Testimony of:
Sloan Shoemaker
Executive Director, Wilderness Workshop

Committee on Natural Resources
Subcommittee on Water and Power
Subcommittee on National Parks, Forests, and Public Lands
Mountain Pine Beetle: Strategies for Protecting the West
Oversight Hearing
June 16, 2009

Introduction

Thank you for the opportunity to bring the on-the-ground perspective to DC.

My name is Sloan Shoemaker and I am the executive director of the Wilderness Workshop, a grassroots, place based conservation organization founded in 1964. Wilderness Workshop self-describes as the conservation watchdog of the White River National Forest.

The White River National Forest is the nation's most visited national forest and one of the crown jewels of the National Forest System. The White River's 2.3 million acres contain a dizzying diversity of ecosystems and attractions, from world class ski resorts like Aspen and Vail to a dozen or so of Colorado's 14,000 ft peaks to the highest concentrations of caves in Colorado to what's reputedly the nation's largest elk herd affording world class hunting opportunities. The White River is considered the Cradle of Wilderness because it was here that the young landscape architect Arthur Carhart, sent to the survey Trappers Lake area for vacation cabins, first articulated the notion that some landscapes are too valuable in their wild state to develop. From this seed grew the 750,000 acres of congressionally designated wilderness now on the forest, wilderness containing such renowned features as the Mount of the Holy Cross and the twin peaks of the Maroon Bells.

These superlatives are not without their costs. The WRNF exemplifies the New West as amenity refugees relocate from their former lives to the resorts and communities surrounding the Forest, attracted to the extraordinary recreational opportunities and quality of life made possible by the Forest. This New West demographic, coupled with the easy interstate access to the Denver metropolitan area's 3 million people and the high volume airports servicing the resort communities, recreation management on the WRNF poses a huge challenge.

In addition, the WRNF provides summer grazing allotments for dozens of ranches inhabiting the lowlands around the forest, ranches that contain the critical winter range for the vast herds of mule deer and elk that summer on the Forest and provide unparalleled hunting opportunities in the fall. The WRNF also overlies the eastern edge of the Piceance Basin, a natural gas sweet spot that's seen unprecedented rates of drilling in the last 8 years. Gas leasing and development is a complex resource management issue in its own right, but made even more difficult by the fact that much of the WRNF's gas potential lies in roadless areas, grazing allotments, or trophy hunting range. Further complicating White River forest management is the fact that it is the partial epicenter of the mountain pine beetle outbreak in northern Colorado, which brings us all together today.

I cite this inventory of forest management challenges to give you some background on the breadth and complexity of resource management issues my organization has been deeply involved with for the last 45 years.

Coming to Terms with the Beetle

The mountain pine beetle outbreak is not an ecological problem, but it is a socio-economic one. One hundred and fifty years ago, the mountain pine beetle outbreak would have run its course as it has for millennia without furrowing a brow. But over the ensuing 100 years, humans have taken up residence in these mountains and now there are densely populated communities embedded in these disturbance dependent ecosystems. Consequently, the pine beetle epidemic has put many socio-economic values at stake.

Interestingly, the beetle outbreak has created a teachable moment. Whereas before, residents old and new had taken the picture-window view for granted, assuming it'd never change, communities are now learning that, not only are forest ecosystems not static, they are subject to rather dramatic and rapid change that we have no control over. That lesson hasn't come easily or painlessly.

As the beetle epidemic has expanded from community to community, I have observed a consistent pattern that closely resembles the classic stages of grieving. At first, people simply deny that it could happen to them. Then, when the evidence is too great to further ignore, they get angry because they love the forest the way it was and don't want it to change. Next comes bargaining when people rather heroically but desperately devise strategies to stop the beetle, saying we're not going to let what happened to the community next door happen to us. In the end, though, comes resignation and acceptance that there are forces at work larger than us and all we are left with is to narrow our focus on identifying what little we can actually do.

Working Together

What's become crystal clear is that none of us can afford to act alone, but that together we can get a whole lot done. This too has presented us with a teachable moment as diverse stakeholders, normally inclined to operate from our own narrow interests, have learned how to sit together at the collaborative table working towards mutually beneficial goals.

I am the Colorado conservation community's representative to the Colorado Bark Beetle Cooperative (CBBC). CBBC started as an intergovernmental group for sharing information on how individual member organizations were approaching the bark beetle issue. Over time it became apparent that a more coordinated response was needed and that the tent must be enlarged to bring in the spectrum of stakeholders that would have to be dealt with eventually anyway. It took us awhile to learn to share the sandbox and trust each other. Perhaps our biggest lesson was that sometimes you have to go slow to go fast and, at times, it had to be learned the hard way. In everyone's understandable rush to get chainsaws running, little misunderstandings or oversights inevitably grow into broad disagreements and things grind to a halt. On the other hand, taking the time to carefully build trust and consensus pays off, greasing the skids for projects in those zones of agreement to hit the ground running. Collaboration and consensus building provides the social license to move forward expeditiously – it's the ultimate process streamlining.

Another important benefit derived from the hard work of hammering out the zone of agreement is that it creates a very safe and attractive place for decision makers and politicians to focus their attention and resources. It's hard to argue when the enviros and the timber industry, the Forest Service and local government, sportsmen, recreationists, and trade associations all

agree on what's to be done. As a result, the CBBC has been extremely successful in capturing the attention of the Colorado delegation who is unified in its legislative efforts to direct relief to the bark beetle affected region.

Prioritizing

As you've heard today, the scale of this outbreak is huge. Conversely though, the resources available to mitigate its effects are quite limited and must be applied very judiciously and strategically where we get the biggest bang for the buck. We simply can't afford to waste precious resources for narrow, marginal or dubious gain. The CBBC's collaborative setting is the ideal venue for diverse stakeholders to come to consensus on priorities, a process that pretty quickly cuts through the rhetoric and grandstanding. CBBC's priorities are the protection of life, property and critical community infrastructure…priorities that transcend this particular disturbance event and strike right at the heart of what it means to sustain mountain communities in the face of disturbance dependent forest ecosystems. Ultimately, our goal is to ensure that, as forest disturbances come and go (fire, bug epidemics, floods, blowdowns, etc), mountain communities remain resilient, insulated from their destructive and disruptive effects. We all recognize that we can't, nor should we, control forest ecosystems. But what we can control is how badly our communities are impacted by them. What does this mean in practice?

Protecting lives means things like:

- Removing hazard trees that could fall directly on people
- Clearing hazard trees from transportation corridors so emergency access and egress isn't impaired
- Protecting homeowners and fire fighters by creating defensible space around homes because no fire fighters life is worth risking to protect an indefensible home

Protecting property means:

- Conducting public education to help homeowners participate in their own rescue by implementing appropriate measures to keep their homes from burning, like:
    - Structures must be constructed of ignition resistant materials...shake roofs guarantee home ignition and loss
    - Reduce fuels creating defensible space within the 40 meters immediately surrounding the structure
    - Scrutinize residences for and eliminate ember traps like needle filled gutters, unscreened roof vents, wood piles under overhanging porches
    - Ensure safe access and emergency egress so that firefighters can get in and get out in a hurry if they need to

Protecting critical community infrastructure means:

- Clear hazard trees from electrical transmission and distribution rights of way
    - Trees can fall on electrical lines causing fires or arcing and blackouts
- Assess wildfire risks along and adjacent to electrical transmission and distribution ROWs and conduct strategic fuels treatments to eliminate the threat of dense smoke caused arcing or heat damage to lines and towers
- Protect water supplies by;
    - removing fuels within the immediate vicinity of water supply delivery system to prevent direct damage from hazard tree fall or direct heat damage from fire

    - conducting watershed risks assessments that identify where mass land wasting events are most likely to occur post-fire
    - pre-engineering and pre-permitting strategically placed erosion catchment structures as informed by the watershed risk assessment - the next fire's location can't be predicted (nor are there enough resources to construct catchments everywhere) but these catchments are intended to be shelf-ready for immediate implementation the day after the fire passes through
    - strategically fell and leave trees on the contour across slopes where sensitive, erosive soils have been identified to reduce fire severity and to pre-position surface water decelerators
- Protect economic infrastructure
    - Remove hazard trees from public land campgrounds, trails, and roads
    - Mitigate beetle kill impacts to ski areas by removing hazard trees and initiating early establishment of critical forest cover between ski runs by replanting trees
    - Remove hazard trees from recreation sites to protect lives as well as to keep them open and generating tourist traffic
    - Reduce hazard tree, fuel, and erosion threats to agricultural irrigation systems; many ranches have irrigation ditches that originate in or travel through beetle affected forests
- Protect transportation system
    - Remove trees within a tree height of community road networks; even light winds will blow down beetle killed lodgepole, quickly cutting off emergency access or egress
    - Reduce fuel loads adjacent to roadways to reduce threat that fire will shut off access/egress or will directly injure traveling public or emergency services personnel.

The abundance of so many red and dead trees also makes apparent the *ever-present* of risk of wildfire. I emphasize ever-present because lodgepole pine is a fire dependent species. It co-evolved with fire which is necessary sustain its presence across the landscape. This ecological reality is often lost upon newcomers to these mountains who misunderstand fire as an alien invader that must be eliminated. Green forests arguably pose a risk of fire equal to and, at times, even greater than that posed by the beetle killed forest. If there is one lesson painfully clear from the last century, it's that fire suppression and attempts to exclude fire from forest ecosystems backfires, simply putting off the problem until it returns with larger, more severe and more damaging fires than would otherwise have been experienced. Protecting communities from wildfire begins out the back door, not in the back country. The most, if not only, effective measures are those prescribed by USFS Fire Scientist Dr. Jack Cohen (see http://www.fs.fed.us/rm/publications/titles/videos/wildfire.html and http://www.fs.fed.us/rm/publications/titles/videos/protecting.html). Dr. Cohen's groundbreaking research has proven that the factors influencing survivability of homes and structures are within the 40 meters immediately surrounding that structure. Because burning embers or firebrands can launch as much as 2 miles from an active flame front, showering communities and homes with a hail of burning material, it's generally ember triggered fires that cause home loss. If homes are Firewise, meaning built of ignition resistant materials and surrounded by defensible space with discontinuous fuels, they have the highest likelihood of survival.

Resources

As communities grapple with where to start, it's becoming immediately apparent that the there is way more work to do than resources to get it done. As we speak, trees are blowing down across county roads in Jackson, Routt, and Grand Counties faster than limited crews can keep up with. Throwing money at the problem would certainly help get equipment and manpower on the ground. But, even if we could get experienced sawyers and enough saws on site, we couldn't do anything with the trees due to a lack of timber haulers. If a flood of haulers magically appeared, there's no place to take the wood. Colorado's wood products industry is bare bones and, alternatively, there simply aren't enough piling yards available to accommodate the volume of material. And with high fuel prices, the hauling distance to existing mills is simply uneconomic in many instances.

For the first time in decades, Coloradoans are interested in bringing back the timber industry to help us deal with all the wood coming out of beetle killed forests. The trouble is, there will be a large pulse of wood flowing off the forests over the next 5-10 years as communities implement their priority projects but wood volume will taper off fairly steeply on the back side of that. The concern is that a reinvigorated timber industry be appropriately scaled and flexible to deal with the near term pulse of wood yet not need to maintain the same level of supply over the long term. Simply put, Coloradoans want a tactical timber industry that can scale up for the near term and scale down as supply wanes.

We all agree that a reinvigorated wood product industry is an important part of the solution. However, there's a persistent and vexing barrier to the wood product industry's reestablishment. No one knows what the long term, guaranteed wood supply is nor where precisely it's located. Given 2 million acres of beetle kill, it may seem a trivial point to get high centered on. However, not all those acres are available or appropriate for harvest. Some are statutorily off limits like congressionally designated wilderness and inventoried roadless areas. There are environmental constraints like steep slopes and wetlands. Finally there are less tangible but equally important constraints imposed by what the public is willing to tolerate. Responsible investors want to know how big is their social license to work in the woods because business plans can quickly run aground when they exceed their social license. Yet, no one has performed the type of comprehensive, state wide assessment of long term wood supply that investors can take to the bank as collateral for loans. And without it, banks are loath to invest in uncertain ventures based on speculative and unsubstantiated assertions of long term wood supply.

We'd all like to see this nut cracked as soon as possible so we can get on with the important business of mitigating the bark beetles effects. Colorado's conservation community is as anxious as the next guy to hear chainsaws in the woods – we just want to make sure that they're treating the right acres. Because durable solutions are rooted in consensus, we are prepared to continue collaborating with all stakeholders to collectively identify what those right acres are. After all, I live, work, play and am raising a family in the midst of this too.

Future Forests

I have appended to my testimony an abridged version the state of the art, consensus science statement on our current understanding of mountain pine beetle ecology and fire behavior. It's a remarkable and ambitious document in the scope of the issues it attempts and diversity of scientific voices it represents. The full report is worth the read and can be found at http://www.fs.fed.us/r2/bark-beetle/mbp6092008.pdf .

Here's my synopsis:

1. The scale and intensity of the ongoing mountain pine beetle epidemic is unlike any outbreak that has been observed before, but that does not mean the end of lodgepole pine in the Rockies.
2. These forests have undergone dramatic change in the past, and they are resilient to mountain pine beetle and other disturbances.
3. Even in the existing forest, variability in age, density, and species composition ensures that there will be different responses to the beetle outbreak.
4. Once an outbreak gets going, there are no known treatments that can influence its spread.
5. Infrequent, large fires are the norm in lodgepole pine forests, as they are likely to be in the future – with or without beetles. There is general agreement that as the dead needles fall from the trees, the probability of crown fire will diminish, but the probability of surface fire may increase.
6. Because mountain pine beetle outbreaks do not disturb the soil, they are not likely to cause increased erosion, though they may increase water yield.
7. Changes such as we are observing in the current mountain pine beetle outbreak are not unlike the changes we should expect from climate change in the decades ahead.

The take-home message is that the bark beetle epidemic is not the ecological Armageddon it's often portrayed as. The future forest is already establishing itself in the understory. And because of the legacy of other tree species in the lodgepole pine forest understory, the new forest will be markedly more diverse than the forest it's replacing. We'll see Engelmann spruce, sub-alpine fir, Douglas fir and aspen trees filling in where previously existed a homogenous sea of lodgepole pine. Contrary to the more hyperbolic rhetoric about the end of lodgepole pine forests in northern Colorado, lodgepole will return, though not exactly in the same density and distribution we are used to.

People often ask what we ought to be doing to accelerate establishment of the new forest. Perhaps a more fundamental question is should we, and if so, where? The first step should be to do a comprehensive assessment of what sort of natural regeneration is already occurring. From a distance, the 2 million acres of beetle kill seem devoid of a green stick. However, if you walk around in the beetle killed forest, it's apparent that the overstory of red or grey trees disguises the extent of young, vigorous new trees now taking advantage of the reduced competition for water and nutrients. A comprehensive assessment would tell us if the type and location of regeneration matches our desired future conditions and whether intervention is warranted or not. But, because this isn't getting done, time and energy is wasted handwringing about the disappearance of the forest and its calamitous implications for our tourist dependent economies.

(Abridged by Wilderness Workshop due to space limitations)

The Status of Our Scientific Understanding of Lodgepole Pine and Mountain Pine Beetles – A Focus on Forest Ecology and Fire Behavior

A synthesis of our current knowledge about the effects of the mountain pine beetle epidemic on lodgepole pine forests and fire behavior, with a geographic focus on Colorado and southern Wyoming.

Merrill R. Kaufmann1, Gregory H. Aplet, Mike Babler, William L. Baker, Barbara Bentz, Michael Harrington, Brad C. Hawkes, Laurie Stroh Huckaby, Michael J. Jenkins, Daniel M. Kashian, Robert E. Keane, Dominik Kulakowski, Charles McHugh, Jose Negron, John Popp, William H. Romme, Tania Schoennagel, Wayne Shepperd, Frederick W. Smith, Elaine Kennedy Sutherland, Daniel Tinker, and Thomas T. Veblen

(complete version available at: http://www.fs.fed.us/r2/bark-beetle/mbp6092008.pdf)

Introduction

Major lodgepole pine forest changes and how they affect us. Mountain pine beetle populations have reached outbreak levels in lodgepole pine forests throughout North America. The geographic focus of this report centers on the southern Rocky Mountains of Colorado and southern Wyoming. The epidemic extends much more widely, however, from the southern Rocky Mountains in Colorado in the United States to the northern Rocky Mountains in British Columbia and Alberta, Canada.

Worries about large-scale tree mortality in lodgepole pine forests have created public concerns across the West. The appearance of red trees during the last decade, a clear sign of recent beetle attack, has been followed by bare dead tree skeletons throughout this large area. Unquestionably, millions of dead trees foretell large forest changes in the near future, and more might be anticipated in areas where the mountain pine beetle has not yet reached epidemic levels.

People are concerned for many reasons. At a minimum, the loss of mature lodgepole pine trees will significantly change the present and future appearance of affected forests for half a century or more. Extensive areas of dead trees and snags are not as aesthetically appealing as live forests. Perhaps more seriously, dying and dead trees raise fears of increased fire danger. Some people worry that the dead needles and wood generated by the mountain pine beetle epidemic will lead, perhaps quickly, to severe wildfires that threaten lives, property, wildlife, and watersheds. Many are concerned that trees not yet attacked will succumb to the epidemic. Some people worry that the forest in and around our communities and recreation areas will become sparse or disappear forever, and that these forest changes will affect timber commodities, game habitat, and recreation resources.

Some contend that the current epidemic with synchronous outbreaks at many locations is unprecedented and a clear warning of global climate change impacts on ecosystems around the world. Scientists and others point to other changes occurring in our region – *Ips* beetle-caused

mortality of piñon pine in the Southern Rocky Mountains, aspen decline, and large fires in Front Range ponderosa pine forests and elsewhere. It is difficult to prove cause and effect, but all of these changes began during the last 10-15 years, coinciding with recent warm climatic conditions, increasing numbers of large trees, and advancing age of many forests. Whether or not the current epidemic is unprecedented is a question to which there is currently no clear answer because of the lack of precise information on extent and severity of beetle outbreaks prior to the early
1900s. Nevertheless, many in the scientific community believe the probability of a similar event historically over at least the past few 100 years is low.

There are many insights and opinions about lodgepole pine being discussed by stakeholders of all kinds -- forest managers, agency administrators, researchers, policy-makers, politicians, the news media, industries, and the general public. Some concerns and fears are supported by scientific evidence. Others are probably justified given the current status of our scientific knowledge, but lack clear scientific support. Still others are myths with little or no basis in science. A further complication is that some of the information emerging from the science community has appeared on the surface to be somewhat contradictory.

The reason for this report. This document is written to report our current scientific understanding of the ecology and fire behavior of lodgepole pine, with a focus on the direct and indirect effects of the current mountain pine beetle epidemic that is so dominant in our minds. We recognize that important socioeconomic implications stemming from the mountain pine beetle epidemic exist, and we hope that examining the status of science will aid in addressing these issues. While this document focuses on lodgepole pine and mountain pine beetles, there are also many other forest types and non-forested systems subject to extreme or at least unexpected impacts of climate, other insect and pathogen species, and other disturbances including fire and wind.

This report results from a meeting in January 2008 convened in Colorado by The Nature Conservancy, bringing together expertise of scientists who study lodgepole pine throughout its geographic range. We hope to provide as much scientific help to stakeholders as possible by sorting out what is known with a high degree of certainty, what we are confident about but with less certainty, and what is truly not understood and in need of more research. While our primary geographic focus during the workshop was Colorado and southern Wyoming, some of the findings may be appropriate for lodgepole pine throughout much of its natural range of distribution. *We urge caution, however, in applying our findings beyond our initial area of focus or to other forest types in the region.*

During the workshop and through subsequent email dialogue, the lodgepole pine team reached consensus on nine key points. As always, science is a work in progress, and uncertainties surfaced during discussion of some key points. For some points we provide what is known with adequate confidence rather than waiting for more definitive information, when this information is useful to interested stakeholders. This report provides the nine key points along with explanatory material intended to help the reader understand the degree of confidence we have from scientific study for these key points. To help the reader, we provide a list of suggested reading at the end of this report for more detailed information on many of the topics discussed. We begin with the obvious.

A. Lodgepole pine forests are being heavily impacted by the ongoing mountain pine beetle epidemic.

From British Columbia to Colorado, forests are experiencing high mortality of lodgepole pine trees from attack by mountain pine beetles. An insect epidemic with multiple outbreaks at this scale has not been observed during the last century of scientific study, though small outbreaks have occurred. This mortality is changing forest structure and composition, and modifying fuels in ways that will affect fire behavior for decades.

B. Not all lodgepole pine forests are the same.

Some forests are composed of nearly pure lodgepole pine established following large fires decades or centuries ago. Others are mixtures of lodgepole pine with subalpine species such as Engelmann spruce, subalpine fir, and aspen at higher elevations, or with mixed conifer species such as ponderosa pine, Douglas-fir, and aspen at lower elevations. Each type of forest has unique features of ecology and fire behavior. And lodgepole pine trees in all three types are vulnerable to attack by mountain pine beetles.

C. Forests are living systems subject to constant change.

It is normal and expected that many natural agents, including mountain pine beetles, fire, and wind, change forests over time. Some changes are so gradual that we barely notice them, while others are relatively sudden and extensive.
The forests that are presently losing many trees to insect attack will not look the same in our lifetimes, but healthy and vigorous forests will eventually return in most locations.

D. Lodgepole pine will not disappear from the southern Rocky Mountains.

The make-up of our forests is already changing where mountain pine beetles cause high mortality of lodgepole pine. However, this event will not cause the extinction or disappearance of lodgepole pine, and forests dominated by or including lodgepole pine will persist in the southern Rockies, though they may look different from those of the past due to changing climate. Future forests will continue to provide valuable ecological services and aesthetic and recreational benefits.

E. Active vegetation management is unlikely to stop the spread of the current mountain pine beetle outbreak.

Mountain pine beetles are so numerous and spreading so rapidly into new areas that they will simply overwhelm any of our efforts where trees have not yet been attacked, and no management can mitigate the mortality already occurring. However, judicious vegetation management between outbreak cycles may help mitigate future bark beetle-caused tree mortality in local areas.

F. Large intense fires with extreme fire behavior are characteristic of lodgepole pine forests, though they are infrequent.

Very dry and windy conditions can lead to large intense fires in lodgepole pine forests. Such fires are a natural way for lodgepole pine to be renewed and are largely responsible for extensive pure lodgepole pine forests.

G. In forests killed by mountain pine beetles, future fires could be more likely than fires before the outbreak. Large intense fires with extreme fire behavior are again possible.

There is considerable uncertainty about fire behavior following a mountain pine beetle epidemic on this scale. In pure lodgepole pine forests, crown fires are possible both before an epidemic and after while needles are still on trees. Intense surface fires are possible after most dead trees have fallen to the ground. The probabilities of such fires are uncertain, and more research is needed to learn in what ways and how long the fuels and fire environment are altered by the beetles. Nevertheless, protection of communities and other values at risk continues to be imperative.

H. Mountain pine beetle outbreaks are not likely to cause increased erosion.

Soils are not disturbed and protective ground cover is not reduced when mountain pine beetles kill lodgepole pine trees. If anything, understory plants may grow more vigorously in the increased light and with the higher available soil moisture and nutrients. Where tree mortality is high, annual streamflow may increase and the timing of water delivery may be changed, because of reduced canopy interception of precipitation and reduced water uptake by the trees.

I. Climate changes will most likely contribute to substantial forest changes in the decades ahead.

Given the climate changes in the last several decades and projected changes for coming decades, large fires and other natural disturbances and shifts in vegetation composition and distribution are anticipated in many ecosystems of Colorado and southern Wyoming. These large disturbances and other changes in growing conditions will likely contribute to restructuring many forest landscapes.

J. Summary

The current mountain pine beetle epidemic affecting lodgepole pine forests is an important ecological event with significant socio-economic implications. What will be the consequences for the affected ecosystems? How do we protect our communities and other human values at risk in ways that are socially and economically (as well as ecologically) feasible? These are difficult questions. This report has focused specifically on the ecology and fire behavior issues associated

with lodgepole pine and the mountain pine beetle epidemic. We recognize that the socio-economic aspects are as important as the ecological issues, but they are beyond the scope of this report.

Ecologically, much is known about lodgepole pine and mountain pine beetles.
Even though the scale of the current epidemic is unprecedented over the past approximately 100 years of reliable observations, beetle-caused tree mortality at some scale has long been part of the dynamics of the lodgepole pine ecosystems. Similarly, fire behavior and its role in ecological processes and fuel management practices are relatively well understood. While we are confident about our general understanding, we have identified at least some scientific uncertainties about lodgepole pine, mountain pine beetle effects, and fire behavior that should be acknowledged and further researched.

We are most concerned about several wildcard issues that create some uncertainty in applying what we know from science. The scale of this epidemic is larger than any mountain pine beetle epidemic studied thus far. We do not fully understand if or how the magnitude of this ecological event will affect future forests in terms of regeneration of the present species or transitions to different vegetation types. Furthermore, there is the question – both tantalizing and troubling – about possible climate change (including its rate, direction and magnitude) and the degree to which scientific findings need to be qualified as they are applied.

If humans were not a part of the equation, forests would simply mature, die, and regenerate or be replaced by other vegetation types, following ecological trajectories over time driven by climate, environment, and species capabilities.

Because humans cause changes in forests by choosing to live there and deriving economic services from them, our communities are impacted by forest changes, whether they are natural or not. Thus both the scale of the mountain pine beetle epidemic and the uncertainties about future forests leave us with questions that are important to us but may not be answerable with the knowledge we have now.

Knowledge from scientific research about lodgepole pine and mountain pine beetles is valuable in two ways. It offers answers to some of the questions we have about forest ecology and provides valuable insight for management of these forests for ecological and community protection purposes. It also clarifies what we do not know. This is valuable not just to direct new research, but also to inform stakeholders of the degree of confidence they should have as land and natural resource management practices are considered.

As noted in the introduction, science is a work in progress. Many of the scientific uncertainties discussed in this report already are receiving attention in the research community. Even as research continues, however, the scientific knowledge already available is usable by a wide variety of stakeholders and in the collaborative and adaptive management process. Adaptive management is perhaps best described as managing while learning on the fly. In this report, the scientific community provides information to managers and other stakeholders, but the scientific community also will help advance the knowledge base through lessons learned as management practices are planned, implemented, monitored, and evaluated. We humans must decide how to

manage forests based upon their intrinsic value and natural processes as well as some desired future condition contingent on human wants and needs. We must be realistic about the degree to which we as observers, managers and stewards of the forest can affect what is happening now and what will happen in the future. Whatever we do from here should be done together.

Authors and their affiliations

- Merrill R. Kaufmann (science team leader), US Forest Service Rocky Mountain Research Station (emeritus) and The Nature Conservancy
- Gregory H. Aplet, The Wilderness Society
- Mike Babler (science team co-leader), The Nature Conservancy
- William L. Baker, University of Wyoming
- Barbara Bentz, US Forest Service Rocky Mountain Research Station
- Michael Harrington, US Forest Service Rocky Mountain Research Station
- Brad C. Hawkes, Natural Resources Canada, Canadian Forest Service Pacific Forestry Centre
- Laurie Stroh Huckaby, US Forest Service Rocky Mountain Research Station
- Michael J. Jenkins, Utah State University
- Daniel M. Kashian, Wayne State University
- Robert E. Keane, US Forest Service Rocky Mountain Research Station
- Dominik Kulakowski, Clark University
- Ward McCaughey, US Forest Service Rocky Mountain Research Station
- Charles McHugh, US Forest Service Rocky Mountain Research Station
- Jose Negron, US Forest Service Rocky Mountain Research Station
- John Popp, US Forest Service Rocky Mountain Research Station
- William H. Romme, Colorado State University
- Tania Schoennagel, University of Colorado
- Wayne Shepperd, US Forest Service Rocky Mountain Research Station (retired)
- Frederick W. Smith, Colorado State University
- Elaine Kennedy Sutherland, US Forest Service Rocky Mountain Research Station
- Daniel Tinker, University of Wyoming
- Thomas T. Veblen, University of Colorado