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Integrating Climate Adaptation Strategies into Local Collaborative Forest Management in Northern Colorado: a Case Study with the Upper South Platte Partnership

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management

for the

Bren School of Environmental Science & Management

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

Joan Dudney

Date

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ACRONYM GLOSSARY

CDPHE	Colorado Department of Public Health and Environment
CFRI	Colorado Forest Restoration Institute
CSFS	Colorado State Forest Service
CUSP	Coalition for the Upper South Platte
CWDG	Community Wildfire Defense Grant
DMP	Denver Mountain Parks
DST	Decision-support tool
FACTs	Forest Adaptation Climate Tools
FPD	Fire protection district
IPCC	Intergovernmental Panel on Climate Change
IRB	Institutional Review Board
JCD	Jefferson Conservation District
JCOS	Jefferson County Open Space
NIACS	Northern Institute of Applied Climate Science
RAD	Resist, Accept, Direct
RMRI	Rocky Mountain Restoration Initiative
RRAD/T	Resistance, Resilience, Acceptance, Direction/Transition
RRT	Resistance, Resilience, Transition
TNC	The Nature Conservancy
USFS	United States Forest Service
USGS	United States Geological Survey
USP	Upper South Platte
USPP	Upper South Platte Partnership
WUI	Wildland-urban interface

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OBJECTIVES

Climate change is altering western dry forests, including those along Colorado's Front Range, underscoring the need for climate adaptation. There are numerous resources available to land and forest managers designed to support climate adaptation efforts. In fact, the sheer number of available tools makes it challenging to determine which are most useful. This project synthesized resources most critical to climate adaptation into a climate adaptation workflow for land and forest managers working in the Upper South Platte Watershed (hereafter, the Watershed). We set the following objectives to guide our work:

1. Evaluate and organize existing climate adaptation resources into a structured workflow to facilitate climate adaptation in local forest management.

2. Assess barriers to climate adaptation through structured interviews with USPP Partners, identify potential solutions to those barriers, and establish recommendations for climate adaptation within the USPP.

3. Develop recommendations for incorporating equity and environmental justice into forest adaptation practices.

SIGNIFICANCE

Climate Change and Colorado's Forests

Healthy forests are the foundation for social and ecological communities in Colorado, providing clean air and water, recreation opportunities, and economic benefits. Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "any change in climate over time whether due to natural variability or as a result of human activity" and is expected to result in higher temperatures, more chaotic precipitation patterns, and more severe storm events[1]. Average annual temperatures in Colorado have increased by 2°F over the last 30 years, with climate models predicting continued temperature increases, earlier snowmelt, more severe drought, and more extreme wildfire behavior[2]. Many stressors amplified by climate change threaten Colorado's forests, including intensifying and persistent drought, severe wildfires, pest and disease outbreaks, earlier snowmelt, and invasive species, all of which threaten forests and the communities who rely on them[2–5].

Historical land management practices have also shaped the forests, in some regions amplifying the impacts of climate change. Land clearing by Western settlers coupled with federal fire suppression policies of the twentieth century contributed to forest densification and accumulated fuels, which often burn at higher severity, particularly during hot, dry periods[6,7]. Colorado's 2020 fire season, which included three record-breaking wildfires, is an example of the increasing vulnerabilities of forested ecosystems to wildfire due to the combination of climate change and historic land management as well as the need for climate adaptation[7]. For example, the largest wildfire in state

history, the 2020 Cameron Peak Fire, burned more than 200 thousand acres of the northern Colorado Front Range for four months[8,9].

Beyond wildfire, stressors to Colorado's forests include insects, diseases, droughts, floods, more severe storm events, and invasive species[2–4,10]. An example of this is the mountain pine beetle epidemic, which has impacted 3.4 million acres in Colorado[11]. Drought increased tree susceptibility and warm temperatures extended the normal reproductive period for the beetles, leading to tree die-off[4,11]. The increasing risk of forest mortality under climate change threatens valuable ecosystem services and underscores the urgent need to develop climate adaptation strategies.

The Need for a Climate Adaptation Workflow

Many researchers are working to understand how climate change affects forests and developing resources to guide climate adaptation. Here we use the United Nations' definition of climate adaptation: "changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change." These resources include everything from technical models and geospatial tools to decision-making frameworks and process-based workflows. They aim to provide land and forest managers with structured, scientifically robust, and novel information to inform management decisions and the development of long-term forest management strategies that prioritize climate adaptation. *(As a note, forest management in this report is meant to encompass forest management for climate adaptation in addition to forest management for other objectives.)*

The challenges, however, are the sheer quantity of information and resources, the difficulty of assessing their quality, a lack of clear guidance on what to use and when to use, and a knowledge gap on environmental justice implications. There is an abundance of tools, models, frameworks, and other resources that provide recommendations for how to facilitate adaptation to climate change, but it can be difficult to evaluate the quality and applicability of all this information. Furthermore, there is often a disconnect between the research questions posed by scientists and the needs of land managers, which can make it challenging to integrate the latest science into projects on the ground. Finally, there is a need to consider how climate adaptation impacts nearby and downstream communities. Management decisions need to better consider the distribution of benefits and burdens associated with forest climate adaptation solutions.

With so many available climate adaptation resources, we identified a need for a workflow that supports managers – our audience – through planning climate adaptation strategies aligned with local management goals and aggregating helpful DSTs. To address this gap, our project synthesized relevant climate adaptation resources, with environmental justice considerations, into a workflow to assist managers as they navigate adapting Colorado's forests in the face of climate change.

BACKGROUND

The Upper South Platte Watershed (the Watershed)

The Watershed is located along the Front Range of the Rocky Mountains (Figure 1). It spans a variety of regions, from urban areas in southwest Denver to grasslands and riparian ecosystems, up to montane, sub-alpine, and alpine zones[12]. The Watershed is defined by the U.S. Geological Survey (USGS) level 8 Hydrological Unit Code (HUC) boundary[13]. Spanning multiple counties, including Jefferson, Park, Clear Creek, Denver, Arapahoe, Douglas, Teller, and a small portion of El Paso County, it includes unincorporated areas and portions of the Denver metro area. Approximately 849,000 people live within the Watershed across urban, suburban, rural, and wildland-urban interface (WUI) areas. The Watershed also provides 80% of Denver's water supply[5,6].

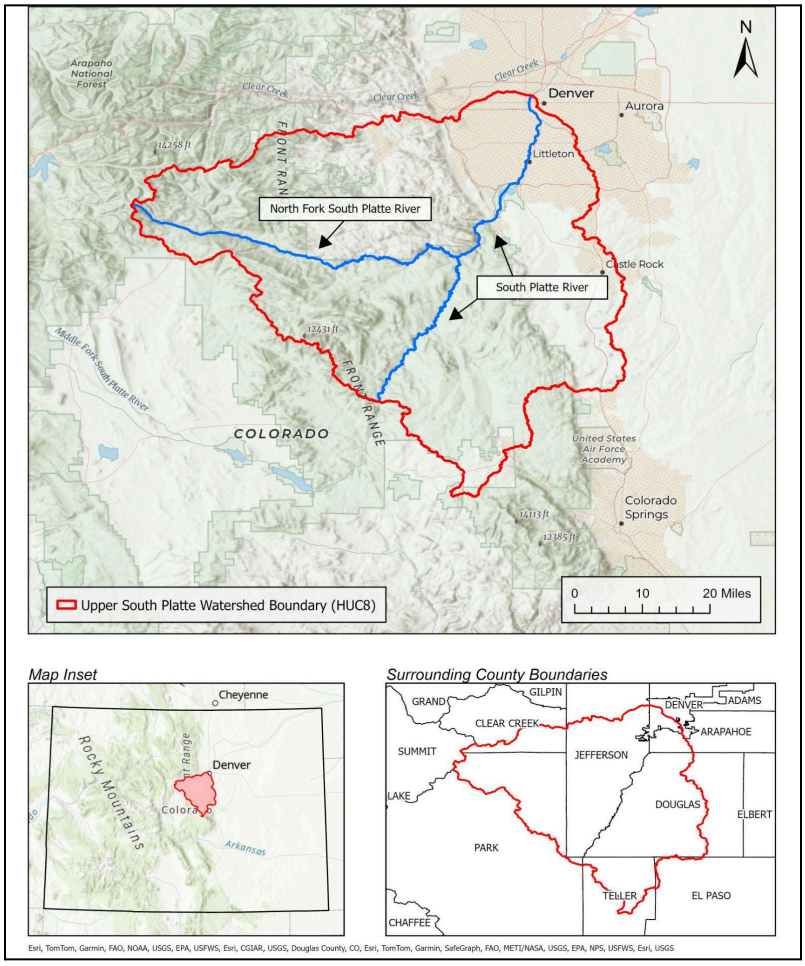

Figure 1. Upper South Platte watershed boundary (HUC8) and surrounding counties.

The Upper South Platte Partnership (USPP)

Our project aims to support the Upper South Platte Partnership (USPP), a collaborative group of land managers, foresters, researchers, firefighters, non-profits, and conservationists (Table 1). The

USPP's mission is to "foster sustainable and resilient landscapes, healthy forests, and proactive fire-adapted communities within [the Watershed] through active forest management."[14] The USPP pays specific attention to supporting wildfire-adapted communities and protecting water resources vital to the Watershed and communities in Denver[14].

Table 1: USPP Partners by organization type. Information obtained from the USPP website[14].

USPP Partners by Organization Type	
Water Districts	Aurora Water and Denver Water
Conservation, Open Space, Parks, and Forest Service Organizations	Colorado Forest Restoration Institute (CFRI), Colorado State Forest Service (CSFS), Denver Mountain Parks (DMP), Jefferson Conservation District (JCD), Jefferson County Open Space (JCOS), Rocky Mountain Restoration Initiative (RMRI), and U.S. Forest Service (USFS)
Fire Protection Districts (FPDs)	Elk Creek FPD, Inter-Canyon FPD, North Fork FPD, Evergreen FPD, Platte Canyon FPD, and West Metro FPD
Non-profit Organizations	Coalition for the Upper South Platte (CUSP), Genesee Foundation, The Nature Conservancy (TNC), and Stewardship West

Types of Climate Adaptation

Climate adaptation frameworks assist managers in making decisions about how to respond to the impacts of climate change. There are two commonly used frameworks in natural resource management: Resist, Accept, Direct (RAD)[15] and Resistance, Resilience, Transition (RRT)[16]. They describe what we refer to as different "types" of climate adaptation. Due to the popularity of these frameworks, we combined the two into one framework hereafter referred to as RRAD/T. Our project explores the use of these adaptation types in forest management, as defined here:

- **Resistance**: Maintaining the current conditions, the management actions taken are toward this system being able to resist change.
- **Resilience**: Similar to resistance, but focus shifts away from maintaining the current system to withstanding and responding to the negative impacts of disturbances.
- **Acceptance**: Deliberately allow climate-related changes to progress without significant mitigation.
- **Direction/Transition**: Intentionally focus on promoting adaptive responses and facilitating change, anticipating climate-related changes, managing for anticipated conditions, and/or deliberately accelerating those changes.

Social and Ecological Vulnerabilities in the Watershed

Due to a general lack of environmental justice considerations in forest management, our project considers the equitable distribution of benefits and burdens associated with forest management. In the sections below, we define environmental justice and describe the current state of social and ecological vulnerabilities of communities in and around the Watershed.

Defining Environmental Justice

The United States Environmental Protection Agency defines environmental justice as follows:

> "'Environmental justice' means the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment so that people: 1) are fully protected from disproportionate and adverse human health and environmental effects (including risks) and hazards, including those related to climate change, the cumulative impacts of environmental and other burdens, and the legacy of racism or other structural or systemic barriers; and 2) have equitable access to a healthy, sustainable, and resilient environment in which to live, play, work, learn, grow, worship, and engage in cultural and subsistence practices."[17]

The environmental justice movement emerged in the U.S. during the 1980s when a company was found dumping hazardous waste- PCB -in a predominately African American neighborhood in North Carolina[18]. In response, affected communities protested and inspired the larger environmental justice movement.[18] Building off this momentum, a landmark report published in 1987 found that a community's race was the main factor in the decision of hazardous waste facility siting[18]. Following the protests and report, the U.S. saw several Executive Orders (EO) including EO 12898, the first acknowledgment of environmental justice by federal agencies, and EO 14008, which calls for government agencies to address environmental injustices across all environmental issues, including forest management and wildfire risk[19–22].

Environmental Justice in the Watershed

The Watershed has experienced several fires, including the historic Buffalo Creek Fire in 1996, as well as the Hi Meadow, Snaking, Schoonover, Hayman, Lower North Fork, Waldo Canyon, and Black Forest Fires[23,24]. In response, the federal government has identified the area as one of the ten National Wildfire Crisis Strategy (WSC) high-risk landscapes in 2022[25]. Within the context of wildfire, Thomas et al. 2022 proposed the below definition of environmental justice. This definition better suits the nature of environmental justice for our project due to the high risk of wildfire exposure in the Watershed and the USPP's mission.

> "When all people, especially those that have not been historically engaged, consulted, and meaningfully involved in governance processes that affect their environment, are inequitably located in high fire risk areas and/or under conditions that make them more susceptible to prolonged exposure to wildfire impacts, smoke or post-fire hazards such as flooding."[26]

In order to organize environmental justice considerations consistently across the deliverables of our project, we chose to use a commonly used framework that divides environmental justice into four categories[27].

1. **Procedural justice**: Fair decision-making processes. This involves observing who has a say in policy development and whether a diverse range of stakeholders are included in policy and decision-making processes.
2. **Distributional justice**: Fair allocation of resources, benefits, and burdens or harms, and observing who bears the costs and who bears the benefits.
3. **Restorative justice**: Rectifying and repairing past harms.
4. **Recognitional justice**: Giving credit where credit is due.

Communities in and around the Watershed

The risk of and vulnerability to wildfire and forest health benefits are not distributed equally amongst communities in the Watershed. In the following section, we describe three distinct communities types found within the Watershed, and discuss some of the unique social and ecological challenges faced by each to further define our approach to understanding the current conditions of environmental justice. This in turn, allows us to make recommendations for incorporating equity and environmental justice into forest management practices.

Headwaters Communities

These communities are in the upper bounds of the Watershed. Within this community, most environmental burdens are relatively low according to the Colorado Department of Public Health and the Environment's (CDPHE) Colorado EnviroScreen 2.0 tool[28]. However, wildfire risk is extremely high[29]. This portion of the Watershed contains more forested land, managed by various federal, state, and local agencies, and is where the majority of USPP projects are located. USPP projects concentrate here because of the combined risks wildfire, poor forest health, and climate change pose. The USPP's work is concentrated in the headwaters in an effort to reduce wildfire risk for these communities.

Downstream Communities

Downstream communities are those within the Denver metro area. These regions also benefit from the USPP's projects in the upper reaches of the Watershed and are part of the Watershed. According to EnviroScreen, these communities have higher environmental burdens[28]. Additionally, their representation in decision-making may be lower than those in the Headwaters Communities because they are not in as close of proximity to USPP projects. Addressing these gaps is critical to fostering equitable management practices throughout the Watershed. Through procedural justice strategies, more accessible opportunities for community input, and other strategies defined later in

this review, downstream communities can more equitably access and connect with the Watershed's upper reaches and its forest management projects.

It is also important to note that as climate change worsens, this portion of the watershed may experience higher risk to wildfires. After the extraordinary Marshall Fire in 2021, grassland and shrubland communities at the fringe of forested areas along Colorado's Front Range, like these communities, may be at greater risk than previously thought[9].

Greater Denver-metro Area

The greater Denver metro communities are those that receive water from the Watershed via local water utilities. These communities also benefit from forest management in the upper reaches of the Watershed by receiving cleaner air and water as a result of the projects. In fact, 80-90% of the water supply for nearly 1.5 million Denver metro residents flows from or through this Watershed.

METHODS

Our methods are broken into 5 main steps as shown in Figure 2: (1) literature reviews focusing on the western dry forest ecosystem, environmental justice considerations in forest management, decision-support tools (DSTs), and resources supporting the climate adaptation menu; (2) a table containing information about relevant DSTs; (3) interviews with USPP Partners and a qualitative analysis of the interview transcripts; (4) climate adaptation menu development; (5) compiling findings from the previous steps into the climate adaptation workflow. These steps follow the order in which they were initiated throughout the project but were not completed chronologically.

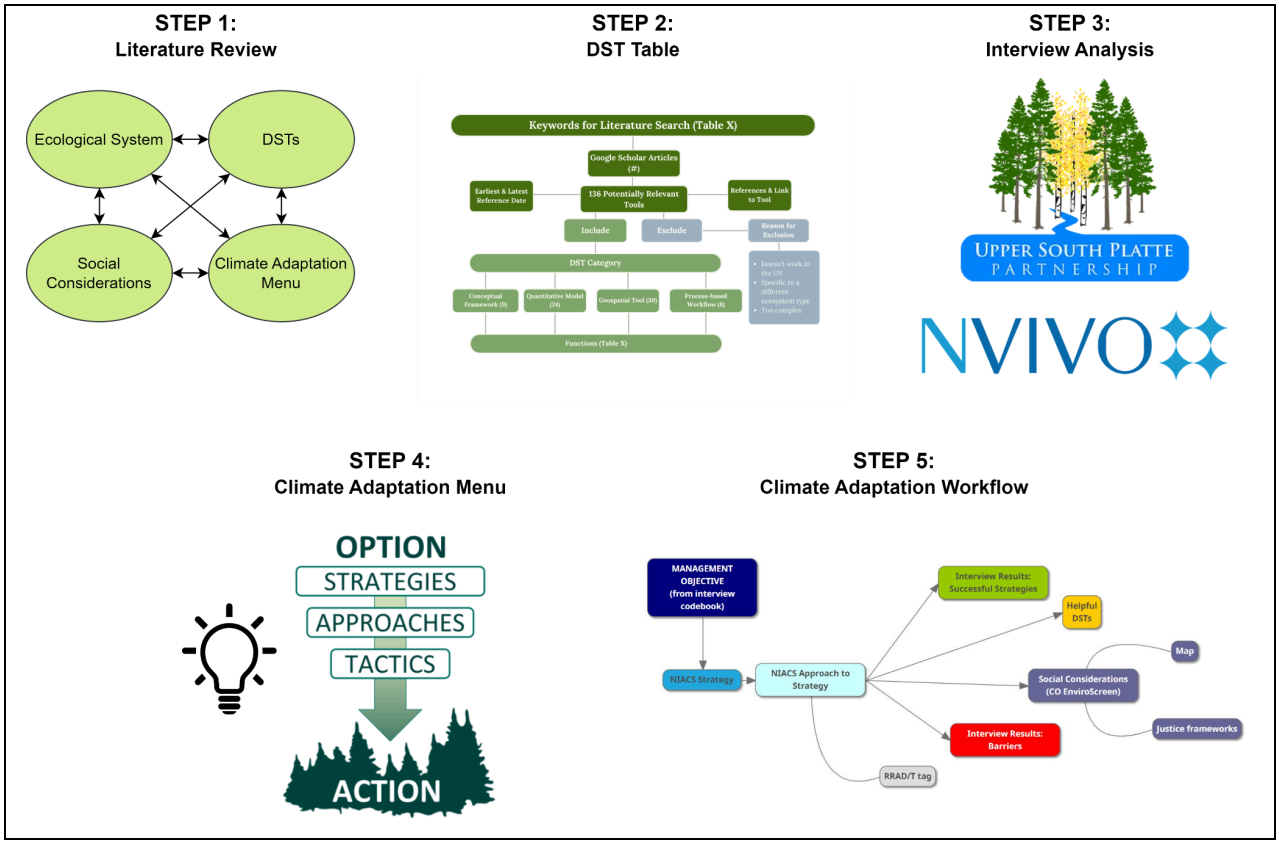

Figure 2. Overview of methods. Steps are labeled in the order that each method is discussed in the methods section, as well as the order in which they were initiated throughout the project.

Literature Review

Local Ecology of the Watershed

This literature review serves as an overview of the ecology of the Watershed in terms of forest types, forest structure, management history, disturbance regimes, ecosystem services, and the current and anticipated impacts of climate change.

The FACTs team read and synthesized information from 247 sources including peer-reviewed journal articles, policy directives, technical support documents, textbooks, and public-facing websites. Materials were found through searches conducted in Google Scholar, Web of Science, and Research Gate, along with recommendations from experts in forest management, climate adaptation, and decision-making science. Search terms used were broad and included various permutations of “forest management”, “climate adaptation”, “dry forests”, “wildfire risk”, “drought”, “insect outbreaks”, “ecosystem services”, “restoration”, “prescribed burning”, “thinning”, “biodiversity”, “recreation”, “collaborative management”, “decision-support tool”, “environmental model”, “geospatial tool”, “conceptual framework”, “process-based management”, “climate vulnerability”, “ecology”, “forest composition”, “forest structure”, “forest succession”, “fuel loading”, “water supply”, “water quality”, “snowpack”, “snowmelt”, “Colorado Front Range”, “ponderosa pine forest”, “lodgepole pine forest”, “mixed-conifer forest”, “yellow pine forest”, “aspen”, “beaver”,

"process-mediated restoration", "riparian corridor", "forest policy", "management history", and synonymous terms.

Environmental Justice

This literature review sets the context for environmental justice in the Watershed. It focused on environmental justice in forest and wildfire management, and identified common barriers to incorporating equity into these management regimes, as well as strategies for addressing these barriers.

The FACTs team read and synthesized information from 37 sources, including peer-reviewed journal articles, policy directives, technical support documents, textbooks, and public-facing websites. Materials were found through searches conducted in Google Scholar, Web of Science, and Research Gate, along with recommendations from experts in forest management, climate adaptation, and decision-making science. Search terms used were broad and included various permutations of "environmental justice," "forest management," "wildfire risk," "equity," "inclusivity," "smoke exposure," "human health," "socio-demographic," "social vulnerability," "demographics," "agency response," "inequality," "wildfire risk management," "justice," and synonymous terms. To ensure the review was pertinent to our study area, we included information specific to the U.S., U.S. policy, the Western U.S., and social and environmental justice frameworks that were specific to forest and wildfire management.

DST Table

Resource Identification and Organization

There is a diversity of DSTs in use for climate adaptation, forest management, ecosystem assessment, risk management, adaptive management, spatial planning, and associated use cases. These DSTs cover an array of forms and functions. As described in Table 2, this review categorizes DSTs into: 1) conceptual frameworks, 2) quantitative models, 3) geospatial tools, and 4) process-based workflows. Many of these DSTs fit more than one of these descriptions and are commonly nested within each other. For example, WildEST, FlamMap, and FSim are quantitative models that predict fire risk and are implemented within the geospatial tool, LandTender.

Table 2. Types of DSTs included in the analysis and supporting definitions.

DST Category	Description & Examples
Conceptual Framework	• Means of establishing common vocabulary and system-level thinking. • Goal of improving communication and collaboration. • Examples include the ideas of adaptive management, resist-accept-direct, and resistance-resilience-transition.
Qualitative Model	• Scientific representation of a system. • A plethora of quantitative models are used in forest management. • Wide use includes:

DST Category	Description & Examples
	• Estimating the value and distribution of ecosystem services • Predicting wildfire risk and behavior • Modeling vegetation composition and structure • Climate change projections • Understanding hydrologic dynamics
Geospatial Tool	• Encompass individual technologies and platforms used for mapping and planning (e..g, Esri ArcGIS Pro). • Often incorporate the functions and results of quantitative models.
Process-Based Workflow	• Many DSTs function as structured processes rather than specific technologies. • These facilitate collaboration, guide decision-making, and ensure adaptability to new information. • Focus on documenting decision rationale • Proactively encourage holistic thinking and novel solutions • Examples include the U.S. Forest Service's WFDSS and the NIACS Adaptation Workbook.

We identified, reviewed, and categorized 132 commonly used DSTs according to relevance, function, and accessibility for climate adaptation in forest management. We reviewed DSTs from free-to-access, peer-reviewed journals. Anything requiring a paywall beyond what the team could access via the University of California, Santa Barbara's campus VPN was not evaluated.

DSTs were initially found via three journal articles presenting meta-analyses of DSTs commonly used and/or cited in policy documents, government reports, and journal articles. The FACTs team then expanded the search through Google Scholar, Web of Science, and ResearchGate using a broad array of search terms including "decision-support tool", "structured decision-making", "quantitative model", "geospatial tool", "process-based workflow", "forest management tool", "risk management", "wildfire prediction", "climate prediction", "hydrology model", "vegetation growth simulation", "ecosystem service estimation", and "adaptation process."

In addition to sorting DSTs into categories, we reviewed them according to cost of use, focal ecosystems, regional limitations, ease of use, and specific functions (i.e.,environmental justice, soil health/erosion, insects and pests, water security, climate models/climate change, wildfire behavior, wildfire risk, management actions/prioritization, land use/human development/WUI, habitat/biodiversity/invasives, and ecosystem services).

Several DSTs that were reviewed were deemed categorically inappropriate for recommendation for the purpose of climate adaptation in western dry forests. These were excluded from further review for reasons such as only functioning on other continents, mismatched ecosystem focus, or irrelevant functionality.

Interviews with USPP Partners

To understand the current practices, barriers, and needs around climate adaptation within the USPP, we interviewed 15 representatives from the USPP, selected by TNC. We had several goals for each interview as listed in Table 3.

The one-hour Zoom interviews were conducted under UCSB's Human Subjects Research approval and requirements and in compliance with the Institutional Review Board's (IRB) conditions. Each interview followed the same order of questions, while allowing for flexibility to ask additional questions as needed.

The FACTs team interviewed employees of the Colorado State Forest Service, Denver Mountain Parks, Denver Water, Elk Creek Fire Protection District, Genesee Foundation, Jefferson Conservation District, Jefferson County Open Space, and The U.S. Forest Service. Additionally, we interviewed the program coordinator of the USPP and the Forest Mitigation Coordinator of the Coalition for the Upper South Platte (CUSP). See Appendix Table 9 for a complete list of interviewees.

Table 3. Interview objectives. The left column provides an overarching goal and the right column provides additional details.

Overarching Goal	Additional Details
Define Climate Adaptation	• Identify how climate adaptation is defined within the USPP. • Determine whether there is a need to create a shared climate adaptation definition.
Identify Climate Adaptation Implementation	• Identify currently implemented and considered adaptation types. • Summarize successful adaptation strategies. • Identify barriers to adaptation. • Understand the process around considering and implementing climate adaptation processes.
Understand Environmental Justice in Planning	• Determine whether environmental justice is part of the process. • If so, in what way? Why? • Determine benefits and barriers to environmental justice work.
Gather Additional Insights and Feedback	• Encourage feedback on our project. • Solicit suggestions for additional interviewees.

Interview Transcriptions

Each interview was recorded and transcribed using Zoom, with the interviewee's permission. Both the transcripts and audio recordings were saved. The resulting transcripts were uploaded as text (.txt) files into NVivo for analysis. As part of the quality control process, the transcripts were

cleaned and organized into a cohesive narrative format, retaining only the timestamps from when each individual started speaking and formatting all that was spoken into paragraphs. Next, an analyst thoroughly read each transcript while listening to the recorded interview to identify and correct any transcription errors. In cases where uncertainties remained, the analyst consulted the original interviewer for clarification to ensure the accuracy of the transcription.

Qualitative Analysis with NVivo

The data managers conducted a qualitative analysis of the interview data. To begin the process, we consulted Dr. Summer Gray, a qualitative environmental sociologist and Associate Professor at UCSB, to outline our approach and ensure a suitable analysis given our number of interviewees, the goals of the interview process, and ways to minimize individual bias in a collaborative coding process. Based on these discussions and following a similar workflow detailed in Fine et al. 2024,[30] our analysis included four steps: 1) pre-coding; 2) first cycle coding; 3) second cycle coding; 4) identifying themes and concepts (Figure 3).

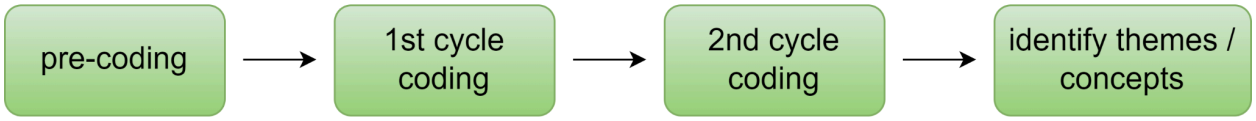

Figure 3. Conceptual framework for the qualitative analysis.

In qualitative analysis, a "code" is a word or short phrase that assigns a summative and salient attribute to a portion of language to organize and interpret qualitative data.[31] A variety of coding approaches exist in qualitative analysis (e.g., values coding, emotion coding, descriptive coding, etc.). Given our interview goals and minimal prior experience with qualitative analysis, we took Dr. Gray's recommendation for descriptive coding as the most fitting analytical approach. Descriptive coding summarizes the primary topic of a passage, avoiding the attribution of emotions or sentiments to excerpts.[31]

Pre-coding

For the pre-coding process, the data analysts created an initial codebook. This codebook consisted of parent codes, which encapsulate a broad subject, as well as child codes, which nest under each parent code and provide more specificity. For example, "Adaptation Strategies" was a parent code, with "Resistance", "Resilience", "Acceptance", and "Direction or Transition" as its four child codes (see Appendix Table 10 for a complete list of codes and their definitions). These parent and child codes were created based on the initial goals of the interview process, the interview questions that were asked, and the information that we expected to be able to obtain. Together, the analysts created consistent definitions for each code to minimize bias.

First Cycle Coding

In the first cycle, each analyst reviewed half of the interviews. This included tagging excerpts with all relevant codes in each interview. Coded excerpts ranged from a single phrase to entire paragraphs, depending on the length of time that the interviewee spent discussing that subject. Additionally, each analyst noted any information that could only be captured by adding a new code. When there was a need for new codes, data analysts mutually discussed and agreed upon the new codes and their definitions. Upon adding a new code, analysts reviewed earlier work to apply appropriate updates.

Second Cycle Coding

The second cycle of coding is a process to minimize bias in interview coding. After each analyst coded their assigned interviews, data analysts exchanged NVivo projects to review and revise each other's work. This review specifically focused on checking the application of codes and adding any relevant codes that were missing. We chose to only add codes, and not remove them, as a consistent practice to ensure intercoder reliability. Additionally, neither analyst found any irrelevant codes which would have necessitated removal.

Identify Themes and Concepts

The final step of the qualitative analysis was to identify themes and concepts emerging from the descriptive codes. We began by ensuring that both analysts had complete and identical copies of all the interviews, along with the assigned codes. The team met to revisit the goals of the interview process, clearly outlining the key information we needed to extract from the interviews. Working off of these goals, the data analysts systematically grouped information by individual codes across interviews to look for emergent themes and patterns. For instance, reviewing excerpts tagged with the descriptive code "Public Perception" led to the creation of the theme "Negative public perception of forest treatment and associated aesthetic changes." This approach facilitated the systematic extraction of meaningful patterns and insights from the data.

Climate Adaptation Menu

We reviewed ten climate adaptation menus created by the Northern Institute of Applied Climate Science (NIACS). The menu topics were: California Forests, Forests, Forested Watersheds, Non-Forested Wetlands, Forest Carbon Management, Urban Forests, Recreation, Tribal Perspectives, Wildlife Management, and Fire-Adapted Ecosystems[33–42]. Through the menu review, we identified goals, strategies, and approaches relevant to climate adaptation in western dry forests and the USPP. We excluded strategies and approaches that were not relevant to the Watershed, or that interviews had indicated were already well-established knowledge and practices within the USPP.

The climate adaptation menu format is a type of process-based workflow used for structured decision-making that starts with broadly defined goals, followed by associated strategies for accomplishing those goals, and specific approaches that can be implemented in projects. Some of

the NIACS menus included RAD framework references. To build upon this, we included additional references using our combined RRAD/T conceptual framework.

Climate Adaptation Workflow

The climate adaptation workflow is the main deliverable of our project, combining the results and findings of all the steps above into a one-stop shop for climate adaptation information. To create the climate adaptation workflow, we used the basic structure of the climate adaptation menu (i.e., approaches to climate adaptation nested within management strategies). Building on that structure, we categorized strategies, and their resulting approaches, by management objectives identified via interviews. Then, we connected the strategies and approaches from the climate adaptation menu with barriers identified through our interviews. Then, we added relevant DSTs that could aid managers in pursuing a given approach. We further tagged each approach with its corresponding RRAD/T adaptation types and environmental justice types (i.e., procedural, distributional, restorative, recognitional).

Finally, we streamlined the components together in an online, click-through workflow using the Qualtrics survey platform. We selected the Qualtrics survey platform because it was a simple service that allowed us to organize the climate adaptation workflow into clear sections: management objectives, strategies, approaches, common barriers within the USPP, helpful DSTs, and respective RRAD/T and environmental justice tags. Using Qualtrics also provides users with the option to go back and forth from page to page and generate reports.

RESULTS

Literature Reviews

Through our review, we identified 104 relevant sources for this project out of a total of 267 sources that we reviewed. These sources covered two broad categories: the ecology of the Upper South Platte Watershed (n = 67), and environmental justice considerations (n =37). The review of the ecology covered important unique characteristics of Colorado's Front Range, management history, past and present forest types, landscape-level forest structure, disturbance regimes including fire and insects, ecosystem services with an emphasis on water quality and security, and the observed and anticipated impacts of climate change. The review of environmental justice considerations incorporated a review of definitions of environmental justice pertinent to this system, an overview of the people of the Upper South Platte Watershed, examples of inequity in forest and wildfire management more broadly, policies impacting environmental justice, and an integration of these concepts with management recommendations. The environmental justice review was limited by a general lack of information in the academic literature on this topic.

DST Table

Through our review, we identified 61 DSTs applicable to climate adaptation in western dry forests. Of the 61 DSTs, ten are process-based workflows, 11 are conceptual frameworks, 39 are quantitative models, and 44 are geospatial tools. In addition to identifying a category for the DSTs, we determined whether the DSTs applied to one or more of 13 topics within forest climate adaptation. Figure 4 provides a visualization of the process we used to identify, evaluate, and select relevant DSTs, and Table 4 provides a summary of which DSTs include which topics.

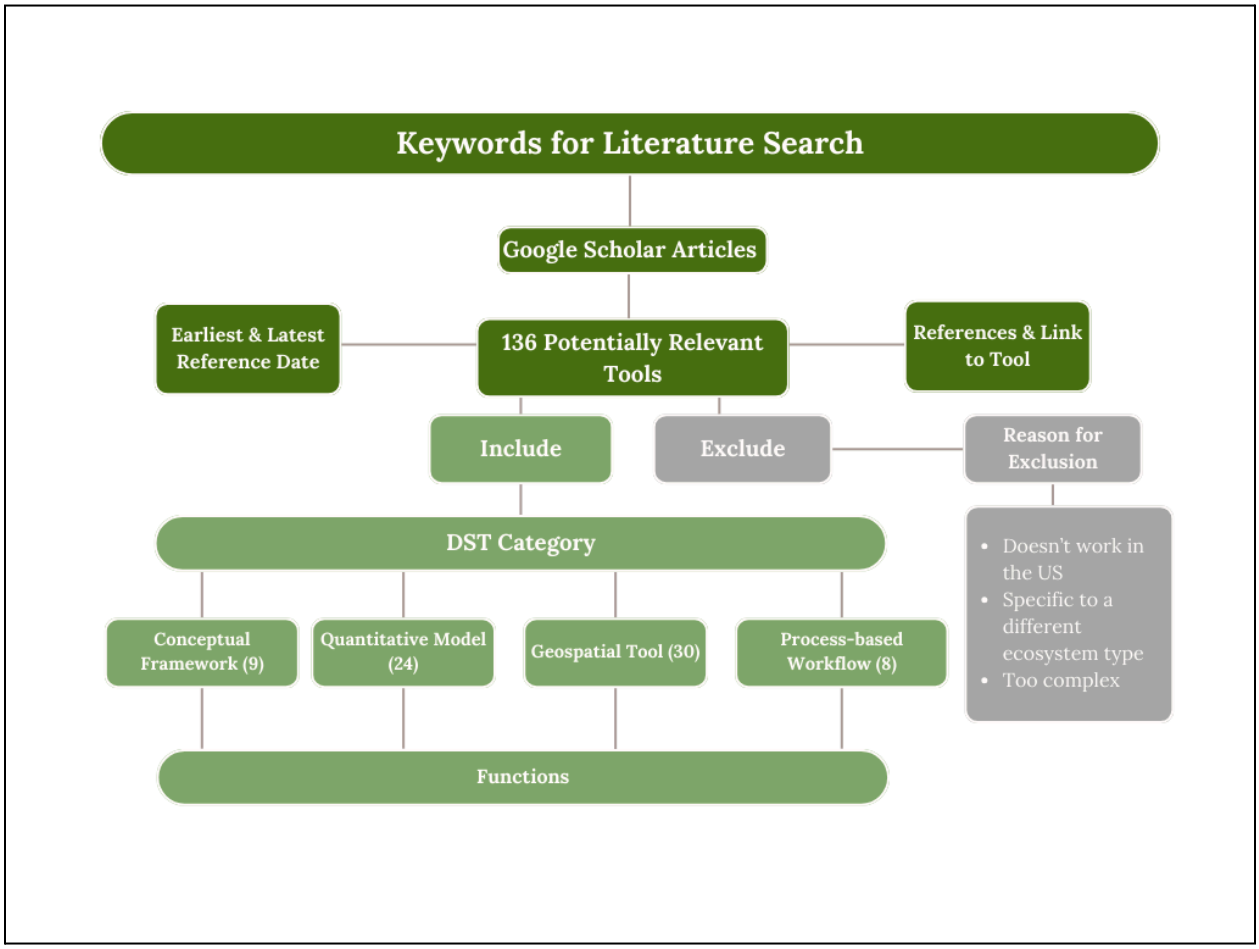

Figure 4. A visualization of the process we used to identify, evaluate, and select relevant DSTs. The darker green represents our process for finding DSTs. The grey represents our process for excluding DSTs. The lighter green represents our process for reviewing and selecting DSTs.

Table 4. Total count of tools covering climate adaptation topics of interest. Tools are ordered from highest to lowest count, and a relevant example is identified for each topic.

Topic	*Count*	*Example Tool*
Management Actions/ Prioritization	41	NIACS Adaptation Workbook & Menus

Topic	*Count*	*Example Tool*
Vegetation Models	31	VDDT© (Vegetation Dynamics Development Tool)
Free to Use	29	LANDIS II Forest Landscape Model
Ecosystem Services	26	Integrated Evaluation of Ecosystem Services and Tradeoffs (InVEST)
Water Security	24	Watershed Erosion Protection Project
Climatic Models/Climate Change	23	TACCIMO (Template for Assessing Climate Change Impacts and Management Options)
Habitat/ Biodiversity/ Invasives	23	Integrated Restoration and Protection Strategy (IRPS)
Land Use/ Human Development/ WUI	22	Rapid Assessment of Values at Risk (RAVAR)
Wildfire Behavior	21	FlamMap
Wildfire Risk	19	Large Fire Simulator Model (FSim)
Soil Health/ Erosion	17	Erosion Risk Management Tool (ERMiT)
Environmental Justice	12	Community Wildfire Protection Plans (CWPP)
Insects & Pests	10	LANDFIRE

Interviews with USPP Partners

Interview results are presented in three categories: the current state of climate adaptation, barriers to effective climate adaptation, and environmental justice in forest management.

Current State of Climate Adaptation

All interviewees use resilience (n = 15 interviewees), most use resistance or acceptance (n = 13 and n = 11, respectively), and about half use direction/transition (n = 7) in their work. The most frequently referenced adaptation type was resilience (n = 41 references), based on the total number of references throughout the interviews. Resistance and direction/transition were also highly referenced (n = 32 and n = 31, respectively), and acceptance was least referenced (n = 25) (Table 5). Overall, taking both the number of interviewees and number of references by interviewees, resilience is the most commonly used adaptation type among respondents, followed by resistance, then acceptance, with direction or transition being the least common. However, many respondents expressed interest in potentially implementing direction or transition types, even if they are not currently doing so.

Table 5. Adaptation type references throughout interviews. Counts, for each type, of the number of interviewees using it and the number of references made to it across all interviews.

Adaptation Type	# of Interviewees Actively Using Adaptation Type	Total # of References by Interviewees
Resistance	13	32
Resilience	15	41
Acceptance	11	25
Direction/Transition	7	31

Interviewees identified a total of 36 distinct management practices that fell under resistance, resilience, acceptance and/or direction/transition adaptation types. Based upon how interviewees identified each different practice, they have been sorted into a Venn diagram in Figure 5 and corresponding Table 6. One practice fell within all four types, three fell within resistance AND resilience AND direction/transition and four fell within resistance AND resilience. There is a significant overlap between the practices identified under resistance and resilience as illustrated in Figure 5 and Table 6. However, many practices fell within only one category: five fell just within resilience, two fell just within resistance, and seven fell just within direction/transition, and 12 fell just within acceptance. No practices were identified as resistance AND direction/transition only, or resilience AND direction/transition only. Of the seven practices within direction/transition, only four were being actively used by interviewees. Acceptance practices could be further broken apart in terms of *where* or *why* managers chose to use acceptance over other adaptation types. Acceptance is employed for a variety of reasons, including landowner preferences against treatment, physical inaccessibility, no community assets in need of protection, and the necessity of preparing for the reality of fire and evacuations.

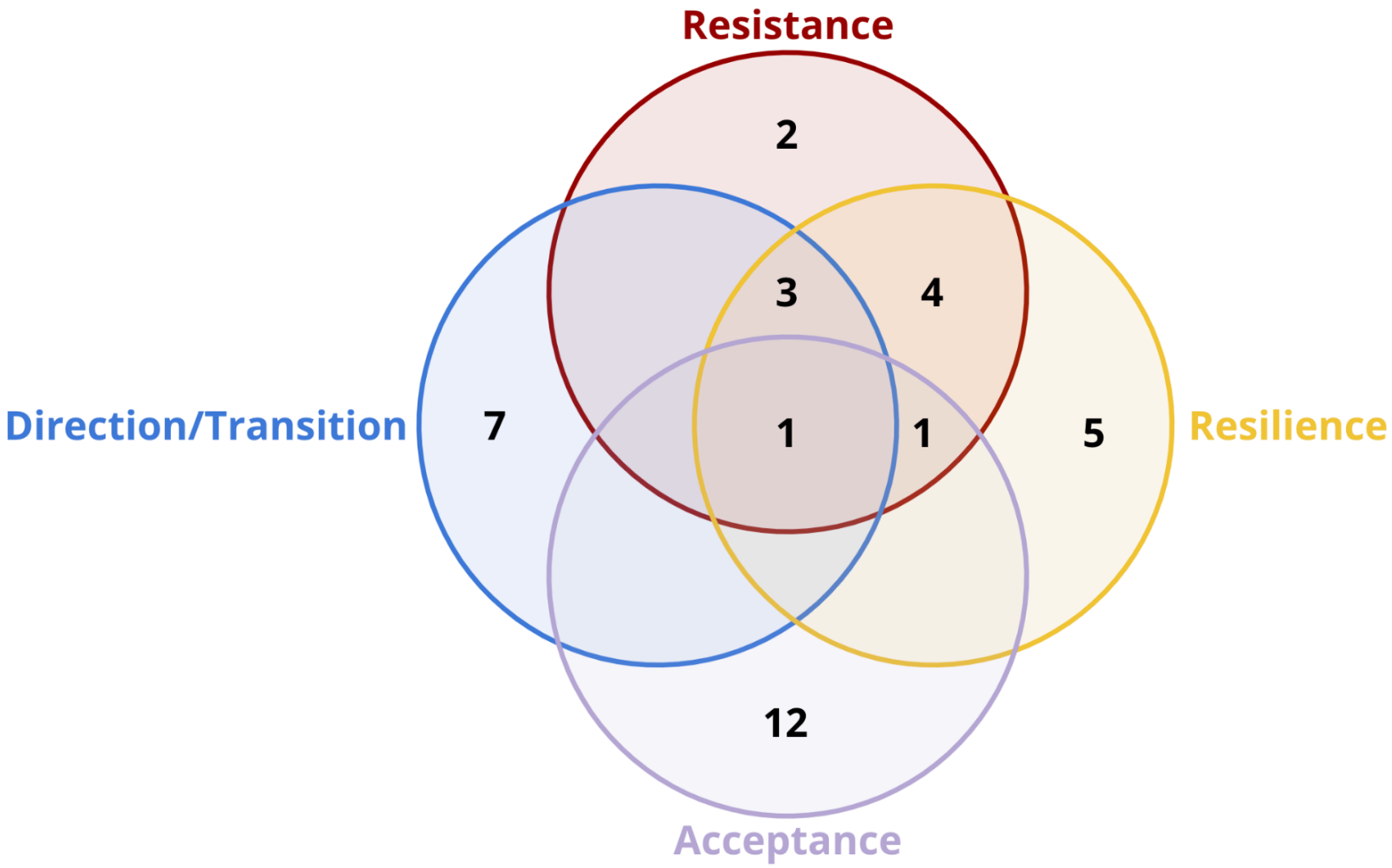

Figure 5. Counts of specific management practices, as identified by interviewees, and associated RRAD/T adaptation type. Specific practices were identified through interview analysis and categorized based on whether interviewees identified them as resistance, resilience, acceptance, and/or direction/transition.

Table 6. Specific management practices, as identified by interviewees, and associated RRAD/T adaptation type. Practices and adaptation types correspond to Figure 5 above. These specific practices were identified by interviewees and through the interview analysis, and categorized based on whether interviewees identified them as resistance, resilience, acceptance, and/or direction/transition. * indicates strategies that are not actively used.

Specific Practice	Adaptation Type			
	Resistance	Resilience	Acceptance	Direction / Transition
Remove douglas-fir				
Control for insects and disease				
Reduce forest densities				
Home hardening				
Reduce ladder fuels				
Remove lodgepole pine				
Retain structures and habitat important for wildlife				
Retain drought- and fire-tolerant species				
Promote ponderosa pine				
Promote aspen				
Enhance spatial heterogeneity				
Promote douglas-fir				
Promote managed fire				
Restore riparian areas				
Maintain mature seed-bearing trees				
Revegetate after fire				
Lack social license to manage				
Prepare for eventuality of fire				
Difficult to physically access				
North-facing slopes; Homogenous				

Specific Practice	Adaptation Type			
	Resistance	Resilience	Acceptance	Direction / Transition
mature forests				
No community assets				
Riparian areas				
High elevation mixed-conifer forests				
Aspen				
Wilderness				
Forest has transitioned to alternate state				
Low priority areas				
At capacity				
Facilitate upward movement of species or genotypes				
Proactive land use planning				
Remove non-native and disturbance-intolerant species				
Revegetate after disturbance with future-adapted species or genotypes				
Facilitate downward movement of species or genotypes*				
Facilitate movement of drought-tolerant and fire-tolerant species or genotypes*				
Genetically modify species to be future-adapted*				

When asked which tools (e.g., geospatial tools, quantitative models, etc.) are most helpful to achieving their management goals, USPP Partners most commonly referenced Esri products (n = 4 references), the USFS's Forest Vegetation Simulator (FVS) (n = 4 references), and Vibrant Planet (n = 3 references) (Table 7). CFRIs Risk Assessment Decision Support (RADS), the Colorado Forest Atlas,

Interagency Fuel Treatment Decision System (IFTDSS), and Wildfire Risk to Communities all received one reference.

Table 7. Helpful tools in forest management referenced by interviewees. Counts, for each tool, of the total number of interviewees who mentioned them.

Tool	Total # of References by Interviewees
Esri products (ArcPro, Survey 123, and Field Maps)	4
Forest Vegetation Simulator (FVS)	4
Vibrant Planet	3
CFRI Risk Assessment Decision Support (RADS)	1
Colorado Forest Atlas	1
Interagency Fuel Treatment Decision Support System (IFTDSS)	1
Wildfire Risk to Communities	1

Overall, interviewees found it challenging to provide specific examples of geospatial or quantitative tools that were particularly helpful or unhelpful, often referring broadly to "geospatial applications" rather than individual tools. This may be attributed to the complexity and time-intensive nature of wildfire risk models and other technical tools in this field. Several USPP Partners noted that research and modeling conducted by partners such as CFRI and the Rocky Mountain Research Station play a crucial role in informing on-the-ground implementation and decision-making.

While there were few direct references to unhelpful tools, multiple interviewees expressed that the overwhelming number of decision support tools (DSTs), combined with their steep learning curves and technical complexity, is a challenge. As one interviewee stated, "*I don't know if it's specific tools, but it's more of just the sheer number of planning tools… It's not that they're unhelpful, I think there's just a lot going on.*" Interestingly, the Wildfire Risk to Communities tool was described as both helpful and unhelpful. Its coarse data resolution limits its effectiveness for precise planning but can be advantageous for certain grant applications, such as the Community Wildfire Defense Grant (CWDG), where broad classifications of high wildfire risk make it easier to secure funding for projects that meet these criteria.

Overall, most interviewees (n = 9) reported a high level of confidence in the effectiveness of forest management actions in the climate adaptation space, some (n = 5) reported a medium or neutral confidence level, and only one mentioned low confidence (Figure 6). When asked to expand upon what they felt confident in, many interviewees identified monitoring and evaluation as critical components of adaptive management, which helps ensure the successful implementation of climate adaptation strategies. Within the USPP, this process is conducted through self-assessments or cross-organizational evaluations to track management actions, assess their effectiveness, and adjust

strategies as needed. Interviewees also emphasized the importance of continued education and staying informed about the latest scientific advancements through the USPP as key to improving adaptation efforts.

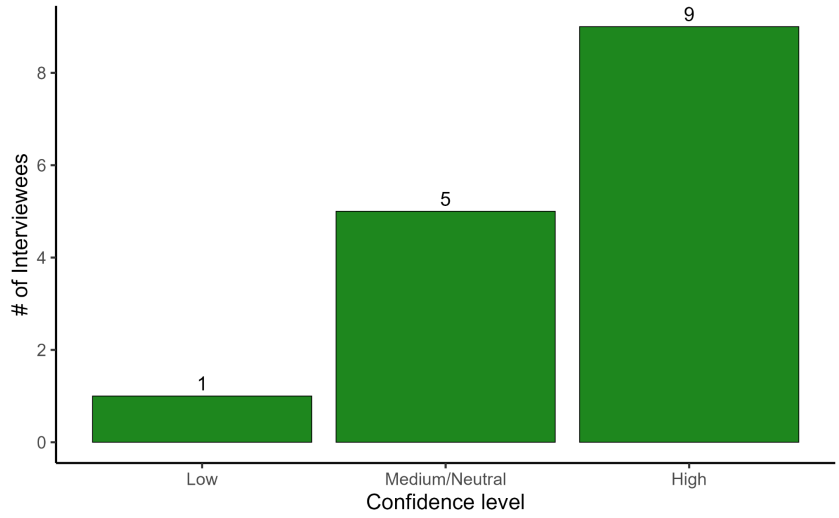

Figure 6. Confidence level of interviewees in the climate adaptation space. Number of USPP interviewees who reported low, medium/neutral, or high confidence in the effectiveness of their climate adaptation practices.

Barriers to Effective Climate Adaptation

In assessing the biggest barriers to achieving more effective climate adaptation, interviewees most commonly mentioned 'public perception' (n = 37 references) and 'financial' (n = 36 references) barriers (Figure 7). Social barriers primarily stem from negative public perceptions of tree removal methods such as clear-cutting, patch-cutting, and thinning. This resistance is likely driven by a general dislike of change and a lack of understanding of forest ecology and the ecological benefits of strategic tree removal. Limited funding restricts the scope, scale, and duration of work, with most financial support coming from government budgets and grants. Since government funding can fluctuate and grants require significant staff capacity to secure, these uncertainties make long-term planning more difficult.

'Other' (n = 28 references) and 'capacity' (n = 25 references) barriers were also referenced somewhat frequently. Other barriers that were mentioned included inadequate wood utilization practices in the area and physical inaccessibility of some sites, among other factors. Capacity barriers involve the need for well-trained, high-quality staff, along with difficulties in offering competitive wages, retaining employees long-term, and providing sufficient training. These constraints further limit the ability to incorporate additional considerations such as climate adaptation. 'Political' (n = 12 references) and 'knowledge-based' (n = 12 references) barriers were mentioned the least by interviewees.

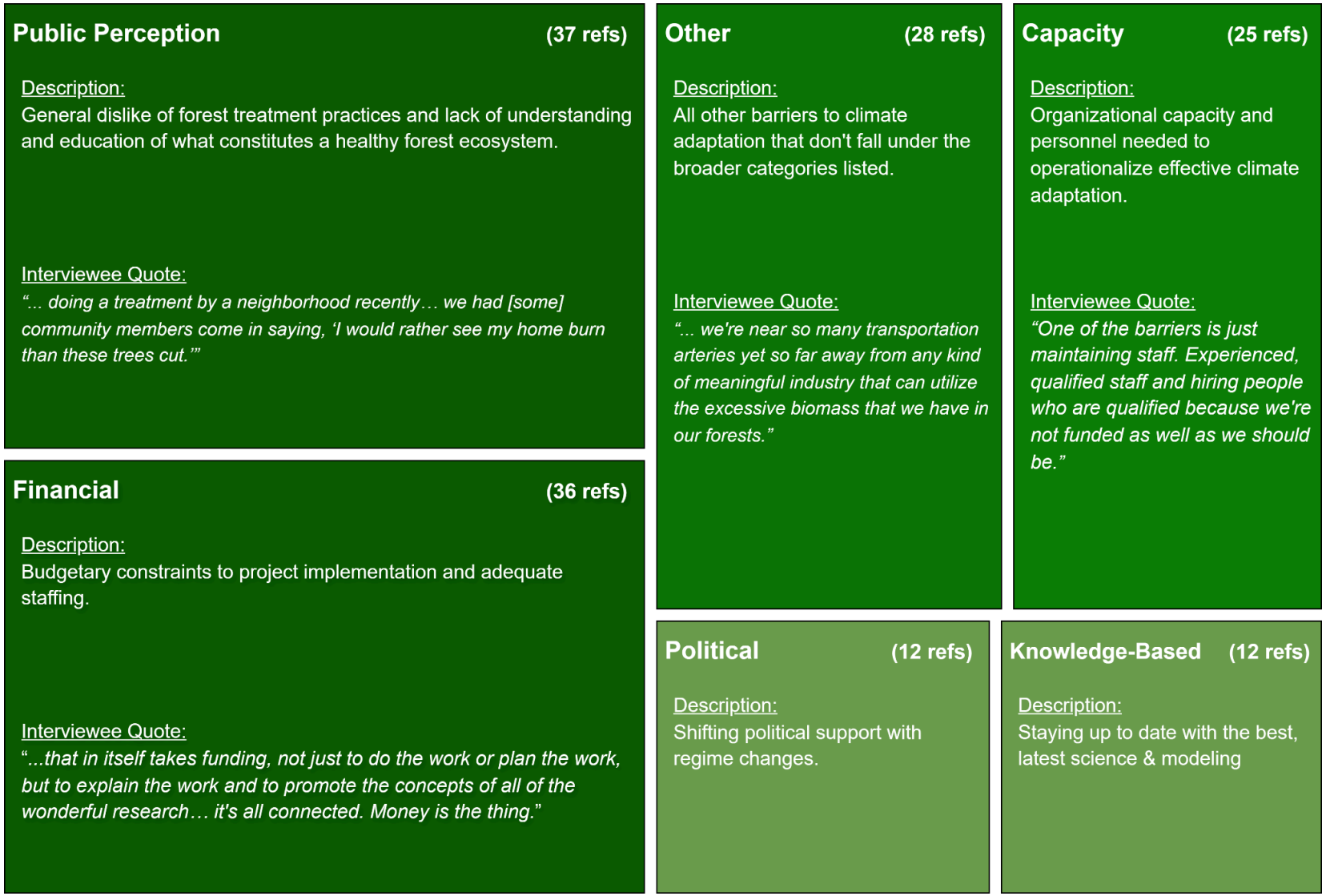

Figure 7. Most frequently referenced barriers to climate adaptation by USPP interviewees. The size of each barrier in the hierarchy chart is represented by the total number of references during the interview process. Larger blocks equate to more frequently discussed barriers.

Environmental Justice

As mentioned earlier, one of the FACTs team's primary interview goals was to assess whether environmental justice is part of the planning process in the USPP. We asked interviewees the following question to evaluate this:

> *"Think about two examples: one in which you were able to successfully implement environmental justice considerations, and one in which you weren't. Tell us a little more about the scenario in which you were successful, and the situation where you weren't."*

When asked this question, many interviewees framed their responses within the broader concept of "one Watershed" rather than identifying specific instances where environmental justice principles were central to decision-making. While this highlights a tendency to focus on watershed-scale management and its associated benefits, USPP Partners expressed genuine interest in learning how to better integrate social and environmental justice considerations into their work. That said, some examples of environmental justice-focused initiatives in forest management throughout the USPP did emerge. Programs such as the Youth Tribal Fire Program represent a direct effort to engage underrepresented communities in forest management, while grant programs over the last several years increasingly include clauses directing resources to disadvantaged groups. Additionally, considerations such as minimizing downstream effects of prescribed burns (e.g., smoke exposure) and enhancing overall watershed resilience demonstrate an awareness of the broader social and environmental impacts of USPP projects.

A persistent theme throughout the interviews was the way financial resources dictate the distribution of forest management efforts. As one interviewee noted, "*money follows money,"* a persistent dynamic in the Watershed. Forest treatments tend to be concentrated in the areas with greater financial resources given the affluence of many communities within the Watershed. While newer grant programs are beginning to request socioeconomic data to guide funding distribution, the reality remains that projects often get implemented where financial capital already exists. This creates disparities in treatment efforts, with wealthier landowners benefiting from more consistent forest management while others struggle to access support. Despite the region's overall affluence, there are still many *"land-rich, money-poor"* landowners who struggle to secure resources for forest treatment as one interviewee put it. These individuals, often overshadowed by their wealthier neighbors, face unique challenges that are not always reflected in regional economic and demographic assessments. Because the Watershed as a whole is categorized as wealthy, it becomes difficult for lower-income landowners to qualify for financial assistance, further exacerbating inequities in access to forest management resources.

Among the most vulnerable communities identified in the watershed are Evergreen, Conifer, and downstream neighborhoods in the Denver metro area. Evergreen and Conifer face extreme wildfire risk, with one interviewee identifying Kings Canyon Neighborhood as "*probably the highest-risk neighborhood in the state*." Many of these communities are home to an aging population with limited financial resources, mobility challenges, and health concerns that make them especially vulnerable to wildfire threats. Many residents in these areas fall into the "*land-rich, money-poor*" category,

meaning they own property in high-risk zones but lack the financial means to implement critical forest treatments.

Downstream communities in the Denver metro area, while not directly at risk from wildfires, are disproportionately affected by secondary impacts such as degraded water quality, damaged infrastructure, and poor air quality from wildfire smoke and prescribed burns. Many of these neighborhoods have fewer socioeconomic resources to mitigate these impacts, making them particularly vulnerable to the consequences of wildfire events.

Climate Adaptation Menu

Our climate adaptation menu is organized in a hierarchical format where "management goals" lead to "strategies" for accomplishing those goals which in turn lead to specific "approaches" for pursuing those "strategies". As opposed to the pre-existing NIACS menus, our adaptation menu does not proceed to the granular, site-specific recommendations referred to as "tactics". That level of granularity can only be achieved through workshops with land managers, which was beyond the scope of this project.

Our menu consists of seven management goals: 1) supporting forest health through ecosystem function & biodiversity, 2) reducing wildfire risk & preparing for disturbances, 3) creating spatial protections for species, 4) protecting people, 5) supporting watershed health, 6) proactively planning for future climate conditions and 7) sequestering carbon. Each of these management goals contains multiple strategies and their associated approaches. Additionally, each individual approach is tagged according to RRAD/T and environmental justice types.

Environmental Justice Considerations

Through interviews with USPP Partners, we have identified the below cases of justice or injustice within the Watershed:

Procedural Justice

USPP Partners actively seek to engage and communicate with communities within and adjacent to their administrative boundaries. However, they acknowledge the need to enhance outreach and engagement efforts with downstream communities in the Denver metro area. This was recognized by one interviewee.

Distributional Justice

Despite recent grant programs requesting more information on the socioeconomic conditions of project areas, funding continues to be disproportionately allocated to regions with existing financial resources. Because of this, a majority of projects remain concentrated in wealthier areas in the USPP. Direct engagement with disadvantaged or underserved communities remains limited. This was recognized by eight interviewees.

Restorative Justice

The Community Wildfire Defense Grant (CWDG) prioritizes underserved and Tribal communities for wildfire mitigation and community wildfire protection plans. Only after grants are dispersed to tribal communities, high-fire-risk areas like the USPP can apply for Community Wildfire Defence Grants. This was recognized by 3 interviewees.

Recognitional Justice

Despite not having any federally designated Tribal lands within or nearby the Watershed, organizations should consider how to incorporate the recognition of historic Tribal presence. This was recognized by one interviewee.

Coincidental Justice

Through our interview analysis, we identified a fifth category of environmental justice: "Coincidental justice." Coincidental justice is when an unintended but beneficial outcome arises from actions taken for other purposes, extending impacts to additional communities.

For example, treatments, often funded by Denver Water, focus on making the Watershed more resilient, benefiting downstream communities in the Denver metro area by providing clean water. This coincidental justice was recognized by 7 interviewees.

No Consideration

Lastly, some interviewees were not able to offer specific examples of where environmental justice was a specific goal or consideration of a project. See Table 8 for a description of each justice type, and the number of interviewees who referenced examples of specific justice types in their management practices.

Table 8. Types of environmental justice with counts of references.

Justice Type	Shorthand Definition	Referenced
Procedural Justice	Engage the community for fair decision-making. Which stakeholders and which community members should be engaged?	**6**
Distributional Justice	Fair allocation of benefits and burdens. Who bears the benefits and who bears the burdens?	**7**
Restorative Justice	Rectifying and repairing past harms. Who was harmed?	**4**

Justice Type	Shorthand Definition	Referenced
Recognitional Justice	Giving credit where credit is due. Who deserves the credit?	0
Coincidental Justice	Unintended but beneficial outcomes that arise from actions taken for other purposes.	**9**

Climate Adaptation Workflow

We created a click-through workflow to support dialogue and decision-making within the context of climate adaptation. The information from the interviews and climate adaptation menu feed into a user-friendly, web-based workflow. The workflow allows Partners to explore different management strategies and specific approaches to climate adaptation. They will be able to easily see which adaptation types (e.g., RRAD/T) and environmental justice concerns apply to specific strategies and approaches. Additionally, it includes references to DSTs relevant to a given approach.

The workflow provides a more interactive and explorative format, which is more conducive to project planning than a traditional written summary. The climate adaptation workflow was assembled on the Qualtrics survey platform, and offers both web and mobile versions for ease of use. Partners will also have the option to generate reports and toggle back and forth between pages to facilitate discussions and planning.

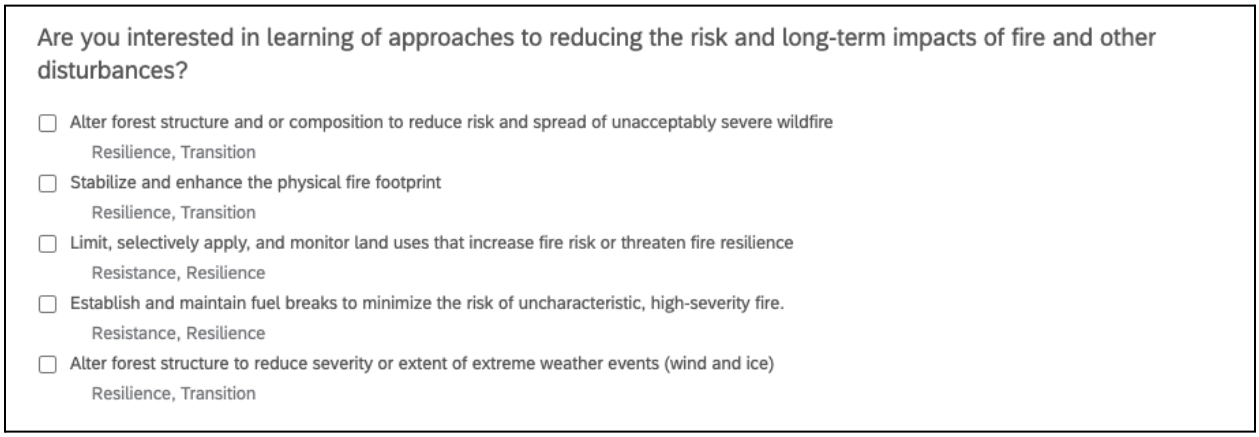

Figure 8. Example of the climate adaptation workflow user interface.

LIMITATIONS

Case Study Limitations

This study is specific to the USPP and the Watershed; therefore, it's fairly limited in its applicability. We interviewed a selected list of Partners rather than everyone in the USPP. Therefore, the perspective on climate adaptation and environmental justice does not reflect the full range of perspectives within the USPP. Furthermore, our interviewees represented management-focused roles more rather than planning or implementation roles, influencing the information we gathered on implementation strategies and DSTs. In addition, all five team members conducted interviews, approaching the task with their own style, likely eliciting different responses to uniform questions. Finally, we utilized the descriptive coding technique rather than thematic coding in an effort to eliminate bias in our interview results.

Additionally, our DST search and evaluation process was not a systematic review. While replicable, it is not a perfectly reproducible process. Similarly, we were unable to find and evaluate all relevant DSTs due to the DST search and evaluation process and project time constraints. However, we provide a detailed methodology for this process in hopes that others may follow a similar approach.

Political Limitations

As of February 20, 2025, the Trump Administration enacted language censorship initiatives regarding resources that are directly linked to the topics of our project. The list of banned words varies by department and the comprehensive list has proven difficult to ascertain. However, the FACTs team has confirmed, at a minimum, that the following terms are included on these lists of banned terminology as of February 20, 2025:

- climate change
- global warming
- climate adaptation
- activism
- activists
- advocacy
- advocate
- advocates
- barrier
- barriers
- biased
- biased toward
- biases
- biases towards
- bipoc
- black and latinx
- community diversity
- community equity
- cultural differences
- cultural heritage
- culturally responsive
- disabilities
- disability
- discriminated
- discrimination
- discriminatory
- diverse backgrounds
- diverse communities
- diverse community
- diverse group
- diverse groups
- diversified
- diversify
- diversifying
- diversity and inclusion
- diversity equity
- enhance the diversity
- enhancing diversity
- equal opportunity
- equality
- equitable
- equity
- ethnicity
- excluded
- female
- females
- fostering inclusivity
- gender
- gender diversity
- genders

- hate speech
- environmental justice
- excluded
- females
- fostering inclusivity
- hate speech
- hispanic minority
- historically
- implicit bias
- implicit biases
- inclusion
- inclusive
- inclusiveness
- inclusivity
- increase diversity
- increase the diversity
- indigenous community
- inequalities
- inequality
- inequitable
- inequities
- institutional
- Igbt
- marginalize
- marginalized
- minorities
- minority
- multicultural
- polarization
- political
- prejudice
- privileges
- promoting diversity
- race and ethnicity
- racial
- racial diversity
- racial inequality
- racial justice
- racially
- racism
- sense of belonging
- sexual preferences
- social justice
- sociocultural
- socioeconomic status
- stereotypes
- systemic
- trauma
- under appreciated
- under represented
- under served
- underrepresentation
- underrepresented
- underserved
- undervalued
- victim
- women
- women and underrepresented

Federal agencies are now barred from publishing or endorsing language around DEIA and the climate crisis. These actions reach beyond the federal government and have already impacted the policies, projects, and publications of nonprofits, local governments, and private industries. Federal grants and other funding, including National Science Foundation grants, are now subject to automatic rejection for containing terms related to these crises. The U.S. Forest Service, an important member of the USPP, has removed public-facing websites, reports, resources, and other materials pertaining to climate change and DEIA. Other Partners of the USPP may be forced to follow suit, and federal grant applications over the next four years will be automatically rejected for containing any of the banned words.

These developments cast obvious doubt upon the fate of our climate adaptation workflow in this hostile environment, as these banned terms and related concepts are inextricable from the objectives we have pursued and the deliverables we have produced. Nonetheless, the objectives we have pursued have been an important and useful endeavor insofar that we have encouraged forest managers to consider climate adaptation and environmental justice, even if such considerations now face greater barriers to being explicitly incorporated into management

DISCUSSION

Management for Climate Adaptation

Our interviews with USPP Partners found that most climate adaptation strategies in current use are resistance- and resilience-focused. Interviewees expressed confidence in their work; however, this evaluation may reflect confidence in general work rather than climate adaptation. Interviewees noted that the collaborative nature of the USPP facilitates the dispersal and integration of emerging climate adaptation science and practices. Timberlake and Schultz 2017 underscore the role of collaborative groups, like the USPP, in driving impactful climate adaptation work[32]. This is particularly true when research-based organizations, like CFRI, provide support in planning, implementing, and monitoring climate adaptation.

Partners are interested in direct/transition climate adaptation types, which are more focused on adapting to future climate conditions when compared to resistance and resilience. The current prevalence of resistance and resilience adaptation types and the associated deficit in direction/transition adaptation actions highlight tensions between adaptation and mitigation discussed in Carter et al. 2024[43]. Additionally, the disconnect between researchers recommending increased climate adaptation implementation and managers working on the ground, as discussed in Halfosky et al. 2018, creates a climate adaptation-implementation lag that is present within the USPP as well[44].

There are opportunities for improving climate adaptation integration in USPP projects. Moving forward, dedicating discussions to direction/transition strategies and climate adaptation broadly can deepen Partners' understanding of how to integrate climate adaptation in the Watershed. The climate adaptation workflow not only fosters Watershed adaptation but also the way Partners speak about climate adaptation and climate change.

Partner Leadership

Timberlake and Schultz 2017, found that informal and formal leadership is key to establishing adaptation goals, plans, and monitoring for success[32]. For the Partnership to effectively integrate climate adaptation, a Partner, or several, should spearhead this effort. However, a potential challenge here is that partners do not have explicit roles or foci within the Partnership. This poses the question: Who will lead conversations about climate adaptation in the future? CFRI, TNC, and the USPP Watershed Coordinator are strong candidates for this role.

Environmental Justice

USPP Partners work for the public good, focusing on protecting the Watershed for local communities, wildlife, and plant species. Their efforts, including forest health treatments, wildfire risk reduction, and water quality projects, benefit thousands of people. However, there is a lack of intentionality in planning projects to address the needs of disadvantaged communities. Most environmental justice actions encompass distributional justice.

We recommend that Partners integrate justice frameworks, placing additional emphasis on all communities. While the Watershed is largely affluent, white individuals, there are "*land rich, money poor*" communities and elderly populations at greater risk from climate-driven wildfire due to resource constraints and limited mobility. Partners, particularly, those working with landowners, could prioritize support for these groups.

Furthermore, engaging partner organizations that have departments, initiatives, and/or programs focused more on connecting people to the Watershed, as well as supporting frontline and disadvantaged communities, can help USPP projects approach forest management, watershed health, and wildfire reduction through a more equitable and just lens.

Integrating the Climate Adaptation Workflow

Our goal was to support the integration of locally relevant climate adaptation, addressing a gap in the literature that states the lack of locally tailored information is a barrier to climate adaptation work as noted in Halfosky et al. 2018, and Timberlake and Shultz 2017[32,44]. Our evaluation of DSTs, informed by extensive literature reviews, addresses this gap for the USPP. We recommend that CFRI and TNC build on this foundational evaluation of climate adaptation strategies for the USPP and the Watershed, leveraging their scientific expertise, also noted in Timberlake and Schultz 2017[32].

Overcoming Barriers

Interviewees noted public perception and financial constraints as major barriers to climate adaptation work. Timberlake and Schultz 2017 recommends land managers and foresters collaborate with academics and researchers to distill scientific concepts for communicating with the public[32]. Future work should involve the development of communication strategies and materials focused on climate adaptation in forest management. Employed within the USPP, this could help USPP Partners address misconceptions around forest health treatments broadly, in addition to climate adaptation work specifically. This could ultimately generate greater public support for this work and lead to more funding in return.

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APPENDIX

Interviewees

Table 9. List of interviewees and the organizations they represent.

Interviewee Name	Organization
Andy Perri	Denver Mountain Parks
Audrey Miles-Cherney	Upper South Platte Partnership
Ben Yellin	Elk Creek Fire Protection District
Brian Banks	U.S. Forest Service
Brian Maillett	Genesee Foundation
Emma Brokl	Jefferson County Open Space
Garrett Stephens	Jefferson Conservation District
John White	Colorado State Forest Service
Kelleigh McConnaughey	Elk Creek Fire Protection District
Madelene McDonald	Denver Water
Matt McLemore	Jefferson Conservation District
Megan Kocina	Coalition for the Upper South Platte (CUSP)
Mikele Painter	U.S. Forest Service
Ryan Kolling	U.S. Forest Service
Tony Auciello	Jefferson County Open Space

Interview Analysis Codebook

Table 10. List of codes (code, subcode, sub-subcode) used in descriptive coding of USPP interview transcripts. Descriptions of codes or subcodes that are greyed out were self-explanatory and did not need to be defined.

Code	Subcode	Description
Adaptation Confidence	Low	
	Medium/Neutral	

Code	Subcode	Description
	High	
Adaptation Strategies Discussion of specific climate adaptation strategies (types) implemented within the interviewee's management actions	Acceptance	Allow climate-related changes to progress without significant mitigation. Ex: When managers deprioritize a site for treatment, they are de facto accepting climate-related changes.
	Direction or Transition	Intentional focus on promoting adaptive responses and facilitating change. Anticipating climate-related changes, managing for anticipated conditions, and/or deliberately accelerating those changes. Ex: In sites currently characterized by cooler temperatures and abundant moisture, planting tree species that are adapted to hotter, drier conditions in anticipation of increased temperatures and drought severity.
	Resilience	Similar to resistance, but focus shifted away from maintaining the current system to withstanding and responding to negative impacts of disturbances. Ex: Could include maintaining mature, seed-bearing and older trees as individuals, varying numbers within groups of trees, increasing spatial heterogeneity of openings and groups across the stand, allowing managed wildfires to burn in treated stands, and promoting species that respond well to disturbance.
	Resistance	Maintaining the current conditions, the management actions taken are toward this system being able to resist change. Ex: Could involve reducing stand density to decrease intraspecific (within species) competition and drought stress; reducing insect activity by maintaining densities below or outside of stand density indices that promote insect population growth; promoting openings and open-canopy conditions, while removing ladder fuels to lessen chances for canopy fire; and maintaining refugia.
Anticipation or Response	n/a	Answers to the question about percent of action in anticipation vs in response to climate change impacts
Climate Adaptation Barriers Mentions of barriers or challenges to climate adaptation	Capacity	Organizational capacity and personnel
	Financial	Insufficient financing or grant funding
	Knowledge-based	From the perspective of the interviewee, lack of knowledge about appropriate strategies/tools/methods of climate adaptation

Code	Subcode	Description
	Political	Politics at the local, state or federal level that discourage adaptation work
	Social	Community or individual opposition to adaptation/management strategies
	Other	Inaccessible or expensive sites (fragmentation, steep slopes, etc.), collaboration, wood utilization
Climate Adaptation Definition	n/a	How the interviewee defines climate adaptation for themselves
Environmental Justice	Considered	Evidence/examples of successful environmental justice considerations
	Not Considered	Evidence/examples of unsuccessful environmental justice considerations
	Vulnerable	Communities identified as most vulnerable in the Watershed due to wildfire risk, socioeconomic status, or other reasons discussed by interviewees
	Not Vulnerable	Communities identified as least vulnerable in the Watershed due to wildfire risk, socioeconomic status, or other reasons discussed by interviewees
	Other	Other aspects of environmental justice in forest management
Feedback or Recommendations	n/a	Any feedback, recommendations, or comments about the utility of our project or something that could be improved/changed, or additional people to talk to
Forest Type Mentions of specific forest types interviewee works with, or actions done within specific forest types	Aspen	
	Douglas Fir	
	Dry Mixed-Conifer	Need to either directly mention dry mixed-conifer or clearly talk about multiple species, including: ponderosa and Douglas-fir, limber pine, lodgepole pine, blue spruce, white fir, and aspen
	Lodgepole Pine	
	Montane Riparian	
	Ponderosa Pine	

Code	Subcode	Description
	Other	
Good Quotes	n/a	Flag quotes that may be particularly representative of a certain topic, to potentially highlight in our findings later
Implementation: Strategies of Methods Any strategies or methods helpful (or not helpful) in implementing or achieving climate adaptation goals	Helpful	
	Not Helpful	
Implementation: Tools Any DSTs helpful (or not helpful) in implementing or achieving climate adaptation goals	Helpful	
	Not Helpful	
Management Goals Management goals in the context of the interviewee's position and organization	Forest Health	Protecting the forest from catastrophic disturbance and ensuring its continued existence and ecosystem function
	Protecting People	Safety of people, protection of property
	Watershed Health	Ensuring good water quality and sufficient water amounts
	Wildfire Risk Reduction	Reducing risk of damaging wildfires and/or reducing severity of wildfires
	Wildlife	Habitat conservation for species persistence
	Other	
Organization Type Organization that interviewee belongs to or mentioned in the	Federal Agency	Public agency at the federal level
	Local Agency	Public agency at anything below the state level
	Nonprofit	
	Private	

Code	Subcode	Description
context of management practices	State Agency	Public agency at the state level
	Other	
Public Outreach	n/a	Community engagement and public education efforts
Public Perception	n/a	Comments about how members of the public perceive, or react to, forest management actions/climate adaptation actions

Interview Questions

During each interview, the FACTs team asked the following questions.

1. Describe the role you play in your organization, in the context of forest health and management in a few brief sentences.
2. What does climate adaptation mean to you?
3. What forest type do you work the most with? *Provide options based on FACTs Lit Review: 1) ponderosa pine forests, 2) dry mixed-conifer forests, 3) lodgepole pine forests, 4) montane riparian forests, 5) aspen forests, 6) other.*
4. Are you practicing resistance strategies? If so, what are they, and where (e.g., what type of forest/management area)?
5. Are you practicing resilience strategies? If so, what are they, and where (e.g., what type of forest/management area)?
6. Are you practicing acceptance strategies? If so, what are they, and where (e.g., what type of forest/management area)?
7. Are you practicing direction/transition? If so, what are they, and where (e.g., what type of forest/management area)?
8. In what percent do you find yourself acting in anticipation of climate-related issues compared to in response? Please elaborate on why.
9. What barriers (e.g., financial, political, social license, knowledge-based) have you encountered to including climate adaptation in your plans or actions?
   Additional prompting when needed:
   - Are there any approaches/methods you've wanted to use but were not able to implement due to cost? Please elaborate.
   - Are there any approaches/methods you've wanted to use but were not able to implement due to reasons other than cost? Please elaborate.
10. How confident are you in the adaptation-related strategies that you are using and what would potentially improve them?
11. Are there any strategies, methods, or decision support tools (like geospatial tools, quantitative tools, models, etc.) that have helped you achieve your climate adaptation objectives? If so, what are they and why are they helpful?

12. What strategies, methods, or tools weren't helpful?
13. We're curious to better understand whether and how the impacts (positive & negative) of forest health/climate adaptation projects are equitably distributed throughout local and downstream communities. Introduce Environmental Justice and our reasoning for asking about it: The EPA definition of Environmental Justice is, "Environmental justice means the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment." Think about two examples: one in which you were able to successfully implement environmental justice considerations, and one in which you weren't. (Give some time to mull it over). Tell us a little more about the scenario in which you were successful, and the situation where you weren't.
14. Throughout the communities in the USP Watershed, who are the communities at risk/vulnerable?
    - What makes them vulnerable, specifically?
15. Can you tell us how people living in and nearby the Upper South Platte Watershed benefit from treatments?
16. How does your organization engage with community members/the public to include them in planning processes and decision-making? Please feel free to share any outreach programs or internal policies that apply.
17. Is there anyone else we should talk to?
18. Is there anything you wish I'd ask that I didn't?
19. Do you have any feedback on our project?