SOUTHWEST COLORADO SOCIAL-ECOLOGICAL CLIMATE RESILIENCE

SUMMARY OF FINDINGS

OVERVIEW

Southwestern Colorado is already experiencing the effects of climate change in the form of larger and more severe wildfires, prolonged drought, and earlier snowmelt. Climate scientists predict more frequent and intense heat waves, longer-lasting and more frequent droughts similar to that experienced by Colorado in 2002, and decreased river flows in the future. These changes will ultimately impact local communities and challenge natural resource managers in allocating water under unpredictable drought conditions, managing forests in the face of changing fire regimes and other stressors, and conserving threatened species under shifting ecological conditions, all while continuing to support the needs of human communities.

To address these challenges, we collaborated with scientists, land managers, and local communities to identify strategies for proactively reducing impacts on people and nature. Understanding potential changes and implementing adaptation strategies to respond to those changes can help nature and people remain healthy into the future. Our work focused on the intersection of climate, ecological, and social systems (Figure 1).

KEY FINDINGS:

- ***Collaborative adaptation planning can be strengthened by integrating social, climate, and ecological components.***
- ***Climate scenarios, bioclimatic zone maps, and ecological response models can help natural resource managers understand uncertainty.***
- ***Three high-level strategies identified are: 1) identify & protect climate refugia sites; 2) maintain and enhance resilience of refugia sites; 3) accept, assist, and allow transformation in non-refugia sites.***
- ***Our process can be used to develop climate adaptation strategies in other landscapes at multiple scales.***

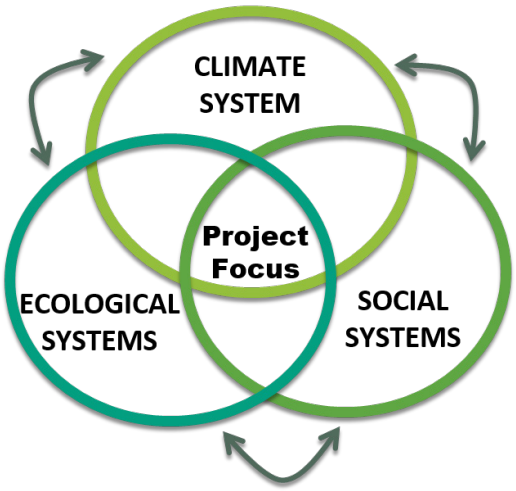

Figure 1. Venn diagram depicting relationship of climate, ecological, and social sectors and area of project focus.

PLANNING PROCESS

An interdisciplinary team of social, ecological and climate scientists collaborated with local stakeholders in the Upper Gunnison and San Juan Basins (Figure 2) to develop and apply an innovative climate adaptation framework. Together, we assessed climate impacts on people and nature, identified interventions to reduce those impacts, and developed strategies and actions to adapt to changes. Through a series of workshops over three years, partners selected four targeted landscapes for analysis, defined three plausible future climate scenarios, developed response models for ecological and social systems, participated in a series of interviews and focus groups, and defined actionable strategies. Each partner can implement these strategies within the context of their respective conservation goals.

We focused our analysis on two social-ecological landscapes of most concern to local managers in each study area. Partners selected ***sagebrush shrublands*** and ***spruce-fir forests*** in the Gunnison Basin, and ***pinyon-juniper*** and ***seeps, springs, and wetlands*** in the San Juan Basin to be the focus of this project, based on their social, economic, and ecological importance.

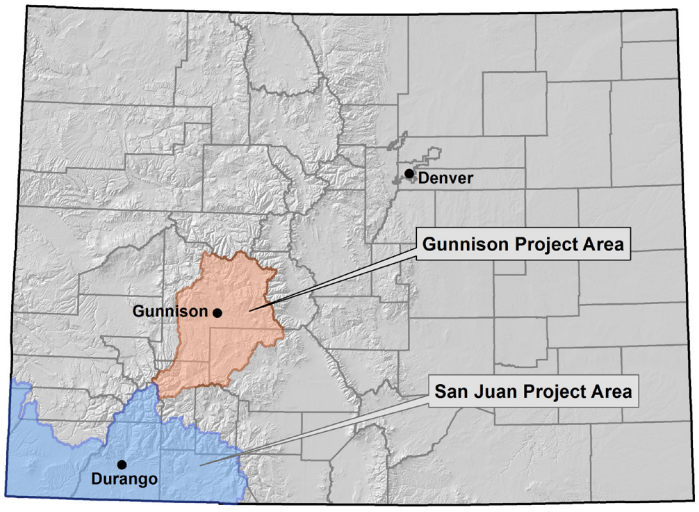

Figure 2. Gunnison and San Juan project areas in Colorado.

POTENTIAL FUTURE CLIMATE SCENARIOS

The team used a scenario planning process to identify robust strategies that would be effective across a range of potential futures. To address uncertainty, project scientists developed attributes associated with three climate scenarios for the 2020-2050 period. Three climate models that represent different, but equally plausible, potential future pathways for the region were selected: a hotter, drier future; a warmer future with increased annual precipitation; and a future with high inter-annual variability between hot dry years and warm wet years (Figure 3). We called these scenarios ***Hot & Dry***, ***Warm & Wet***, and ***Feast or Famine***.

Hot and Dry

- Longer growing season (+3 weeks), reduced soil moisture, increased heat stress
- Snowline moves up in elevation (+1200 ft)
- Frequent extreme spring dust-on-snow events
- Earlier snowmelt and peak runoff (+3 weeks, earlier with dust events), decreased runoff (-20%)
- Longer fire season (+1 month), greater fire frequency (12x) and extent (16x) in high elevation forest

Warm and Wet

- Longer growing season (+1 week)
- Snowline moves up in elevation (+600 ft)
- Occasional extreme spring dust events in dry years (comparable to current conditions)
- Earlier snowmelt and peak runoff (+1 week), no change in runoff volume
- Increased fire frequency (4x) and extent (6x)

Feast or Famine

- Longer growing season (+2 weeks)
- Snowline moves up in elevation (+900 ft)
- Increased extreme spring dust events in dry years
- Earlier snowmelt and peak runoff (+2 weeks, earlier with dust events), decreased runoff (-10%)
- Very high fire risk during dry years following wet years, greater fire frequency (8x) and extent (11x)

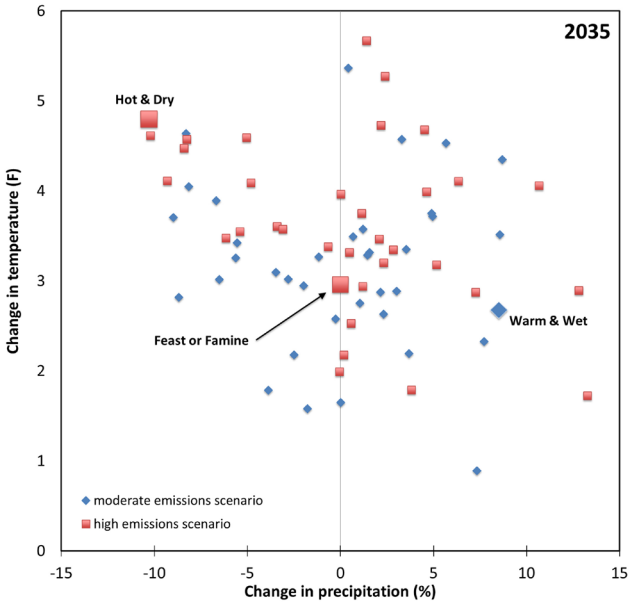

Figure 3. Three climate models representing different but equally plausible future scenarios. Graph shows changes in annual temperature and precipitation by 2035 (2020-2050) relative to 1970-2000 annual normals over southwestern Colorado from 72 climate models.

ECOLOGICAL RESPONSE MODELS AND BIO-CLIMATIC ZONES

To identify and evaluate potential impacts of the three climate scenarios on sagebrush, spruce-fir, pinyon-juniper, and seeps/springs/wetlands, we held a series of workshops with natural resource managers to develop reference condition and ecological response models (Figure 4) for each of these four landscapes. The team worked with the U.S. Forest Service to develop spatial ecological response

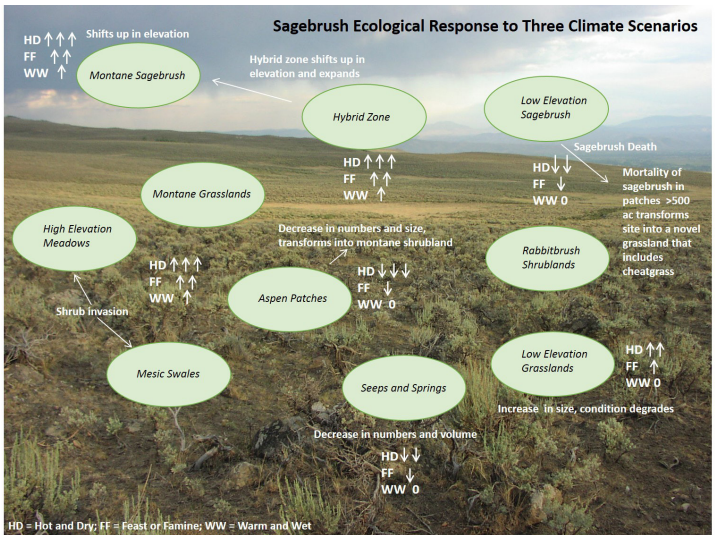

Figure 4. Ecological response model to three climate scenarios for for the Sagebrush landscape.

models (bio-climatic models) for dominant species in the targeted landscapes to depict projections of climate change impacts (e.g., Figure 5). The resulting maps were used to help identify the most appropriate management actions for climate adaptation of vegetation for specific bioclimatic zones (i.e., lost, threatened, persistent and emergent areas).

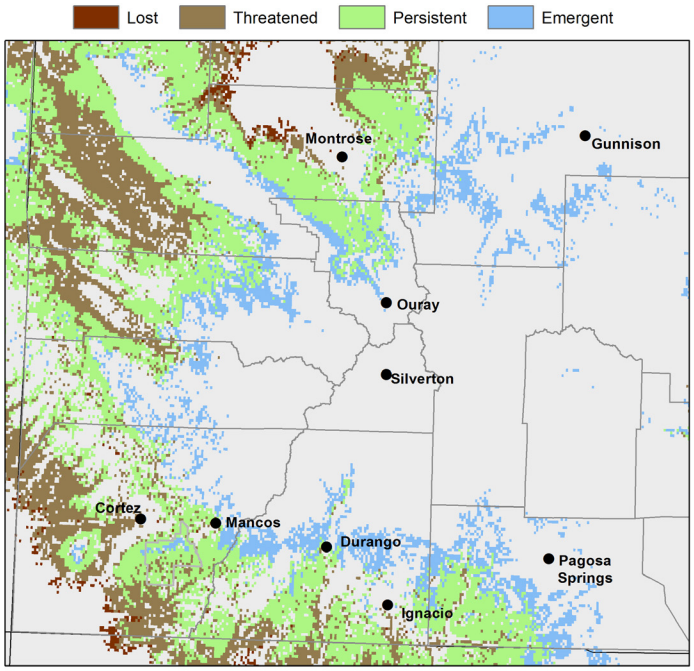

Figure 5. Spatial bio-climatic model for pinyon pine under the Hot & Dry scenario. Source: CNHP

UNDERSTANDING THE VIEWS OF DECISION-MAKERS

Social scientists conducted in-depth interviews, focus groups, and workshops with ranchers and public land managers from state and federal agencies. Interviews examined how climate change might impact local communities. Focus groups and workshops utilized narrative scenarios to understand how people manage for a range of futures and make decisions under uncertainty. This helped the team understand:

- Use, importance, and status of landscapes
- How changes to landscapes impact people
- Different approaches for dealing with uncertainty
- Options for potential strategies and actions

DEVELOPING ADAPTATION STRATEGIES

The team tested two different approaches to interpret the results of ecological response models and social science research: *Situation Analysis* and *Chain of Consequences*. Situation Analysis identifies connections between people and nature, and allows exploration of the political, socioeconomic, cultural, institutional and ecological context of a landscape. The Chain of Consequences method begins with a primary impact (e.g., drought), and then identifies a chain of consequences resulting from the impact. The team identified intervention points using the Situation Analysis and Chain of Consequences. They then created "results chains"—diagrams that depict linkages between potential strategies and desired outcomes through a series of intermediate outcomes and actions (e.g., Figure 6).

TOP IMPACTS AND STRATEGIES ACROSS THREE CLIMATE SCENARIOS

Using narrative scenarios and the results from the situation analysis and chain of consequences exercises, stakeholders developed conservation goals and three overarching landscape-scale adaptation strategies, each with a suite of potential actions required to reach a desired future condition. The three key strategies are: 1) identify and protect climate persistent areas as refugia sites, 2) maintain or enhance the resilience of climate refugia sites, and 3) accept, assist and allow for transformation in non-climate refugia sites. Managers then identified challenges to, and opportunities for, successful implementation of the adaptation strategies.

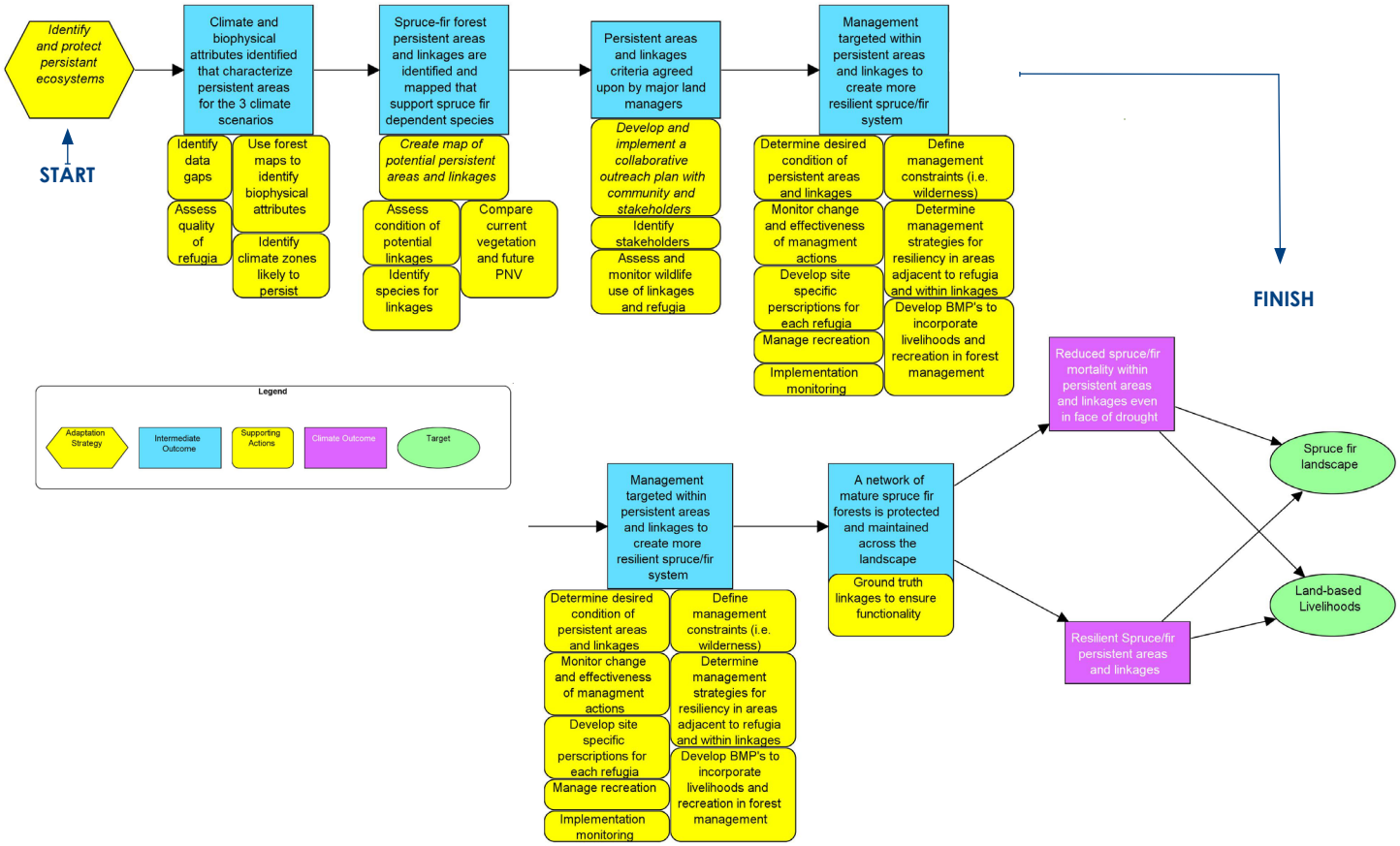

Figure 6. Results chain for the "Identify and Protect Refugia strategy" in the Spruce-Fir landscape.

Goal, Impacts, and Strategies for Sagebrush - Gunnison Basin

Goal: Protect, maintain and enhance large interconnected, naturally functioning and resilient sagebrush landscapes across all jurisdictional boundaries that support stable or increasing viable populations of sagebrush obligate species, livelihoods and ecosystem services (e.g., clean water, recreation opportunities, hunting, food and shelter, carbon sequestration) in the face of a changing climate.

Key Impacts	Strategies
Ranchers selling land Habitat conversion Loss of sagebrush	Identify and protect refugia • Protect ranches and manage development • Identify soil attributes that favor sagebrush
Increased invasives Increased soil erosion Sagebrush die-off Reduced grazing capacity	Proactive treatment for resilience • Coordinate basin-wide management of invasives • Improve soil health (e.g., seeding and grazing practices, erosion reduction) • Improve water retention (e.g., snow fences)
Altered succession Aspen mortality Sagebrush die-offs and shifts	Assist and allow transformation • Explore climate-smart seed mixes • Selectively treat aspen stands

Goal, Impacts, and Strategies for Spruce-Fir - Gunnison Basin

Goal: A resilient spruce-fir subalpine forested landscape that supports viable populations of species of concern and supplies human communities with a suite of ecosystem services in the face of a changing climate. Allow natural processes to function within the landscape (e.g., fires, insects), while protecting people, infrastructure, and refugia. Where spruce-fir is vulnerable and where climate suitability will be changed, facilitate a vegetation conversion to suitable tree species (e.g., aspen, mixed conifer).

Key Impacts	Strategies
Forest mortality Loss of old growth Increased wildfire risk	Identify and protect refugia • Maintain diversity of structural stages, canopy cover classes • Restore post-disturbance forests • Protect healthy trees in larger stands that are affected by insects, disease, fire
Forest mortality (insects, fire) Altered succession	Proactive treatment for resilience • Protect young trees when salvage logging • Improve size and age class diversity • Proactively manage regeneration
Severe wildfire Drought	Assist and allow transformation • Maintain or expand warm-dry refugia for seed source and genotypes to assist with transformation • Allow transformation of subalpine forests into appropriate types (e.g., grassland, mixed conifer)

Goal, Impacts, and Strategies for Seeps, Springs, and Wetlands - San Juan Basin

Goal: In the face of a changing climate, protect, enhance, connect, and maintain seeps, springs, and wetland resources to support native biodiversity of viable populations of target plant and animal species of concern, and obligates of springs and wetlands, while supplying human communities with a suite of human values and ecosystem services (e.g., clean and abundant water, recreation opportunities, hunting, food and shelter, and cultural and spiritual values).

Key Impacts	Stratgegies
Altered hydrological regime	Identify and protect refugia • Conserve refugia that contribute to watershed flows • Conserve persistent wetlands that remain wet during severe droughts, especially within special management areas
Physical damage by grazers Loss of wetlands Altered species composition Altered soil chemistry Altered groundwater recharge Altered fire regime	Proactive treatment for resilience • Adjust management of domestic and wild grazers through placement of water tanks, distribution and type of animals, and herd size • Increase subsurface and surface water storage • Apply climate-smart restoration techniques when re-foresting, re-seeding after disturbance • Control weeds and prevent the spread of invasive species

Goal, Impacts, and Strategies for Pinyon-Juniper - San Juan Basin

Goal: In the face of a changing climate, protect and maintain a resilient landscape that: 1) includes pinyon, juniper, mountain shrublands, sagebrush, grasslands, and other small patch types that support viable populations of plant and animal species of concern, and 2) supplies people with a suite of ecosystem services, including clean water, recreation, tourism, hunting, food and shelter, carbon sequestration, and forest products. In 2035 we will still have a mosaic of resilient pinyon-juniper woodlands, primarily associated with climate refugia (persistent) zone. This zone will allow for natural colonization into upper elevation zones that do not currently support pinyons and junipers. In addition, we will prepare for a potential loss or degradation of pinyon-juniper woodlands in areas that are unlikely to have a suitable climate for regeneration. The managed mosaic of emergent, persistent, and decreasing pinyon-juniper zones will allow natural processes to occur and will have adequate representation of functioning seeps, springs, and wetlands.

Key Impacts	Strategies
Altered fire regime Tree mortality (drought, insects fire) Declining obligate species	Identify and protect refugia • Conserve refugia and habitat connectivity for pinyon-juniper obligate species • Manage for highest at-risk values (e.g., property, certain trees)
Reduced soil health Decreased undergrowth diversity Increased tree mortality Decreased stand resilience Loss of connectivity	Proactive treatment for resilience • Increase native understory to stabilize soil and improve habitat for small mammals • Ensure a variety of pinyon age classes (especially old growth) and structure within climate refugia stands • Reduce the impact of invasive species such as cheatgrass so that pinyon-juniper systems are more resilient to climate change • Protect identified archeological and cultural resources from erosion
Altered species composition Tree mortality (fire, drought)	Assist and allow transformation • Where pinyon-juniper is vulnerable and climate suitability is likely to change, facilitate transition into juniper savannas at lower ecotones and into ponderosa pine at upper ecotones

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Project Leads: Colorado Natural Heritage Program at Colorado State University, Mountain Studies Institute, The Nature Conservancy, University of Colorado Boulder, University of Montana, U.S. Geological Survey, and Western Water Assessment.

Key Partners: Black Canyon of the Gunnison National Park, Bureau of Land Management, Colorado Parks and Wildlife, Curecanti National Recreation Area, Gunnison National Forest, Mesa Verde National Park, Natural Resources Conservation Service, San Juan National Forest, Southern Ute Tribe, Ute Mountain Ute Tribe, and Western State Colorado University.

Stakeholders: We thank our two public-private partnerships—the Gunnison Climate Working Group and the San Juan Climate Initiative—and many other natural resource managers, decision-makers, biologists, private landowners, and other stakeholders for participating in this project. For complete list of stakeholders for each landscape, see final reports accessible from www.cnhp.colostate.edu and www.mountainstudies.org/cip.

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