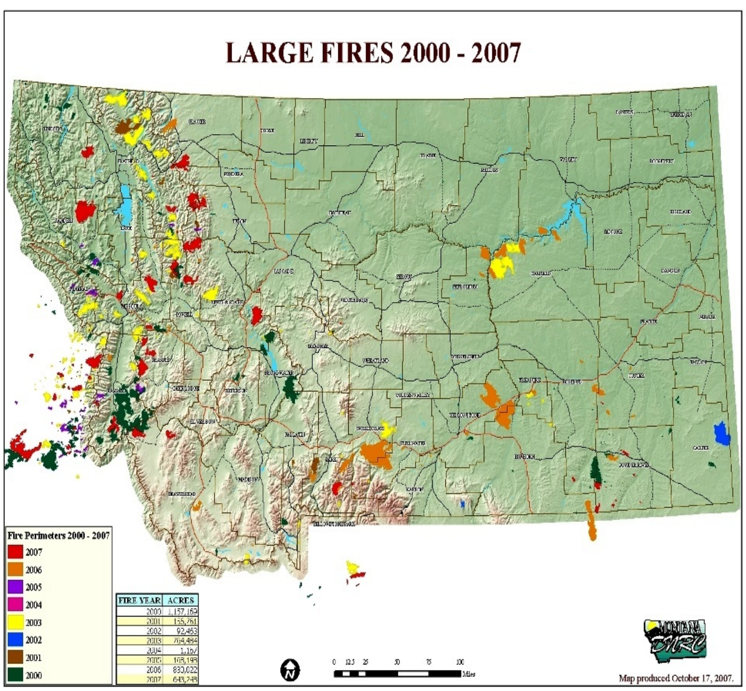
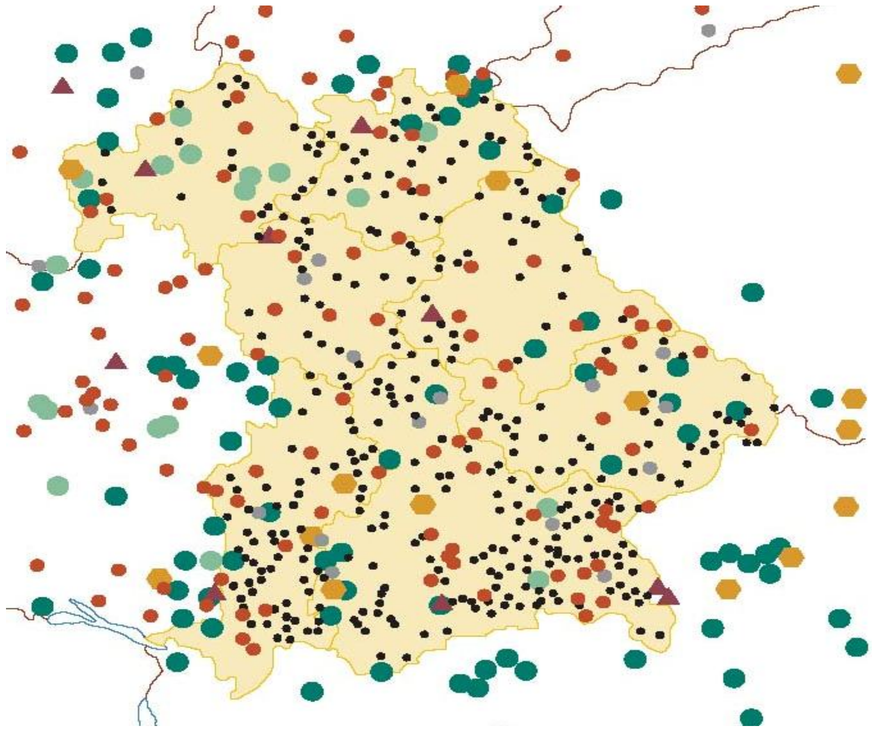


Figure 2 (Source: Bavarian Forestry Institute 2008)

Diagram of wood processing and utilization plants in Bavaria, Germany,



Larger circles are sawmills, black dots a wood based bio-energy facilities, rust dots a wood heating pellet manufacturing facilities.

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