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silviculture

Silviculture across Large Landscapes: Back to the Future

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The Mountain Pine Beetle Response (PBR) Project on the Black Hills National Forest demonstrates how resource professionals and the public can collaborate, anticipate, and apply a suite of silvicultural tools across large landscapes to more effectively respond to quickly changing ecosystems within the legal framework governing national forests. Across the West, bark beetle epidemics have been outpacing the ability of resource managers to respond with traditional approaches. In the Black Hills, it was time for a change, especially because local communities and stakeholders had become anxious and eagerly supported new approaches. Borrowing the best from research and practical experiences and with a fresh eye on the future, foresters developed the PBR Project across a million acre landscape in western South Dakota and northeastern Wyoming, with adaptive features to more swiftly address expanding pine beetle populations and reduce hazardous fuels.

Keywords: Black Hills National Forest, USDA Forest Service, Mountain Pine Beetle Response Project, mountain pine beetle/MPB, adaptive management large landscapes

The US Department of Agriculture (USDA) Forest Service has articulated the need for restoration and has estimated that approximately 65 million acres of National Forest System lands are at high or very high risk of catastrophic wildfires and the threats that ensue after wildfire to forest ecosystems, watersheds, and communities (USDA Forest Service 2012a). This need builds on the premise that sustainable resources depend on healthy, resilient ecosystems (USDA Forest Service 2000). Since 2000, mountain pine beetle (MPB) populations have caused significant tree mortality, resulting in increased dead fuel loads covering a 23-million acre footprint on national forests in the western United States. The footprint increases to some 43.1 million acres when tree mortality from all western bark beetles is counted (USDA Forest Service 2013b).

Although it is clear the Forest Service cannot treat every forest acre nor does it propose to, its strategy outlines a set of priorities to address safety, recovery of affected areas, and resilience to approaching beetle infestations (USDA Forest Service 2011). In 2012, the USDA Forest Service responded with a wide array of restoration treatments to improve watershed conditions, improve and establish forest vegetation, and reduce hazardous fuels on 2,200,000 acres across all NFS lands. Restoration treatment examples include road decommissioning, treating invasive plants, restoring riparian vegetation, and restoring forest structure and composition by mechanical methods and prescribed fire. Across the western national forests, approximately 287,000 acres were treated to address the top priorities in the Western Bark Beetle Strategy (WBBS).

Fire and insects are common disturbance agents in the western fire-adapted forests. Resource managers use Fire Regime Condition Class (FRCC or Condition Class) 1, 2, and 3 to describe the current condition with respect to departure from historic fire regimes. Whereas FRCC 1 has a low departure, FRCC 2 has moderate departure, and FRCC 3 has high departure. The relative risk of fire-caused losses of key components that define the system increases for each higher number with little or no risk at the FRCC Class 1 level (USDA Forest Service 2000). Silviculturists and fuels specialists typically design treatments to reduce Condition Class (e.g., change Condition Class 3 to 2) or to maintain Condition Class 1. Treatments needed to change the condition class can require a significant investment, often $1,000 per acre or more in the West. The acres in Condition Class 2 and 3 and the need to treat hazardous fuels can be seen in Table 1 which provides a comparison of the cumulative acres in need of restoration in 2012 against the result of restoration treatments generally and the area, treated specifically in the WBBS and to improve condition class (USDA Forest Service 2011).

Although it is not feasible or necessary to treat all acres, there is a clear need to increase the pace and scale of restoration and to select the most suitable and beneficial areas for treatment. Federal resource managers face a number of challenges to meet this need, and this article describes ways that this challenge is being addressed in the Black Hills of South Dakota and Wyoming.

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Table 1. Restoration needs and 2012 treatments across National Forest System lands.

Parameter	Value
Total National Forest Service acres	192,977,000
Condition Class 2 and 3 acres	115,786,000
Restoration needs acres	65,000,000–82,000,000
Western bark beetle-affected acres	43,100,000
2012 acres restored	2,200,000
2012 acres moved to better condition class	450,000
2012 acres treated in WBBS	287,000

The Black Hills—A Case Study for Restoration

History

The Black Hills, the "island in the plains," is sacred to Native Americans. The forest is dominated by ponderosa pine stands that have been shaped by insects and fire, both wildfire and aboriginal fire, for centuries. The Black Hills is widely noted for its abundant forest regeneration and resilience to disturbance.

The Black Hills area was settled by Europeans beginning with a gold rush in the 1870s. The mining companies wanted timber from the Forest Reserves, and the early leaders sought the need for regulated forest management. The first Chief of the Forest Service, Gifford Pinchot, recognized the favorable forest conditions and selected the area for the nation's first federal timber sale, "Case No. 1," sold in 1899.

Homesteading in the early 1900s created a settlement pattern of roads serving small ranches, farms, and communities in the Black Hills. Today there are some 3,700 miles of interior boundary inside the National Forest, often referred to as the "wildland-urban interface." The Forest has been actively managed for more than a century with an integrated forest products and forest restoration industry. Yet, similar to other western forests, tree density has increased followed by a marked increase in MPB and large fire activity over the last 10–15 years. As predicted by research on the Black Hills, most MPB epidemics have originated in even-aged, high-density stands (Schmid et al. 2007). Increased stocking levels have occurred, in part, due to fire suppression over the past century (Figure 1). Fire suppression is used to protect nearly 300,000 acres of interspersed private and state lands that have been developed adjacent to National Forest System lands over the last century.

Since 1996, MPB activity has been found on more than one-third of the 1.2 million-acre forest and on the adjacent state and private lands (Figure 2). The public and resource managers took notice. In 2005, the Black Hills Forest Plan was amended, recognizing and managing the dynamic changes in the forest ecosystem due to insects and fire. Citizens and communities strongly encouraged addressing the MPB infestations and hazardous fuel conditions. Landscape-level analysis of projects, following procedures under the National Environmental Policy Act of 1969 (NEPA), quickly increased in size from 5 square miles to some 50 square miles (approximately 35,000 acres) with the goal of increasing forest diversity, largely through enhancing hardwood composition and making conditions less favorable to insect spread and stand-replacing wildfire. After several years of implementing largely successful projects at these smaller scales, there was a clear need to increase the pace and scale of projects across even larger landscapes to provide silviculturists added flexibility in addressing rapidly changing conditions. Widespread public education and support from state and local governments, federal officials, stakeholders, and the Black Hills National Forest Advisory Board set the stage to dramatically increase the scale of response and collaboration to act.

Challenges

Several key challenges remain to be overcome if this work is to be successful:

- Native bark beetles are expanding rapidly in dense pine forests, killing trees and thereby increasing dead fuel loads that are increasing the risk of uncharacteristic wildfire under a changing climate.
- The public expects forests to be managed for diverse, multiple uses and seeks action to address insects and fuel conditions and to protect watersheds, scenery, habitat, infrastructure, communities, and forest-dependent jobs and tourism.
- Federal resource managers must comply with a suite of environmental laws, e.g., the NEPA, National Forest Management Act, and Endangered Species Act in their ecological restoration projects.
- Because MPB populations move faster and cover larger areas than traditional NEPA processes, federal resource managers need tools to help them respond swiftly to

Management and Policy Implications

In the Black Hills area, 416,000 acres have been affected by mountain pine beetles (MPBs) since 1996. Each year the Black Hills National Forest has taken action to address the MPB in selected landscapes and continues to increase its collaboration with partners addressing MPB and hazardous fuels. Thinning at the appropriate scale and time continues to make ponderosa pine forests more resilient to MPB infestations. Monitoring of research plot clusters indicates that thinning reduced MPB-caused tree mortality when sufficient stocking levels of 60 square feet of basal area were achieved (Schmid and Mata 2005, Schmid et al. 2007, Allen and Ambourn 2013).

Under the authority of the Healthy Forests Restoration Act of 2003, the Black Hills National Forest developed the Mountain Pine Beetle Response (PBR) Project at the forest landscape scale, with adaptive design features to more swiftly address the expanding MPB populations and to reduce hazardous fuels. The PBR Project increases landscape scale restoration by moving from 25,000-acre landscapes to one-quarter million acres, resulting in significant cost savings. Creative local partnerships have attracted millions of dollars from the states of Wyoming and South Dakota, counties, and private stakeholders. The extensive collaboration and engagement by partners has resulted in strong ownership and support for both adaptive resources strategies and public land stewardship practices. On Dec. 10, 2012, the Record of Decision for the PBR Project was signed. As an adaptive project, the PBR project allows a quicker and larger scale response to MPB outbreaks, to reduce hazardous fuels, and to evaluate and learn from the ongoing actions. It allows resource professionals the flexibility to anticipate and prioritize a suite of silvicultural techniques to be in the right place at the right time.

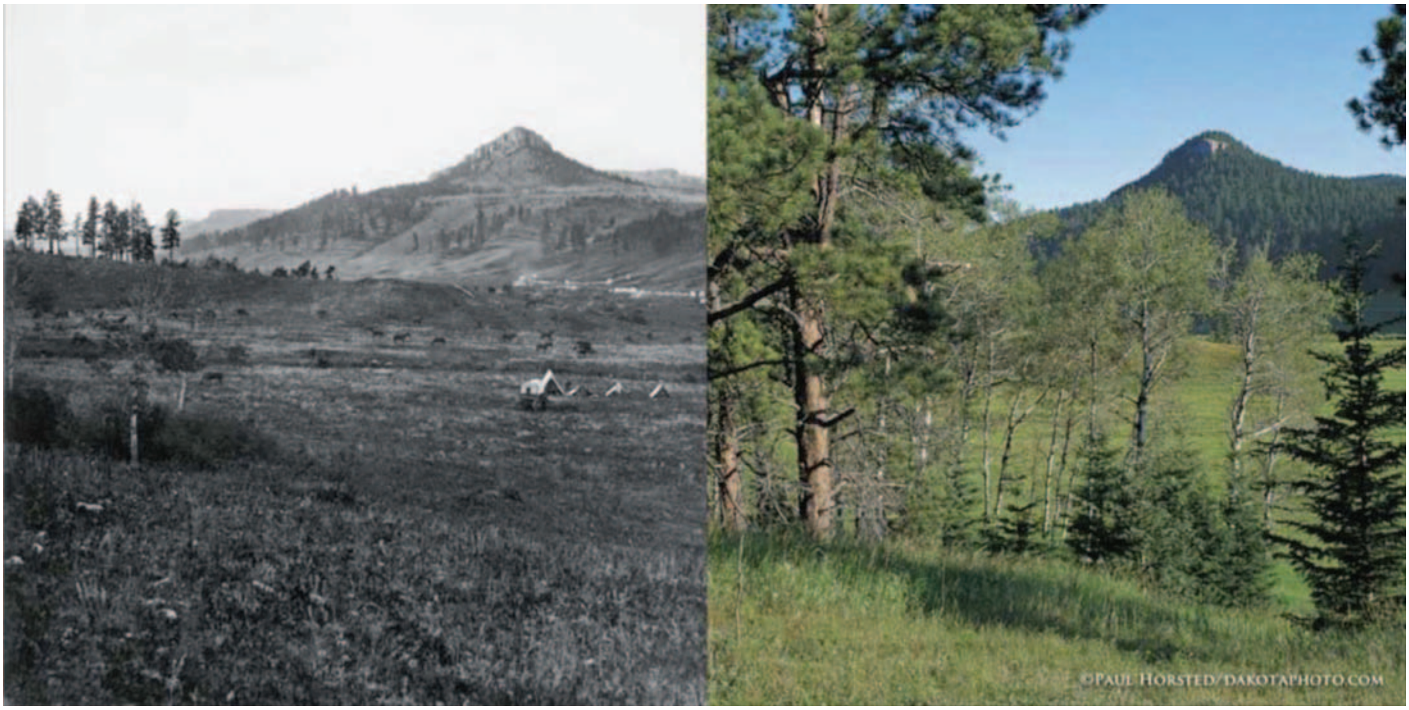

Figure 1. (Left) Black Hills 1874 Custer Expedition photo showing lightly stocked forests. (Right) Contemporary photo showing dense forests surrounding same meadow. (Courtesy of Paul Horsted.)

yearly changes in MPB infestations, and across larger scales.

• Silviculturists need to prioritize treatments, to be efficient, and to use a suite of silvicultural techniques when resource managers and industries lack the capacity to apply the preferred treatment on all acres.

• Silviculturists and other resource managers need ways to efficiently incorporate emerging science and new techniques during the life of large projects.

The Mountain Pine Beetle Response (PBR) Project: Higher Performance, NEPA Efficiency, and within Laws, Regulations, and Policy

In August 2011, the Black Hills National Forest set out to meet these challenges, using an adaptive management approach over a larger scale, with its PBR Project. Based on determination of a pine beetle epidemic by the USDA Forest Service Forest Health and Protection entomologists, the Forest focused its approach under the authority and guidelines of the Healthy Forests Restoration Act of 2003, Section 102(a)(4) as a hazardous fuels reduction project. There are 56 at-risk communities located within the PBR Project. The purpose and need for action are well defined: develop a vegetation condition in the project area that reduces the threat to ecosystem components, including forest resources, from the existing MPB epidemic, and help protect local communities and resources from large-scale wildfire by reducing hazardous fuels (Figure 3).

The PBR Project is forestwide in scope. The project identified forested areas rated as high risk to MPB infestation outside of wilderness areas, roadless areas, botanical areas, and other special areas where response is limited under the Forest Plan. High-risk areas were identified by using risk ratings from research and extracted from the forest spatial database. Approximately 248,000 acres of potential treatment areas were identified. These potential treatment areas were analyzed in this single project to complement the 264,000 acres that had been treated since 2000 on many earlier, smaller project area decisions.

The PBR Project uses adaptive management, design criteria, monitoring, and evaluation to guide its course during the life of the project. It builds on research and known methods while allowing flexibility to adjust to rapidly changing conditions and emerging science. Using its design criteria, specialists identify any additional resource inventory needs and specify the appropriate measure to meet forest and project plan goals and objectives. Silviculturists apply a suite of silvicultural prescriptions or integrated pest management techniques to reduce the spread of MPB, reduce fuels, and manage and protect ecosystem components (USDA Forest Service 2012b, p. 18–19). The Record of Decision, issued in December 2012, implements an array of silvicultural prescriptions over the next 5–7 years across portions of 248,000 acres of high-risk forest to reduce the spread of pine beetles, such as commercial thinning (or other stand density-reducing treatments) on 122,000 acres to make forests more resilient to insects and wildfire.

Silvicultural Treatments in the Black Hills

Several unique characteristics of the Black Hills make the area well suited for management with different silvicultural techniques. Ponderosa pine seed are produced abundantly each year. Frequent rain showers (March–August) and optimal temperatures more than 50° F throughout the growing season contribute to the prolific growth and establishment of ponderosa pine (Shepperd and Battaglia 2002). These conditions allow the silviculturist to use a suite of systems to treat across the landscape.

Even-aged management, using various forms of partial cutting, is commonly applied in the Black Hills. Clearcutting areas over 5 acres or stand-replacing prescribed fire is rarely used. Thinning at the appropriate scale and time continues to make pon-

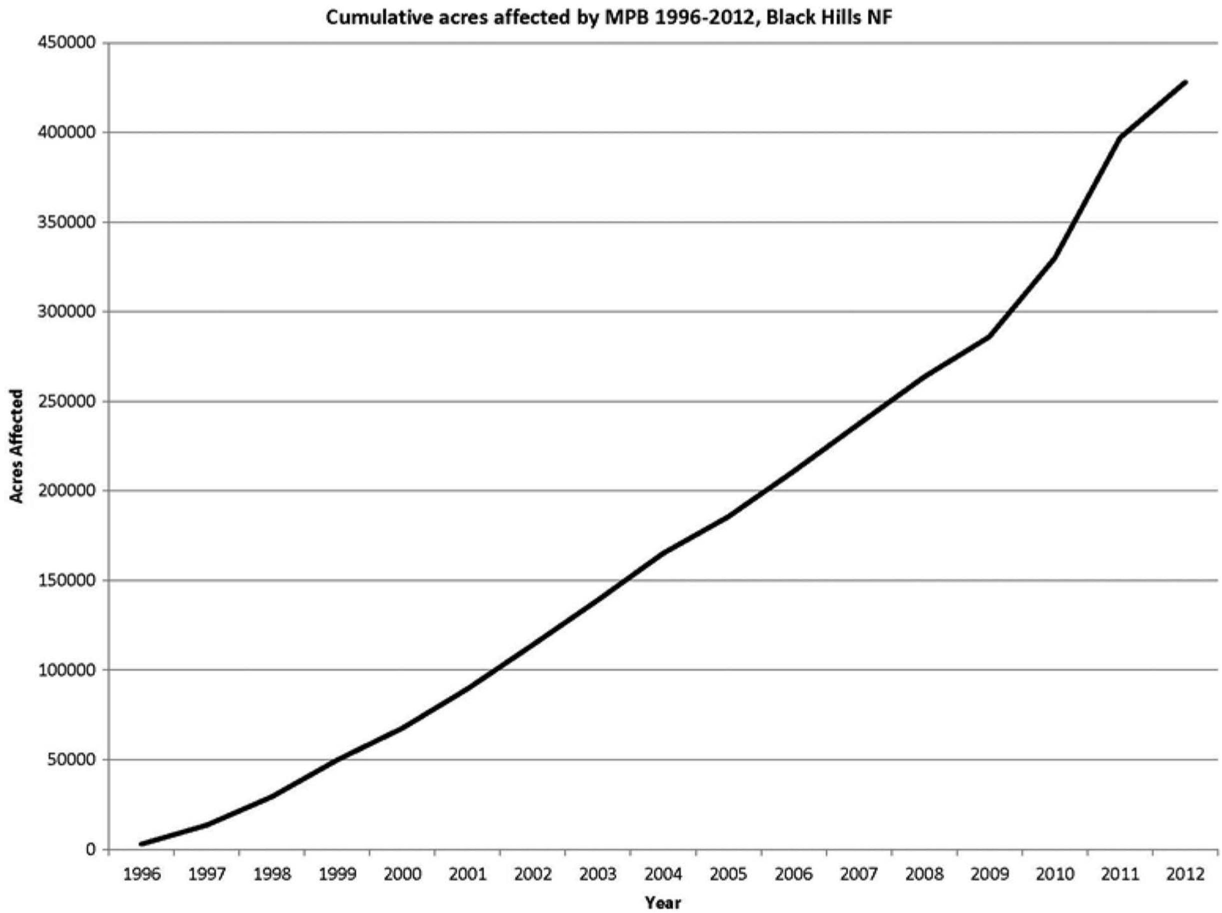

Figure 2. Graph depicting steady, annual increases in MPB infestation from 1996 to 2012, resulting in a cumulative total of 416,000 acres affected on the Black Hills National Forest.

derosa pine forests more resilient to MPB infestations. Monitoring of research plot clusters indicate that thinning reduced MPB-caused tree mortality when sufficient stocking levels of 60 ft^2 of basal area were achieved (Schmid and Mata 2005, Schmid et al. 2007, Allen and Ambourn 2013). Commercial thinning to achieve this stocking level is currently applied on approximately 50% of the some 24,000 acres treated annually on the Black Hills National Forest. Shelterwood and seed-tree systems are commonly used with the abundant natural regeneration of ponderosa pine, which represents nearly 90% of the forest cover type. Most even-aged prescriptions specify whole-tree yarding, often followed by prescribed fire, to reduce the hazardous fuels and improve the Fire Regime Condition Class. Uneven-aged systems, including single tree and group selection, are currently applied on about 10% of the commercially harvested areas and in advance of epidemic infestations of MPB.

The Integrated Pest Management Framework developed for the PBR Project is the basic guide used on the Forest to better understand the tools, techniques, purpose, scope/scale, and various management evaluation points that silviculturists will use to design treatments for a specific landscape. In addition to the silvicultural systems described above, removing individual MPB-infested trees in sanitation cuts and felling and bucking infested trees on site are techniques frequently applied as "holding actions" before even- or uneven-aged systems can be implemented. Spraying individual trees with insecticides is done annually in campgrounds or high-value areas to prevent MPB attack. Although silvicultural and fuels treatments exceed 30,000 acres annually, inadequate funding requires priority setting and ongoing evaluation (Figure 4).

Monitoring and evaluation by specialists and cooperators, with feedback from the public, help guide and adjust landscape-level strategies and tactical techniques to be as efficient and effective as possible. Strategies are evaluated by high-resolution aerial photography and ground sampling to quantify infestation levels after treatments. Uncertainty remains regarding cost-effective sanitation techniques when infested trees cannot be removed from the site. One technique being evaluated is the timing and specifications to fell and buck infested trees ("cut/chunk") as an alternative to felling and removing MPB-infested trees. The PBR Project design engages collaborators, which helped shape the original proposal throughout its implementation to meet the desired conditions (Figure 5).

Collaboration, Integration, and Implementing an "All Lands" Strategy: A Model Approach

The PBR Project provides a "springboard" to apply many of its features across even larger landscapes in the Black Hills and beyond. The collaboration that occurs with this project reflects the broad-based interest for addressing forest conditions in the region generally, regardless of ownership, known as an "all lands" approach. The Black Hills National Forest Advisory Board working with the Forest Service and the Conservation Leaders Group representing states, counties, federal agencies, conservation districts, and a

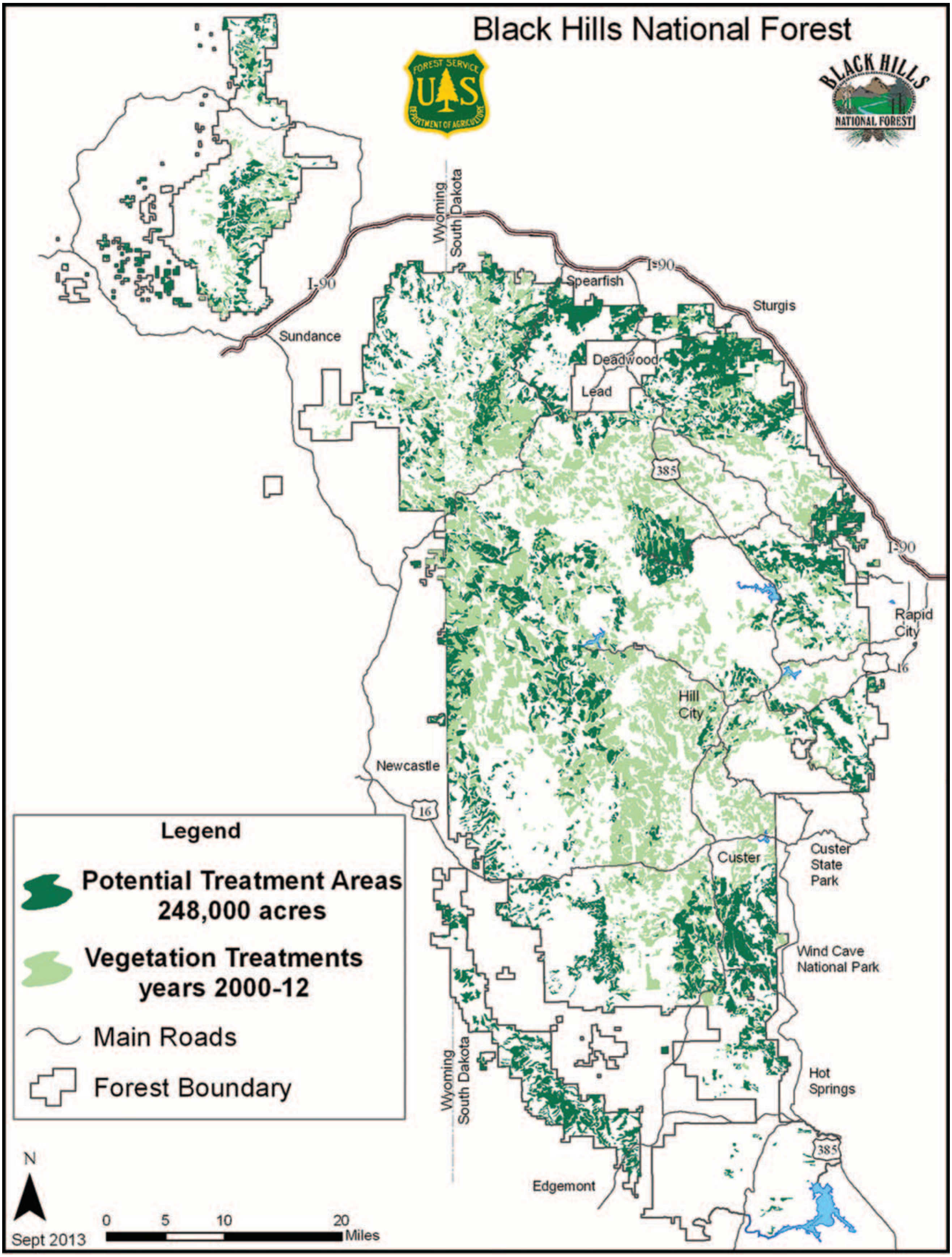

Figure 3. Map shows recent vegetation treatments since 2000 and potential treatment areas under the PBR Project on the Black Hills National Forest.

variety of stakeholders simultaneously developed a long-term MPB strategy. Although each responsible agency or organization retains its authority, this approach leverages public education and learning, joint resource and geospatial intelligence, joint monitoring and evaluation, integrated prioritization and action plans, and implementation across large landscapes. These actions serve as examples for silviculturists to engage at multiple scales (Graham and Bollenbacher 1999, Hann and Bunnell 2001). For the Black Hills National Forest, this allows evaluation and prioritization of approximately 362,000 acres where NEPA is already implemented.

From 2000 to 2012, approximately 264,000 acres have been treated on landscapes of the Black Hills National Forest, with an additional 200,000 acres of mitigation activities on other ownerships. The successes have attracted several million dollars from state governments as well as county and private fund investments to address the MPB. The forest products industry and stewardship contractors have been very nimble in adjusting work plans to priority areas and processed nearly one-third of their production as "blue-stained" wood, demonstrating their commitment to reduce MPB populations. Removing these less valuable trees reduces profitability but improves forest health when MPB-infested trees are taken from the forest, thereby reducing insect spread to nearby trees.

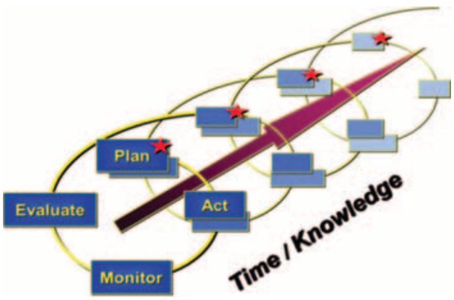

Figure 4. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable ecosystems.

Learning

Silviculturists, fuel specialists, resources managers, contractors, leaders, and stakeholders in the Black Hills have a new working dynamic. Shared learning and cooperative action not only improves efficiency but also builds trust. Much of the uncertainty is centered on what types of MPB mitigation treatments should be used, at what scale, and at the time to be most effective (USDA Forest Service 2013a). Each involved party, while leveraging assets and seeking to do more, understands the collective limits on capacity. It creates an environment of respectful dialogue, a willingness to take risks and learn, and a strong foundation to grow with new challenges.

One of the features of the PBR project and the collaboration in the Black Hills area is the ability to incorporate emerging science at various scales. For example, silviculturists are working with researchers and adapting new marking prescriptions for goshawks, a sensitive species in the Black Hills, based on updated methods from Reynolds et al. (1994). Silviculturists and biologists examine habitat needs across suitable landscapes and adapt stand prescriptions, considering the latest advice from research scientists.

Using the forest-scale PBR Project as a


Figure 5. Landscape thinning on the Black Hills National Forest in advance of mountain pine beetle (Black Hills National Forest photo).

platform, the Black Hills National Forest is applying state-of-the-art science known as the "Wildfire Risk Assessment and Prioritization Process" (Thompson et al. 2012). In this process, resource professionals and cooperators identify resource and public values at risk and then use geospatial modeling to help inform decisions on the priority areas to treat. With the recognition that MPB infestations are contributing to increased dead fuels in untreated areas, this approach allows use of the best available science in ecological restoration planning and implementation. It helps identify more specific areas, including treatments, where industries can obtain sawtimber, small pole material, and wood-to-energy resources consistent with forest plans, current strategies, and shared goals.

The outcomes and trends for the land and communities are the following: reduced threats and more favorable conditions for watersheds, protection of carbon stocks, more diversity, creating and sustaining jobs, and more resilient forest conditions on the Black Hills. The PBR Project serves as a model approach for many of the suggested features cited earlier (USDA Forest Service 2000, Ecological Restoration Institute 2013).

Summary

The PBR Project, with its adaptive management design, gives silviculturists the flexibility to apply an array of treatments across very large landscapes in the best places and at the right time. The adaptive features allow silviculturists to determine priorities and alter treatments based on emerging science and through monitoring and evaluation during the life of the project.

Silviculturists and other resource professionals still need to make hard choices. Even with the flexibility, there is insufficient capacity, due to budget, workforce, ecosystem goals, and capacity in the private sector to treat all areas. Silviculturists need to be engaged and collaborate with diverse interests in setting priorities. Under the collaborative model, silviculturists work in an environment of shared goals, trust, and respect and make adjustments based on the diverse interests that are represented.

The silviculturist can work with the speed and flexibility of the past, while learning, adapting, and applying professional practices at multiple scales in dynamic environments to ensure silviculture matters. It is back to the future.

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