

Rocky Mountain Forests at Risk

Confronting Climate-driven Impacts from Insects, Wildfires, Heat, and Drought

HIGHLIGHTS

An unprecedented combination of tree-killing insects, wildfire, and heat and dryness is putting the forests of the Rocky Mountains at greater risk than ever before in U.S. history. Scientific evidence shows that climate change is the major force driving these changes.

If today's trends continue, even hotter and drier conditions in the future could cause important forest tree species to decline substantially in much of the region, fundamentally changing Rocky Mountain landscapes. But we can take action today to prevent the worst impacts on Rocky Mountain forests and preserve them for current and future generations, by managing them for resilience, increasing the capacities of forest managers and vulnerable communities, and reducing our emissions of heat-trapping gases.

Americans revere the Rocky Mountains for their aesthetic, environmental, and economic value. The Rockies are home to some of the crown jewels of the national park system, including Yellowstone, Grand Teton, Glacier, and Rocky Mountain National Parks. These parks alone receive 11 million visitors each year and generate more than \$1 billion annually in visitor spending. Another 60 million people visit the region's 37 national forests each year.

Today, however, the forests of the Rocky Mountains are facing a triple assault: tree-killing insects, wildfires, and heat and drought. If allowed to continue unchecked, these stresses and their impacts could fundamentally alter these forests as we know them.

Human-caused global warming is driving these detrimental effects by bringing hotter and drier conditions, which not only cause their own effects but amplify those of other stresses. An exceptionally hot and dry stretch from 1999 to 2003 produced unusually severe impacts on the region's forests. If these trends continue, even hotter and drier conditions could become commonplace, leading to even greater effects on Rocky Mountain forests.

This report documents the latest evidence on how climate change is already disrupting the forests of the Rocky Mountain region and what scientists project for the decades ahead, and suggests how we can best meet these challenges.



Recent outbreaks of mountain pine beetles and other insects have left mountainsides like these in Colorado's Flat Tops Wilderness colored reddish-brown by dead and dying conifers.



National Park Service/Mike Lewelling

Large wildfires, such as the 2013 Alder fire in Yellowstone National Park, have become more frequent in Rocky Mountain forests, driven largely by a changing climate.

Tree-Killing Insects

Native bark beetles have always been agents of change in western forests. In the early 2000s, however, bark beetle outbreaks across western North America, including the Rocky Mountain region, killed more trees, at a faster pace, for longer periods, and over more acreage than any other known infestations.

From 2000 to 2012, bark beetles killed trees on 46 million acres—an area just slightly smaller than Colorado. The U.S. Forest Service estimates that as many as 100,000 beetle-killed trees now fall to the ground every day in southern Wyoming and northern Colorado alone.

The changing climate played a key role in these outbreaks. Exceptionally hot, dry conditions stressed and weakened trees, reducing their ability to ward off the beetle attacks. Milder winters meant less extreme cold in winter—which had previously kept beetle populations in check. Higher temperatures also allowed more beetles to produce offspring in one year instead of two, leading to explosive population growth.

More Wildfires

Wildfires have always been an important feature of the forest cycle. But in today's Rocky Mountain forests, the number of large wildfires has risen dramatically. One study documented

Bark beetles killed trees on 46 million acres in the western United States from 2000 to 2012—an area slightly smaller than the 48-million-acre state of Colorado.

a 73 percent increase in the annual number of large wildfires in the region from 1984 to 2011. Another study compared western wildfires in two time periods: 1970 to 1986 and 1986 to 2003. During the more recent period, nearly four times as many large wildfires occurred, they burned nearly seven times as much total area, and wildfire seasons lasted two and a half months longer.

A robust body of scientific research has linked these increases in wildfires to a changing climate. One important change is higher spring temperatures, which produce earlier spring snowmelt and peak streamflows, leaving forests drier and more flammable in summer. The recent increases in wildfires are also affecting people, especially because many more now live in and adjacent to forests and woodlands, where they and their property are vulnerable.

More Heat and Dryness

Besides increases in tree-killing insects and wildfires, scientists have found a rise in “background mortality”—the rate at which trees die from no obvious cause. For example, tree mortality in relatively undisturbed old-growth forests across the West has doubled in recent decades, with no compensating increase in the number of tree seedlings. And tree mortality has been highest in recent years. Scientists suggest that hotter and drier conditions across the West are driving these changes.

Impacts on Iconic Tree Species

These threats are already severely affecting three iconic tree species of the Rocky Mountains: whitebark pines, aspens, and piñon pines.

Whitebark pines (*Pinus albicaulis*)—a high-elevation species with unique ecological importance in the Northern Rockies—have faced both blister rust and epidemic-level infestations of mountain pine beetles, part of the recent West-wide outbreak. Earlier outbreaks of mountain pine beetles at high elevations were shorter and less severe, because winter temperatures were typically cold enough to kill the beetles. However, the sustained higher temperatures of recent winters have allowed the beetles to overwinter and thrive.

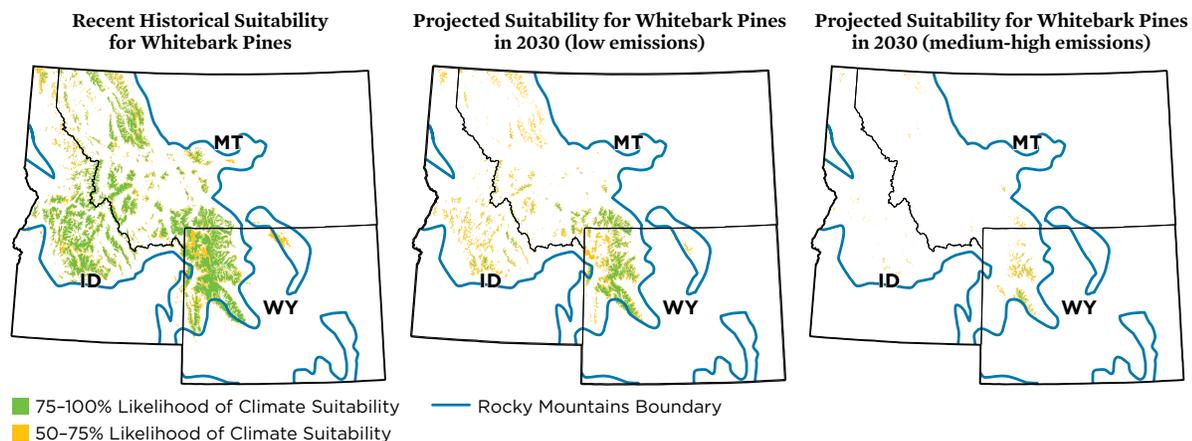
The West had nearly four times as many large wildfires during the period 1987 to 2003 compared with 1970 to 1986.

Today whitebark pines are in catastrophic decline throughout their range in western North America. Mortality in some areas has been 90 percent to 100 percent. This die-off has led the U.S. Fish and Wildlife Service to determine that they are in such risk of extinction that they qualify for listing under the Endangered Species Act.

Quaking aspens (*Populus tremuloides*), an emblematic species of the Rocky Mountains, have seen abrupt and extensive die-off across large areas of their range, in response to extreme heat and dryness at the beginning of this century. From 2000 to 2010, some 1.3 million acres in the Southern Rockies saw significant aspen decline, and regeneration of new aspens has been much lower than normal.

Piñon pines (*Pinus edulis*) are a foundation species of the forests that flank the Southern Rockies and many other areas in the Southwest. In 2002–2003, these areas suffered a mass die-off of piñon pines triggered by severe drought and exceptional

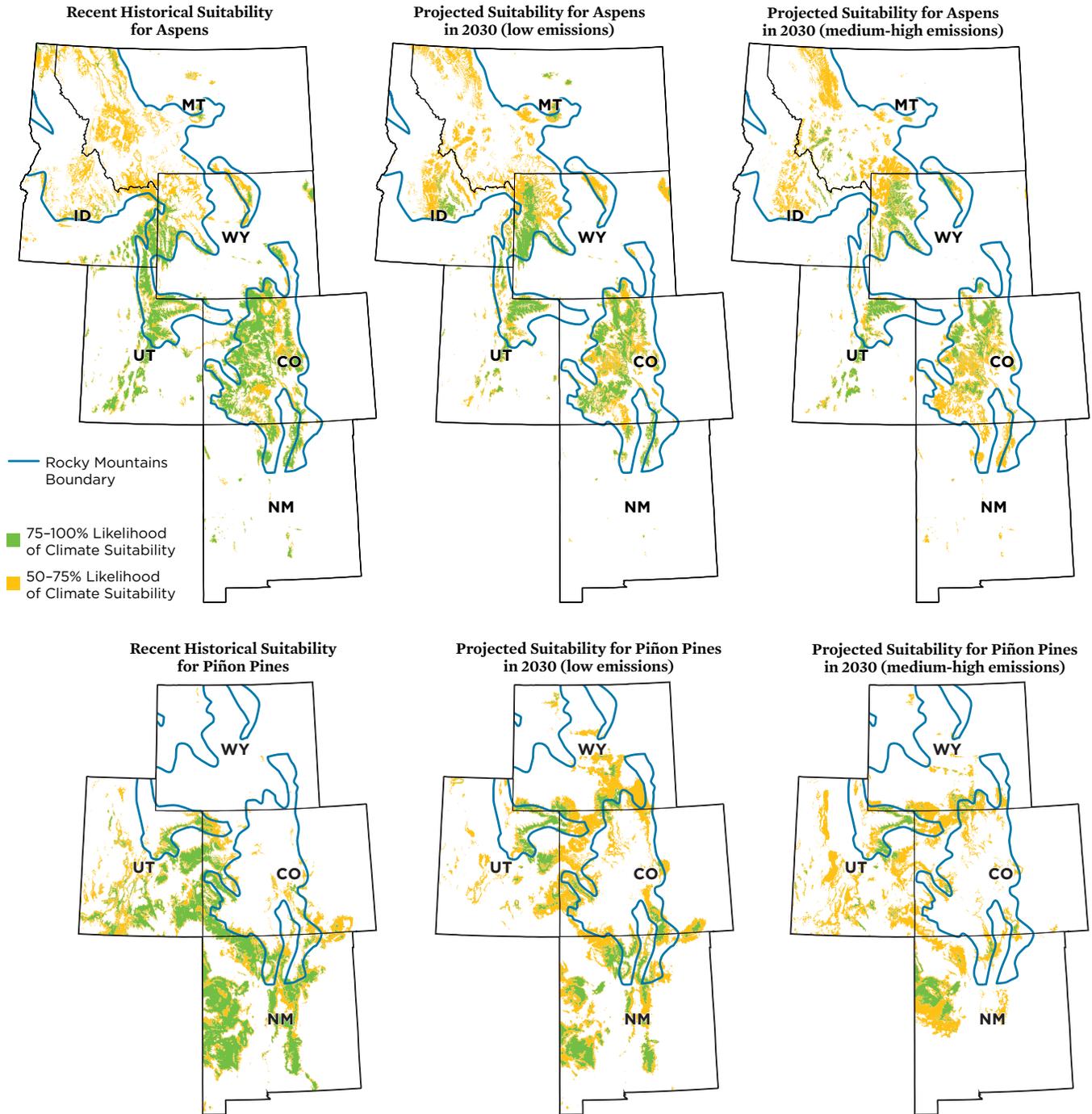
Modeled Suitable Range for Whitebark Pines—Today and under Two Climate Scenarios



Climate change is projected to greatly reduce the amount of western land suitable for whitebark pines. These maps depict areas modeled to be climatically suitable for the tree species under the recent historical (1961–1990) climate (left), conditions projected for 2030 given lower levels of heat-trapping emissions (center), and conditions projected for 2030 given medium-high levels of emissions (right). Areas in yellow have a 50–75 percent likelihood of being climatically suitable according to the models; areas in green have more than a 75 percent likelihood. These models do not address other factors that affect where species occur, such as soil types. (The two future emissions levels are the B1 and A2 scenarios of the Intergovernmental Panel on Climate Change, respectively.)

SOURCES: BASED ON USFS MOSCOW LAB 2014 AND USFS N.D. C.

Modeled Suitable Ranges for Aspens and Piñon Pines—Today and under Two Climate Scenarios



The degree of climate change will affect the amount of western land suitable for aspens (top) and piñon pines (bottom) in 2030. The maps on the left depict areas modeled to be climatically suitable for the tree species under the recent historical (1961–1990) climate; the maps in the center depict conditions projected for 2030 given lower levels of heat-trapping emissions; the maps on the right depict conditions projected for 2030 given medium-high levels of emissions. Areas in yellow have a 50–75 percent likelihood of being climatically suitable according to the models; areas in green have more than a 75 percent likelihood. These models do not address other factors that affect where species occur, such as soil types. (The two future emissions levels are the B1 and A2 scenarios of the Intergovernmental Panel on Climate Change, respectively.)

SOURCES: BASED ON USFS MOSCOW LAB 2014 AND USFS N.D. C.

Projected Changes in Land Area Suitable for Aspens, Rocky Mountain Region

State	1961–1990	2060			
	Recent Historical Suitability (acres)	Projected Suitability (acres)	Area Lost (%)	Area Gained (%)	Net Area Lost (%)
Colorado	18,210,000	10,060,000	-60	16	-45
Idaho	13,090,000	1,972,000	-97	12	-85
Montana	20,670,000	6,039,000	-81	11	-71
New Mexico	3,799,000	975,000	-77	2	-74
Utah	10,130,000	2,815,000	-75	3	-72
Wyoming	9,633,000	7,449,000	-71	48	-23
Total	75,532,000	29,310,000	-77	15	-61

More than 75 percent of the historical range for aspens in the Rocky Mountain region is projected to become unsuitable for them by 2060, given medium-high levels of heat-trapping emissions (the A2 scenario of the Intergovernmental Panel on Climate Change). Other areas—equivalent to 15 percent of the historical area—are projected to become newly suitable. Overall, aspens in the Rocky Mountains face a projected decline of about 60 percent in suitable area. “Projected Suitability” encompasses those areas projected to have a 40 percent or greater likelihood of being climatically suitable for aspens in 2060. These models have inherent uncertainties; for more details see www.ucsusa.org/forestannex.

SOURCE: WORRALL AND MARCHETTI 2014, BASED ON WORRALL ET AL. 2013.

heat. Sites in Mesa Verde National Park in Colorado, near Los Alamos in northern New Mexico, and near Flagstaff, AZ, lost some 90 percent of their piñon pines. One team of scientists described the mass piñon pine die-off as “one of the most extensively documented examples of a sudden ecosystem crash in response to climate change.”

The Driver: Climate Change in the Rockies

The Rocky Mountain region has warmed more than the country as a whole since 1895, when modern record keeping began. Rising regional temperatures have led to reduced spring snowpacks, earlier snowmelt, and earlier peak streamflows. A growing number of studies conclude that these changes in western temperature and hydrology are outside the range of natural variability—driven largely by climate change.

An exceptionally hot and dry period occurred from 1999 to 2003, when the region recorded the second-hottest five-year interval since 1895, and the fourth-lowest five-year precipitation total. And 2002 was the driest year since 1895, with precipitation 22 percent below average. This exceptionally hot, dry period triggered many of the forest impacts documented in this report.

If climate change continues unchecked, scientists expect the region to become even hotter and drier—and the impacts on its forests even more severe. Depending on future levels of our heat-trapping emissions, the regional climate may be

much hotter and perhaps drier later this century than even from 1999 to 2003. And if these emissions remain high, temperatures would be far hotter than they have been in several thousand years.

Our new analysis of information used in the 2014 National Climate Assessment shows that, given very low future carbon emissions, average temperatures in the six Rocky Mountain states could rise to about 3°F above 1971–2000 levels by mid-century and remain that high into the last decades of the century. However, if emissions continue unchecked, average temperatures could rise by about 6°F by mid-century—and by 10°F in the last decades of the century.

Robust science offers strong evidence of what likely lies ahead for Rocky Mountain forests. As the report explains in detail, scientists project the following effects:

- Further increases in bark beetle outbreaks, including expansion into new areas, are likely.
- Large, intense, and more frequent fires will occur in western forests. Even relatively modest temperature increases will likely mean large increases in acreage burned.
- In the Northern Rockies, earlier snowmelt and reduced spring snow cover, driven by higher temperatures, will create new water stresses and lead to a substantial decline in forest vitality.
- Although all such projections have inherent uncertainty, if climate change continues along today’s trends, modeling

projections suggest that the climate would become less suitable for widespread, characteristic conifer species such as lodgepole pine, Engelmann spruce, ponderosa pine, and Douglas fir, as well as iconic species including whitebark pine, aspen, and piñon pine. These species could be eliminated from much of their current ranges, potentially changing the fundamental makeup and extent of Rocky Mountain forests.

A Call to Action

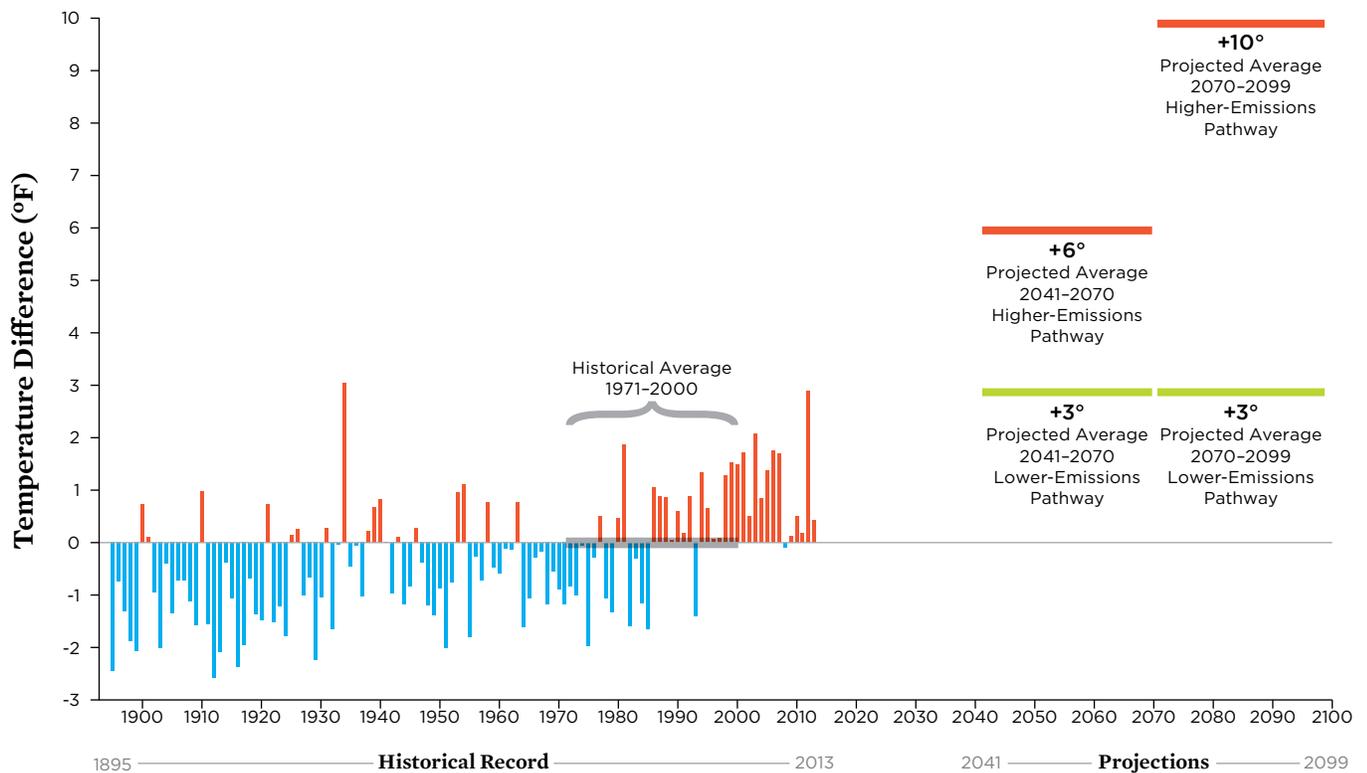
The dramatic impacts Rocky Mountain forests already face—coupled with scientific understanding of what is driving them—mean that unchecked heat-trapping emissions will bring more abrupt, damaging, and potentially irreversible effects.

The future of these forests depends on the speed and effectiveness of our efforts to limit global warming emissions, as well as to reduce other stresses.

We propose six sensible, practical steps to guide our efforts to protect these precious resources:

- **Assess risks.** More detailed scientific information will help policy makers choose the right priorities for managing these forests. The U.S. Forest Service has issued a new climate change response strategy calling for assessing risks as the first of three essential steps. Other agencies have also begun assessing the vulnerabilities to forested lands in the face of climate change, as well as gaps in our knowledge about those risks.
- **Engage stakeholders.** Because the effects of climate change on Rocky Mountain forests are so complex, engaging partners in seeking solutions is critical to managing

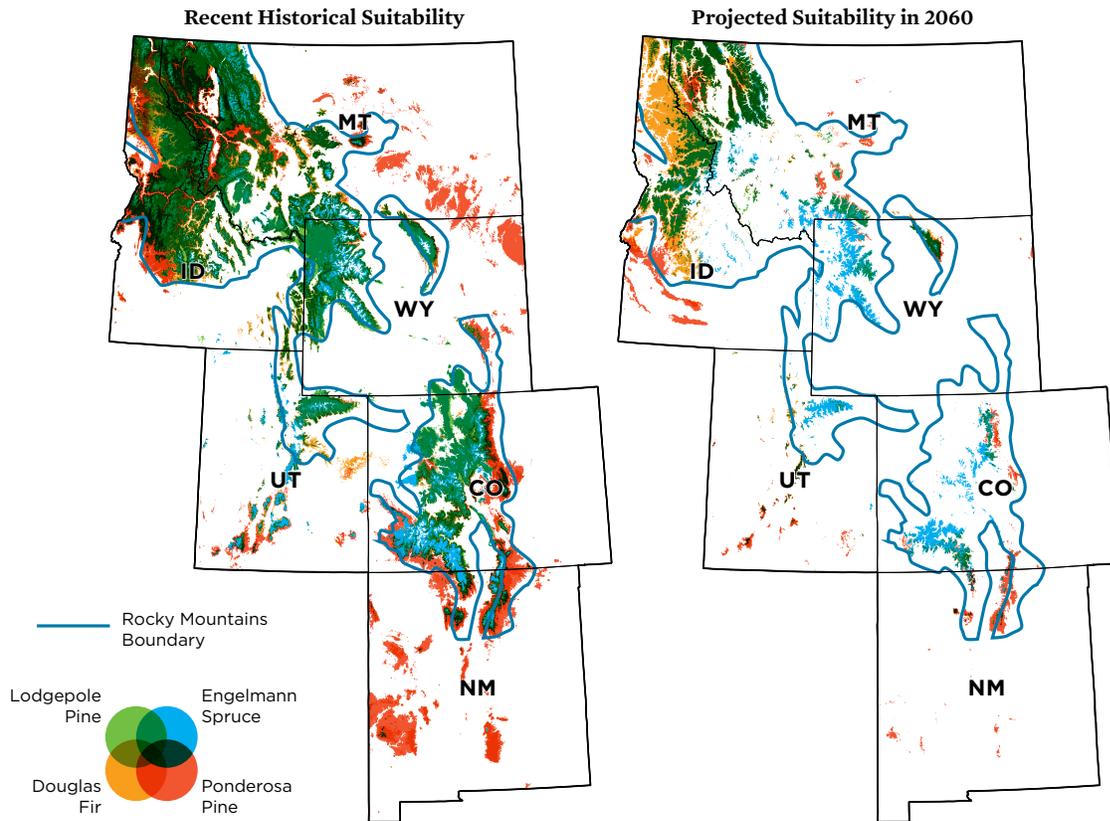
Changes in Average Temperatures in the Rocky Mountain Region—Historical and Projected



Average temperatures in the six Rocky Mountain states have risen and are projected to rise further, with the increase depending on heat-trapping emissions. The left side of the figure shows changes in average temperatures from 1895 to 2013 compared with the 1971–2000 average. The right side of the figure depicts projected changes in average temperatures for 2041–2070 and 2070–2099 compared with the 1971–2000 average. Changes in future averages are projections from multiple climate models, based on lower emissions (representative concentration pathway, or RCP, 2.6) and higher emissions (RCP 8.5). If future emissions are high, average annual temperatures could be far higher than historical levels, with dramatic effects on Rocky Mountain forests.

SOURCES: WRCC N.D.; KUNKEL AND STEVENS 2014, BASED ON WALSH ET AL. 2014.

Projected Changes in Suitable Ranges for Key Rocky Mountain Tree Species



Much of the current range of these four widespread Rocky Mountain conifer species is projected to become climatically unsuitable for them by 2060 if emissions of heat-trapping gases continue to rise. The map on the left shows areas projected to be climatically suitable for these tree species under the recent historical (1961–1990) climate; the map on the right depicts conditions projected for 2060 given medium-high levels of heat-trapping emissions. Areas in color have at least a 50 percent likelihood of being climatically suitable according to the models, which did not address other factors that affect where species occur (e.g., soil types). Emissions levels reflect the A2 scenario of the Intergovernmental Panel on Climate Change.

SOURCE: UCS ANALYSIS OF PROJECTIONS FROM USFS MOSCOW LAB 2014; MAP BASED ON USFS N.D.



Grasslands like these in New Mexico's Continental Divide Wilderness Study Area, along with shrublands and other non-forest ecosystems, could replace some forests, especially in the southernmost Rocky Mountains.

these impacts. Indeed, the Forest Service posits engaging stakeholders as the second pillar of its climate change response strategy. Early examples of stakeholder engagement are already yielding lessons on which to build.

- **Manage for resilience.** In 2012, the U.S. Forest Service adopted “managing for resilience” as the third principle of its climate change response strategy. Managing for resilience begins with incorporating information on climate change into decisions on protecting important resources, and includes tackling other stresses that combine with climate change to produce cumulative effects on forests.
- **Increase the capacity of public agencies.** To combat the severe threats to Rocky Mountain forests and other national resources from climate change, public land managers must take an extraordinary suite of actions. Yet Congress has not even provided the relatively limited funds that federal agencies have requested for this essential work. Congress should provide the funds that the federal land-management agencies need to fulfill their responsibility to protect our nationally significant natural resources from climate change—in the Rocky Mountains and elsewhere.
- **Address the vulnerability of communities.** The impacts of climate change on forest resources will affect communities throughout the region and the nation. State and local governments, with federal agencies, need to assess existing impacts and consider those of future climate scenarios, and then work with others to combat them. Some effects, such as the growing risks of wildfire in the wildland-urban interface, will require federal, state, and local cooperation to reduce the exposure of people, property, and resources and to prepare for and respond to the remaining risks.

- **Reduce emissions.** The future of Rocky Mountain forests ultimately depends on how much and how quickly we can curb heat-trapping emissions. As individuals, we can help by taking action to reduce our personal carbon emissions. But to fully address the threat of global warming, we must demand action from our elected leaders to support and implement a comprehensive set of climate solutions.

Reducing emissions can strengthen our economy. For example, the public health and climate benefits of the Clean Power Plan of the Environmental Protection Agency will be worth an estimated \$55 billion to \$93 billion per year in 2030—far outweighing the costs of \$7.3 billion to \$8.8 billion. State and local governments also have an essential role to play in reducing emissions, and many are taking action to curb emissions and climate change while promoting economic growth.

For the many Americans who cherish the forested landscapes and snowy peaks of the Rocky Mountains as iconic images of the American West, the choice is stark: unless we want to sit by and watch this majestic landscape and treasured resource degrade irrevocably, we must act now to preserve it.

If climate change continues unabated, important tree species may decline substantially—fundamentally altering the region’s landscape.

FIND THE FULL REPORT ONLINE: www.ucsusa.org/forestsatrisk
AND AT: www.rockymountainclimate.org/reports_6.htm

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CLIMATE**
Organization

The Rocky Mountain Climate Organization works to reduce climate disruption and its impacts, to help keep the Interior West the special place that we cherish. We do this in part by spreading the word about what a disrupted climate can do to us and what we can do about it.

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