Forest Health Study

TEN

TAKEAWAYS

to Inform the Colorado Water Plan

INTRODUCTION

Forest health is an important driver of overall watershed health and water resources in Colorado. Because of its importance, the Colorado Water Conservation Board (CWCB) is placing additional focus on forest health in the pending update to the Colorado Water Plan.

The CWCB completed a study of the "state of the science" surrounding watershed and forest-health-related issues that impact water quality and quantity. Staff reviewed findings from recent forest health research, identified active workgroups focused on watershed and forest health, and assessed modeling and analysis tools for critical decision making. The research helped the CWCB better understand the knowledge gaps, challenges, and opportunities related to forest health. Stakeholder outreach was another critical part of this assessment. The CWCB conducted 30 interviews with state and local subject matter experts on forest and watershed health. The subject matter expert interviews provided grassroots insight into the challenges and opportunities regarding forest health. To highlight their feedback, this document includes either direct quotes from various interviews or figures that summarize interview responses.

This white paper identifies 10 "takeaways" that emerged from the research and interviews conducted in the study which will inform the statewide context, challenges, and opportunities around forest health. The takeaways tell the story of how the CWCB will consider forest health in the Colorado Water Plan update and provide ideas for how basin roundtables can support healthy forests and watersheds. This document can guide stakeholders in their local forest health and/or watershed health enhancement efforts.

ALIGNING WITH THE COLORADO WATER PLAN:

What do we know about forest health efforts and what are the challenges?

This document focuses on 10 takeaways from the CWCB's forest health study that will inform the update to the Colorado Water Plan in 2022.

OUTREACH STATISTICS

CONDUCTED

30

INTERVIEWS

with Forest Health experts across the state

COLLECTED INFORMATION ON

30 STUDIES + **14** MODELS & TOOLS

ENGAGED

13

ORGANIZATIONS

Colorado State Forest Service, U.S. Forest Service, Colorado Forest Restoration Institute, Conservation Districts, The Nature Conservancy, Mountain Studies Institute, Colorado State University, local Utilities (Denver Water, Aurora Water, Colorado Springs Utilities), U.S. Department of Agriculture, Consultants, Colorado Forest and Water Alliance

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Dan Omasta	Regional Program Officer, Great Outdoors Colorado
Ellen Roberts	Southwest Wildfire Impact fund
Eric Howell	Colorado Springs Utilities Forest Program Manager
Heather Dutton	San Luis Valley Water Conservancy District
Jessie Olson	Left Hand Watershed Center
Kevin Zimlinghaus	U.S. Forest Service - Arapahoe/Roosevelt National Forests and Pawnee National Grasslands
Mark Shea	Arkansas Basin Roundtable Chair
Maya MacHamer	Boulder Watershed Collective
Michael Remke & Anthony Culpepper	Mountain Studies Institute
Mike McHugh	Aurora Water
Mike Preston	Steering Committee RMRI SWCO, Coordinating Committee Dolores Watershed and Resilient Forests Watershed, Weenuch-u' Development Corporation, Forest Health Advisory Council
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Nancy Fishering	Colorado Forest and Water Alliance
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Sandy White	Arkansas Basin Roundtable Member
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Brown AND Caldwell *This document was developed with the assistance of Brown and Caldwell*

ONE

FOREST HEALTH *is a part of*
WATERSHED HEALTH

TWO

THE SCIENCE IS EVOLVING
and points to a range of outcomes

THREE

CLIMATE CHANGE IS FOREST CHANGE...
but changes are unclear

FOUR

SUPPORT AND LEARN
from working groups

FIVE

We support
THOUGHTFUL DECISION MAKING

SIX

Colorado-specific
RESEARCH IS KEY

SEVEN

WILDFIRE, DROUGHT, *and* **FLOOD**
are **COSTLY**

EIGHT

Climate change and natural hazards have
RISING COSTS

NINE

Planning scenario updates
SHOULD CONSIDER FOREST HEALTH

TEN

We need to **KEEP SUPPORTING**
and funding research and planning

IDEAS

IDEAS
for Basin Roundtables and the Colorado Water Plan Update

ONE

FOREST HEALTH
is a part of
WATERSHED HEALTH

Context

Forest health and watershed health are closely linked. A majority of Colorado's water supply comes from forests in the Rocky Mountains (Hutson et al, 2004; Venable et al, 2017). Colorado's forests cover a little over a third of the state (about 24 million acres). Our forested watersheds are home to birds, fish, and wildlife. Healthy forests influence water supply in many ways, principally by enhancing soil moisture storage and groundwater recharge, moderating the timing of snow melt and runoff, reducing the likelihood of flooding, protecting soil and preventing erosion, filtering contaminants, and protecting and maintaining plant communities (CSFS, 2009; CSFS, 2016b; Venable et al 2017).

Colorado's forested watersheds provide critical water supplies to rural agricultural areas and support $41 billion in economic output from agricultural activities (CSFS, 2020). Healthy forests are central to many of the recreational opportunities that make Colorado an attractive place to live. A recent study entitled "The Economic Contributions of Water-related Outdoor Recreation in Colorado" cited $18.8 billion of economic output from water-related outdoor recreation in Colorado in 2019 (Business for Water Stewardship, 2020).

WATERSHED

A watershed is an area of land that connects and drains rain or snow into rivers, lakes, and wetlands. These areas supply water for drinking, agriculture, and industry, and provide recreation opportunities. Watersheds provide vital ecosystem services, such as habitat, carbon sequestration, and water supply filtration.

WATERSHED HEALTH

Watershed health is a measure of ecosystem structure and function. Functional, healthy watersheds are resilient, i.e. they are able to absorb and recover from disturbances. Healthy forested watersheds infiltrate snowmelt and rain, store and filter it in the soil, and yield clean water to streams and groundwater.

FOREST HEALTH

Forest health is a measure of the processes and factors that lead to ecological sustainability and the degree to which forests meet human needs.

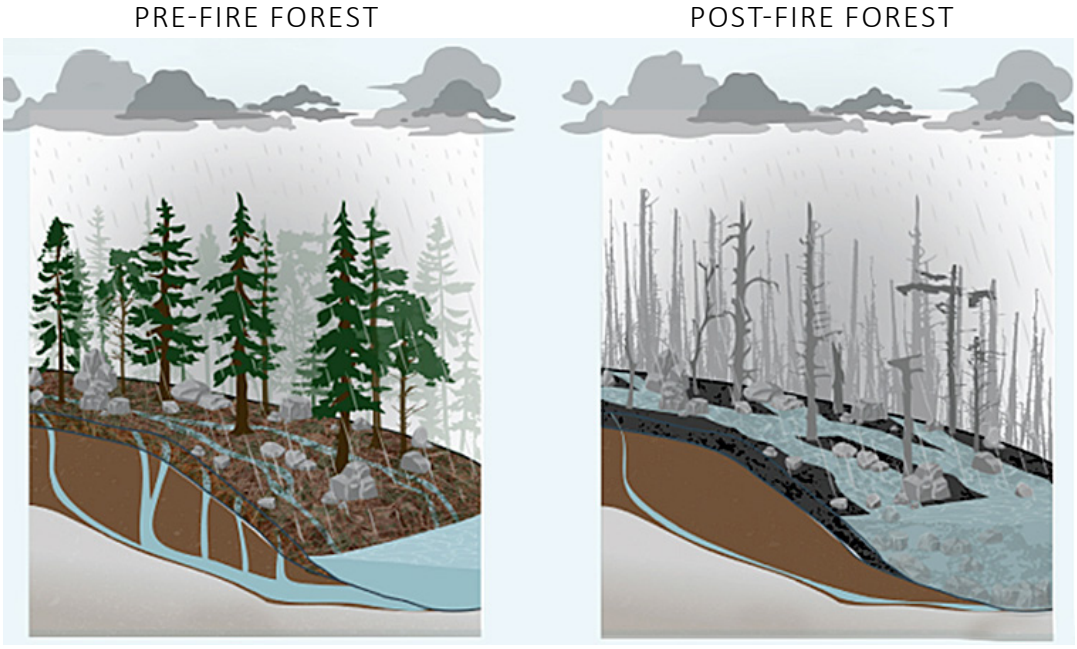


Illustration credit: Water Education Colorado and USGS

Challenges

The health of Colorado's forests is a concern as wildfire risk has increased due to drought, fuel buildup, and insect outbreaks. Healthy forests are critical to thriving watersheds that provide our water supplies and sustain ecosystem services. However, too often, the conversation about forest health is disconnected from that of overall watershed heath. In most of the state, forest health and watershed health are directly related and must be considered in an integrated way.

Forest disturbances, such as a severe fire, can diminish a forest's health. Certain severe fires can create water-repellent or "hydrophobic" soils. After these fires, rain events can flush ash, sediment, and nutrients into waterways and impact essential water infrastructure and water quality. The illustration above shows an example of a healthy forested watershed versus a post-fire environment, respectively.

Forest disturbance, such as wildfire and insect and disease outbreaks, are a natural part of the cycle of forested landscapes. Over the last two decades, however, Colorado has witnessed both growing numbers of large, high-severity wildfires and unprecedented levels of tree mortality caused by bark beetle outbreaks. Recent research has advanced scientific understanding regarding the watershed implications of these disturbances, yet much remains to be learned. Projections of increased disturbance frequency and severity have therefore created concerns regarding the sustained delivery of clean water from headwater forests (Venable et al, 2017).

OUR FORESTED WATERSHEDS ARE CRITICAL

80% of COLORADO RESIDENTS rely on forested watersheds for municipal water supplies

$41B of economic output from AGRICULTURAL ACTIVITIES are supported by water supplies from forested watersheds

$18.8B of economic output from water-related OUTDOOR RECREATION in Colorado

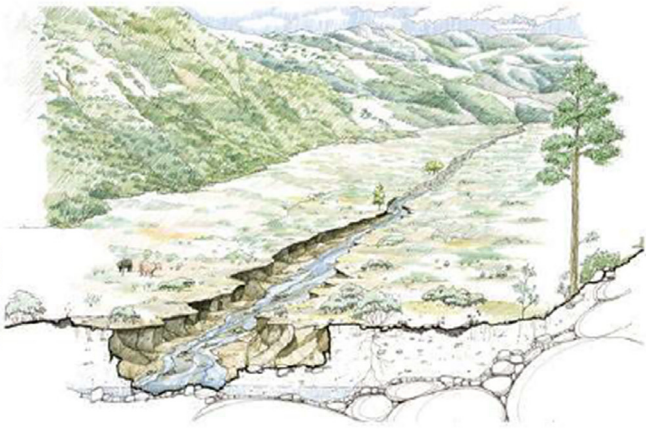
Opportunities

Thriving watersheds are vital to our environment and economy and to the water supplies that sustain them. Improving and maintaining the health of our watersheds is an opportunity to provide resiliency in the face of climate change and the associated risks to our forests. The illustration below demonstrates how healthy meadows can provide resiliency. Healthy meadows support floodplain functions that help mitigate increases in post-fire runoff and sediment transport, limiting impacts of wildfires to downstream water uses. However, unhealthy meadows may do little to slow post-fire flood flows or capture sediment, which increases risk to downstream water uses.

The Colorado Water Plan will identify actions that support thriving watersheds and will integrate forest-health-related discussions and actions into management strategies related to creating and sustaining healthy, thriving watersheds.

Environmental needs, watershed health, and forest health are all interconnected in a thriving watershed. Stream, watershed, and forest management projects are crucial to protecting water supplies and improving watershed resilience to climate change.

Healthy Meadow



Impacted Meadow

Illustration credit: National Park Service and Restoration Design Group for American Rivers

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TWO

THE SCIENCE IS EVOLVING

and points to a range of outcomes

Context

The scientific understanding of the relationship between forest health and watershed health is rapidly evolving. Research on the relationship between forest/watershed health and water supplies suggests there are a range of outcomes that are directly related to forest structure, climate, and topography. Furthermore, climate change and other human-induced stressors are poised to alter wildfire patterns and ultimately forest composition, which will have unknown effects on watershed health.

Recent research has challenged the widespread assumption that forest cover loss results in increased water yield due to the decrease of evapotranspiration. Extensive tree mortality in Colorado has provided the opportunity to evaluate the hydrologic response to forest disturbance in a variety of watersheds. Some relevant papers described below explain the complexities of the forest health and watershed health nexus:

- A 2020 study that evaluated the hydrologic response to forest disturbance in 78 watersheds found that, while most cases resulted in increased stream yield, certain forest conditions did not result in increased yield, particularly in cases where disturbance was due to drought, insects, or low-severity wildfire. Hydrologic response depends on vegetation structure, climate, and topography (Goeking and Tarboton, 2020).
- A 2015 study evaluated the annual streamflow changes in eight watersheds in central Colorado following a beetle kill infestation. Changes in streamflow post-beetle kill were generally undetectable and even decreased in one severely impacted watershed (Biederman et al., 2015).

In Goeking's research of 78 studies of stream flow response to disturbance, some observed a post-disturbance increase in water yield while others observed a decrease. Definitive projections of how forest disturbance will affect streamflow in a watershed requires a comprehensive understanding of interactions among tree canopy, topography, and climate across the landscape. Identifying and characterizing these relationships in critical watersheds impacted by forest disturbance will add to the understanding of streamflow response factors.

> *"Severe wildfires are burning more frequently in sensitive high-elevation watersheds where wildfires are historically uncommon. The long time interval between these wildfires combined with changing climate conditions create significant uncertainty about responses to the 2020 wildfire season."*
>
> *—CHUCK RHOADES, U.S. Department of Agriculture, U.S. Forest Service, Research Biogeochemist, Rocky Mountain Research Station*

In addition to altering hydrologic responses, forest disturbances can degrade the water quality and water infrastructure capacity for years. Flash flooding of a post-fire watershed can carry burnt earth and debris into reservoirs and water infrastructure sites. More information related to recent literature from post-wildfire studies in Colorado can be found in **Takeaway 7**.

Challenges

A primary challenge in the rapidly evolving field of forest health and watershed health is disseminating the results of research and communicating important findings in a timely manner to stakeholders so they can make good management decisions based on the best science. The research and information are plentiful; however, connecting this information to decision making is critical, and too often research and action do not make a practical connection. Also, research efforts need to continue so that a clearer understanding of the relationship between forest health and hydrology in Colorado's varying topographies, climates, and ecosystems can be developed.

Opportunities

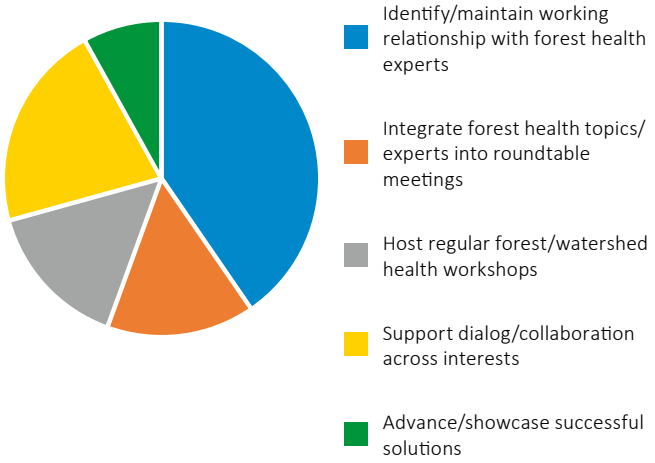
Effective and timely communication of forest health research and findings will help stakeholders better understand forest health issues and pursue actions that are supported by the best science. Forest health experts provided the CWCB with meaningful feedback on how forest health and watershed health advocates can stay in touch with the research efforts on forest health as it relates to watershed health. Five main themes that emerged from the experts' feedback are summarized in the pie chart on this page.

Interviewees identified the following organizations as forest health experts that are leading innovative and informative research across Colorado:

- Colorado Forest Restoration Institute
- Colorado State Forest Service
- Colorado State University
- Mountain Studies Institute
- Northern Colorado Fireshed Collaborative
- Rocky Mountain Research Station
- WaterSMART Grantees (Bureau of Reclamation)
- The Nature Conservancy

GIVEN THE COMPLEXITY OF THE TOPIC, HOW DO WE STAY IN TOUCH WITH RESEARCH EFFORTS ON FOREST HEALTH AS IT RELATES TO WATERSHED HEALTH?

Outreach Feedback



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THREE

CLIMATE CHANGE IS FOREST CHANGE...

but changes are difficult to predict

Context

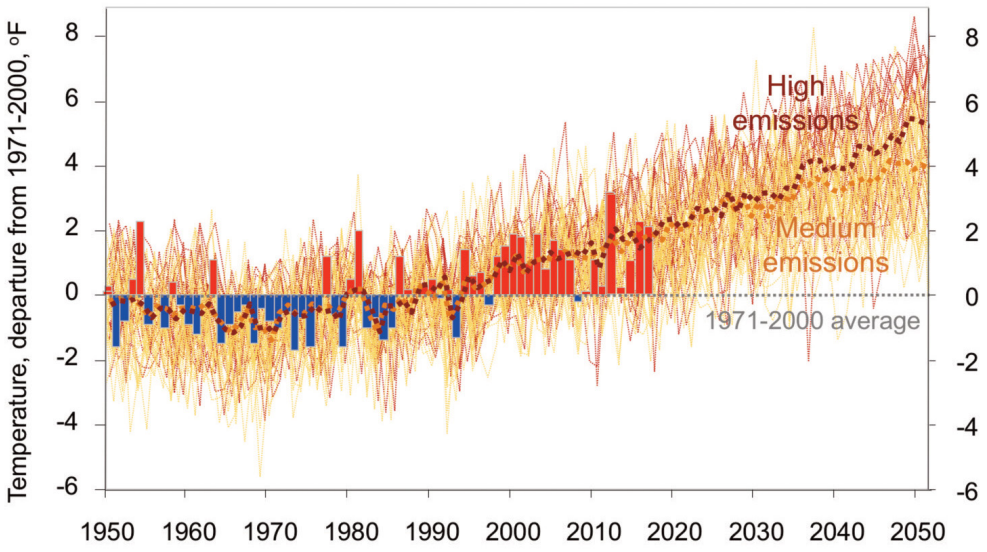
We know that climate change will result in changes to our forests, but we don't fully understand what all those changes are or how they will evolve.

In a 2014 document titled "Rocky Mountain Forests at Risk" three factors driving forest change were identified (Funk et al, 2014):

- **Tree-killing Insects:** From 2000 to 2012 across western North America, bark beetles killed trees on 46 million acres—an area just slightly smaller than Colorado.
- **More Wildfires:** Rocky Mountain forests have seen a large increase in the number of wildfires, the burn area, and the length of fire season when comparing periods prior to the mid-1980s with periods after the mid-1980s.
- **More Heat and Dryness:** Besides insects and wildfires, "background mortality"—the rate at which trees die from no obvious cause—has been observed to be increasing, and scientists suggest hotter and drier conditions are driving this change.

The following figure shows observed and projected annual temperatures in Colorado relative to a 1971-2000 baseline. Warmer temperatures could increase the frequency and severity of wildfire and make trees more vulnerable to insect infestation. Both have implications for water quality and watershed health.

One important change is higher spring temperatures, which produce spring snowmelt and peak streamflows, leaving forests drier and more flammable in summer (Funk, 2014).



Source: Adapted from Lukas et.al, Climate Change in Colorado, 2014

Observed annual temperatures are shown as red and blue bars relative to 1971–2000 baseline. Projected temperatures are shown by yellow lines (greenhouse gas middle-emission scenario) and red lines (greenhouse gas high-emission scenario). The heavy dashed lines are the average projection for each emissions scenario (Colorado Climate Plan, 2014).

Challenges

Several papers and experts identified drivers that can impact forest ecosystem resilience. While we understand many of the relationships between forest health and these drivers, uncertainties in the future state of these drivers make it difficult to predict how potential changes in our forested landscapes may unfold. The following research describes the causes and implications of diminished forest ecosystem resilience:

- Climate change impacts of warming temperatures, drought, a shift in winter precipitation from snow to rain, and earlier timing of snowmelt are creating a moisture deficit in Colorado's forests (Lukas et al., 2014).
- A climate-driven moisture deficit in forests will increase fire severity and frequency (Rocca et al., 2014).
- An emerging body of research from across western North America suggests that climate change and other human-driven changes could create conditions leading to fire-driven forest conversion. A paper titled "Wildfire-Driven Forest Conversion in Western North American Landscapes" observed that forest conversion from pre-fire forest to a different forest type or non-forest vegetation could result from a loss of forest resilience driven by several factors (Coop et al. 2020). Following high-severity forest fires, scientists have found forest recovery may be compromised by lack of tree seed sources, warmer and drier postfire climate, and short-interval reburning.
- Forest conversions may affect erosion rates and water quality and quantity by decreasing transpiration and increasing overland flow (Wine et al, 2018).
- Several papers cite the complexities associated with understanding how climate change may impact forest hydrology, and this has been reinforced by forest health experts interviewed for this study.

Uncertainty in climate-change impacts on forest health presents a challenge for forest management practitioners to predict where, when, and how forests will be impacted.

Opportunities

While there is much uncertainty that limits our capacity to predict futures changes, we know we need more research to fill our knowledge gaps. Additional research and monitoring programs can give scientists, forest managers, and water stakeholders information to better understand how forests are evolving and potentially help anticipate the changes that may occur in the future.

Example Opportunity: Upper Yampa Water Conservancy District

To address the uncertainty of hydrologic response to a changing climate the CWCB is funding a soil moisture study in Upper Yampa Basin. The Upper Yampa Water Conservancy District is installing a network of network of soil moisture monitoring stations to provide a continuous record of landscape conditions in a changing climate. The project is an effort to connect relevant climate-change science data with regional water management decision making.

"Experts have cited a significant knowledge gap around understanding of how changes in forest condition, cover, and species composition influence water quantity and quality on a watershed scale."

—HEATHER DUTTON, Manager, San Luis Valley Water Conservancy District Director

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FOUR

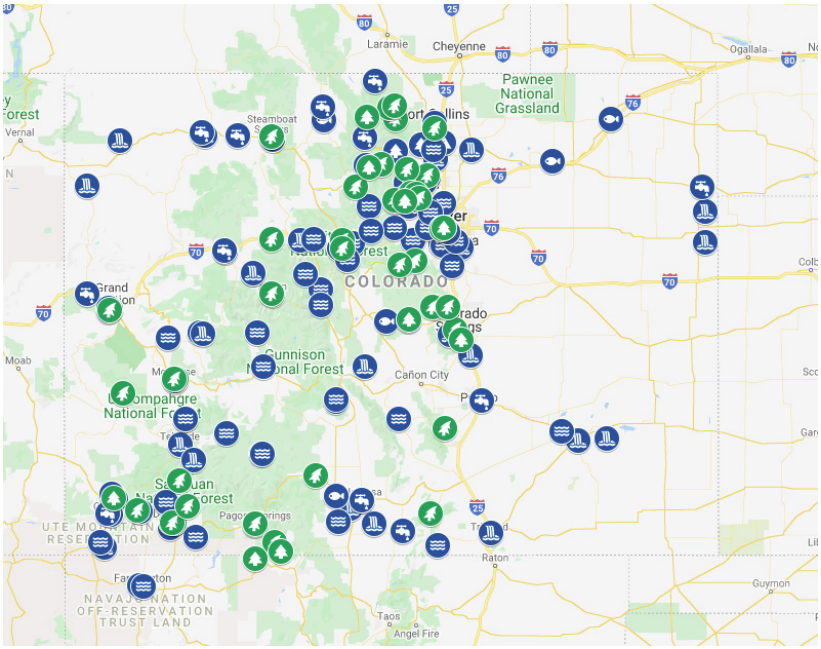
SUPPORT AND LEARN

from working groups

Context

Statewide forest health assessments and strategic plans, such as the Colorado State Forest Action Plan, identify the need to address risks to forest and watershed health with coordinated planning across boundaries. Local, place-based collaborative groups are a vital component to successfully approaching these multi-scale efforts (Kooistra and Sanderson, 2021). While there is a lot of diversity in the forms and functions of collaboratives in Colorado, they are generally comprised of people representing government agencies, nonprofits, businesses, or just themselves that work together to decide how to use and manage natural resources such as land and water. Collaboration often means partners pool their resources and create shared goals, processes, and structures to support their new, joint work. Collaborative groups explore, prioritize, deliberate on, and implement the solutions they have developed together (Huayhuaca and Reid, 2019).

Much of the forest health and watershed planning and management across the state occurs at the local level. The Center for Collaborative Conservation began a project in 2013 to identify and describe collaborative initiatives focused on natural resource management. As of 2020, more than 220 long-term collaborative and multi-stakeholder initiatives were acknowledged, more than half of which focus on forest and/or water related issues. As shown in the figure on the right, there are different areas of focus within forest and watershed group categories.



From Atlas of Collaborative Conservation Colorado

Forest- and water-related collaboratives are located throughout Colorado

WATER/WETLAND

- water quality
- aquatic ecosystem health
- water supply/ administration
- forested watershed health
- fish and wildlife
- emergency preparedness/ disaster recovery
- forest resilience/wildfire

FOREST

- forest resilience/wildfire
- forested watershed health
- land use/ land stewardship

A full list of collaboratives can be found at the Atlas of Collaborative Conservation in Colorado.

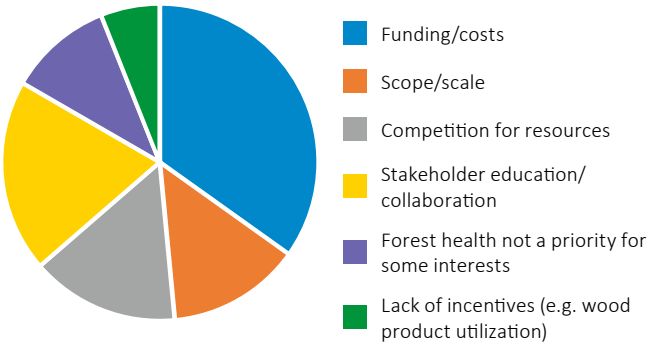
Challenges

Collaboratives face a myriad of challenges in implementing impactful forest and watershed health initiatives. Forest health experts were asked to describe the greatest obstacles that collaboratives face when addressing forest and watershed health issues. The most widespread issues expressed by stakeholders, shown in the pie chart, include:

- Funding is always needed, and opportunities are competitive.
- Fostering stakeholder collaboration can be a challenge. Smaller watershed groups may be faced with large-scale fire recovery challenges and would benefit from connecting with larger collaboratives and state/federal agencies for assistance and guidance.
- The size and scope of necessary forest health work may be beyond the capacity of some collaboratives.

WHAT DIFFICULTIES DO LOCAL COLLABORATIVES FACE WITH FOREST HEALTH AND WATERSHED HEALTH INITIATIVES?

Outreach Feedback



Opportunities

Resolving issues related to funding and stakeholder collaboration were the most pressing among interviewees:

- **Funding.** Obtaining the appropriate funds necessary to make progress toward forest and watershed health is a theme woven throughout the 10 findings.
- **Foster stakeholder collaboration.** When asked how to improve collaboration among local groups focused on forest health, interviewees responded that groups should focus on initiating dialog across interests, which encompasses local/state/federal collaborations as well as multi-interest group collaboration. Interviewees also cited the potential benefit of integrating state-level management of forest and watershed health, in which the CWCB could be a key player.

Additionally, the Center for Collaborative Conservation cites the need for a statewide organization, such as those in other western states, that specifically seeks to support and represent forest and watershed health collaboratives. While Colorado is rich with place-based collaborative groups who work to improve forest health, water reliability, and wildfire resilience in their geographies, a statewide network of collaboratives could harness the collective potential of the individual groups.

Appendix A has a list of several federal and state funding opportunities available to collaboratives focused on forest and watershed health.

"Well-planned and supported forest health implementation requires capacity-building funds to organize the collaboratives, set transparent goals and priorities, apply science, put good project plans in place, and monitor outcomes. While essential to success, funds to undertake these capacity-building activities are the hardest to come by."

—MIKE PRESTON, former GM of the Dolores Water Conservancy District and Chair of Southwest Basin Roundtable, Dolores Watershed Resilient Forest Collaborative, and Rocky Mountain Restoration Initiative

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Kooistra C and J Sanderson. 2021. Center for Collaborative Conservation: Situation Assessment for a Network of Forest Collaborative Groups in Colorado. Available https://collaborativeconservation.org/media/sites/142/2021/09/CCC2023.pdf

Huayhuaca C and Reid R. 2019. Center for Collaborative Conservation: The Atlas of Collaborative Conservation in Colorado. Available https://collaborativeconservation.org/media/sites/142/2019/02/Atlas-Report-v.8-Feb-26-Final.pdf

FIVE

We support

THOUGHTFUL DECISION MAKING

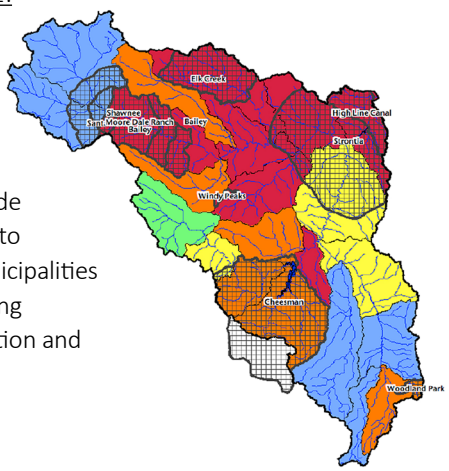
Context

Effective forest and watershed management requires coordinated planning across jurisdictions, communities, and landscapes. As highlighted in **Takeaway 4**, local, place-based collaborative groups play a key role in implementing these multi-scale efforts. The forms and functions of collaborative groups in Colorado are diverse, and each group is unique in the way that it gathers data, prioritizes issues, and implements solutions (Huayhuaca and Reid, 2019). One aim of this forest health study was to identify how these collaborative groups are making decisions, and if there are tools or processes that could benefit other efforts. Through the forest health study outreach and literature review we have learned how placed-based collaboratives are making thoughtful decisions with:

- **Tools:** Using models and tools to plan and prioritize management activities
- **Local application of analyses:** Applying these models and tools at a refined/calibrated scale for their region
- **Collaboration:** Engaging multiple stakeholders and landowners and leveraging resources

Numerous models and tools were identified that can be helpful in prioritizing geographic regions for watershed/forest management activities. The following are a few example tools used by local collaboratives and water managers:

- WATERSHED WILDFIRE ASSESSMENT TOOL: a methodology developed by the Watershed Wildfire Protection Group that identifies 6th-level watersheds that provide critical water supplies to communities and municipalities and assists in prioritizing watersheds for mitigation and protection measures.



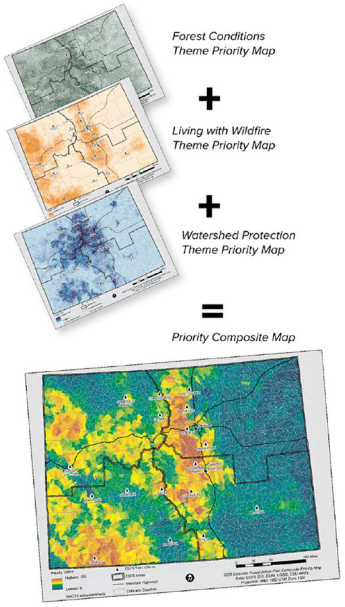
Mapping considers:

- Wildfire Hazard
- Flooding or Debris Flow Risk
- Soil Erodibility
- Water Uses

Composite Hazard Ranking

- Low
- Moderate
- Moderate-High
- High
- Very High

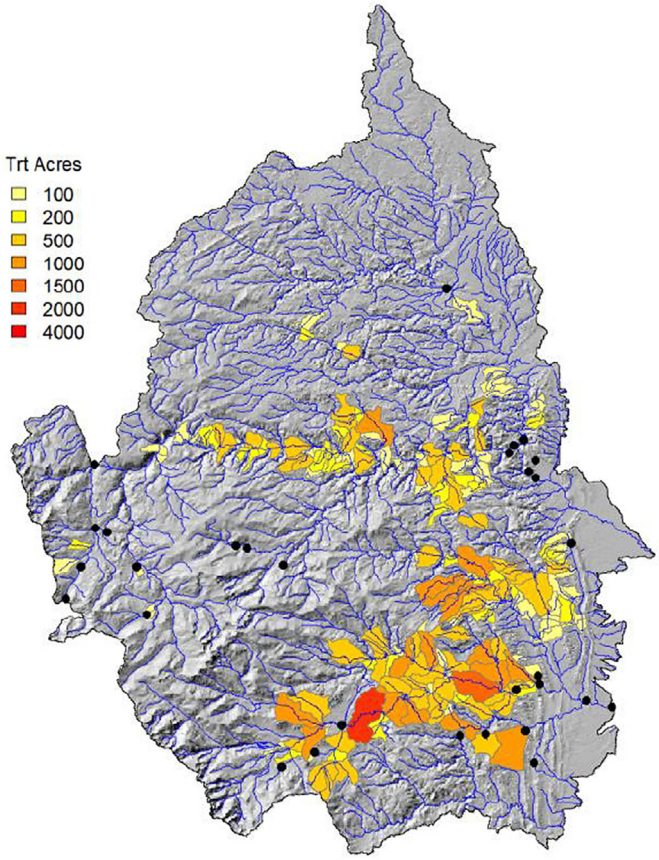
- COLORADO FOREST ACTION PLAN: provided by Colorado State Forest Service (CSFS) – includes an online atlas to help identify areas within a basin that have the greatest need for forest and watershed health activities.



Three themes:

- Forest Conditions
- Living with Wildfire
- Watershed Protection

- WATERSHED INVESTMENT TOOL:
  Developed by the Colorado Forest Restoration Institute (CFRI) at Colorado State University – spatially prioritizes forest management investments at large landscape scales.



Optimal Treatment Plan for 20% Risk Reduction in the Cache la Poudre and Big Thompson Watersheds

Challenges

Though models and tools help inform thoughtful decision making, challenges arise including:

- **Scale:** The size of watersheds that can be modeled vary from tool to tool (i.e., HUC levels 6-14). Stakeholders identified that models need to be refined to a smaller scale to be more meaningful at a local-watershed level, otherwise these models are not applicable.
- **Local data integration:** Local knowledge and data help inform models and tools to produce meaningful results. Some tools do not have the capability to integrate local data.
- **Cost-effective treatments:** Affordable and easy treatment (i.e., along roads and mellow-angled slopes) may not always be the best return on investment. Models and tools that identify strategic locations for best use of stakeholder funds is crucial.
- **Problem characterization and prioritization:** Framing the questions that local watershed groups are trying to answer in a way that is compatible with available data, tools, and models can be a challenge.

Opportunities

There are many opportunities for local stakeholders and collaboratives to use tools and models to make thoughtful decisions. Many respondents who participated in outreach for this study stated that regional models can be used as a planning tool, particularly when identifying priority action areas. Regional tools that lend themselves to smaller scales are helpful for resource-strapped organizations. Modeling and planning efforts can be most effective and actionable when coupled with robust community engagement.

Appendix B has an annotated list of models and tools useful for water managers and collaboratives focused on forest and watershed health.

One program under development by the CWCB is the "Wildfire Ready Watersheds," funded by Senate Bill 21-240 signed by Governor Polis on June 15, 2021. The aim of the effort is to assess the susceptibility of Colorado's water resources, communities, and critical infrastructure to post-wildfire impacts and advance a framework for communities to plan and implement mitigation strategies to minimize these impacts before wildfires occur. The statewide susceptibility analysis will identify, evaluate, and map post-fire hazards to determine potential impacts on values at risk. The framework will further describe and provide guidance on how to refine the susceptibility evaluations for local communities to use at watershed scales. It will serve as a guide for best planning practices in advance of a wildfire and will also support post-fire mitigation strategies (Sturm, 2021).

The following are additional resources to help inform thoughtful decision making:

- Watershed Wildfire Protection Group
- Potential Operational Delineations: On the Ground Experiences and Future Directions
- The Right Work in the Right Places: Prioritizing Fuels Reduction to Protect Water Supplies

Wildfire Ready Watersheds

This CWCB program aims to assess the susceptibility of Colorado's water resources, communities, and critical infrastructure to post-wildfire impacts and advance a framework for communities to plan and implement mitigation strategies to minimize these impacts BEFORE wildfires occur.

SECTION REFERENCES:

Hyayhuaca C and Reid R. 2019. Center for Collaborative Conservation: The Atlas of Collaborative Conservation in Colorado. Available https://collaborativeconservation.org/media/sites/142/2019/02/Atlas-Report-v.8-Feb-26-Final.pdf

Sturm C. September 16, 2021. Memorandum: Agenda #22 Wildfire Ready Watersheds, Statewide Susceptibility Analysis and Framework Update. Available https://dnrweblink.state.co.us/cwcb/0/edoc/215299/22.pdf?searchid=cee461ab-57d3-42f5-a43a-49ca1751cab3

SIX

Colorado-specific RESEARCH IS KEY

Context

The large diversity of forested ecosystems, combined with a high concentration of people living in the wildland-urban interface, make Colorado highly vulnerable to forest health impacts.

> *Research on the relationships between forest and water have been conducted in Colorado since 1910. Intensive studies from Wagon Wheel Gap, the Fraser Experimental Forest, Manitou Experimental Forest, and other sites provide a thorough understanding of how changes in forest cover affect evapotranspiration, soil moisture storage, and the amount and timing of runoff (MacDonald and Stednick, 2003).*

Understanding the impacts of site-specific forest management actions on local hydrologic systems is paramount. As such, science-based forest management actions should be tailored to Colorado's needs.

The amount of Colorado-specific research that evaluates the relationship among forest health, watershed health, and water supply is extensive and continues to grow.

Photo credit, C. Rhoades, USFS-RMRS

Logging operations to remove dead Engelmann spruce and subalpine fir near the summit of Monarch Pass on the Pike-San Isabel National Forest. This pilot project is the first in Colorado to use novel tethered logging equipment to fall and transport timber on steep slopes. Research conducted by the U.S. Forest Service, Rocky Mountain Research Station, and Colorado State University is quantifying the impact of this approach on soil erosion, potential fire behavior, and tree generation.

The outreach component of the forest health study identified numerous research efforts currently being conducted in Colorado. A few examples of current forest health research in Colorado include:

- Eric Howell with Colorado Springs Utilities is conducting multiple research projects in Upper Monument Creek to evaluate efficacy of post-wildfire treatments from the 2012 Waldo Canyon fire. He is also researching best management practices to identify safe conditions for prescribed fire to better protect water infrastructure.
- Dr. Stephanie Kampf at Colorado State University has been monitoring watersheds impacted by the 2020 Cameron Peak fire. Per an interview with Stephanie, her research team was monitoring the watershed prior to the 2020 fire. The fire provided an opportunity to evaluate post-fire impacts on snowpack, streamflow, reservoir sedimentation, and geomorphic channel change.
- Chuck Rhoades with the USDA is involved with Arkansas River Watershed Collaborative on a study evaluating a novel forest harvesting technique called "tethered logging" that involves steep-slope salvage logging in an effort to reduce fuels, and ultimately wildfire severity, in a cost-effective manner. Fire mitigation practices in areas with steep slopes have historically been cost prohibitive.

Throughout the forest health expert outreach effort, the CWCB compiled a list of tools and resources that evaluated the following (see Appendix B for more detail):

- Characterization of how different types of forests burn and how climate change may impact current patterns/trends
- Long-term sedimentation impacts from forest disturbance
- Lasting impacts on hydrology at a regional scale resulting from forest disturbance or change
- Ability to model future forest hydrology under climate change

Challenges

Understanding the site-specific impacts of forest management actions on watershed health and water supplies remains a challenge. While Colorado shares many common characteristics of states in the Western U.S., it has many unique aspects as well. Given the great diversity of topography, climate, and ecosystems across the state, more science-based forest management studies and solutions specific to Colorado are needed to better understand the short- and long-term connection between forest health and hydrology at local and regional scales. Once identified, these solutions should be shared across the state.

Opportunities

Basin roundtables provide a good forum for sharing and discussing science-based forest management practices and the interconnection between forests and water. For example, in November of 2020, the Southwest Basin Roundtable hosted a forest health workshop that provided a forum for:

- Exchanging information about the state of the science between forest and watershed health
- Understanding the role that local forest health collaboratives play and how they tackle water issues
- Learning about the relationship between southwest Colorado and statewide efforts
- Positioning the roundtable to determine its role and interest in forest health
- Engaging in a productive and motivating discussion with Southwest Basin Roundtable members and maximizing the value of the BIP update process

In addition, **Takeaway 10** identifies opportunities for supporting research, and the final section of this document provides ideas for basin roundtables and the Colorado Water Plan update that focus on supporting/funding research and collaboration.

SEVEN

WILDFIRE, DROUGHT, *and* FLOOD *are* COSTLY

Context

Wildfire, drought, and flood events can be catastrophic and extremely costly, both in terms of dollars spent and in the loss of other systems whose costs cannot be quantified or replaced, such as ecosystem services. Colorado has seen a rise in severe and extreme events over the last two decades in part because of climate change. Forest health is impacted by and can exacerbate these events in that droughts can increase wildfire risk, and wildfires generally increase the risk of flooding.

Costs from these extreme events are often not limited to the event itself, as there can be lasting impacts to watersheds. For example, the Cameron Peak Fire near Walden burned nearly 209,000 acres between August 13, 2020, and January 12, 2021. The fire cost more than $132M to fight and contain, with market property loss estimated at $6.3M and total structure loss estimated near $100M (Blumhardt, 2020) (Whitehead, 2021). The estimated cost of post-fire watershed recovery efforts, such as aerial mulching and post-fire flood protections, is between $35M and $45M (ArcGIS StoryBoard, 2021).

650,000+

ACRES BURNED

2020 saw the three largest wildfires in recorded Colorado history

100%

DROUGHT

2020 saw the first time in 8 years that the entire state of Colorado was in drought or exceptionally dry conditions

20,000+

HOMES IMPACTED BY FLOOD

2013 saw rainfall totals of 10″ to 18″ across the Front Range, resulting in flooding that damaged or destroyed more than 20,000 homes

Challenges

Adverse water quality impacts to streams and reservoirs following a wildfire and floods can last more than 10 years depending on burn severity. This creates lasting implications for communities with source water(s) or critical water infrastructure in wildfire and flood-impacted areas. Recovery to pre-fire hydrology may never occur in some systems because of burn severity and climate change.

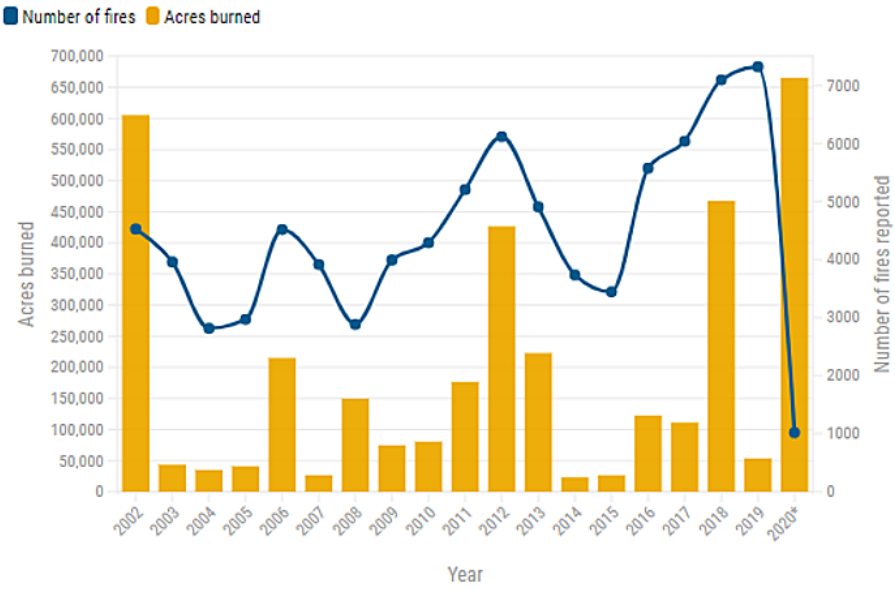
Identifying and working with funding sources for natural-hazard mitigation are significant challenges. In addition, risk mitigation and understanding proper cost and scale of necessary pre-hazard work compared to the cost and scale of post-hazard work are ongoing challenges.

> *"About 10 percent of Colorado's 24 million acres of forest are in urgent need of action to address forest health, wildfire risk, and threats to forested water supplies, at a cost of $4.2 billion."*
>
> *—2020 Colorado Forest Action Plan, CSFS*

WHAT TO EXPECT AFTER A WILDFIRE

Recent literature from post-wildfire studies in Colorado help answer stakeholder questions about soil erosion and impacts to water resources and infrastructure.

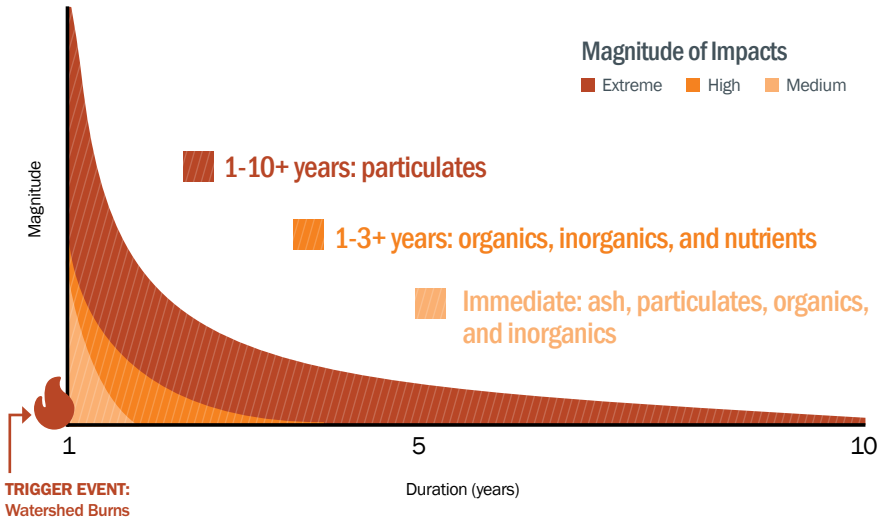
Number of wildfires and acres burned in Colorado by year



Source: *Rocky Mountain Area Coordination Center*

*2020 numbers are as of the morning of Oct. 23, 2020. The number of fires reported for the year will likely increase as smaller jusidictions catch up with their reporting.

From: Five charts that show where 2020 ranks in Colorado wildfire history (coloradosun.com)



Types and magnitude of wildfire impacts to stream systems over time

Opportunities

Pre-fire mitigation and planning are opportunities to reduce risk and lower costs associated with wildfire. Ongoing work by the Colorado-based Southwest Wildfire Impact Fund (SWIF) has shown that **for every $1 spent on wildfire mitigation work an estimated $5 is saved in reduced or eliminated post-fire damages** (SWIF, 2021). Community wildfire protection plans, a framework developed by the Colorado State Forest Service, are a helpful tool in raising community awareness of wildfire risk and the benefits of forest health treatments. These plans provide risk assessments and recommendations for designing fuel treatment, defensible space, fire response, and community involvement (CSFS, 2021).

Labor, time, expense, and coordination with multiple agencies can be barriers for communities and landowners who want to implement forest health mitigation actions. Several organizations are working at the regional level and consist of diverse stakeholders to leverage resources to plan, finance, and implement forest health treatments. Two examples include Southwest Wildfire Impact Fund and the Rocky Mountain Restoration Initiative.

Examples of multi-stakeholder regional wildfire mitigation programs:

Southwest Wildfire Impact Fund

Rocky Mountain Restoration Initiative

SECTION REFERENCES:

CSFS (Colorado State Forest Service). Accessed 2021. Community Wildfire Protection Plans. Available: https://csfs.colostate.edu/wildfire-mitigation/community-wildfire-protection-plans/#1447445534635-f9b2037e-38d6

Blumhardt M. "Cameron Peak Fire's long and historic run leaves stories of miracles and misery". November 17, 2020. The Coloradoan. Retrieved 2021-10-21.

Whitehead D. "Cameron Peak Fire causes $6.3 million in property loss, report says". January 13, 2021. KUSA.com. Retrieved 2021-10-21.

ArcGIS Storymap: Recovery Efforts for the Cameron Peak Fire. 2021. Available: https://storymaps.arcgis.com/stories/66393e20dd674741b43d024a2f2d9188

SWIF (Southwest Wildfire Impact Fund). Accessed 2021. Available: Southwest Wildfire Impact Fund | Wildfire Prevention (swifproject.org)

EIGHT

Climate change and natural hazards have RISING COSTS

Context

The impacts and costs associated with wildfire, drought, and flooding are significant and are projected to get worse with a growing population and a potentially drier future. If these hazards increase in frequency and intensity with a warming climate, and communities develop without increasing resilience, the economic damages and ecosystem losses from these hazards will likely reach new extremes.

To evaluate the potential future costs of doing nothing and the importance of taking action, the CWCB (with funding and support from several partners) developed a tool named the Future Avoided Cost Explorer: Colorado Hazards, or "FACE Hazards Tool". The tool quantifies current and future risk from flood, drought, and wildfire across multiple sectors of Colorado's economy. Risks are quantified as expected annual damage expressed in dollars.

Economic vulnerabilities from these hazards are analyzed both today and at a 2050 planning horizon. Potential future risk and costs due to flooding, drought, and wildfire can be evaluated using multiple climate and population projections that consider potential future development and increased hazard frequency and intensity.

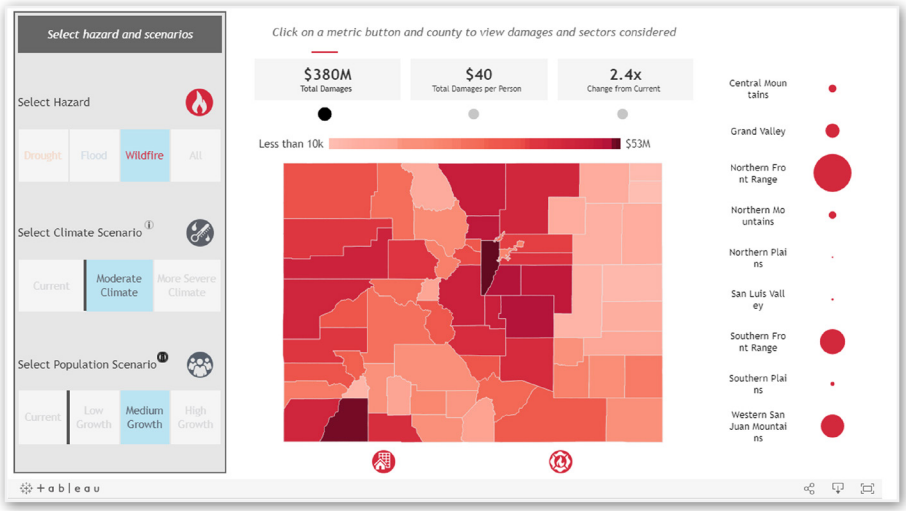
Click to visit page

The FACE Hazards Tool estimates Colorado's vulnerability to flood, drought, and wildfire hazards using sectors that are representative of statewide economic impacts:

- **Flood sectors:** buildings and bridges
- **Drought sectors:** agriculture, livestock, and the skiing and boating industries
- **Wildfire sectors:** buildings and suppression costs

The tool includes an interactive dashboard that allows the user to "choose their own adventure" and explore how flood, drought, and wildfire may cause economic damages under a variety of climate and population scenarios statewide or in different counties. The tool also allows the user to focus on potential future costs by sector, by region, or by future scenario.

Relative costs and level of effort can be explored for various resilience actions that could be implemented to mitigate potential future impacts from flood, fire, and drought.



Dashboard image showing potential future annual wildfire damage by county under a "moderate" change in climate conditions and medium population growth

Challenges

Colorado will be confronted with a wide variety of challenges to mitigate the potential safety and financial risks associated with wildfire, flood, and drought. Investing in mitigation measures ahead of hazard occurrence can be difficult for organizations and agencies in the face of competing needs for financial resources. Many times, large scale mitigation actions can involve coordination among a wide array of stakeholders with their own goals and constraints. Raising funds to construct or implement mitigation strategies can also be a challenge.

Opportunities

The data and information in the FACE Hazards Tool can be a catalyst for conversations and actions that will help lower potential risks from wildfire, flood, and drought. A user feedback survey conducted during the FACE Hazards Tool testing phase provided several potential avenues for using the tool:

- Gather relevant information for presentations to elected officials
- Identify impacts that changing climate and populations will have on different regions of the state
- Present climate change projections for Colorado in terms of economic impacts
- Perform local hazard mitigation planning
- Communicate the economic benefits of hazard planning
- Identify regions/sectors where a strong case can be made for locally based funding mechanisms
- Provide a reference for updating Community Development Codes
- Educate middle and high school students about natural hazards and empower them to develop resilience strategies for their communities

The FACE Hazards Tool is available at:
https://cwcb.colorado.gov/FACE

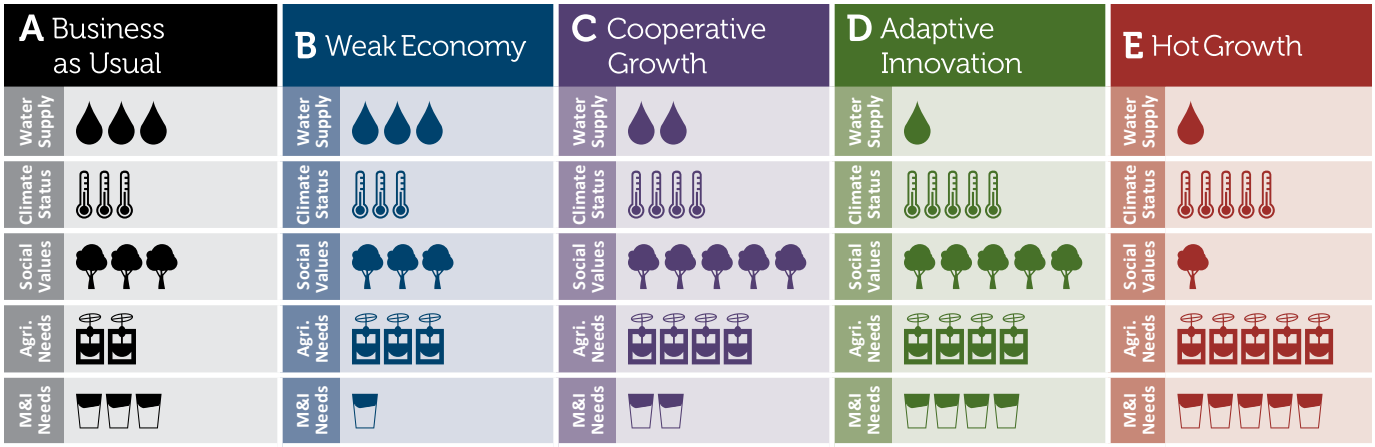
NINE

Planning scenario updates

SHOULD CONSIDER FOREST HEALTH

Context

The five future planning scenarios in the Colorado Water Plan contemplate what our water supplies and demands could look like in the year 2050 based on a variety of drivers. The scenarios each consider several water resources drivers and how the drivers may change. The drivers include population, urban land use, climate change, industrial water needs, agricultural conditions, and adoption of municipal and agricultural water conservation measures. The graphic below provides a brief overview of the drivers and the scenarios.



A Business as Usual

- Population growth increases at trends predicted by the State Demography Office (SDO).
- Future hydrology, per capita water demands and adoption of conservation measures are similar to what has recently occurred.

B Weak Economy

- The world's economy slows, and the state's population growth is less than predicted.
- Hydrology is similar to recent patterns.
- This scenario puts the least amount of stress on future water supplies and is a bookend for scenarios.

C Cooperative Growth

- Statewide population is similar to SDO predictions but is distributed differently across the state.
- Climate is moderately warmer, and irrigation demands increase.
- People seek to mitigate increased demands by more aggressively adopting water conservation.

D Adaptive Innovation

- Both scenarios assume that population growth is higher than projected and both assume a much warmer and drier future climate.
- The scenarios' primary differences revolve around conservation. In the Adaptive Innovation scenario, the state aggressively adopts conservation measures in both municipal and agricultural sectors. In the Hot Growth scenario, conservation is not a focus.

Refer to the Analysis and Technical Update to the Colorado Water Plan, Sections 2.1.3 and 2.1.4, for more details on the scenarios and drivers (https://cwcb.colorado.gov/colorado-water-plan/technical-update-to-the-plan).

The 2015 Colorado Water Plan noted the importance of forest health and indicated that warmer temperatures could increase the frequency and severity of wildfire and make trees more vulnerable to insect infestation. Forest health conditions and wildfires impact hydrology, runoff, and water quality and could be considered when evaluating future water supplies; however, neither the Colorado Water Plan nor the planning scenarios provided specific guidance on how to quantitatively project forest-health-related impacts to water supplies.

Challenges

Future updates to planning scenario and Technical Update modeling analyses could potentially consider forest health, but several challenges need to be overcome:

- CONNECTION BETWEEN FOREST DISTURBANCE AND STREAMFLOW IMPACTS:
  The connection between specific types of forest disturbance and resulting impacts to the volume and timing of runoff needs to be better understood. For example, if planning scenarios contemplate an increase in insect infestation, the impacts of current levels of insect infestation on streamflow needs to be understood. The streamflow impact could then be adjusted to reflect increased levels of infestation described in planning scenarios. As described earlier in this document (see **Takeaway 2**), the science is evolving and currently points to a range of streamflow impacts in the wake of disturbances.

- SHORT-TERM VERSUS LONG-TERM STREAMFLOW IMPACT:
  The amount of time a specific forest disturbance continues to impact streamflow depends on the severity of the disturbance and the resiliency of the forest in the affected area. Streamflow impacts from forest disturbances may be temporary as regrowth and recovery from the disturbance occurs. The short-term impacts may include localized flooding, degraded water quality, and damaged water infrastructure. In the longer term, forest disturbances, particularly under future climate-adjusted conditions, may lead to permanent changes to forest vegetation and have long-term impacts on hydrology. In addition to impacts from disturbances, long-term hydrology may also be impacted by changes in forest health and composition due to warmer temperatures and altered precipitation, and to runoff amounts and timing.

- PROJECTED FUTURE FOREST DISTURBANCES:
  Forest disturbances are a result of many factors, including climatic conditions, forest management, and human activity. Predicting where and what type of future disturbances may occur is difficult. For example, it is difficult to predict where a lightning strike or human activity may ignite the next fire (Mountain Studies Institute, 2015). Additionally, it is difficult to project how extensively a fire might spread before containment (although studies regarding vegetation levels and forest management efforts can provide insight on areas at higher risk). Being able to predict forest fires under current conditions is important for predicting where they may occur in the future and how they may impact water supply infrastructure. The location and magnitude of other types of disturbances are also difficult to predict, particularly under changing climate conditions. Regional assumptions can be made to represent potential forest disturbances in future statewide planning efforts, but these assumptions should be supported by observable trends from local studies and reflect a reasonable range of potential future disturbances.

- WATERSHED SCALE:
  Scale is another important consideration. Stakeholder feedback indicated that at smaller watershed scales, we have a greater ability to predict water supply impacts from disturbance, but this predictability diminishes at larger spatial scales. This was also suggested in the literature. For example, hydrologic studies on watersheds with forest disturbances concluded that subsequent water yields were highly dependent on local vegetation structure, climate, and topographic characteristics (Goeking and Tarboton, 2020; Biederman, et al., 2015). Evaluating hydrologic impacts from forest disturbances on a basin scale would require knowledge of the local scale characteristics of the subbasins within the larger basin.

Opportunities

With the three largest wildfires on record in Colorado burning more than 650,000 acres in 2020, it is important to integrate forest health in statewide planning efforts and to continue to pursue solutions to mitigate the impact from future forest disturbances. **Additional studies are needed**, ideally at a variety of locations throughout Colorado's forests, to develop appropriate assumptions and modeling on how disturbances may impact water supply and water quality in the short and long terms. Basin roundtables have identified or are conducting studies that will advance our understanding of the relationship between forest health and water supply. Examples are:

- A potential future project in the Gunnison Basin Implementation Plan to evaluate and mitigate risks to critical water supply infrastructure from wildfire and subsequent changes to hydrology, hydraulics, and sediment transport post-fire.
- Multiple projects in the Southwest Basin Implementation Plan that use both field tests and hydrologic modeling to evaluate soil moisture conditions, runoff, and consumptive use in areas with differing forest composition and after different forest-health-related treatments.
- A hydrologic modeling study currently being conducted by the Rio Grande Basin Roundtable that examines potential changes in runoff due to forest disturbances and climate change.
- Numerous projects basin roundtables identified in their basin implementation plans focus on implementing forest health improvements.

Photo credit, D. Snyder, Brown and Caldwell - Photo taken in the burn scar of the 2018 416 Fire - San Juan National Forest

SECTION REFERENCES:

Biederman, et al., 2015: Recent Tree Die-off has Little Effect on Streamflow in Contrast to Expected Increases from Historical Studies. Water Resources Research, Volume 15, Issue 12, December

Goeking and Tarboton, 2020: Forests and Water Yield: A Synthesis of Disturbance Effects on Streamflow and Snowpack in Western Coniferous Forests

Mountain Studies Institute, 2015: Fire Risk to Water Supplies Assessment, A Partnership Pursuing the Protection of Community Resources (San Juan Headwaters Forest Health Partnership)

TEN

We need to

KEEP SUPPORTING

and funding research and planning

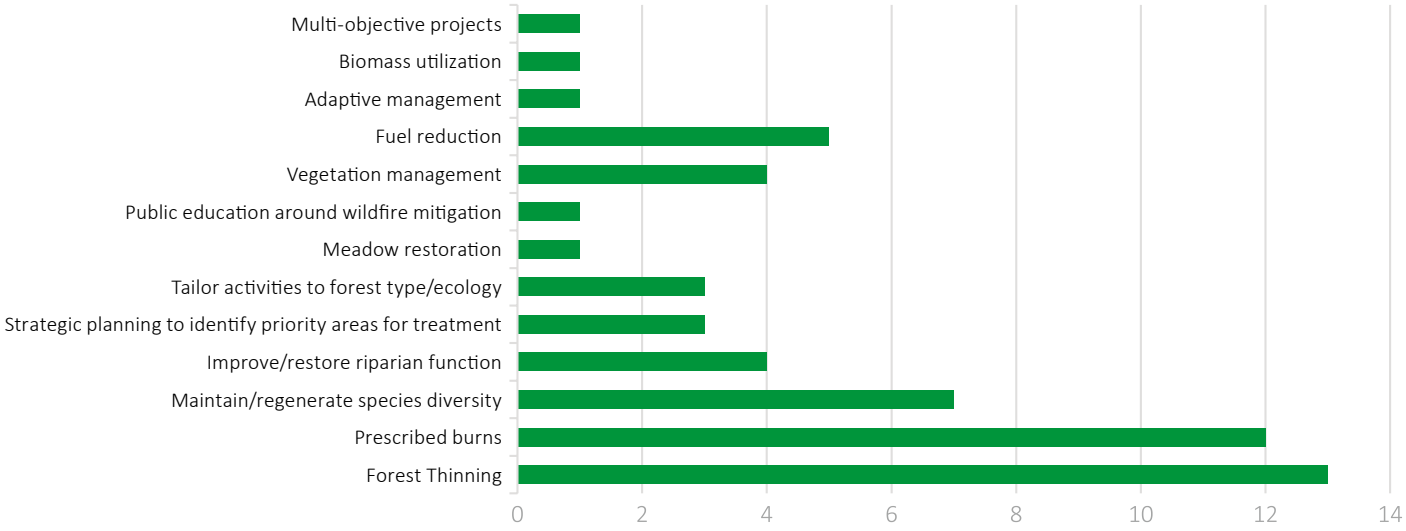
Context

Through the literature review and outreach conducted as part of this study, it is clear forest health research and planning efforts need continued support. As discussed in previous findings, Colorado-specific research on forest health is driving better forest health practices, and ultimately better forest management policies. The CWCB recognizes the significance of forest health to watershed health and has a key role in facilitating forest health research in tandem with water planning efforts. The CWCB also acknowledges the important, concurrent research being conducted by forest health experts across the state, such as the CSFS, CFRI, and others.

In addition to research and planning, implementation of forest health restoration and enhancement activities is also important. Colorado forest health experts were asked about the top three restorative activities for improving forest health. Answers varied, but forest thinning, prescribed burns, maintaining or regenerating species diversity, fuel reduction, and improving/restoring riparian function were the top answers. Several respondents added the caveat that the activity will be site-specific and depend largely on forest type.

RECOMMENDED RESTORATIVE ACTIVITIES FOR IMPROVING FOREST HEALTH

Outreach Feedback



Challenges

Adequate funding, guidance, and connectivity are challenges that confront stakeholders who are focused on forest health projects and planning.

- While communities and watershed groups understand the importance and need for action to manage forest health, they lack adequate funding for planning studies to identify and prioritize forest health management action.
- Communities need assistance and guidance with best planning practices that produce actionable results.
- Communities and watershed groups need to be connected to ongoing and future research and need help applying the latest scientific data and strategies to achieve the greatest positive impact in maintaining healthy ecosystems that are more resilient to climate change, wildfires, and floods.

Opportunities

Forest health experts weighed in on the best options for CWCB to advance forest health with respect to water resources, and funding for forest health initiatives was the top response (see additional detail on feedback from this question in the next section). While the CWCB provides funding for forest-health-related planning and projects, the funding is limited to projects that relate directly to protection of water supplies and quality. The CWCB encourages partnerships with other agencies that fund additional types of forest health management practices and leveraging funds from multiple sources to achieve more broad-ranging goals.

As a part of this study, the CWCB identified and cataloged information about funding sources for forest health initiatives that benefit watershed health (see Appendix A). The CWCB will continue to look for ways to leverage resources for forest health actions and to optimize forest health and watershed health efforts.

Photo credit, D. Snyder, Brown and Caldwell - Photo taken in the burn scar of the 2002 Missionary Ridge Fire - Haflin Creek drainage basin near Durango, CO

IDEAS

for Basin Roundtables and the Colorado Water Plan Update

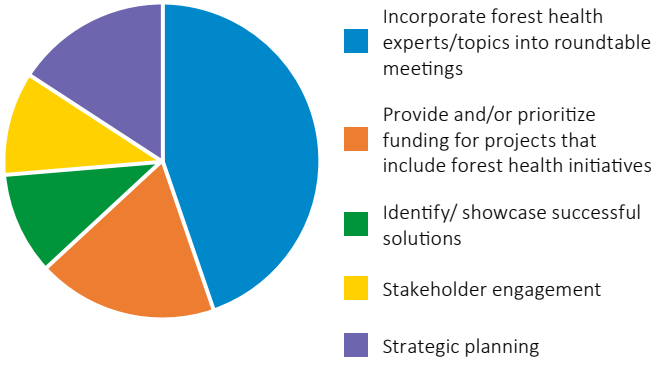
Through the research and outreach conducted for this study, several forest health actions and strategies emerged that could be useful for basin roundtables and for the update to the Colorado Water Plan.

Ideas for Basin Roundtables

During the outreach portion of this study, forest health experts were asked directly how they thought basin roundtables could engage in forest health issues. The responses are summarized in the pie chart below. The majority of respondents suggested incorporating discussion of forest health topics and engagement of experts during roundtable meetings. Funding, strategic planning, and collaboration with respect to forest health projects and issues also were identified.

WHAT IS THE MOST EFFECTIVE WAY FOR ROUNDTABLES TO ENGAGE IN FOREST HEALTH ISSUES?

Outreach Feedback



The CWCB developed a set of ideas for basin roundtables interested in forest health issues to consider. While these ideas could be incorporated into goals and strategies in basin implementation plans they can also be adopted by basin roundtables at any time in the future and would not need to be directly tied to the plans.

- **Form a forest health subcommittee:**
  A forest health subcommittee could monitor local and statewide research activities, attend forest-health-related events, identify successful forest or watershed management projects, and share information with their roundtable.
- **Support watershed and forest-health-related projects with Water Supply Reserve Fund (WSRF) grants:**
  The roundtable could identify and prioritize projects that focus on forest health and advance them using the WSRF grant program.
- **Foster connections and communication:**
  The roundtable could serve as a resource for connecting stakeholders with forest health experts. It could also host forest-health-related workshops to help disseminate information and foster collaboration.
- **Provide guidance and expertise:**
  In the aftermath of a forest disturbance, roundtable members with expertise or contacts related to forest health could provide appropriate assistance to affected stakeholders.
- **Disseminate useful information via the Public Engagement, Participation, and Outreach (PEPO) liaisons:**
  Basin websites and other communications could be used to educate stakeholders on forest health issues and disseminate information.

Ideas for The Colorado Water Plan Update

The research and outreach conducted for this study was used to develop ideas for the CWCB to consider during the update to the Colorado Water Plan. While not all ideas may result in actions in the updated Colorado Water Plan, they provide important input that will form the foundation of the actions and vision related to forest and watershed health in the plan.

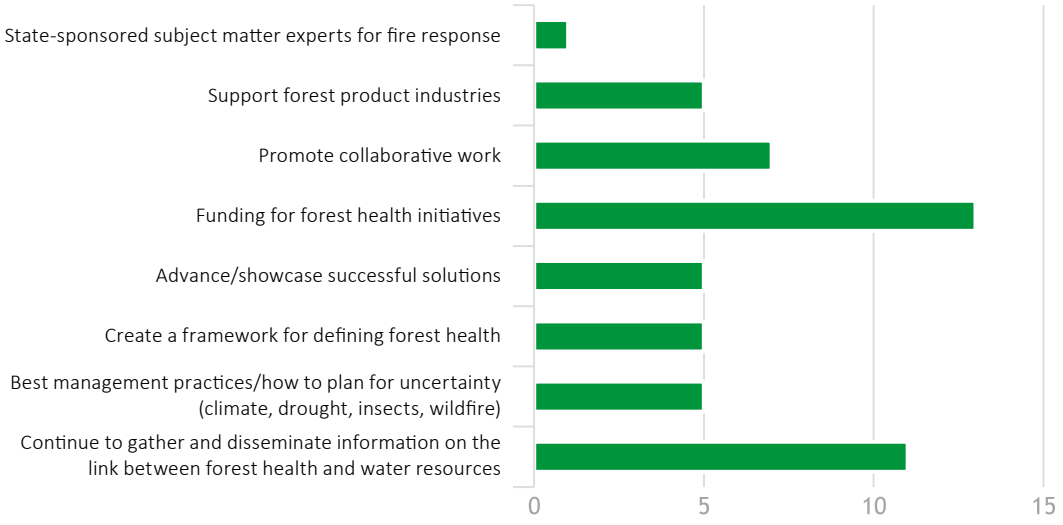
During the outreach portion of this study, stakeholders were asked to provide input on ideas for advancing forest health issues in the context of water resources planning. Stakeholder feedback on this matter is summarized in the bar chart below and suggests that providing funding and fostering collaboration are key areas for CWCB consideration during the Colorado Water Plan update.

The following is a consolidated set of specific ideas for consideration for the Colorado Water Plan update:

- **Funding:** The CWCB currently provides grant funding to projects that seek to improve forest health but funding is limited to projects that are directly connected to protecting water resources. While this limitation will remain, the CWCB can seek to foster partnerships that will pool resources and help leverage CWCB funds along with other types of funding that can support forest health needs, such as thinning, and supporting forest product industries. Additional funding for forest and watershed health initiatives can also be considered.
- **Collaborative actions:** The Colorado Water Plan update could consider actions that create opportunities to disseminate forest- and watershed-health-related research and success stories as well as provide a forum for stakeholders to make connections and collaborate. In addition, the Colorado Water Plan could encourage stakeholders to collaborate on ways that forest health can be incorporated into existing planning processes, such as stream management plans and integrated water management plans.
- **Fire response:** Stakeholders impacted by a fire often need timely guidance and expertise on how to respond. The Colorado Water Plan could consider actions that organize and promote existing services and expertise that the State already provides and could also seek to identify gaps in services that could be filled.
- **Support post-fire susceptibility studies:** The Colorado Water Plan could support and encourage stakeholder-led, post-fire susceptibility studies to better understand risks to water infrastructure, life, and property and to identify and prioritize forest health actions to mitigate wildfire risk.
- **Identification of focus areas:** Several tools for thoughtful decision making exist that could be used to identify, from a high level, areas that are both vulnerable to wildfire and have critical water supply infrastructure. Some of these tools were highlighted earlier in this document. The Colorado Water Plan update could explore the creation of strategies and/or mapping analyses that identify areas in the state that should be prioritized for pre-fire planning to protect critical water supply infrastructure.

WHAT ARE TOPICS OR IDEAS RELATED TO ADVANCING FOREST HEALTH WITH RESPECT TO WATER RESOURCES THAT THE CWCB COULD CONSIDER?

Outreach Feedback



Appendix A

FUNDING OPPORTUNITIES

APPENDIX A SUMMARY

Appendix A is an annotated list of funding opportunities that was compiled in support of the Colorado Water Conservation Board's Forest Health Study. Note that the list of funding opportunities and their criteria is not comprehensive and will evolve with additional opportunities created in the future. The reader should obtain more information on funding opportunities of interest to confirm requirements for eligible applicants, matching criteria, and intended uses of funding sources. The list of funding opportunities was developed to provide an overview of potential support for land and watershed managers, landowners, and members of the public interested in efforts to improve forest health and watershed health. Each funding opportunity includes either a direct weblink to the resource or includes a reference on where to find for additional information.

Appendix A. Funding Opportunities that Support Forest Management and Watershed Health in Colorado

Funding Opportunity	Funding Entity	Who Can Apply	Match	Description
Colorado Water Plan Grants	CWCB	Governmental entities – municipalities, districts, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities Covered Entities as defined in Section 37-60-126, C.R.S., are eligible if the applicant has adopted an approved water conservation plan Private entities - mutual ditch companies, non-profit corporations, and partnerships	≥ 50% match required for all construction projects. ≥ 25% match required for all plans or studies. CWCB loans are considered matching funds.	The purpose of the Colorado Water Plan Grant funding is to support stakeholder efforts and progress on the actions identified in the Colorado Water Plan.
Water Supply Reserve Fund Grants	CWCB/General Assembly	Public government and districts, private incorporated entities, and private individuals	≥ 25% percent match of the total grant request from other sources, including but not limited to Basin Funds.	Grants to support projects that address critical water supply issues and interests. Requests from the accounts must be approved by a Basin Roundtable and the CWCB.

Appendix A. Funding Opportunities that Support Forest Management and Watershed Health in Colorado

Funding Opportunity	Funding Entity	Who Can Apply	Match	Description
Colorado Watershed Restoration Grant	CWCB	Established non-profit organizations, watershed coalitions, State of Colorado departments and agencies, local governments conservation and water conservancy districts and Colorado's two Ute Tribes	Project costs may consist of a combination of in-kind and cash match, but no more than half of the match may be in the form of in-kind services.	The program provides grants for watershed/stream restoration, flood mitigation, and stream management projects. Grant money may be used for planning and engineering studies, including implementation measures, to address technical needs for watershed restoration and flood mitigation projects throughout the state. Special consideration is reserved for planning and project efforts that integrate multi-objectives in restoration and flood mitigation. This may include projects and studies designed to: restore stream channels, provide habitat for aquatic and terrestrial species, restore riparian areas, reduce erosion, reduce flood hazards, or increase the capacity to utilize water. Costs associated with forest health project initiatives, e.g., forest fuels mitigation, can be used as match for projects having components that qualify for Watershed/Stream Restoration or Flood Mitigation Grants.
Non-reimbursable Investment Grants	CWCB/General Assembly	Any private or public entity	Not specified	Projects that are too large or do not fit into the Water Plan Grant funding categories including water-related projects or studies of statewide impact or importance; large regional feasibility studies and projects designed to address statewide/region water issues.
Flood & Drought Response Fund	CWCB	Local governments, variable	Not specified	This is not a formal grant program, with established guidelines or timelines or applications. It is by design an as-needed program to react to flood and drought-related circumstances.
Technical Assistance for Federal Cost Share [1]	CWCB	Local governments, non-profits, incorporated ditch, and irrigation companies	Not specified	Provides resources to eligible entities to develop competitive projects/grants for federal cost-share assistance.
Colorado State Conservation Board Matching Grants	Colorado State Conservation Board	All Colorado Conservation districts that are in "Good Standing"	100% dollar-for-dollar match with a 50% minimum cash match	Provides matching state funds towards projects and activities of conservation districts; support for private on the ground conservation projects and education activities.

[1] *Colorado Water Conservation Board Members. 2020. 8a. 2021 Projects Bill – Non-Reimbursable Projects Investments "En-Bloc" Approval. November 18-19, 2020, Board Meeting. Available here.*

Appendix A. Funding Opportunities that Support Forest Management and Watershed Health in Colorado

Funding Opportunity	Funding Entity	Who Can Apply	Match	Description
Forest Restoration & Wildfire Risk Mitigation Grant Program	Colorado State Forest Service	Local community groups, local government entities such as fire protection districts, public and private utilities, state agencies, and non-profit groups	50% match (no more than half of applicants matching funds can come from other state funding), and 25% match for qualifying projects in areas with fewer economic resources	Fuels and forest health projects and/or capacity building projects on non-federal lands in Colorado. Project awards have ranged from $3,000-$250,000.
Forest Legacy Program	Colorado State Forest Service	Private landowners	The Federal government may fund up to 75 percent of program costs, with at least 25 percent coming from private, state or local sources. Great Outdoors Colorado (GOCO) funds, private funds, local land conservation organizations and others commonly partner to provide this funding match.	A federally funded and state-administered program that supports efforts to protect private forest lands that are environmentally, economically, and socially critical. The program helps prevent fragmentation of forests and preserves natural vistas for all to enjoy. The program focuses on the acquisition of partial interests in privately owned forest lands through conservation easements. Priority for acquisitions of lands at-risk of being converted to non-forest uses.
Good Neighbor Authority	U.S. Forest Service	States, counties, and tribes	Not specified	Good Neighbor Authority allows the U.S. Forest Service to enter into agreements with state forestry agencies to do the critical management work to keep our forests healthy and productive. The primary goal of Good Neighbor Authority is to increase the pace and scale of restoration at a watershed scale and to strengthen partnerships between state, tribal, county, and federal agencies to get more done across jurisdictional boundaries.
Collaborative Forest Landscape Restoration Program	U.S. Forest Service	Not specified	Up to 50% of the cost	The Collaborative Forest Restoration Landscape Program was designated to accelerate ongoing restoration treatments that provide long-lasting ecological, social, and economic benefits to priority forest landscapes.

Appendix A. Funding Opportunities that Support Forest Management and Watershed Health in Colorado

Funding Opportunity	Funding Entity	Who Can Apply	Match	Description
Joint Chiefs Landscape Restoration Partnership	U.S. Department of Agriculture & Natural Resource Conservation Service	Jointly designed and submitted by local Natural Resource Conservation Service, U.S Forest Service, and State Foresters	Not specified	The goal is to improve the health and resiliency of forest ecosystems where public and private lands meet through a partnership between the U.S. Forest Service and Natural Resource Conservation Service. The vision is to restore lands across large landscapes regardless of ownership, reduce wildfire threats to communities and landowners, protect water quality and supply, and improve habitat for at-risk species seamlessly across public and private lands. No additional funds are appropriated for this program; funds come from existing U.S. Forest Service and NRCS budgets. Funding will vary by year.
Western States/ Wildland Urban Interface Grant Program	U.S. Forest Service	Applications must be submitted through the appropriate state/island agency (typically the State Forester).	The allocated grant amount must be matched in full by the recipient using a non-federal source.	National Fire Plan funds to mitigate risk from wildland fire within the Wildland Urban Interface are available and awarded through the Western Fire Managers competitive process within the 17 western states and Pacific territories.
Hazardous Fuel Reduction Grant	U.S. Forest Service	Activities on non-Federal Land	Not specified	Reduce the undesired effects of large, destructive wildfires by reducing the volume of hazardous fuels on forests, woodlands, shrublands, and grasslands. The program focuses on reducing the risk of wildland fire and long-term damage to resources and property in high priority areas. The desired outcome of the program is to reduce the risk of unplanned and unwanted wildland fire to communities and to the environment.

Appendix A. Funding Opportunities that Support Forest Management and Watershed Health in Colorado

Funding Opportunity	Funding Entity	Who Can Apply	Match	Description
Landscape Scale Restoration Program	U.S. Forest Service	The state forestry agency is the applicant but can be collaborative with all landowners/ interested parties in project identification	1:1 match from the state forestry agency	The Landscape Scale Restoration Program is a Forest Service State and Private Forestry competitive grant program that promotes collaborative, science-based restoration of priority forest landscapes and furthers priorities identified in State Forest Action plans. In doing so, the program helps ensure that our nation's forests continue to provide important benefits to the American public, including timber and fuel wood, wildlife habitat, watershed protection, and well-paying rural jobs. Each grant request limited to a maximum of $300,000. Only 3 applications may be submitted per state.
Innovative Finance for National Forests	National Forest Foundation	Non-for-profit organizations, Indian Tribes & Intertribal Consortia, State/ Interstate/local government agencies, Academic institutions, For-profit companies, Public/private partnerships are encouraged. Unincorporated individuals, Federal agencies are not eligible.	≥ 20% non-federal match requirement	The Innovative Finance for National Forests grant program supports the development and implementation of innovative finance models that leverage private and public capital other than US Forest Service appropriations to support the resilience of the National Forest System.

Appendix B

MODELS & TOOLS

APPENDIX B SUMMARY

Appendix B is an annotated list of tools and models that was researched and compiled in support of the Colorado Water Conservation Board's Forest Health Study. Note that the list of tools and models is evolving, and additional resources will likely be created in the future. This list of resources was developed to support land and watershed managers, forest landowners, and members of the public interested in learning about or implementing forest health best management practices in Colorado. Each model or tool includes either a direct weblink to the resource or includes a reference on where to find additional information.

Appendix B. Helpful Tools and Models that Support Forest Best Management Practices in Colorado

Tool or Model Name	Entity	Scale	Description	Anticipated Tool Use(s)
Boulder Wildfire Erosion and Sediment Transport Tool (WESTT) [1]	City of Boulder and Colorado Forest Restoration Institute	Developed for use within Boulder County	WESTT was developed to serve as a long-term planning tool for the City to predict post-fire erosion and sediment transport to the city's drinking water diversions, determine the most effective placement of post-fire rehabilitation strategies to stabilize hillslopes and trap sediment, and estimate watershed rehabilitation costs.	Intended for pre- and post-fire planning efforts in Boulder County (Boulder County and City of Boulder employees only).
Colorado Forest Action Plan, 2020	Colorado State Forest Service	Various scales across the state	The Colorado Forest Action Plan was developed under the leadership of the Colorado State Forest Service and its partners. The plan provides a strategic framework to address the benefits, conditions, and trends in Colorado's forests, as well as the threats and challenges the state's forests face across political, jurisdictional, and ecological boundaries.	Statewide wildfire strategy and planning objectives.

[1] *City of Boulder. 2019. Wildfire Planning for Source Water Protection. Prepared for the Water Resources Advisory Board. Available here*

Appendix B. Helpful Tools and Models that Support Forest Best Management Practices in Colorado

Tool or Model Name	Entity	Scale	Description	Anticipated Tool Use(s)
Colorado Forest Atlas	Colorado State Forest Service	Various landscape- scales in Colorado	The Colorado Forest Atlas is a web portal providing a suite of interactive mapping applications portraying information about Colorado's forests. These applications provide Colorado citizens the best available information about forest conditions and Colorado State Forest Service activities. Currently, the Colorado Forest Atlas hosts three applications – the Wildfire Risk Viewer (public viewer), Wildfire Risk Reduction Planner (professional viewer), and the 2020 Forest Action Plan. The Forest Action Plan is described separately in this document.	Different tools are tailored to different audiences/uses regarding wildfire risk and planning in Colorado.
Colorado Post-Fire Recovery Playbook	Collaborative effort between federal, state, municipal, non-profit, and consultant groups	Various scales across the state	Counties, tribes, municipalities, and water providers are typically the entities most directly and immediately impacted by wildfire and post-fire erosion and flooding. The Post-Fire Recovery Playbook serves as an actionable worksheet that includes critical and specific steps to take and contacts to make before, during, and within the first 30 days of a fire to facilitate the recovery process.	Wildfire preparation and recovery guidance for counties, tribes, municipalities, and water providers.
Colorado Resiliency Office Department of Local Affairs	Colorado Resiliency Office	Statewide	The Colorado Resiliency Office's goal is to support a long-term adaptable and vibrant future for all Coloradans by building stronger, safer, and more resilient systems in the face of natural disasters and other shocks and stressors.	A variety tools, resources, and information to help empower communities to become more resilient in the face of changing conditions.
Forest Health Index Tool (FHI)	Aspen Center for Environmental Studies (ACES)	Large watershed-scale (e.g., HUC 8 and above)	FHI evaluates 12 specific indicators of forest health on an annual scale, and displays which factors are changing the most when compared to historical conditions. Indicators include variables such as temperature, precipitation, and fire risk. This tool is broken down by river basin, and tracks forest condition for 38 forested watersheds across Colorado.	Enables user to research or monitor forest health indicators for specific watersheds over time.
ForWarn Forest Change Assessment Viewer	U.S. Climate Resilience Toolkit	Various scales across the country	The Assessment Viewer is an online geospatial tool delivering phenological data to better understand landscape conditions and to warn of potential forest disturbances. The Assessment viewer incorporates a satellite-based forest disturbance monitoring system for the conterminous US, called ForWarn, which delivers new forest change products every eight days and provides tools for attributing abnormalities to insects, disease, wildfire, storms, human development, or unusual weather. Archived data provide disturbance tracking across all lands since 2000.	Intended for use by resource managers and forest landowners to monitor forest health.

Appendix B. Helpful Tools and Models that Support Forest Best Management Practices in Colorado

Tool or Model Name	Entity	Scale	Description	Anticipated Tool Use(s)
Geospatial Technology and Applications Center (GTAC)	U.S. Forest Service	Various scales across the country	GTAC provides leadership in geospatial science implementation in the U.S. Forest Service by exploring and developing emerging technologies, working with partners to demonstrate their application in land and resource management, and providing solutions to inform decision making. GTAC has helped with the publication of a variety of products and tools including agency data, map products, and interactive web tools.	Various tools allow users to learn about or help optimize best land management practices on Forest Service lands.
Potential Operational Delineations (PODs)	U.S. Forest Service and Rocky Mountain Research Station	Small to large landscape-scale	PODs were developed to pre-plan for fire using a risk management approach, and to give land managers a formal process for developing landscape-scale wildfire response options before fires start. PODs are spatial units or containers defined by potential control features, such as roads and ridge tops, within which relevant information on forest conditions, ecology, and fire potential can be summarized. PODs combine local fire knowledge with advanced spatial analytics and promote cross-boundary planning and prioritization.	The PODs framework is intended for use by land managers to develop a common understanding of risks, management opportunities, and desired outcomes to determine fire management objectives.
Risk Analysis and Decision Support System (RADS): Prioritizing Fuels Reduction [2]	Colorado Forest Restoration Institute	Small to large watershed- scales	The RADS framework uses science-based methods to identify the most effective fuel treatment types and locations to reduce wildfire risk to water supply and maximize return on investment. RADS uses quantitative risk assessment to value fuel treatment benefits and then optimizes the type and location of treatment while accounting for feasibility and budget constraints. Case studies have shown that wildfire risk to water supplies can be meaningfully reduced by strategically treating a small portion of large watersheds.	RADS is intended for use by land managers to optimize fuel treatment types and locations to reduce wildfire risk. The framework of RADS can be expanded to other valued resources such as recreation and wildlife habitat.
Source Water Assessment and Protection (SWAP)	Colorado Department of Public Health and Environment	Small to large watershed-scale	SWAP is a web portal providing several resources to assist with the protection of public drinking water supplies including templates, funding resources, and example plans. There are specific resources for wildfire and watershed assessment planning.	The web portal provides resources to develop a Source Water Protection Plan.

[2] *Colorado Forest Restoration Institute. 2019. The Right Work at the Right Time: Prioritizing Fuel Reduction to Protect Water Supplies. Available: https://cfri.colostate.edu/wp-content/uploads/sites/22/2019/05/CFRI_wRADS_2Pager_May2019.pdf*

Appendix B. Helpful Tools and Models that Support Forest Best Management Practices in Colorado

Tool or Model Name	Entity	Scale	Description	Anticipated Tool Use(s)
Terrestrial Condition Assessment (TCA) [3]	U.S. Forest Service	Various scales on U.S. Forest Service lands across the country	TCA evaluates effects of stressors and disturbance on land-type associations (LTAs) to identify restoration opportunities on national forest system (NSF) lands in the US. The TCA was implemented with the ecosystem management decision support (EMDS) system, a spatial decision support system for landscape analysis and planning. TCA information has been used to generate a variety of GIS-based mapping products available to the public, such as the TCA Wildfire Hazard Potential tool.	The TCA Wildfire Hazard Potential tool allows users to view areas of uncharacteristic fuel buildup, which have a higher probability of high-intensity fire.
Watershed Erosion Prediction Project (WEPP)	U.S. Forest Service Climate Change Resource Center	Intended for hillslope and small watershed scales. Larger watersheds possible with advanced GIS programming skills.	WEPP is a physically-based soil erosion prediction technology with a number of customized interfaces developed for common applications such as roads, managed forests, forests following wildfire, and rangelands. The purpose of the model is to estimate erosion and sediment processes on hillslopes and small watersheds, taking into account climate, land use, site disturbances, vegetation, and soil properties.	The WEPP model can be used to assess soil and water response(s) to different forest management scenarios.
Watershed Investment Tool (WIT)	Peaks to People	Large watershed or landscape-scale	WIT is a risk-based assessment and planning tool designed to estimate the benefits of forest fuels reduction and leverage this information to optimize fuel treatment type and location. When forest management investments at large landscapes are spatially prioritized, risks to water supplies are reduced. The WIT analyzes forest fuel conditions, erosion potential, and connectivity to water supplies.	The WIT tool allows interest groups to identify and fund forest management projects that will provide the best outcomes and ensure return on investment.

[3] *Cleland D, K Reynold, R Vaughan, B Schrader, H Li, L Laing. 2017. Terrestrial condition assessment for national forests of the USDA Forest Service in the continental US. Available https://www.fs.usda.gov/treesearch/pubs/55800*

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Tool or Model Name	Entity	Scale	Description	Anticipated Tool Use(s)
Watershed/Wildfire Assessment Tool	Watershed Wildfire Protection Group (WWPG) and its partners	Most often used in medium to large watershed-scale (e.g., Fourth-level or 8-digit HUC)	The Watershed/Wildfire Assessment methodology was developed to identify sixth-level watersheds that provide critical water supplies to communities and municipalities and assist in prioritizing watersheds for mitigation and protection measures. The methodology analyzes and ranks wildfire hazards, flooding and debris risks, soil erodibility, and water use. The methodology was developed in 2009 in a collaborative effort by Front Range water providers, U.S Forest Service, Colorado State Forest Service, U.S. Geological Survey, Bureau of Land Management, Colorado Department of Public Health and Environment, and National Resources Conservation Service. It has become the accepted methodology by all agencies to identify and prioritize "at risk" watersheds for hazard reduction treatments and other watershed protection measures. For example, Denver Water has used this methodology to identify "zones of concern" within its watershed in which to focus its treatment efforts.	The Watershed/ Wildfire Assessment Tool framework has become an accepted methodology among several agencies that operate in Colorado to identify and prioritize "at risk" watersheds for hazard reduction treatments and other watershed protection measures.
Wildfire Risk Assessment Framework for Highly Valued Resources and Assets	US Department of Agriculture, US Forest Service, and Rocky Mountain Research Station	Small to large landscape-scale	The Wildfire Risk Assessment Framework for Land and Resource Management provides a means with which to assess the potential risk posed by wildfire to specific highly valued resources and assets (HVRAs) across landscapes. It also provides a scientifically based foundation for fire managers to think strategically and proactively about how to best manage fire and fuels in a way that integrates with broader land and resource management goals. The wildfire risk assessment framework is comprised of four primary components: 1) wildfire simulation, 2) highly valued resource and asset (HVRA) characterization, 3) exposure analysis, and 4) effects analysis.	The Wildfire Risk Assessment framework is intended to provide fire and land managers with a helpful set of guiding principles and tools for assessing and mitigating wildfire risk.