WEP Phase II Report

Non-Consumptive Needs Assessment

June 2021

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ACKNOWLEDGEMENTS

This work was supported through grants by the Colorado Water Conservation Board and the Southwest Basin Roundtable. The Upper San Juan Watershed Enhancement Partnership and Mountain Studies Institute performed critical coordination activities and numerous local individuals and organizations volunteered time to participate in presentations, discussions, and workshops.

DISCLAIMER

This assessment relies on high-level data collection and assessment to characterize gaps in E&R water supply needs. Collaborative stakeholder dialog is required to review this information, help resolve areas of potential conflict, prioritize management issues, and identify projects and processes that can improve the management of water for the benefit of multiple uses.

This planning approach and its outcomes should not be used or viewed as an alternative to Colorado's water allocation system - the prior appropriation doctrine. Just as water supply planning in a municipal context defines needs and offers solutions, this assessment does the same for E&R uses in the upper San Juan, Blanco and Navajo watersheds.

The methods and results presented here that assign numerical values to E&R needs <u>should not</u> be construed as minimum standards for meeting those needs during planning for future water supply projects etc. Future evaluations that contemplate the specific impact of a proposed project or altered hydrological condition will be better served through the application of an incremental assessment approach[1] and more intensive site-specific investigations. Long-term monitoring and diagnostics may be required to further validate relationships identified between flow conditions and the various ecosystem and recreational attributes evaluated here.

Cover Photo Credit: Kind Design (https://www.kinddesign.co)

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[1] Cavendish, Mary G., and Margaret I. Duncan, "Use of the Instream Flow Incremental Methodology: A Tool for Negotiation."

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EXECUTIVE SUMMARY

This San Juan Watershed Enhancement Partnership (WEP) is coordinating a planning effort for the upper San Juan River, upper Rio Blanco, and upper Navajo River that aims to bring together scientific and engineering evaluations and local stakeholder values/concerns to produce a list of high priority actions for meeting diverse water use needs. The overall purpose of the project is to develop an understanding of the community's water-related values, agricultural irrigation structural needs, and environmental and recreational (E&R) water supply needs in the area, and to identify and evaluate opportunities for projects to benefit the diversity of water users present in the upper San Juan River basin.

This effort specifically responds to the call for Environmental and Recreational (E&R) water use planning articulated by the Colorado Water Plan and the 2015 SWBIP[2]. Tight interrelationships between water, agriculture, recreation, tourism and industry create a complex template for understanding and optimizing the management of limited water resources to support the diversity of water uses in the San Juan watershed. This assessment intends to promote collaborative learning about the system, help develop a shared understanding of tradeoffs involved in any given management action, and identify collaborative projects and processes to help optimize the management of water for the full diversity of human and environmental needs. The assessment presented here builds upon decades of research, studies, water planning, and legal analysis focused on water resource issues in the basin.

The assessment effort described in this report is the primary deliverable for Phase II of the three-phase WEP planning process. Phase I, conducted during 2018 and 2019, reviewed and summarized the body of historical reports related to environmental and/or recreational uses of water in the planning area. Phase II, conducted in 2020 and 2021, provides an evaluation of current and future E&R water use needs and a characterization of consumptive water use infrastructure. The Phase II efforts rely on community input, expert review, and robust scientific data analysis. The work presented here will inform the third phase of work beginning in the summer of 2021. Phase III will include the development of an integrated water management plan document. That document will identify and prioritize environmental, recreational, and agricultural water use projects across the planning area and communicate those priorities to the Southwest Basin Roundtable (SWBRT) as a set of Identified Projects and Processes (IPPs) for integration into the Southwest Basin Implementation Plan (SWBIP)[3].

Phase II of the WEP planning effort aims to 1) characterize existing and historical hydrological conditions, 2) enhance understanding of timing and geographic patterns in E&R uses, 3) evaluate the ways that E&R needs may change under a suite of future climate scenarios, 4) probe the nexus between forest health and hydrology, 5) assess the condition of surface water diversion, delivery and irrigation water application infrastructure, and 6) point stakeholders toward the highest priority issues and/or geographies for further consideration. Ongoing collaborative stakeholder dialog is required to review this information, help resolve areas of potential conflict, prioritize management issues, and identify projects and processes that can support multiple water uses. This planning approach and its outcomes should not be used or viewed as an alternative to Colorado's water allocation system - the prior appropriation doctrine. Just as water supply planning in a municipal context defines needs and offers solutions, this assessment does the same for E&R uses in the San Juan watershed.

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[2] Oliver and Lile, "Southwest Basin Implementation Plan."

[3] Id.

The flows in the San Juan River above Navajo Reservoir are largely unaltered compared to other western U.S. rivers. However, some segments of the mainstem and several tributaries are heavily utilized for municipal and agricultural purposes. The Rio Blanco and Navajo Rivers are significantly affected by large water diversions through the U.S. Bureau of Reclamation (USBR) San Juan—Chama Project. The high-level analyses presented here indicate that E&R water supply gaps do exist for the maintenance of riparian and fishery health on some segments. Several other issues also appear to limit fishery health and recreational use. Reductions in stream network connectivity caused by the San Juan—Chama Project collection system significantly limit access to habitat for some native and sport fish in the Rio Blanco and Navajo basins. Entrainment of fish in diversion canals and structures that impede upstream-downstream movement may negatively impact native fish populations. Recreational uses on the San Juan River are primarily constrained by natural flow variability and constraints on access.

Phase III of the WEP planning effort will consider these issues and others in an effort to identify projects, processes, and collaborative management opportunities (described here collectively as "*cooperative measures")* for meeting and protecting existing consumptive *and* E&R needs across the upper San Juan watershed. Cooperative measures considered by stakeholders include market-based water use/conservation programs, water conveyance and application efficiency measures, water supply projects, and channel modifications, among others. Ongoing stakeholders dialog will help ensure that planning activities remain well-aligned with local and regional perspectives. The planning process will continue to refine its focus and direction through community input on questions including, but not limited to, the following:

1. What are our water use and management priorities?

2. What aspects of forest health, fishery and recreational use management are we most concerned about?

3. What kind of water future do we envision for our children growing up in the upper San Juan, Rio Blanco, and Navajo watersheds?

The completion of the WEP planning effort will yield a list of projects, processes, and management actions that enjoy a broad base of community support, exhibit limited legal/political/administrative constraints, have identifiable champions for implementation, and present logical funding sources. Ultimately, a compilation of a set of locally-defined IPPs under the subsequent phase of this planning effort will increase the likelihood that any one of those projects, processes, or management actions receives financial assistance from the State of Colorado under the funding mechanism set up under Proposition DD (2019) to support state water projects. Funding support from the state, in turn, greatly increases the chance that an IPP is implemented in the San Juan watershed.

Notable Findings: Hydrology

Streamflows in much of the upper San Juan, Rio Blanco, and Navajo watersheds reflect natural conditions, particularly during winter and early summer months. Surface water diversions supporting agricultural and municipal uses are widespread but are most abundant in the Rio Blanco and Navajo River watersheds. Notable findings of the hydrological assessment effort conducted here include:

- Climate change scenario modeling suggests that future hydrology may be characterized by earlier snowmelt runoff throughout the planning area. Analysis performed on the San Juan River mainstem indicates and potential reduction in summer water yields.
- Several tributary streams, including Fourmile Creek and Mill Creek are largely captured by surface water collection systems during most of the irrigation season.
- The segment of the San Juan River below the Park Ditch is the most significantly affected segment of the mainstem San Juan River above its confluence with Mill Creek.
- The San Juan – Chama Project significantly alters the hydrological behavior of the Rio Blanco, Little Navajo River and Navajo River below the collection points on each stream.
- Changing climate may significantly reduce streamflows available to support consumptive and non-consumptive uses by 2050. Climate change scenarios also indicate a wider range of variability in peak flows and low flows (e.g.,higher, infrequent runoff events and stronger, infrequent dry summer conditions).
- Potential hydrological changes brought about by climate change include a longer low flow summer season, and lower median and minimum flows on the mainstem rivers and their various tributaries. These changes will likely lead to longer periods in any given year when some sections of stream are completely dewatered or experience elevated stream temperatures due to partial dewatering—conditions that might impact the fishery, macroinvertebrates, and other aquatic biota.
- Any changes in peak flow timing and the median flows in summer months on the mainstem San Juan River will likely impact the ways that recreational boaters and anglers use the river.

Notable Findings: Forest Health

The condition and function of forests in mountainous landscapes are expected to exert a strong control on streamflow behavior. An assessment of forest health was performed, and potential linkages between climate characteristics, soil moisture, canopy wetness, and streamflow behaviors were considered. Notable findings of the forest health/water nexus assessment effort conducted here include:

- An analysis of historical data shows a trend toward increasingly warm air temperatures in each month of the year.
- Available soil moisture data indicates a trend toward drying soil columns. This trend is particularly acute in the period since 2015.
- Satellite imagery indicates significant trends toward earlier snowmelt timing in low and mid-elevation areas, particularly on southern and western aspects.
- A watershed-wide investigation of trends in forest canopy wetness shows a significant trend toward drying forest canopies over the period from 1999 and 2020.

- A “drying out” of the forest may be correlated with observed trends in historical streamflow behavior but no specific causal mechanism was identified.

Notable Findings: Post-Fire Erosion and Debris Flows

As a drying climate increases the risk for high-intensity wildfire across the planning area, the risk for increased erosion and transport of hillslope soils to the river channel also increases. Drainages that experience high-intensity fires are expected to produce large yields of sediment in the years following the fire. Notable findings of the post-fire erosion and debris flow assessment effort conducted here include:

- Wildfire hazards were assessed using the Extreme Weather fire time mapping product from the Colorado Forest Service.
- Post-fire erosion risks were evaluated using the Disturbed WEPP simulation model. The greatest risk for elevated rates of hillslope erosion was identified in the upper Rio Blanco and upper Navajo River watersheds. High-intensity fires in these drainages may be followed by significantly elevated rates of sediment delivery to streams and rivers.
- Channel response zones may be subject to rapid shifts in channel location following intense wildfire and heavy precipitation events. These areas are geomorphologically active on relatively short timescales. Five, large channel response zones were identified by this analysis: two on the West Fork San Juan, one on the East Fork San Juan, and one each on the Rio Blanco and Navajo River
- Risk reduction in channel response zones may include the development of emergency response plans prior to wildfire occurrence, forest treatments to reduce wildfire risk, and/or long-term application of conservative planning principles (i.e., avoiding new development in these zones).

Notable Findings: Stream Channel Sediment Transport

The potential for cascading impacts between alteration of hydrology or sediment supplies, channel morphology, and habitat quality for native species make sediment transport characteristics an area of specific management concern to local stakeholders. Notable findings of the stream channel sediment transport assessment effort conducted here include:

- Peak flows required to perform channel maintenance activities on the mainstem San Juan River historically occurred at least once every ~2 years.
- San Juan – Chama Project water diversions on the Rio Blanco and Navajo River significantly alter the sediment regime on downstream river segments. Altered flood flow behavior and patterns of coarse and fine sediment delivery to channels below these diversions may degrade aquatic habitat quality for fish and aquatic macroinvertebrates.
- Shifts in either the peak flow characteristics of the San Juan River or in the delivery of sediment to the river channel from hillslopes and tributary streams can lead to shifts in channel form and behavior and corresponding impacts on aquatic/riparian habitat and water delivery and transportation infrastructure located in the river corridor.
- Scenario modeling indicates that under a “Business as Usual” future, flows required to perform channel maintenance activities will continue to occur at least once every 2-4 years. Scenarios that contemplate the potential impacts of climate change (i.e., scenarios C, D and E) indicate a decline in the magnitude of

floods with 2-4 year recurrence intervals. If these flood magnitudes are decreased and sediment inputs to the system remain unchanged, altered channel form and behavior on some sections of the San Juan River is likely. The largest change in mainstem peak flow behavior under climate change is expected on pocket floodplains and large alluvial valley bottoms. The San Juan River below Fourmile Creek and segments of the East Fork and West Fork San Juan may be the first places changes to channel form and behavior will manifest following diminished peak flow magnitudes.

- The risk for synergistic impacts of decreased peak flow magnitudes due to climate change and increased sediment delivery following wildfire appear greatest in reaches of the Rio Blanco and Navajo River. These river corridors are home to both warm-water and cold-water fish and contain numerous homes, diversion structures, roads, and other infrastructure. Thus, changes in channel form and behavior in these reaches of river may impact both consumptive and non-consumptive water uses and may endanger human life and/or property.

Notable Findings: Riparian Areas

The San Juan watershed is home to unique and diverse riparian forests. Preservation and restoration opportunities for riparian areas exist across the WEP planning area. Notable findings regarding riparian areas include:

- Colorado Natural Heritage Program (CNHP) and Pagosa Wetland Partners provide detailed investigations and discuss management needs for high-value riparian and wetland areas throughout the planning area. Several of these areas have high biodiversity conservation significance.
- Observed or potential hydrological impacts to riparian areas noted by CNHP are typically associated with historical or ongoing grazing activities rather than water use/management for municipal needs or irrigation of crops.
- Direct impacts from grazing activities on the lower reaches of McCabe Creek and Mill Creek make both streams candidates for low-cost process-based restoration designed to elevate water tables and reconnect streams with their historical floodplain.
- Potential future impacts to the unique geothermal wetlands in downtown Pagosa Springs are directly tied to the management of outflows from the Pagosa Hot Springs. Protecting the unique biological characteristics of these wetlands likely requires maintenance of historical patterns of hot springs water delivery in timing, quantity, and frequency.
- Reductions in peak flow magnitude predicted by climate change scenarios C, D, and E may lead riparian forests along the San Juan River below Fourmile Creek to become smaller and less diverse.

Notable Findings: Aquatic Biota

Most limitations to native fish survival and recovery are common among species, with some exceptions. Many are hydrological: reduced seasonal connectivity to spawning and rearing habitat, reduced spring flood flows, and reduced late summer baseflows. Others are physical: entrainment in diversion ditches and canals; modification of backwaters, side channels, and other off-channel habitat; and fragmentation of habitat by dams and other in-channel structures. Water quality impairment (including temperature), non-native fish competition and predation, and hybridization round out the top challenges these fishes face. The effects of climate change are predicted to exacerbate many of these limitations. Conservation opportunities for native fishes in the WEP planning area arise from addressing limitations: increasing or protecting flood and summer streamflows; installing fish screens in diversions and providing for fish passage around diversions; controlling or eliminating invasive fish species, to name a few. Specific findings regarding the fishery include:

- The WEP planning area is home to a diverse assemblage of native warm-water fish and trout, as well as several non-native sport fish species.
- Fish habitat quality, as assessed by R2Cross analysis, exists in a suboptimal state in many locations across the watershed during certain portions of the year. The duration and magnitude of these suboptimal conditions tend to increase under increasingly dry climate change predictions (e.g.,scenarios C, D, and E), particularly in the late summer and fall months.
- Reduced fall streamflows predicted by climate change scenarios may be particularly problematic for species that spawn in the fall, like brown trout.
- Flow-mediated habitat conditions on the mainstem San Juan River above and through Pagosa Springs generally appear more conducive to native warm-water fish than rainbow or brown trout. However, the suitability of habitat for non-native sport fish appears less sensitive to changes in flow along these reaches. This finding suggests that native warm-water fish may receive more significant benefits from a highly connected stream network—allowing them to range widely as flows fluctuate to locate preferable habitat conditions.
- The ability of local aquatic biota to respond and adapt to changing climate conditions may be constrained by limited stream network connectivity in some parts of the watershed. Diversion dams associated with the San Juan – Chama Project greatly reduce aquatic organisms ability to access diverse habitats/refugia across different times of year in those watersheds.
- Entrainment of native trout, native warm-water fish and managed sport fish in surface water diversions throughout the planning area may reduce the number of individuals able to reproduce in any given year. However, only limited anecdotal evidence is available to assess the scope of this issue.
- The range of native cutthroat trout populations is limited to relatively short tributary reaches at high elevations. These populations may be particularly susceptible to reductions in streamflow brought about by a warming and drying climate.

Notable Findings: Recreation

Whitewater boating activities are an important contribution to the local economy and an important quality-of-life contributor to some residents in Archuleta County. Notable findings of the whitewater boating and angling use analysis conducted here include:

- Boatable Days analysis indicates strong seasonal patterns dominate the distribution of days available for whitewater boating use on reaches along the San Juan River. This reflects the natural, snowmelt runoff hydrology that is characteristic of these reaches.
- Scenario modeling that characterizes the impacts of climate change (i.e., scenarios C, D, and E) indicates the potential for a significant decrease in the number of days suitable for whitewater boating activities on the San Juan River in the early summer.
- Comparison of flow conditions across different reaches, times of year, and hydrological scenarios provides information about the role of variable hydrology in mediating patterns of angling use.

- High streamflows during May-June limit bank and wade-fishing opportunities throughout the watershed.
- Bank fishing opportunities are less sensitive to hydrological variability than wade fishing opportunities.
- Lower peak flows associated with climate change hydrological scenarios (i.e., scenarios C, D, and E) tend to increase the number of optimal and acceptable days for both wade and bank fishing during the April-May period. Lower late-summer flows associated with climate change hydrological scenarios tend to decrease the number of optimal days for float, wade and bank fishing on all reaches.
- Angling quality is tightly coupled with aquatic habitat availability and the health of the fishery. Therefore, consideration of results presented in the aquatic biota section is equally important for understanding existing and potential future angling opportunities across the San Juan watershed.
- Climate change induced changes in streamflow lead to a reallocation of acceptable and optimal days between months and among various recreational uses. Overall, flows are predicted to become less supportive of all activities in the late summer and fall.

GLOSSARY OF TERMS

Alluvial: River segments characterized by broad floodplains and active lateral channel movement.

AW: American Whitewater

BLM: Bureau of Land Management

Boatable Days: A metric used to evaluate the number of days in a year or month that a stream segment can support recreational boating activities. The metric is based on user-defined relationships between patterns of streamflow and user preferences for various flow ranges.

CDWR: Colorado Division of Water Resources

CNHP: Colorado Natural Heritage Program

Conditional water rights: Water rights that are decreed by the Colorado Water Court but are not currently in use.

Consumptive use: Uses of water that remove physical water from the system through evaporation, transpiration, or export from a basin. Agricultural and industrial uses are generally considered consumptive uses.

Cooperative Measures: Collaboratively-identified projects, processes, or management actions intended to support multiple water uses on the San Juan River and its tributaries.

CPW: Colorado Parks and Wildlife

CWCB: Colorado Water Conservation Board

Decreed water rights: Water rights granted to users for beneficial use by the Colorado Water Court.

Demand shortages: The difference between the water available to support a given consumptive or non-consumptive use and the demand for that use.

E&R: Environmental and Recreational

Fishable Days: A metric used to evaluate the number of days in a year or month that a stream segment can support recreational fishing activities. The metric is based on user-defined relationships between patterns of streamflow and user preferences for various flow ranges.

Hydrograph recession: The period of falling streamflows that generally occurs in early summer as snowpacks become thinner.

Hydrological regime: The characteristic behaviors of streamflow observed or expected on a given segment of stream.

Invasive species: Plants or animals that are not native to a basin or stream. These organisms tend to disrupt local ecosystems and can, eventually, displace many native species.

IPP: Identified Project and Processes included in the Southwest Basin Implementation Plan

ISF water right: Instream Flow water rights held by the CWCB for the protection of aquatic species.

Prior appropriation doctrine: The system of water right allocations and administration in Colorado that gives older users in a system the first opportunity to use water in periods of scarcity.

R2Cross: An assessment methodology used by the CWCB to establish ISF water rights in many streams across Colorado.

Riparian zones: The vegetated areas adjacent to streams and rivers that tend to support high levels of biodiversity.

SWBRT: Southwest Basin Roundtable

StateMod: The simulation model used by the CWCB to simulate hydrology and water rights administration in basins across Colorado.

SWBIP: Southwest Basin Implementation Plan, a component of the Colorado Water Plan.

SWSI: Surface Water Supply Initiative conducted by the CWCB.

Trans-basin diversion: Diversion of water across a watershed divide.

USFS: United States Forest Service

USGS: United States Geological Service

Water supply gaps: The amount of water required to make up the difference between the water available to support a given consumptive or non-consumptive use and the demand for that use.


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1. BACKGROUND AND PURPOSE

The Colorado Water Plan left environmental and recreational water (E&R) needs planning to local stakeholders.[4] The Plan quantified municipal, industrial, and agricultural water supply gaps, but noted the knowledge gaps and lack of common metrics for E&R flows prevented a similar statewide analysis. To bring the State's understanding (and methods for understanding) of E&R needs on par with consumptive needs, the State set a goal that E&R planning (i.e., "Stream Management Planning) should occur on 80 percent of locally prioritized rivers by 2030. Local stakeholders retain control in deciding which rivers to prioritize and management objectives to pursue.

The WEP planning effort responds to the call for E&R water use planning for the San Juan Basin articulated by the Colorado Water Plan and the 2015 Southwest Basin Implementation Plan (SWBIP) [5]. Similarly, the Southwest Basin Roundtable (SWBRT) identified a significant gap the in information necessary to understand E&R water needs in the basin during development of the SWBIP.

> "With respect to the Southwest Basin's Environmental and Recreational values and water needs, the Roundtable recognizes that there are significant gaps in the data and understanding regarding the flows and other conditions necessary to sustain these values. The Roundtable also recognizes that the tools currently available to help maintain those conditions are limited."[6]

Understanding E&R water uses in the Southwest Basin is particularly challenging given the size of the basin and the diversity of the nine major sub-drainages that it encompasses. In 2010, the SWBRT completed a basin-wide E&R needs assessment as part of the Statewide Water Supply Initiative (SWSI) [7]. That assessment provided information about the type and geographic location of E&R water uses throughout the basin, but did not quantify water supply needs for those uses. Responding to this gap in E&R water needs data and planning, the SWBRT supported this effort to assess E&R needs and gaps in the San Juan watershed.

Colorado water planners and engineers have quantified consumptive use needs for a century: the methodologies for determining an agricultural producers existing need or a city's future need are well understood and extensively practiced. Water demand has exceeded water supply when a senior water right holder places an administrative call. On streams without instream flow rights or recreational instream diversion water rights, it is less clear when an environmental need goes unsatisfied. A single or universal approach for characterizing E&R use needs in streams and rivers across the state does not exist. This is largely a result of the complexity and dependence between a river's hydrological, hydraulic, biological, and chemical components. Environmental needs depend on a river's physical attributes (e.g., width, depth, gradient) and the community of plants and animals present. Recreational needs depend on river structure and user preferences for various streamflow

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[4] Planning is distinguished here from the Colorado Water Conservation Board's ongoing appropriations of water for instream flow. *See* Colorado Water Plan §§ 5-15, 6-18, and 6-167.

[5] Oliver and Lile, "Southwest Basin Implementation Plan."

[6] Id.

[7] Colorado Water Conservation Board, "Southwest Basin Nonconsumptive Needs Assessment: Environmental and Recreational."

conditions (e.g., what water levels are too low or too high to float), aesthetics, opportunities for access, and other factors. To capture that complexity, a somewhat comprehensive approach was required for assessing E&R needs and gaps across the upper San Juan watershed.

The assessment presented here provides a platform for understanding the diversity of water use needs in the San Juan River basin. This effort builds upon decades of research, studies, water planning, and legal analysis focused on water resource issues in the basin. Parties responsible for completing past investigations include state and federal resource management agencies, academic institutions, private consultants and attorneys, non-profit organizations and others. The following is a sample of the existing literature foundational to the development of this assessment effort:

- Conservation Strategy for Colorado River Cutthroat Trout in the States of Colorado, Utah, and Wyoming (2006)
- Colorado's 2015 State Wildlife Action Plan (2015)
- Conservation Agreement & Strategy for Roundtail Chub, Bluehead and Flannelmouth Suckers (2006)
- East Fork of the San Juan Restoration
- Fire Risk to Water Supplies Assessment (2015)
- Lower Blanco River Restoration Project (2010)
- Navajo River In-Stream, Riparian & Wetland Improvement Project (2015)
- San Juan Planning for Biodiversity Model Project, Phase II (2006)
- San Juan River Historical Ecology Assessment (2015)
- San Juan River Workgroup Final Report (2011)
- Southwest Basin Roundtable Basin Implementation Plan (BIP)
- State Water Supply Inventory (SWSI)
- Stollsteimer Creek Watershed Master Plan (2006)
- Survey of Critical Wetlands and Riparian Areas in Archuleta County (2006)
- Town of Pagosa Springs San Juan River Improvement Project (2020)
- Water & Soil Resource Management Considerations (2011)

These references provide a rich set of functional characterizations and articulate goals and expectations for ecosystem behavior and recreational use opportunities on the San Juan River and its major tributaries. An annotated bibliography of relevant studies and reports was provided by the WEP as the primary deliverable from Phase I of the planning effort. Maps and geospatial data coverages relevant to this effort are compiled in Appendix A.

Tight interrelationships between water, agriculture, recreation, tourism and industry create a complex template for understanding and optimizing management of limited water resources to support the diversity of use needs in the San Juan watershed. Nonetheless, comprehensive water management decision-making supported by the WEP planning effort can promote collaborative learning about the system, help develop a shared understanding of tradeoffs involved in any given management action, and identify projects and processes to help optimize management of water for the full diversity of needs.

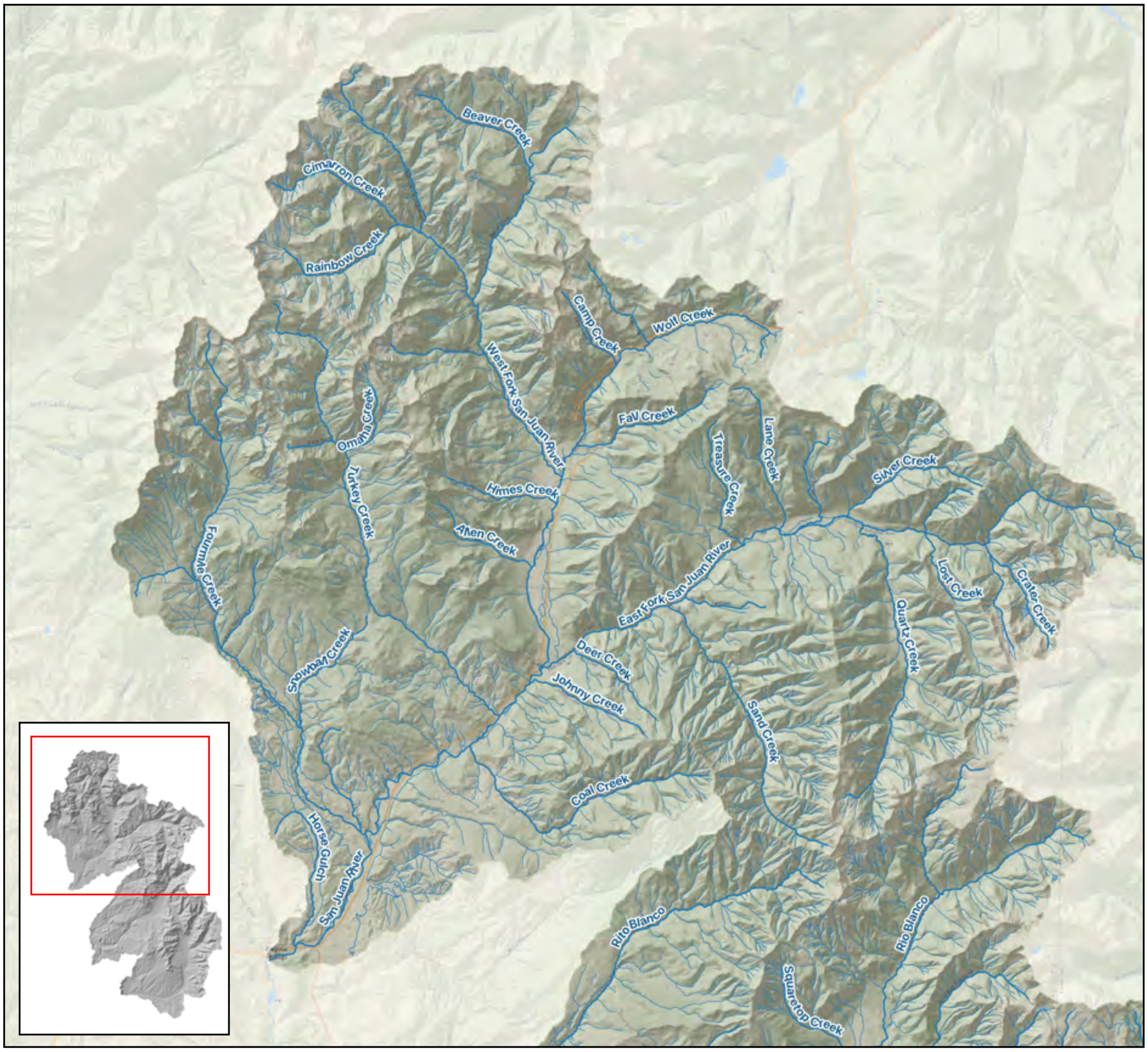

Figure 1. Streams and rivers in the upper San Juan WEP planning area.

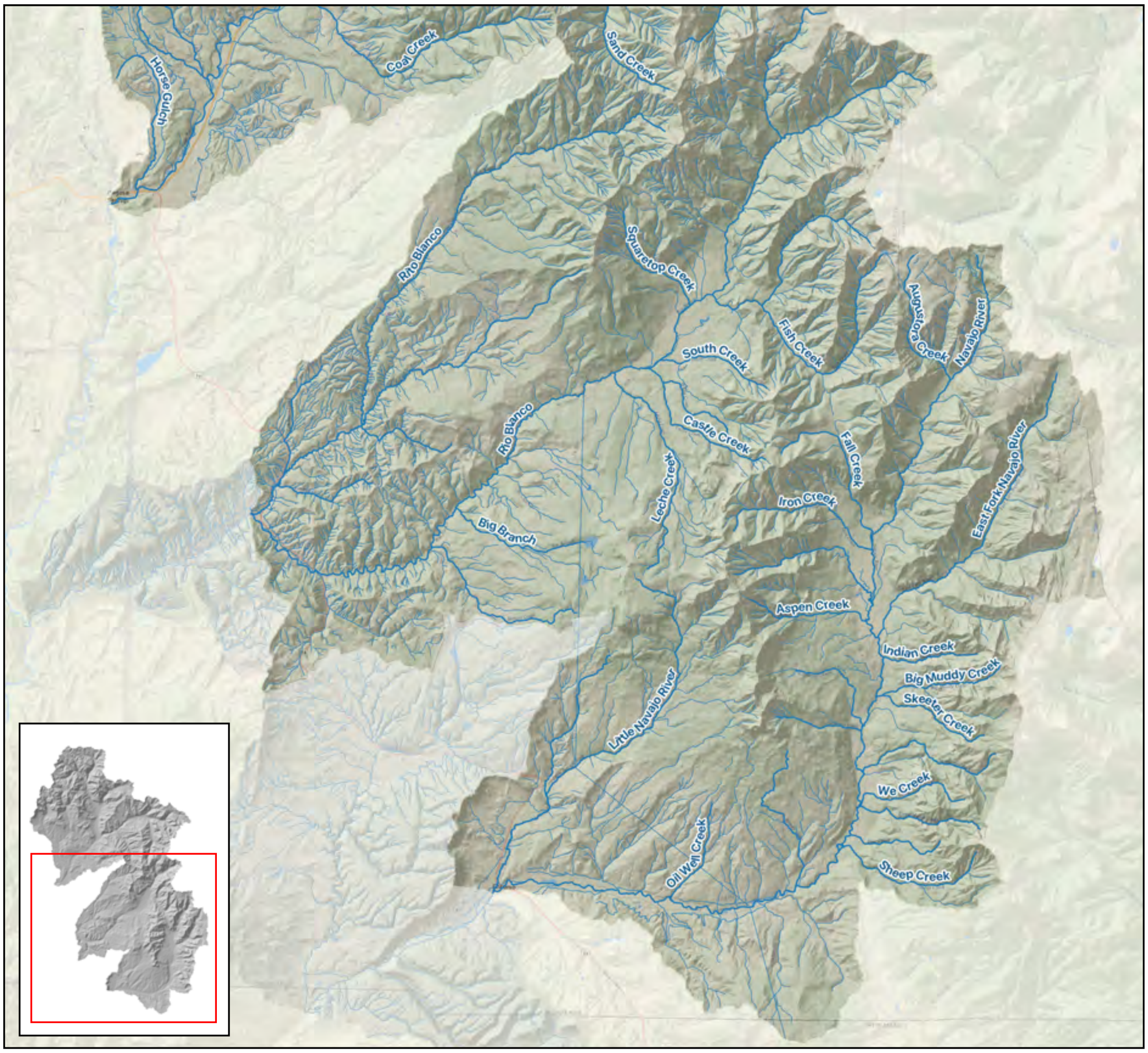

Figure 2. Streams and rivers in the upper Rio Blanco and Navajo River WEP planning area.

1.1 Planning Objectives

The WEP planning effort relies on high-level data collection and assessment to characterize gaps in E&R water supply needs. That information is summarized in this report. Collaborative stakeholder dialog is required to review this information, help resolve areas of potential conflict, prioritize management issues, and identify projects and processes that can improve the management of water for the benefit of multiple uses. The WEP planning effort implemented a stepwise planning process (Figure 3) as the fundamental structure for guiding the schedule and focus of different deliverables and stakeholder dialogs.

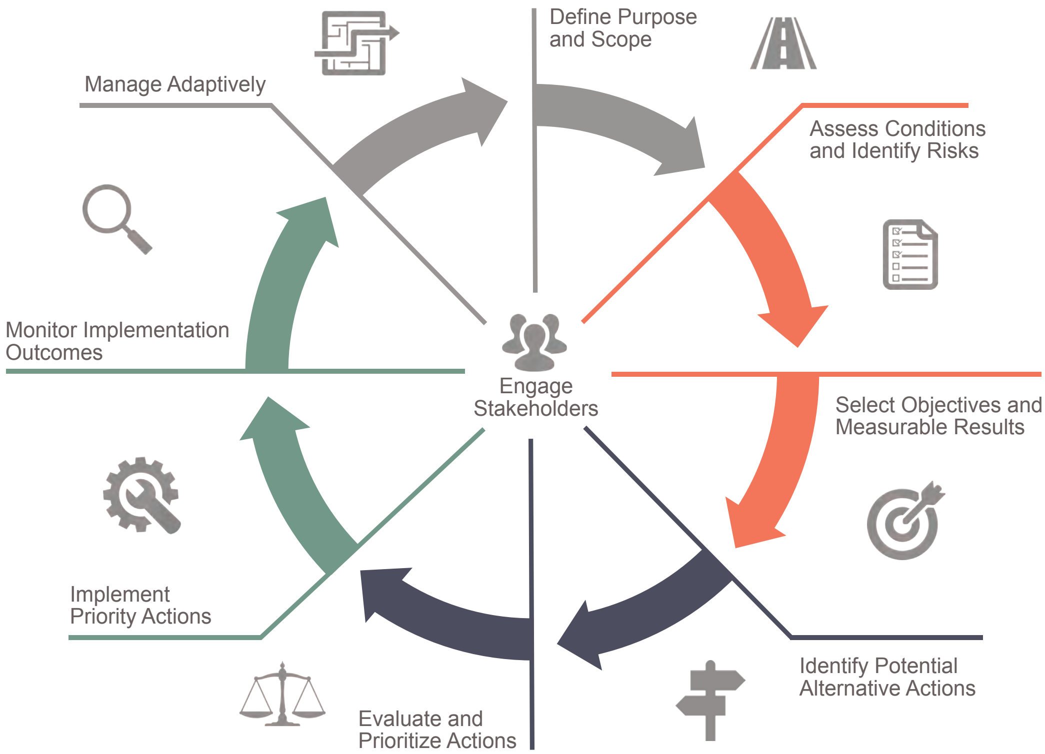

Figure 3. The multi-phase planning process guiding the WEP planning effort.

This phase of the WEP planning effort did not attempt to include each of the planning steps indicated in the figure above. Rather, the planning effort began with a Definition of Purpose and Scope during Phase 1 (2018 – 2019) and progressed through an Assessment of Conditions and Risks in Phase II (2020 – 2021) and will begin the process of objective selection, alternative identification, and the evaluation and prioritization of potential actions in Phase III, commencing in the summer of 2021. The implementation, monitoring, and adaptive management of these actions are expected to occur once the planning effort is complete. It is worth noting here that this planning approach and its outcomes should not be used or viewed as an alternative to Colorado's water allocation system - the prior appropriation doctrine. Just as water supply planning in a municipal context defines needs and offers solutions, this effort does the same for E&R uses in the planning area.

Phase II of the WEP planning effort aims to 1) characterize existing and historical hydrological conditions, 2) enhance understanding of timing and geographic patterns in E&R uses, 3) evaluate the ways that E&R needs may change under a suite of future climate scenarios, 4) probe the nexus between forest health and hydrology, 5) assess the condition of surface water diversion, delivery and irrigation water application infrastructure, and 6) point stakeholders toward the highest priority issues and/or geographies for further consideration. This project specifically responds to recommendations included in the 2015 Southwest Basin Implementation Plan:

> "1. Evaluation of environmental and/or recreation gaps is planned to be conducted for improvement of non-consumptive resources and/or in collaborative efforts with development of consumptive IPPs. The evaluations may be conducted by a subgroup of the Roundtable or by individuals, groups, or organizations with input from the Roundtable. The evaluation may utilize methodologies such as the southwest attribute map, flow evaluation tool, R2 Cross, and any other tools that may be available.
>
> 2. Where environmental and/or recreational gaps are identified, a collaborative effort will be initiated to develop innovative tools to protect water identified as necessary to address these gaps."[8]

1.2 WATERSHED CHARACTERISTICS

Planning for optimized water use and management begins with the development of a shared understanding of existing conditions. To this end, this section provides a brief summary of watershed geography, geology, vegetation types, hydrology—the physical and biological template upon which all management decisions are made.

The 575 square mile WEP planning area includes the portion of the San Juan River watershed above Pagosa Springs and the portions of the Rio Blanco and Navajo River watersheds east of Hwy. 84. Land ownership is dominated by the U.S. Forest Service in the upper San Juan and the upper Rio Blanco. Private ownership is dominant in the upper Navajo River watershed (Figure 4). The reaches of the San Juan River, Rio Blanco, and Navajo River that flow through the planning area begin in the San Juan mountains near the continental divide and flow westward, eventually flowing together and draining to Navajo Reservoir on the Colorado-New Mexico border. Diverse climate and geological characteristics create a rich mosaic of stream and river types, vegetation communities, and aquatic and riparian ecosystems throughout the planning area.

1.2.1 Geology, Climate and Hydrology

Surficial rock and soils vary widely in the watershed, owing to the variety of geological processes at work (Figure 5). The same Tertiary volcanic rocks that are common across the San Juan Mountain Range dominate in high elevation headwaters tributaries. These rocks, formed between 66 and 2.6 million years ago, are frequently underlain by Mancos Shale. Descending from the San Juan Mountains, streams enter the Colorado Plateau physiographic province, incising narrow, deep canyons into the sandstone, siltstones and shales common in the middle watershed. Resistant sandstone layers prevent erosive siltstone and shale embedded within from crumbling, maintaining steep canyon walls along many valleys. In the lower basin, streams flow through sedimentary rocks of the Jurassic and Triassic Age.

[8] Oliver and Lile, "Southwest Basin Implementation Plan."

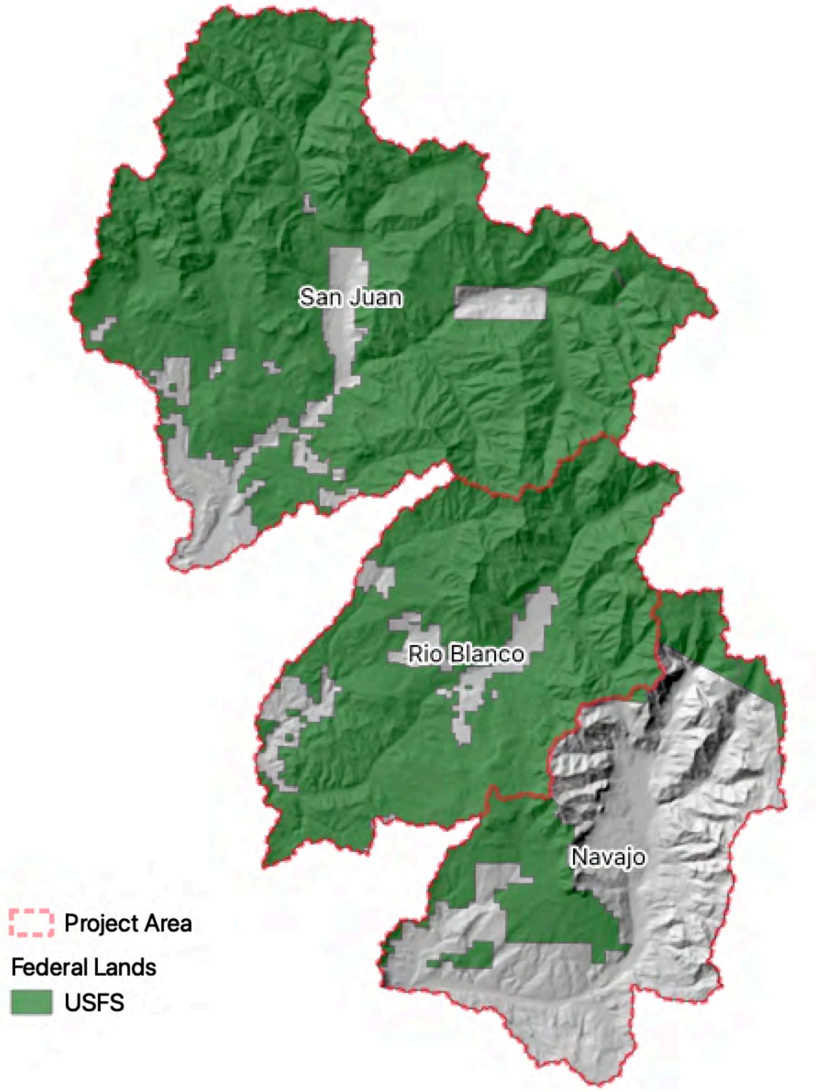

Figure 4. Federal land ownership (green areas) in the San Juan watershed is extensive. The upper San Juan and Rio Blanco drainages are dominated by federal land. Private land is dominant in the Navajo River drainage.

Large elevation gradients contribute to significant differences in climatic characteristics between the headwaters and the lower basin. Climatic patterns parallel elevation patterns. The headwaters receive almost four times as much precipitation as the lower elevations. Precipitation falls mainly as winter snow in the upper basin and late summer rain across the planning area. Higher elevations near the continental divide are significantly colder than the western portion of each watershed. Maximum and minimum average temperatures vary predictably along an elevation gradient that generally trends downward when moving from the continental divide in the east toward valleys, foothills, and mesas in the south and west.

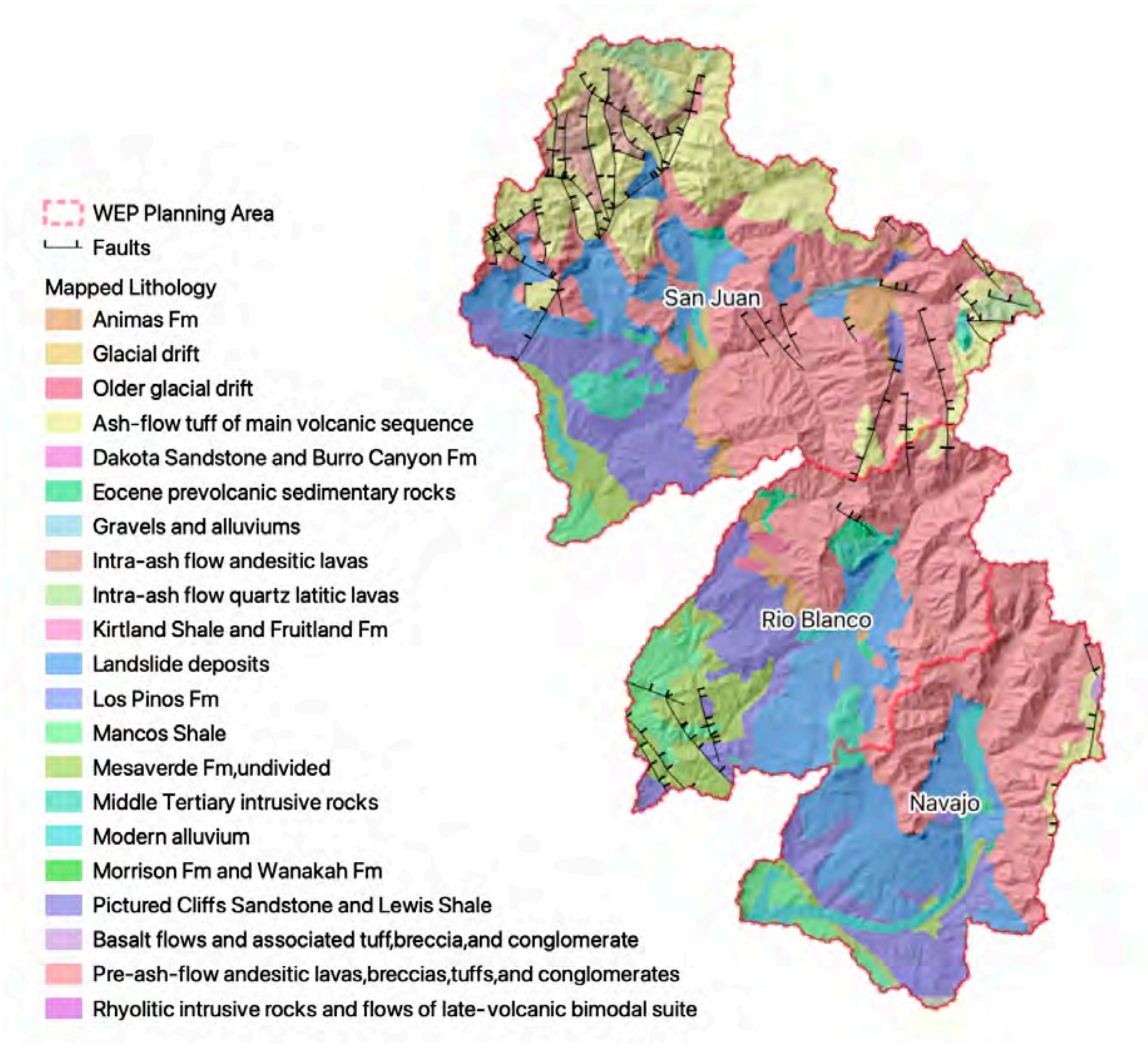

Figure 5. Surficial geology of the San Juan watershed

1.2.2 Land Cover and Land Use

Vegetation type, extent, and density also provide controls on hydrological regime. Changes to land cover or land use may produce cascading effects on local hydrology, geomorphology, and ecology. Dominant cover types in the upper basin transition from barren rock and tundra near the divide to denser forests interspersed with shrubs as elevation decreases. In the lower and western watershed, tree cover density decreases and shrubs and grasses become more dominant.

Ecoregions represent areas characterized by similar ecosystem and natural resource characteristics. Their delineation synthesizes similarities between spatial patterns in geology, climate, land use, vegetation, physiography, and soils. Identification of ecoregions in the context of water use planning is important as it helps land and water managers understand how the physical landscape, climate, and resource use interact to govern local channel dynamics, hydrological regime behavior, and the response of local ecosystems to each of the former. Additionally, mapping ecoregions can facilitate the approximation of dominant characteristics and landforms in different areas of the landscape, the streams and rivers they contain, and the prediction of how each may respond to changes in climate, management, or land cover. The WEP planning area contains four EPA Level IV Ecoregions [9] (Figure 7).

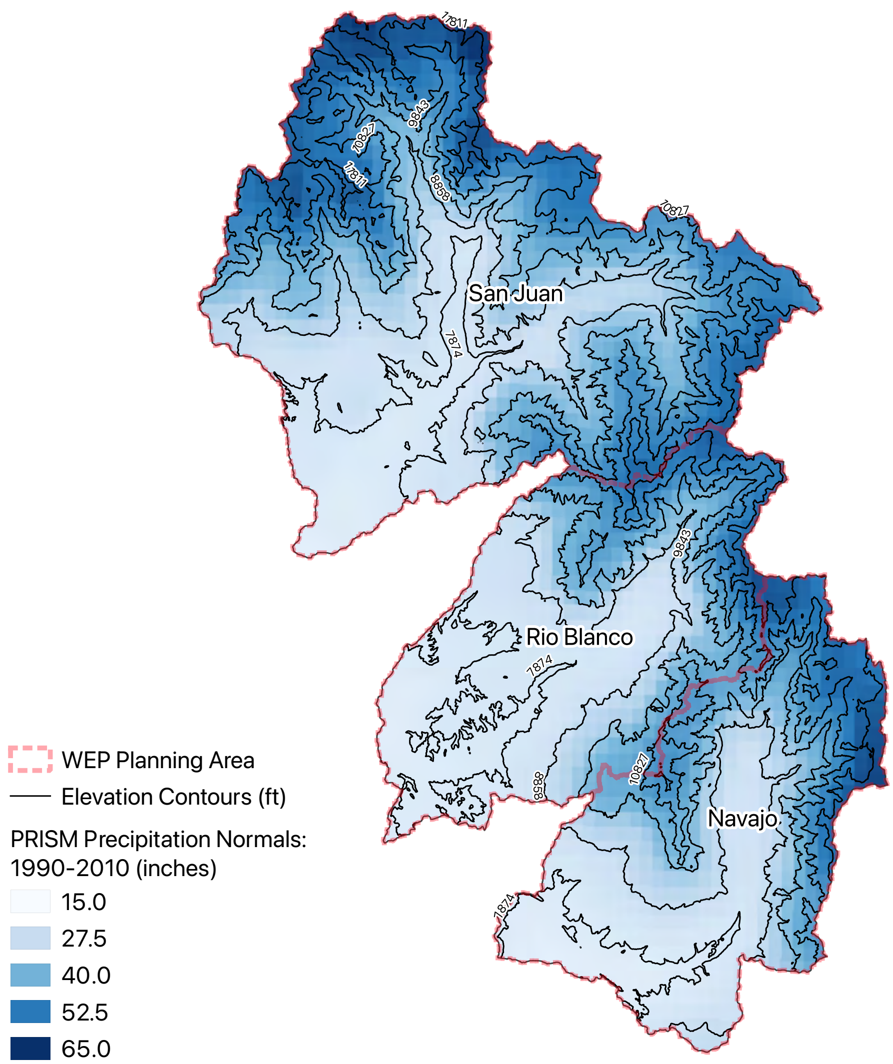

Figure 6. 30-Year Annual Precipitation Normals mapped across the planning area indicate the strong correlation between elevation and snowfall.

[9] Chapman et al., "Ecoregions of Colorado."

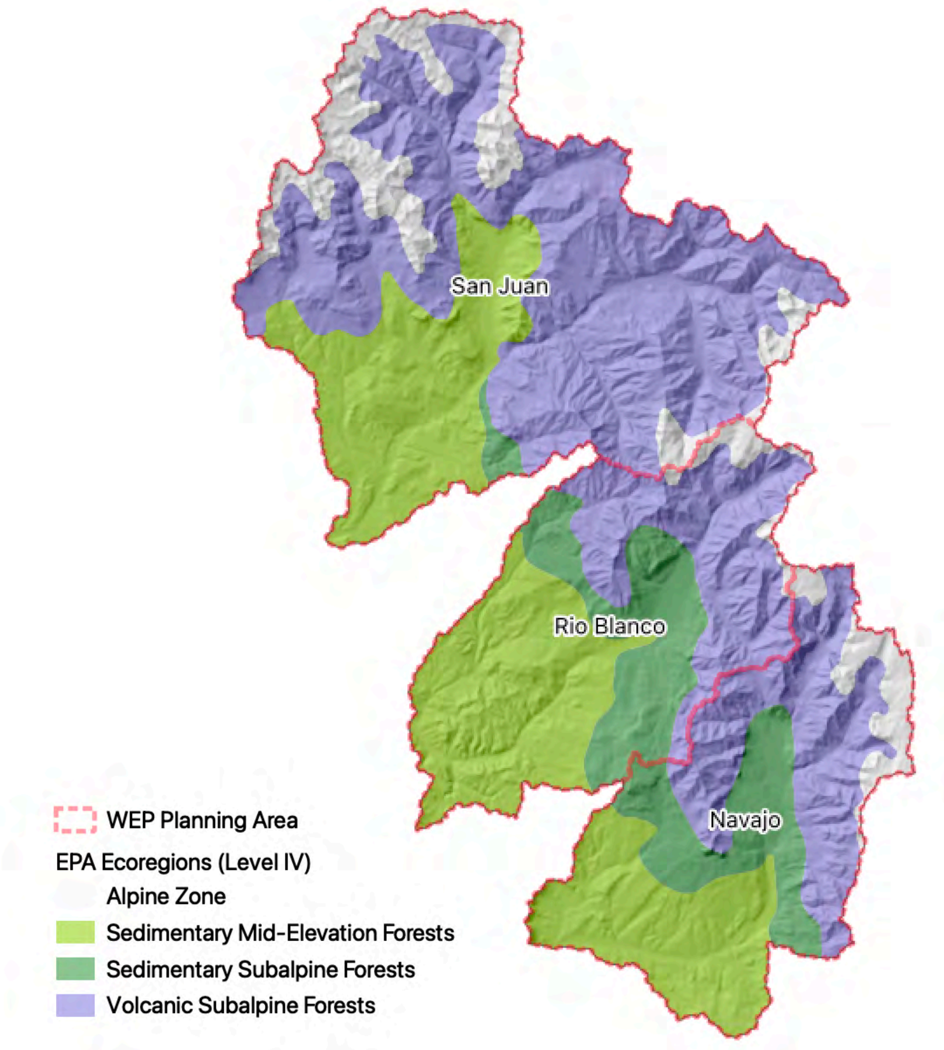

Figure 7. Three EPA Level IV Ecoregions dominate the landscape within the WEP planning area.

1.2.2.1 Sedimentary Mid-Elevation Forests

Occupying the lowest elevation band of the Southern Rockies (< 9,000 ft.), this partially glaciated area is characterized by low ridges, hillslopes and moderate to high gradient perennial streams. Precipitation is moderate, falling more as rain than snow, and temperatures are slightly warmer than in higher zones. Sedimentary limestone, siltstone, shale and sandstone are the predominant surficial geology. Soils weathered from underlying limestone are fine-textured and alkaline. Ponderosa pine, Gambel's oak, pinyon pine, aspen, and a shrub-grass understory make up forests.[10] Land uses include wildlife habitat, limited timber production, grazing, and recreation (hunting, fishing, etc.).

[10] https://gaftp.epa.gov/EPADataCommons/ORD/Ecoregions/co/co_front.pdf

1.2.2.2 Sedimentary Subalpine Forest

Occupying a slightly higher elevational band than Mid-Elevation Forests (up to ~10,000 ft.), this region continues many of the same trends found lower. Landforms include glaciated peaks, rocky outcrops, and steep streams. Vegetation is mostly forest of subalpine fir, Engelmann spruce, white fir and Douglas fir interspersed with aspen, with an understory of berry shrubs, sedges and forbs. Much of the spruce in this area was killed by beetle infestations in recent years. Annual precipitation increases in both total amount and the ratio of snow to rain. This zone provides a perennial water source for lower elevation arid regions. Soils originate from the same sedimentary geologies of the Mid-Elevation Forest.[11] Land use is confined to wildlife habitat, limited grazing, and recreation, with relics of legacy timber extraction activities. USFS implements fuel treatments and prescribed burns in these forests periodically.

1.2.2.3 Volcanic Subalpine Forest

The steep, mountainous Volcanic Subalpine Forests ecoregion is composed of volcanic and igneous rocks, predominately andesitic with areas of basalt. The area is highly mineralized, and gold, silver, lead, and copper are often found in the underlying geology. The mountains in this ecoregion are relatively young, geologically, and are among the highest and most rugged of North America. These areas of the WEP planning area still contain some large areas of intact habitat. Englemann spruce, white fir, Douglas fir, subalpine fir, and aspen forests dominate.[12] Much of the spruce in this area was killed by beetle infestations in recent years. Land use is confined to wildlife habitat, limited grazing, and recreation, with relics of legacy timber extraction activities. USFS implements fuel treatments and prescribed burns in these forests periodically.

1.2.2.4 Alpine Zone

Occurring mostly above treeline, this high relief zone is known for glaciated peaks, exposed rocky outcrops and alpine meadows. Streams are steep with boulder, cobble, and bedrock channel substrate. Vegetation in this harsh environment of the transitional tundra is limited to sparse *krummholz* (dwarfed trees) of spruce, fir, and pine. Sedges, wildflowers, shrubs, and cushion plants fill alpine meadow areas, with willow thickets in wet meadows. The 35-70 inches of annual precipitation fall mostly as snow and are a major water source for lower, more-arid ecoregions.[13] Land use is confined to wildlife habitat and recreation, with relics of legacy hard rock mining and timber extraction activities.

1.2.3 The Hydrological Template

The structural form and functional integrity of a riverine system are described by a suite of hydrological, physiochemical, biological, geomorphological, and hydraulic processes. Complex bi-directional interactions occur between each process, complicating the evaluation of any one component of the system in isolation from the others. However, the overall form and function of a river are primarily influenced by its natural hydrology. In turn, fluvial ecologists often treat flow regime as the "master variable" exerting the largest influence on

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[11] https://gaftp.epa.gov/EPADataCommons/ORD/Ecoregions/co/co_front.pdf

[12] Id.

[13] Id.

riverine ecosystem form and function.[14] The Natural Flow Paradigm [15] postulates that hydrology represents the key driver of riverine structure and function.

The daily, seasonal, and inter-annual variations in a stream's flows make up its *hydrologic regime*. Changes in the timing and magnitude of various elements of the hydrologic regime can produce cascading effects—or positive feedback loops—between: 1) the availability and quality of aquatic habitat, 2) the condition and extent of riparian zones, and 3) the dynamics and evolutionary trajectory of channel structure. Broad patterns of precipitation and topography largely determine a river's flow regime. River systems subject to hydrological change due to changing climate or human management are vulnerable to shifts in the composition and resiliency of both structural and biological components of the ecosystem.

Hydrological regimes exhibited by streams in the planning area reflect dominant climatological drivers. High elevation headwaters flow from zones of significant winter snowfall. These streams exhibit typical snowmelt hydrology for the Rocky Mountains, with peak flows driven by melting snowpack occurring between April and June. Low flow periods extend from September through March, punctuated by occasionally significant summer and fall storms (Figure 8). Gauge records across the watershed show the highest natural flows during spring runoff, while several large peak flood pulses measured near Pagosa Springs occurred in the late summer or early fall, indicating the important role the monsoonal rainfall plays in local hydrology.

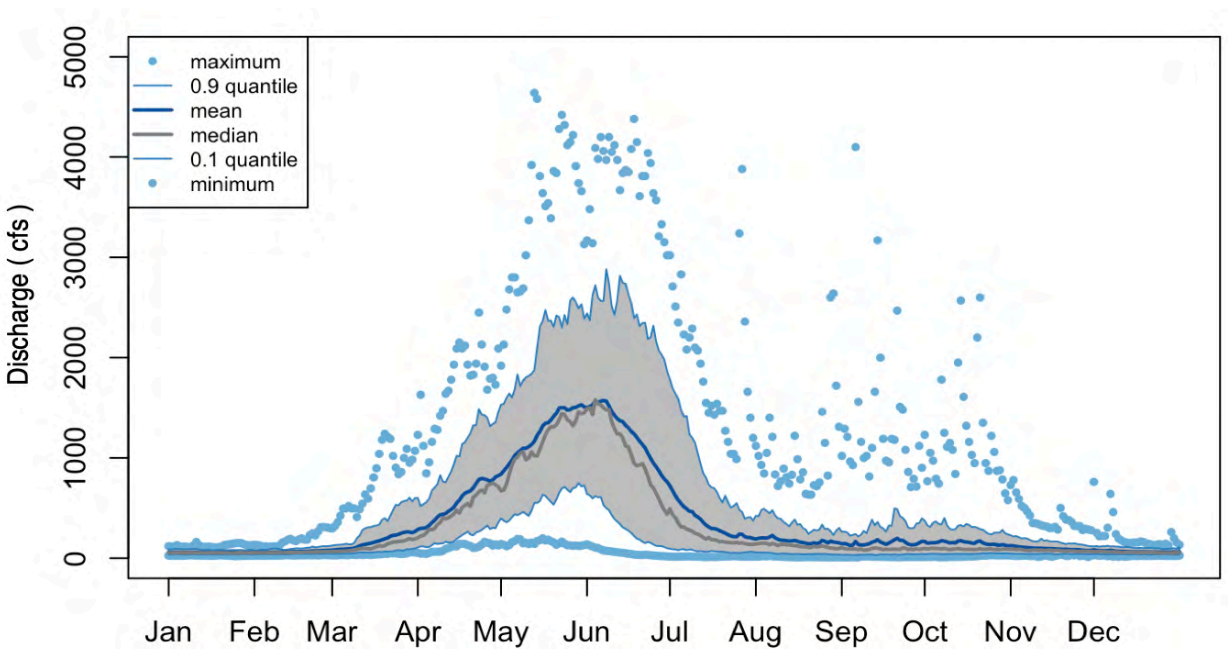

Figure 8. Hydrological regime plot for the San Juan River at Pagosa Springs

[14] Poff et al., "The Natural Flow Regime."

[15] Id.

Activities that deplete or augment streamflow have the potential to impact important regime characteristics, including: total annual volume, magnitude and duration of peak and low flows, and variability in timing and rate of change. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g., the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change.[16]

1.3 Water and the Economy

The San Juan region is sparsely populated—approximately 14,000 people reside in the Archuleta County.[17] Similar to other Western Slope areas, the region continues to experience a gradual transition away from an economy dominated by agriculture and extractive industries (i.e., mining and logging) to an economy driven by real estate development, tourism and recreation.

Historically, the WEP planning area was inhabited by the Southern Ute Tribe. The Utes hunted game in the San Juan mountains, drank water from the rivers, relaxed in local hot springs, and named many of the local geographic features. The word "*Pagosa*" means "healing" or "boiling water" in the Ute language. The Utes were largely pushed out of the area by European settlers seeking gold and other resources in the late 19th century.

Mining and timber extraction played a significant role in the European settlement of the planning area between the 1850s and 1920s, but drastically receded over the 20th century as available resources became scarce. A large sawmill near the intersection of Hwy. 160 and Hwy. 84 closed in the 1970s (Figure 9). Around the same time, real estate development in and around Pagosa Springs became an important driver of the local economy. The area's outstanding scenery, temperate summer climate, and opportunities for numerous recreational activities fueled development of condominiums, and second homes.

Figure 9. Historic saw mill at the intersection of Hwy. 160 and Hwy. 84. The mill closed in the 1970s.

Throughout the last 150 years, irrigated agriculture has shaped the landscape and productive agriculture remains an important component of the local economy. Cattle and horse ranching provide a livelihood for residents in and around Pagosa Springs, in the Rio Blanco valley, and in the Navajo River basin. Diversion of surface water from the San Juan River, Rio Blanco and Navajo River (and their many tributaries) continues to support hay and alfalfa production. Colorado Department of Natural Resources estimates approximately 7,620 acres of land in the three watersheds remains under agricultural production [18].

[16] Johnson, Beardsley, and Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams."

[17] archuletacounty.org

[18] "2010 Irrigated Parcels, Division 4."

Figure 10. A view of the Pagosa Hot Springs in the late 1800s.

Recreational tourism is a noteworthy contributor to the economy of Pagosa Springs, and by extension, the rest of Archuleta County. Recreational opportunities across the watershed abound and include: skiing, fishing, camping, hiking, biking, hunting, and rafting. An estimated 30% of the jobs in Archuleta County are related to tourism[19]. Each year, visitors to the area, largely attracted by the local scenery and opportunities to participate in these activities, spend money earned elsewhere in local businesses. The high quality of life enjoyed by local residents is similarly bound to the area's open spaces, recreational opportunities and aesthetic qualities. Many recreation and social values are directly tied to the biological and physical condition of local rivers, streams, and lakes. Notably, area hot springs have drawn people to the Pagosa Springs area for centuries and many visitors and residents still enjoy this unique amenity (Figure 10).

1.4 Existing Patterns of Water Use

At their heart, the activities of the WEP constitute a water planning effort. As such, it is critical to view it within the context of existing legal and administrative frameworks for water use and management in Colorado. A brief introduction to those frameworks and some major controls on water use and management in the planning area are discussed in the sections below.

The Colorado Division of Water Resources (DWR), a state agency housed within the Department of Natural Resources, administers water rights in Colorado.[20] Water rights are a property right, separate and distinct from land ownership, that entitles the holder to use water from a natural stream, without waste, for a beneficial use.[21] Water rights are created through application of water to a beneficial use, and are confirmed by the state's system of water courts. There is no official enumerated list of authorized beneficial uses[22], though the most common ones are irrigation, domestic, industrial, and municipal uses. A water right's water court decree will typically specify a point of diversion, maximum flow rate (in cubic feet per second or "cfs"), beneficial use, and place of use. Any desired modification of a water right's use not contemplated in its decree must be approved by the water court through what is commonly known as a 'change case.' A water court will approve the desired modifications if the applicant shows the proposed change will not injure other water users.

Legal administration of water use in the upper San Juan, Rio Blanco, and Navajo River watersheds allocates water among multiple users according to Colorado's water law. Rights are decreed in a seniority system. Colorado allocates water according to the Prior Appropriation Doctrine. In times of water shortage, the water right first confirmed by judicial decree has a superior right to divert as against those confirmed subsequently,

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19 Economic Development District of SW Colorado, Region 9 Base Analysis Report, 2018

20 The Division's homepage is http://water.state.co.us/Home/Pages/default.aspx

21 A great introduction to water rights in Colorado is "Colorado Water Law for Non-Lawyers" by P. Andrew Jones and Tom Cech.

22 However, some beneficial uses have been specifically authorized by statute, such as instream flow and agricultural water protection water rights.

giving rise to the phrase "first in time, first in right."[23] Upon an administrative 'call', DWR will curtail so-called junior water rights in order to deliver water to the calling senior right. Thus, in periods of scarcity, senior rights are fulfilled first and junior rights may receive a portion or none of their decreed amount. Water rights with senior priorities are, therefore, more reliable in drier years than water rights with junior priorities. However, there are statutory mechanisms that may improve the reliability of junior water rights, such as plans for augmentation.[24] The same is true for reservoirs: water stored in reservoirs must be stored under the reservoir's priority – usually at peak flow during runoff. However, once legally stored and released, the released water no longer carries a priority and may be delivered to its place of use downstream regardless of intervening senior priorities.

Groundwater in Colorado is presumed to be tributary to natural streams, and therefore well pumping also operates within the prior appropriation system. The list of exceptions to this rule is extensive and beyond the scope of this document.[25]

Nearly a third of Colorado's river miles have flow protections for environmental and habitat purposes.[26] Slotted into the priority system, instream flow (ISF) water rights specify an upper and lower terminus, a flow rate (often with rates that vary by season[27]), and are held by the Colorado Water Conservation Board (CWCB). These water rights are administered in priority in the same manner as all other water rights. When in priority, the flow in that river segment may not be reduced beyond the decreed flow rate by junior water users. Because the legislature did not recognize the validity of instream use of water until 1973, most instream flows are junior in priority; however, the CWCB may acquire through voluntary transactions senior water rights to restore flows to rivers.[28] CWCB holds numerous ISF water rights in the WEP planning area.

Water courts began recognizing in-river recreational uses of water as early as 1992.[29] Several communities, including Vail, received decrees for recreational flows before the legislature stepped in to create process and restrictions around those river recreation projects in 2001.[30] Now formally known as Recreational In-Channel Diversions (RICDs), these non-consumptive water rights are tied to structures that control flow in rivers to enhance boating experience. They have decreed flow rates to be delivered to the boating structures in priority.

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[23] A water right's first use, known as its 'appropriation date', is also taken into account in determining priority. The relationship between adjudication date and appropriation date is known as the Postponement Doctrine. Between two water rights adjudicated in the same year, the water right with the earlier appropriation date is senior.

[24] For more detail, visit https://waterknowledge.colostate.edu/water-management-administration/water-rights/types-of-water-decrees-rights/#1532968027727-8a64f4df-4a12

[25] For more detail, visit https://waterknowledge.colostate.edu/water-management-administration/water-rights/groundwater-rights/

[26] More information on the State's Instream Flow Program can be found at http://cwcb.state.co.us/environment/instream-flow-program/Pages/main.aspx

[27] For example, a summer protected flow rate may be larger than the winter protected flow rate. This is due to water availability.

[28] These acquisitions may be permanent or temporary. For more detail, visit http://cwcb.state.co.us/environment/instream-flow-program/Pages/WaterAcquisitions.aspx

[29] Findings of Fact, Conclusions of Law, Judgment and Decree After Remand from the Colorado Supreme Court, No. 86CW317 (District Court, Water Division 1 December 5, 1994); See also Thornton v. Fort Collins (Colorado Supreme Court April 20, 1992).

[30] Concerning the Establishment of a Procedure for the Adjudication of a Recreational In-Channel Diversion by a Local Government, and Making an Appropriation Therefor, Senate Bill 01-216.

Only certain types of government entities are authorized to hold RICDs.[31] There are no RICDs in the WEP planning area at this time.

Water from the San Juan River, Rio Blanco, Navajo River and their tributaries support agricultural production, municipal water use, transmountain diversions, and a number of minimum instream flow rights, all administered to deliver water to the oldest existing uses in priority before newer uses.

1.4.1 Municipal Use

The Pagosa Area Water and Sanitation District (PAWSD) supplies approximately 75% of Archuleta County residents with treated drinking water from surface water diversions in the upper San Juan watershed. PAWSD's primary water supply is from adjudicated surface water diversion rights decreed for municipal uses on the West Fork of the San Juan River (5 cfs), the mainstem San Juan River (8 cfs), and Fourmile Creek (12.8 cfs). The Fourmile Creek diversion is "called-out" by senior users in that drainage for much of the year and PAWSD must rely on the other two diversion points. These diversions supply raw water to a system of reservoirs in the Pagosa Lakes area. PAWSD can access and manage approximately 4,070 acre-feet of combined water storage in Hatcher Lake, Stevens Lake, Lake Pagosa, Lake Forest and Village Lake.[32] Existing water rights and developed water sources are generally considered by PAWSD to be adequate for meeting existing needs in the Pagosa Springs area under normal and drought conditions.[33] PAWSD recently completed a Water Conservation Plan[34] and a Drought Management Plan.[35] These documents outline strategies for water use and management that ensure uninterrupted municipal water supply to users during times of shortage.

1.4.2 Agriculture

Agricultural production occupies a significant position in the history, culture, and economy of the San Juan Basin. Approximately 7,620 acres of irrigated agriculture[36] occupy the valley floor, relic terraces and benches around Pagosa, and along the Rio Blanco and Navajo Rivers (Figure 11). These farms and ranches contribute to the vibrancy of local economies and to the scenic nature of the landscape. Agricultural production is supported by a network of surface water diversion structures, canals, ditches, pipelines, small storage facilities, and groundwater wells. Agricultural rights are among the most senior in the planning area. Over 520 active decreed water rights exist on the three mainstem rivers and their numerous tributaries and most of these support local ranches. The majority of surface water diversions occur along the mainstem San Juan River, Fourmile Creek, the upper Rio Blanco, and along the Navajo River mainstem (Figure 12).

Much of the water diversion, conveyance and application infrastructure in the planning area is old and would benefit from some degree of repair, reconstruction, or modernization. Improvements to infrastructure may reduce operation and maintenance costs for local water users. Piping or lining ditches and implementing more efficient water application methods (e.g., sprinklers) may yield efficiency improvements that enable users to divert less water at the point of diversion and still provide a crop with adequate supply. An investigation, led

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[31] For more information on RICDs, visit http://cwcb.state.co.us/environment/recreational-in-channel-diversions/Pages/main.aspx

[32] PAWSD 2018 Drought Management Plan (https://www.PAWSDd.org/downloads/2018-Drought-Mgmt-Plan.pdf)

[33] PAWSD 2018 Drought Management Plan (https://www.PAWSDd.org/downloads/2018-Drought-Mgmt-Plan.pdf)

[34] PAWSD 2008 Water Conservation Plan (https://www.PAWSDd.org/downloads/2008-Water-Conservation-Plan.pdf)

[35] PAWSD 2018 Drought Management Plan (https://www.PAWSDd.org/downloads/2018-Drought-Mgmt-Plan.pdf)

[36] "2010 Irrigated Parcels, Division 4."

by the San Juan Conservation District (SJCD) with technical assistance from the Natural Resources Conservation Service (NRCS), was conducted throughout the planning area. This investigation identified needs and opportunities for a variety of agricultural infrastructure improvements throughout the WEP planning area (Appendix B).

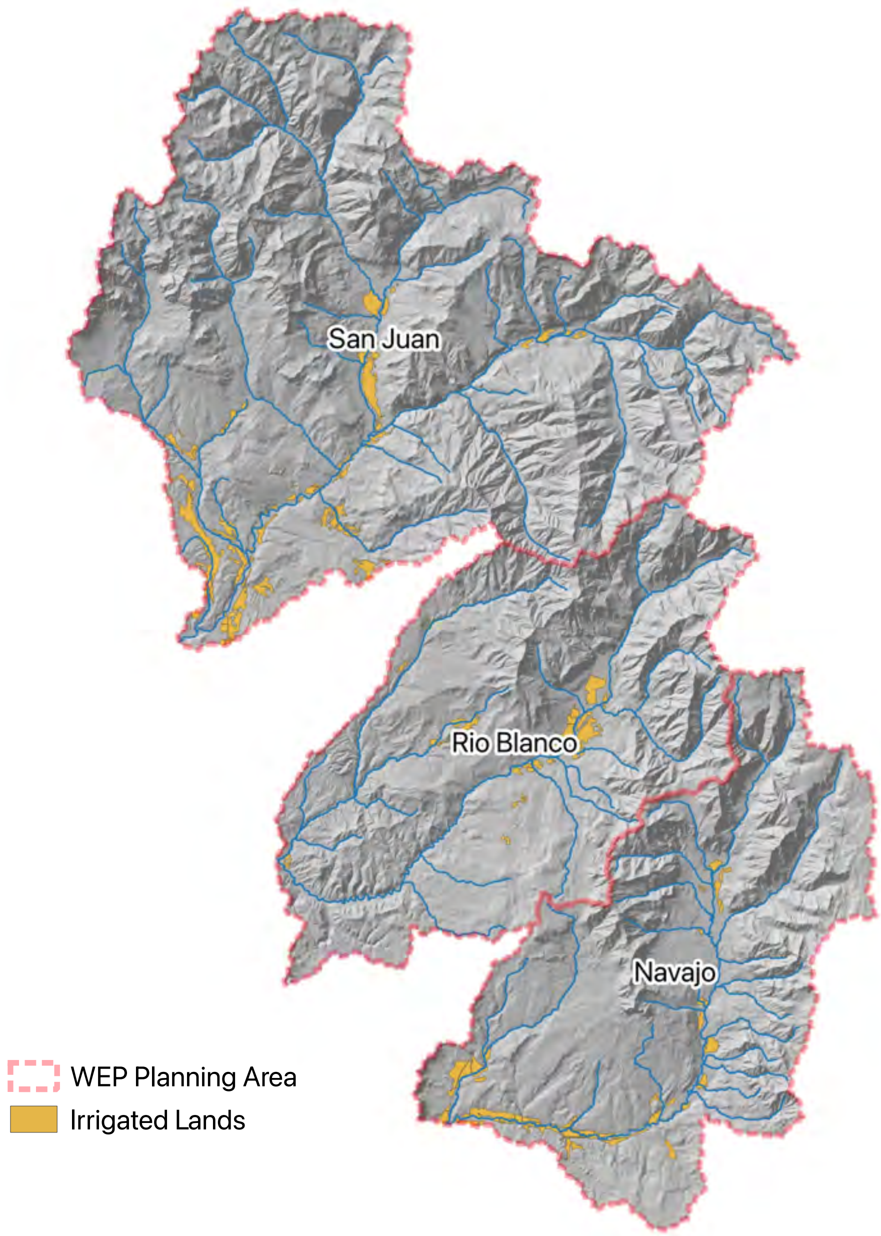

Figure 11. Irrigated lands in the WEP planning area.

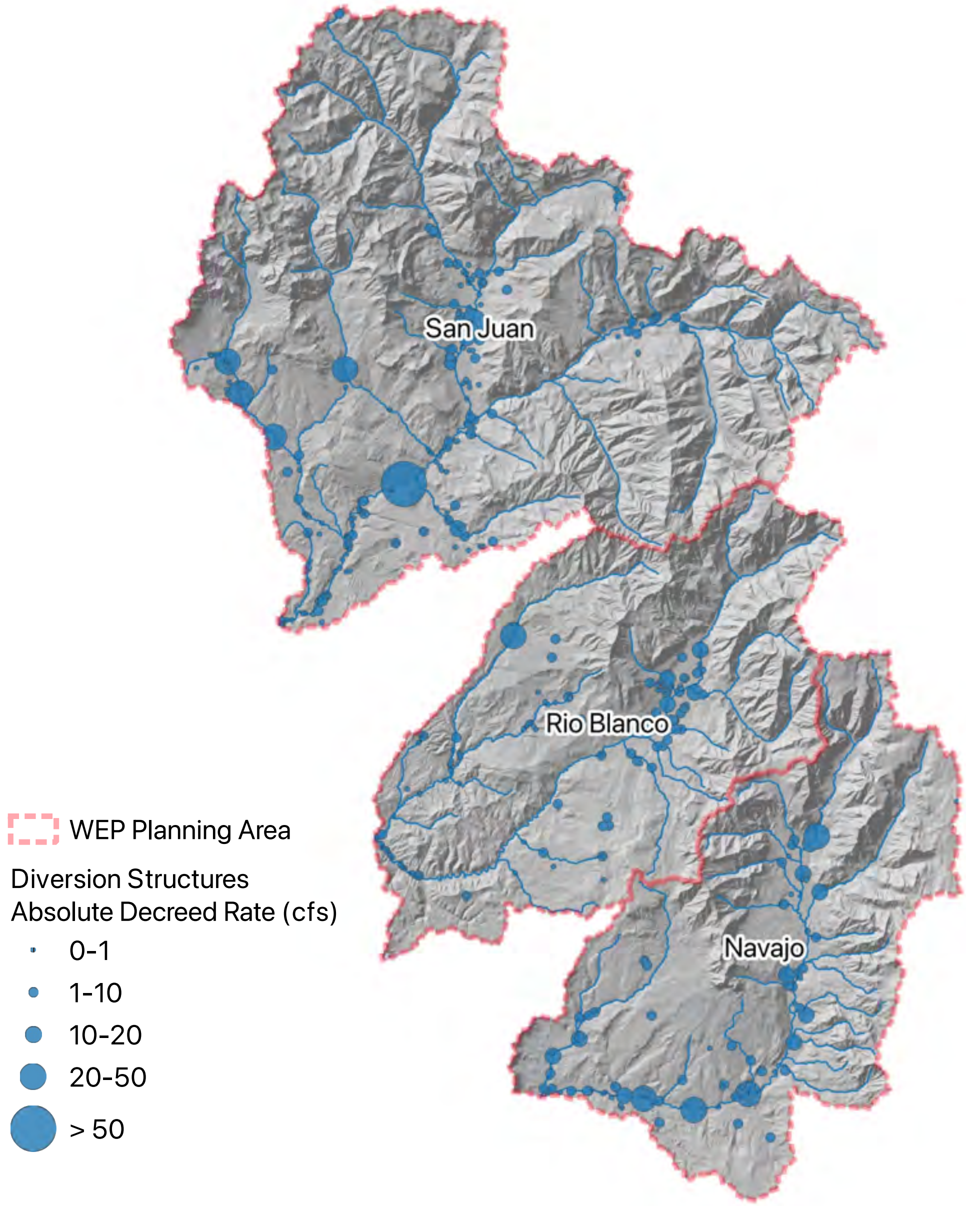

Figure 12. Surface water diversion water rights located on streams and rivers across the WEP planning area.

1.4.3 Trans-Basin Diversions

A large trans-basin diversion system, called the San Juan—Chama Project, moves water out of the upper Rio Blanco, Little Navajo River, and Navajo River and across the continental divide into the Chama River basin (Figure 13). This collection of diversions canals and tunnels was constructed in the 1960s and can move approximately 100,000 acre-feet of water out of the Rio Blanco and Navajo drainages each year. As a point of comparison, the average annual yield of the San Juan River at Pagosa Springs is approximately 256,500 acre-feet. The diversion feeder on the Rio Blanco has a capacity of 520 cfs, while the diversion feeder capacities on the Little Navajo and Navajo River are 150 cfs and 650 cfs, respectively. The Azotea Tunnel, which carries the collected water over the continental divide, has an optimum operational capacity of less than or equal to 950 cfs, though it does carry higher flows from time to time. The feeder conduit and tunnel capacities are sufficient to divert a majority of the flow from each of the three source rivers throughout the year during normal and dry year types. The Project primarily diverts flow during spring runoff and early summer and becomes supply limited as available flows above the collection points decline to or below the bypass requirements (Table 1). Water diversions by the Project generally do not affect water availability for other agricultural uses in the WEP planning area, but they do significantly reduce the amount of water available to support E&R uses on the Rio Blanco below the Blanco Diversion Dam and along the mainstem Navajo River below the Oso Diversion Dam.

Table 1. Bypass requirements at each of the three primary collection and diversion points in the San Juan - Chama project that fall within the WEP planning area. Bypass rates that differ from the CWCB instream flow right are indicated in red and blue where red indicates the bypass is less than the instream flow right and blue indicates the bypass is larger than the instream flow right.

River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rio Blanco	15	15	20	20	40	20	20	20	20	20	20	15
Navajo River	30	34	37	37	88	55	55	55	55	37	37	37
Little Navajo River	4	4	4	4	27	27	27	27	27	4	4	4

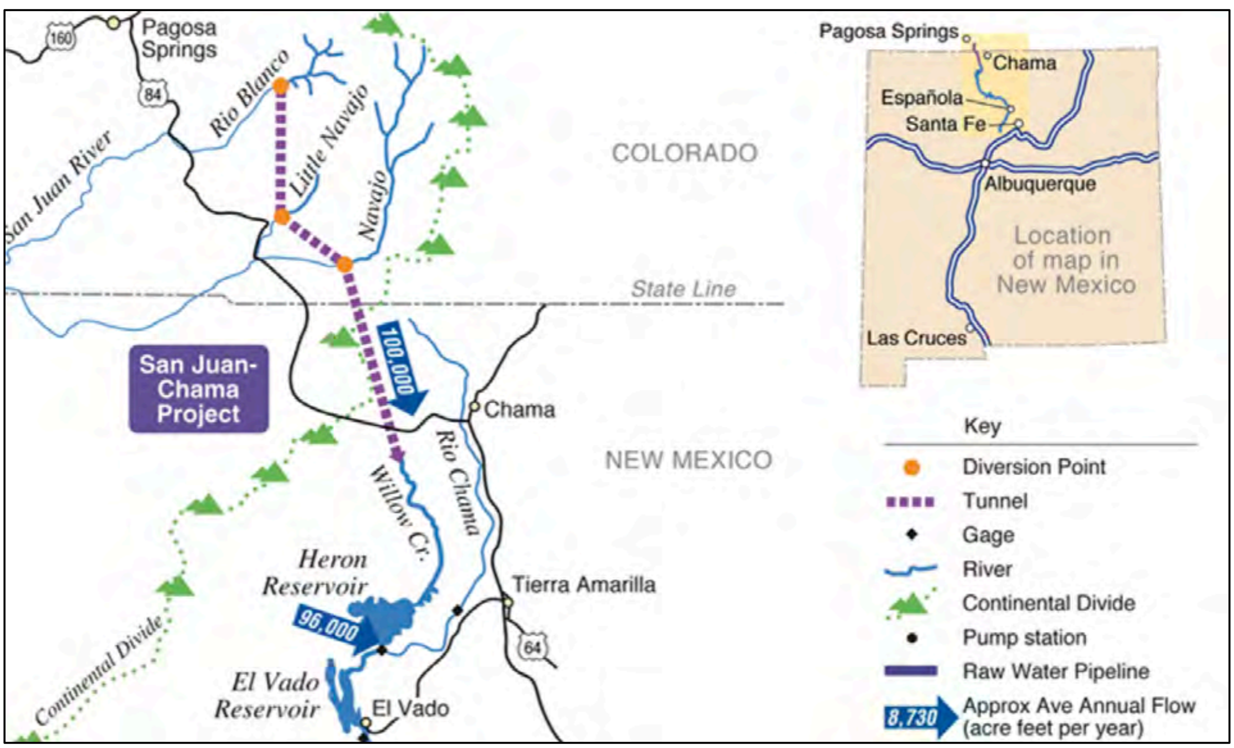

Figure 13. Schematic representation of the export of water out of the WEP planning area by way of operation of the San Juan - Chama Project. (Source: https://bddproject.org/history/san-juan-chama-project)

1.4.4 *Instream Flows*

The CWCB holds numerous ISF water rights on the mainstem San Juan River, Rio Blanco, Navajo River, and their collective tributaries (Table 2, Figure 14). ISF rights are intended to provide some measure of environmental use benefit under the prior appropriation system. Many of these ISF rights go unmet during moderate and severe drought conditions in late summer and early fall due to water availability constraints and their relatively junior priority when compared to municipal, agricultural, and storage water rights.

Table 2. Instream flow water rights on stream reaches in the WEP planning area.

River	Upper Terminus	Lower Terminus	Case No.	Flow (cfs)
San Juan River	Confluence with E.F. & W.F. San Juan River	Confluence with McCabe Creek	80CW0040	50 (3/1 - 8/31), 30 (9/1 - 2/29)
Turkey Creek	Outlet of Turkey Creek Lake	Snowball Ditch Headgate	80CW0039	4 (1/1 - 12/31)
West Fork San Juan River	Confluence with Wolf Creek	Confluence with E.F. San Juan River	80CW0041	25 (4/1 - 8/31), 14 (9/1 - 3/31)
East Fork San Juan River	Confluence with Lane Creek	Confluence with Sand Creek	80CW0029	15 (4/1 - 8/31), 8 (9/1 - 3/31)
East Fork San Juan River	Confluence with Sand Creek	Confluence with WF San Juan River	80CW0037	25 (4/1 - 8/31), 12 (9/1 - 3/31)
Rio Blanco	Rio Blanco Diversion Dam	Confluence with San Juan River	74W1295	20 (10/1 - 4/30), 29 (5/1 - 9/30)
Navajo River	Oso Diversion Dam	New Mexico state line	74W1296	37 (10/1 - 4/30), 55 (5/1 - 9/30)
Fall Creek	Headwaters	Confluence with Wolf Creek	80CW0032	1 (1/1 - 12/31)
Lane Creek	Headwaters	Confluence with E.F. San Juan River	80CW0036	1 (1/1 - 12/31)
Quartz Creek	Outlet Quartz Lake	Confluence with E.F. San Juan River	80CW0035	8 (1/1 - 12/31)
Sand Creek	Headwaters	Confluence with E.F. San Juan River	80CW0038	10 (4/1 - 8/31), 4 (9/1 - 3/31)
Silver Creek	Headwaters	Confluence with E.F. San Juan River	80CW0034	2 (1/1 - 12/31)
Waterfall Creek	Headwaters	Confluence with E.F. San Juan River	80CW0033	1 (1/1 - 12/31)
Wolf Creek	Headwaters	Confluence with W.F. San Juan River	80CW0031	11 (3/1 - 8/31), 6 (9/1 - 2/29)

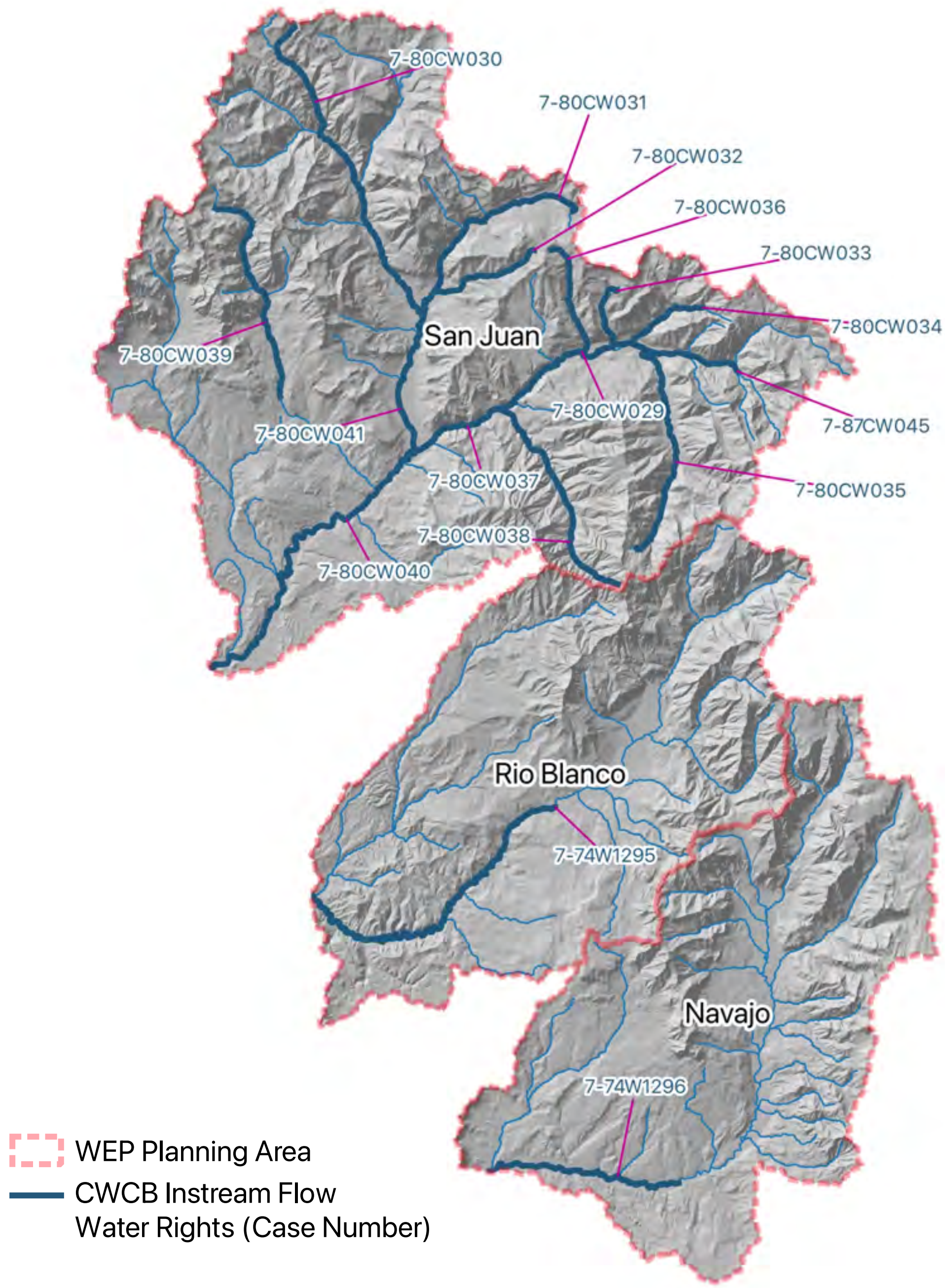

Figure 14. River and stream reaches with ISF water rights and associated case numbers in the WEP planning area.

2 CONDITIONS AND RISKS

The assessment of environmental and recreational needs and conditions investigated the intersection between climate, hydrology, forest health, hillslope erosion, channel hydraulics, the riverine processes and conditions most relevant to aquatic and riparian biota, and recreational user preferences. Implementation of this framework resulted in a collection of loosely coupled statistical, numerical, and analytical models. In some instances, results from these models were used to explore relationships between patterns of snowfall, snowmelt, summer air temperatures, soil moisture, forest drought sensitivity, and metrics of hydrological regime behavior. In other cases, analysis results clarified relationships between the timing and magnitude of streamflow, indices of biological health, and opportunities for recreational use. Narrative assessments accompany the numerical characterizations in several of the sections below to provide additional context for future planning activities. The quantitative results and narrative assessments presented here aim to provide local stakeholders with a foundational understanding of the relationships between the physical template of the watershed, the ecological function of streams and rivers, and the recreational qualities of waterways within the WEP planning area. Focused consideration of the results presented here in Phase III of the WEP planning effort should allow stakeholders and resource managers to efficiently evaluate the current functional condition of the riverine ecosystem, explore risks to the system brought about by climate change, and anticipate ecological costs and/or benefits realized by any proposed projects or alternative resource management strategies.

2.1 Hydrological Characteristics and Trends

River science experts often treat the flow regime (i.e., the annual and longer-term fluctuation in streamflow levels) as the "master variable" exerting the largest influence on river ecosystem form and function[37]. Activities that deplete or augment streamflow have the potential to impact important regime characteristics, including: total annual volume, magnitude and duration of peak and low flows, and variability in timing and rate of change. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g., the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change[38].

Streamflow gauges on the San Juan River at Pagosa Springs (USGS 09342500) and Navajo River at Banded Peak Ranch (USGS 09344000/CDWR NAVBANCO) provide relatively long data records suitable for evaluating historical changes in hydrological regime behavior. Both gauges are useful for assessing watershed-scale changes in hydrology driven by long-term drought and/or a changing climate due to the limited impact of human water management activities on flows at each location. Analysis results for the San Juan River at Pagosa Springs indicate significant trends in some metrics of annual flow behavior since the 1970s. Similar, albeit weaker, patterns are observed downstream on the Navajo River at Banded Peak (Table 3, Figure 15, Figure 16) (Appendix C). Generally, these trends indicate a shift toward earlier snowmelt runoff and lower flows across the summer and fall seasons. On the San Juan River in Pagosa, year-over-year reductions in summertime streamflow volumes are decreasing at an average rate of 700 acre-feet per year—approximately equivalent to the storage volume of Village Lake. Earlier runoff and reduced summer flow volumes may increase periods of water shortages experienced by non-consumptive and consumptive users alike. Reductions in late summer and fall flows likely restrict the availability and quality of aquatic habitat for fish and other

[37] Poff et al., "The Natural Flow Regime."

[38] Johnson, Beardsley, and Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams."

species. If the drought conditions observed over the previous 20 years persist into the coming decades, these downward trends may become stronger and/or statistically significant.

Table 3. Significant pre-whitened, non-parametric trends (Mann Kendall p-value > 0.05) in streamflow behavior observed on the San Juan River at Pagosa Springs and the Navajo River at Banded Peak over the 1970-2020 period. Reported trend values calculated as the Theil-Sen's slope.

River	Metric	Units	Trend
San Juan	July - September Yield	acre feet/year	-700
	Time to Runoff	days/decade	-5
	August Median	cfs/year	-2
	September Median	cfs/year	-3
Navajo	May Maximum	cfs/year	-9
	September Mean	cfs/year	-1

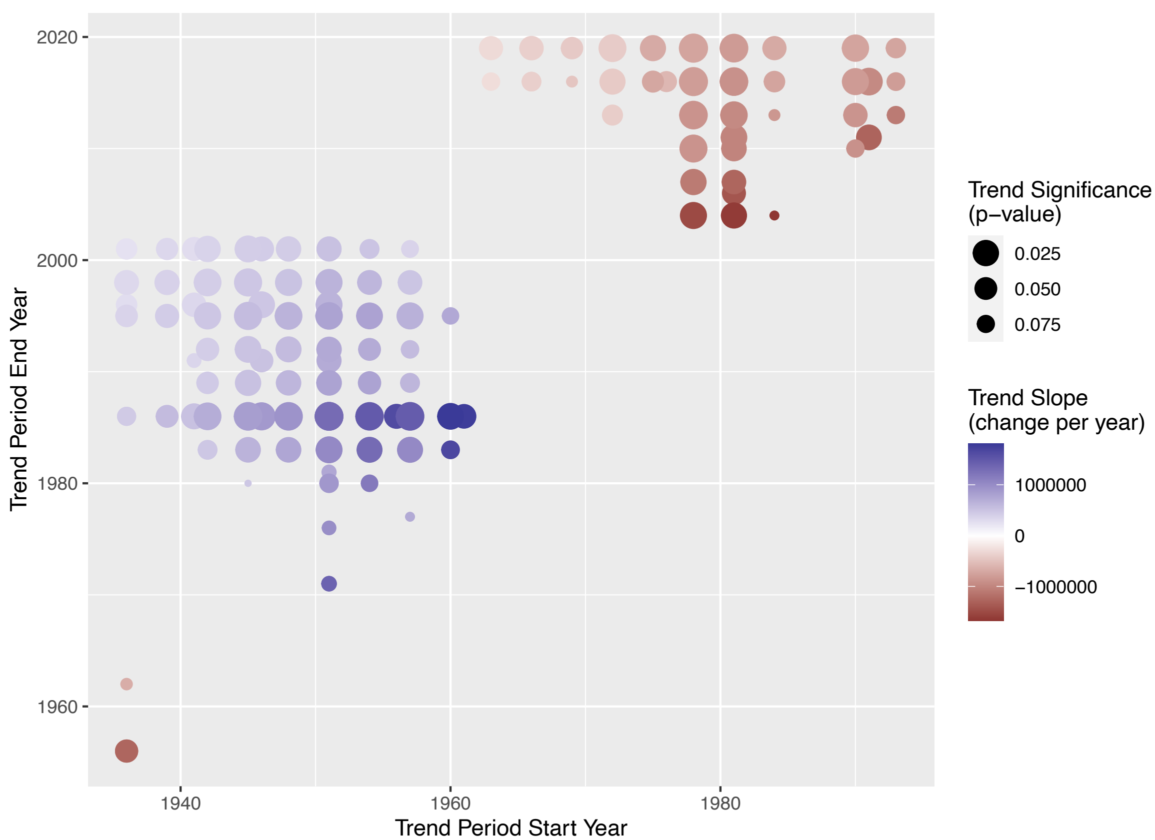

Figure 15. Trends in Jul-September volumes (trend slope values are in cubic meters) for the San Juan River at Pagosa Springs observed over various time period in the 20th century. A period of unusually large snowfall in the early 1980s drives an upward trend between the 1940s and 1980s. From the 1960s to the present, a persistent downward indicates declining runoff volumes during the summer months.

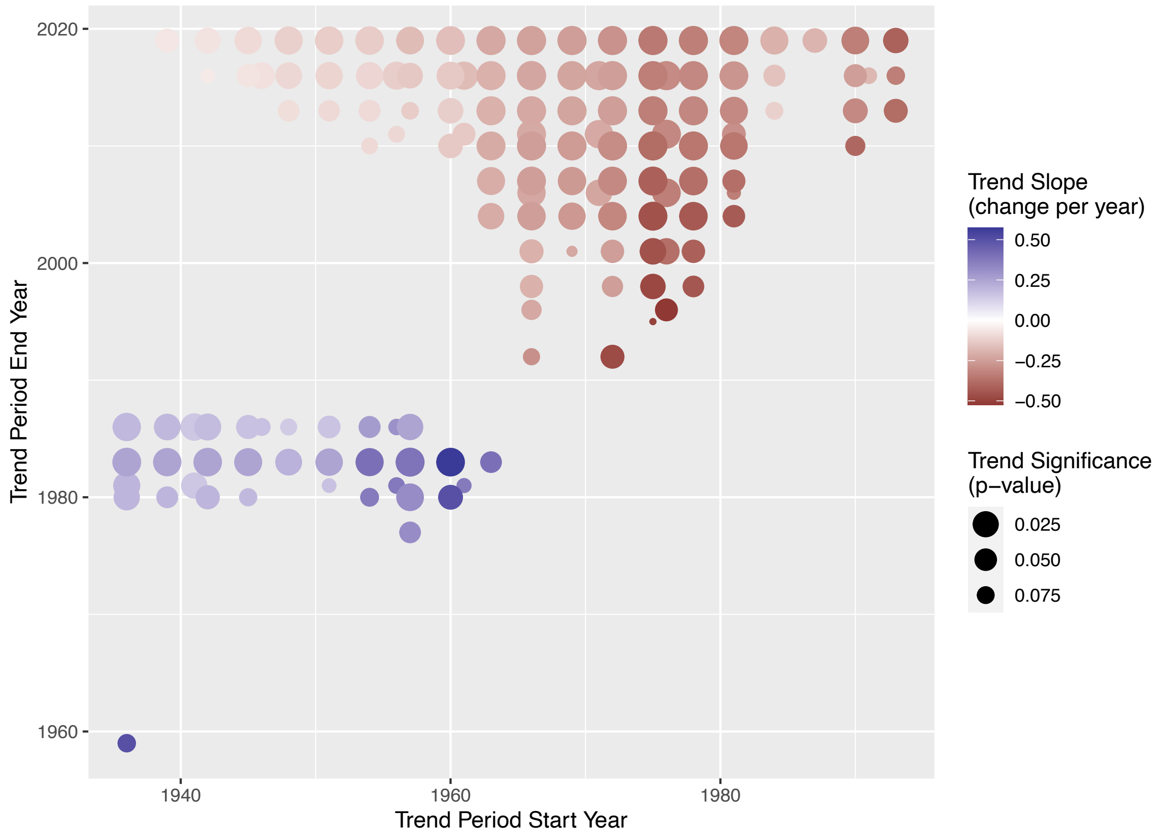

Figure 16. Trends in time to snowmelt runoff measured as Julian days to 33% of the total annual runoff for the San Juan River at Pagosa Springs observed over various time periods. The trend toward earlier snowmelt runoff strengthens over the second half of the 20th century. The trend slope calculated over the most recent 30-year period indicates snowmelt runoff is beginning ~5 days earlier each decade.

Long-term streamflow records are not available for every tributary in the San Juan watershed and historical trends assessment is limited in its ability to predict future conditions. This assessment, therefore, relied extensively on hydrological simulation modeling to estimate flow behaviors in areas without streamflow gauges and to explore the potential impacts of population growth and climate change on hydrology. These simulation models are discussed in a subsequent section.

2.2 Indicators of A Changing Climate

Changes in local weather and climate are expected to drive the characteristic hydrological regime behaviors and trends observed over recent history. The rivers and streams in the WEP planning area are fed, primarily; by snowmelt. Any changes to precipitation or air temperatures that affect the proportion of annual precipitation that falls as snow, drive earlier melt of the snowpack; or increase sublimation, evaporation and/or transpiration of water from the land surface and soil column are mechanistically tied to streamflows. Meteorological data collection at three SNOTEL stations in and around the WEP planning area provide a rich data set for examining changes in annual precipitation totals, snowpack water content, air temperatures, and soil moisture. Two stations located near the top of Wolf Creek Pass (Upper San Juan: 840 and Wolf Creek Summit: 874) provide a signal from high elevation zones (~10,200 – 11,000 feet above mean sea level), while a station located near the Navajo River (Chamita: 394) characterizes conditions at low elevation zones (~8,400 feet above mean sea level).

A Mann-Kendall test for trends was performed on average monthly air temperature collected at each of the SNOTEL stations between 1990 and 2020. Results indicated a statistically significant upward trend in air temperatures at the 95% confidence level for all months at each station except for the month of May at Chamita (p-value = 0.248) and the month of February at Upper San Juan (p-value = 0.064).

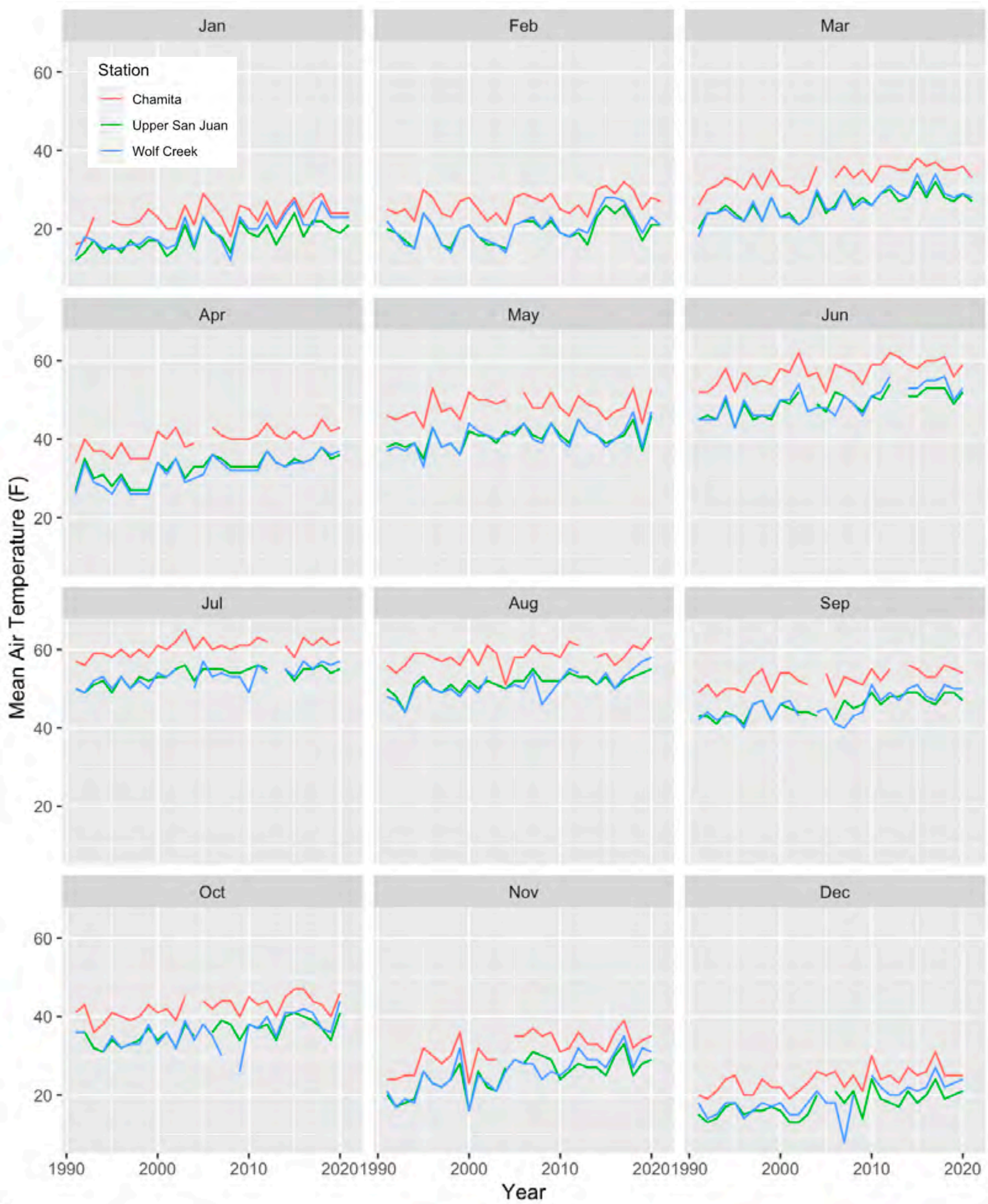

Figure 17. Monthly mean temperatures observed between 1990 and 2020 at three SNOTEL stations in the WEP planning area. Statistically significant upward trends were observed at all three stations during a majority of months.

A Mann-Kendall test for trends was performed on April 1st snow water equivalent (SWE)—a standardized measure of maximum annual snowpack—for data collected between 1983 and 2020 at the Upper San Juan and Chamita stations. Results indicated a statistically significant downward trend in SWE at the 95% confidence level for both stations. An average rate of decline (i.e., Sen's slope) of 3.1 inches per decade was estimated for the Upper San Juan station. An average rate of decline of 1.9 inches per decade was estimated for the Chamita station.

A Mann-Kendall test for trends was performed on monthly total precipitation for data collected between 1990 and 2020 at all three SNOTEL stations. Results indicated a statistically significant downward trend in monthly precipitation at the 95% confidence level for several months at each station. Trends toward decreasing precipitation were observed in April at the Upper San Juan station; in the months of July and September at the Upper San Juan and Wolf Creek Summit stations; and in the months of April, September and December at the Chamita Station. The reductions in precipitation observed at all three stations in the summer and fall months may indicate a weakening monsoon. Trends toward decreasing precipitation in winter months are, likely, correlated with trends toward decreasing SWE discussed above.

Decreasing snow packs and increasing air temperatures are expected to drive earlier snowmelt. This assumption was tested in the WEP planning area using data derived from MODIS satellite imagery collected between 2001 and 2018.[39] Continuous snowmelt timing data coverages representing each year in the observation period were overlaid on the WEP planning area. Trends in snowmelt timing were assessed by performing a Mann-Kendall test on a 500-meter grid, such that trends were independently evaluated on the full time series at each location across the entire planning area. Results indicated a statistically significant trend toward earlier snowmelt in low- and mid-elevation areas in the San Juan, Rio Blanco, and Navajo River watersheds (Figure 18, Figure 19).

Seventy-eight percent of the land area where statistically significant trends toward earlier snowmelt were observed fell within the Sedimentary Mid-Elevation Forest Ecoregion. Thirteen percent fell within the Volcanic Subalpine Forests, and nine percent fell within the Sedimentary Subalpine Forests. A majority of landscape positions where shifts in snowmelt timing were observed fell between elevations of 7,500 – 8,200 feet above mean sea level on aspects ranging from southeast to west.

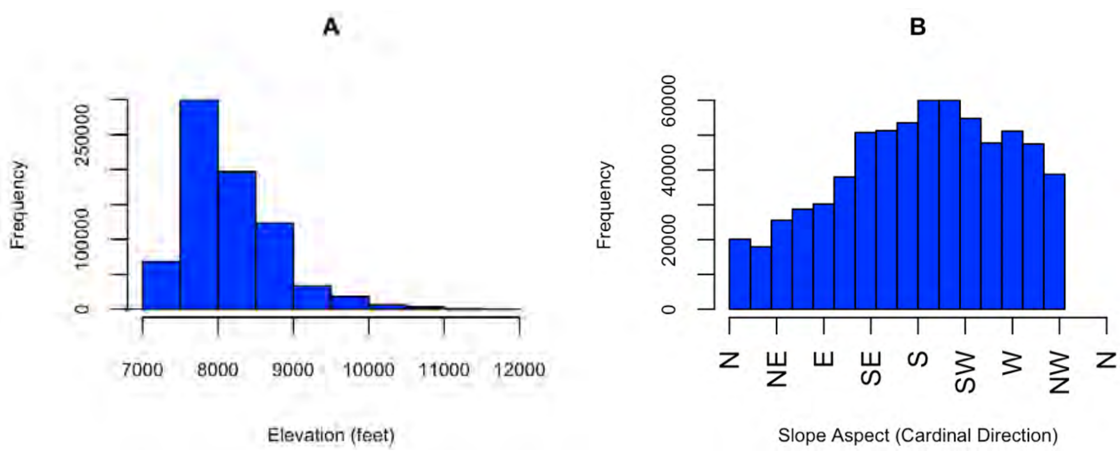

Figure 18. Distributions of landscape positions where a statistically significant trend toward earlier snowmelt was observed. Left: distribution of elevation values exhibiting earlier melt times. Right: distribution of slope aspects exhibiting earlier melt times.

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[39] https://doi.org/10.3334/ORNLDAAC/1712

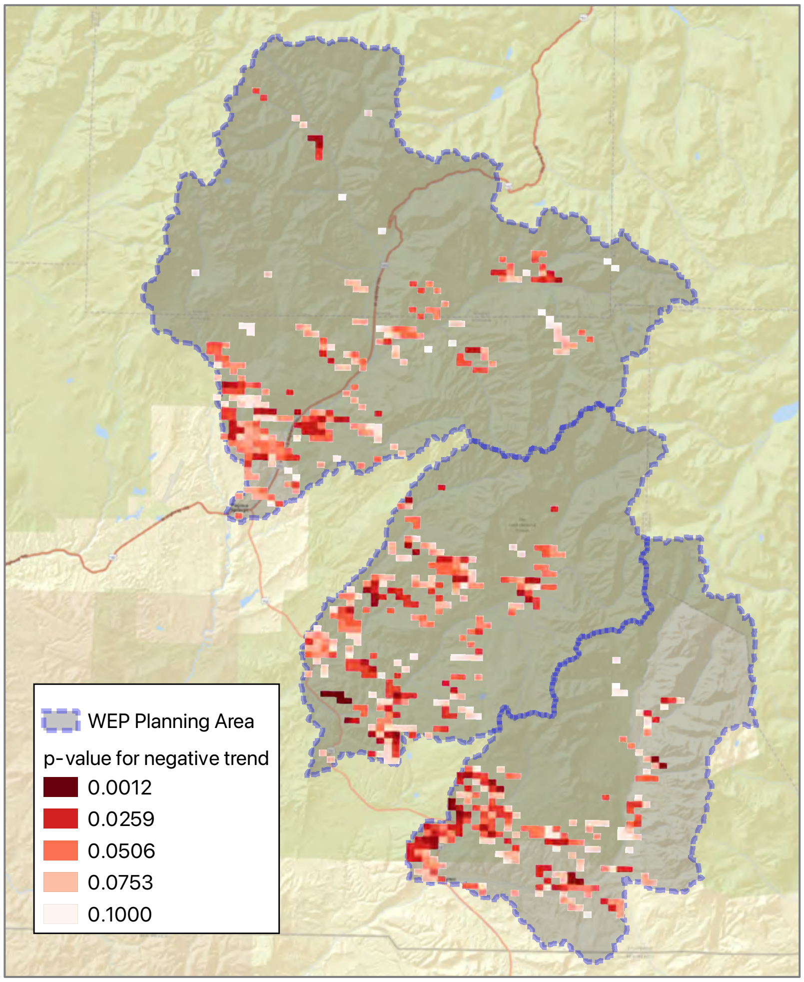

Figure 19. Mann-Kendall test results for snowmelt timing. All significant results indicated above are associated with a decreasing trend slope, indicating earlier snowmelt. A p-value less than or equal to 0.05 indicates results are significant at the 95% confidence level, etc.

2.3 Forest Health Implications

Trends toward decreasing SWE, earlier snowmelt, and increased summer air temperatures are expected to result in some response from vegetation across the landscape. Thinner snow packs mean less water is available to infiltrate into the soil column as snowmelt progresses. Earlier snowmelt exposes the soil surface to a longer period of exposure to solar radiation and may result in the evaporation of water directly from the land surface. Increasing temperatures and lengthening of the growing season may synergistically drive increased evapotranspiration from plants across the year (Figure 20). Each of these forcings is expected to result in a reduction in soil moisture—a measure of water held in the soil column.

A Mann-Kendall test for trends was performed on average monthly soil moisture (%) for data collected between 2005 and 2020 at the Upper San Juan and Wolf Creek Summit stations (Figure 21). Results indicated a statistically significant downward trend in soil moisture at three soil depths (2, 8, and 20 inches) at the 95% confidence level for most months. No significant trend was identified during May at a depth of 20 inches and in June at the 2-inch and 20-inch depth. The strength and magnitude of the trend increase as the summer progresses toward fall.

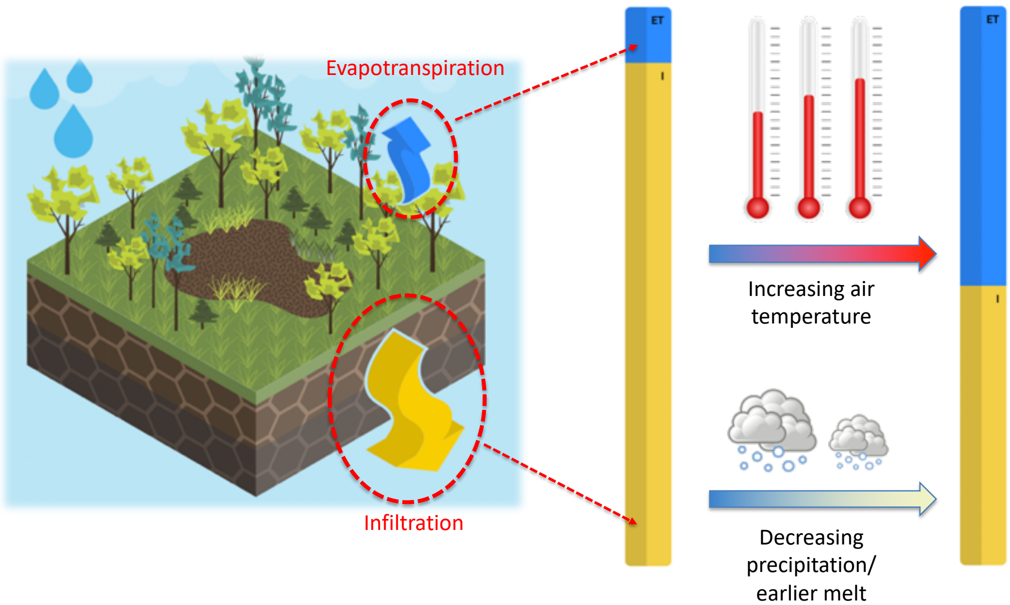

Figure 20. Increasing summer air temperatures and decreasing precipitation or earlier snowmelt is expected to lead to increased evapotranspiration by plants, a reduction in soil moisture, and a reduction in the amount of snowmelt that makes its way to groundwater via infiltration and, subsequently, contributes to flows in streams and rivers. Soil moisture is expected to exert a strong control on late-season baseflows. (Graphics modified from Stroud Research Center[40])

Figure 21. Average monthly soil moisture characteristics observed at three soil depths at the Upper San Juan and Wolf Creek Summit SNOTEL sites between 2005 and 2020. A negative downward trend is particularly evident in the late summer and fall months over the 2015-2020 period. No historical soil moisture data is available for lower elevations in the WEP planning area.

[40] https://runoff.modelmywatershed.org

Understanding the widespread effects of changing soil moisture on forest health is difficult. Unfortunately, the only historical soil moisture data sets available from within the WEP planning area are from two high elevation stations located in close proximity to one another. We are, therefore, left to assume that trends observed at high elevations are indicative of conditions elsewhere. Remotely sensed measures of forest canopy wetness can help correlate declining soil moisture at point locations with vegetative responses throughout the upper San Juan, Rio Blanco and Navajo River watersheds. The Normalized Difference Water Index (NDWI) can be derived from satellite imagery.[41] The index value reflects the amount of water contained in the forest canopy.

NDWI values across WEP planning area were derived from Landsat 8 Tier 1 satellite imagery collected between 1999 and 2020.[42] Continuous spatial data coverages representing each year in the observation period were overlaid on the WEP planning area. Trends in the minimum NDWI observed between April and October of each year were assessed by performing a Mann-Kendall test on a 100-meter grid such that trends were independently evaluated on the full time series at each gridded location across the planning area. Results indicated a statistically significant downward NDWI trend in high- and mid-elevation areas in the San Juan, Rio Blanco, and Navajo River watersheds (Figure 22, Figure 23).

Thirty-four percent of the land area where statistically significant trends toward decreasing NDWI were observed fell within the Sedimentary Mid-Elevation Forest Ecoregion. Fifty percent fell within the Volcanic Subalpine Forests, five percent fell within the Sedimentary Subalpine Forests, and nine percent fell within Alpine Zones. A majority of landscape positions where shifts in NDWI were observed fell on southwestern and western aspects and were fairly evenly distributed across all elevation bands within the planning area.

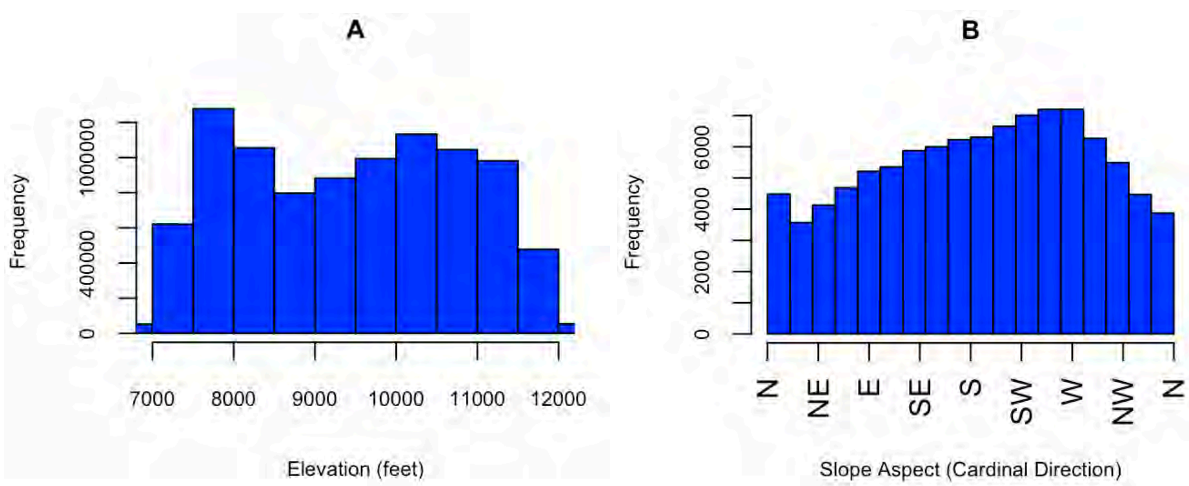

Figure 22. Distributions of landscape positions where a statistically significant trend toward decreasing NDWI was observed. Left: distribution of elevation values exhibiting decreasing NDWI values. Right: distribution of slope aspects exhibiting decreasing NDWI values.

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[41] https://en.wikipedia.org/wiki/Normalized_difference_water_index

[42] https://developers.google.com/earth-engine/datasets/catalog/LANDSAT_LC08_C01_T1_32DAY_NDWI

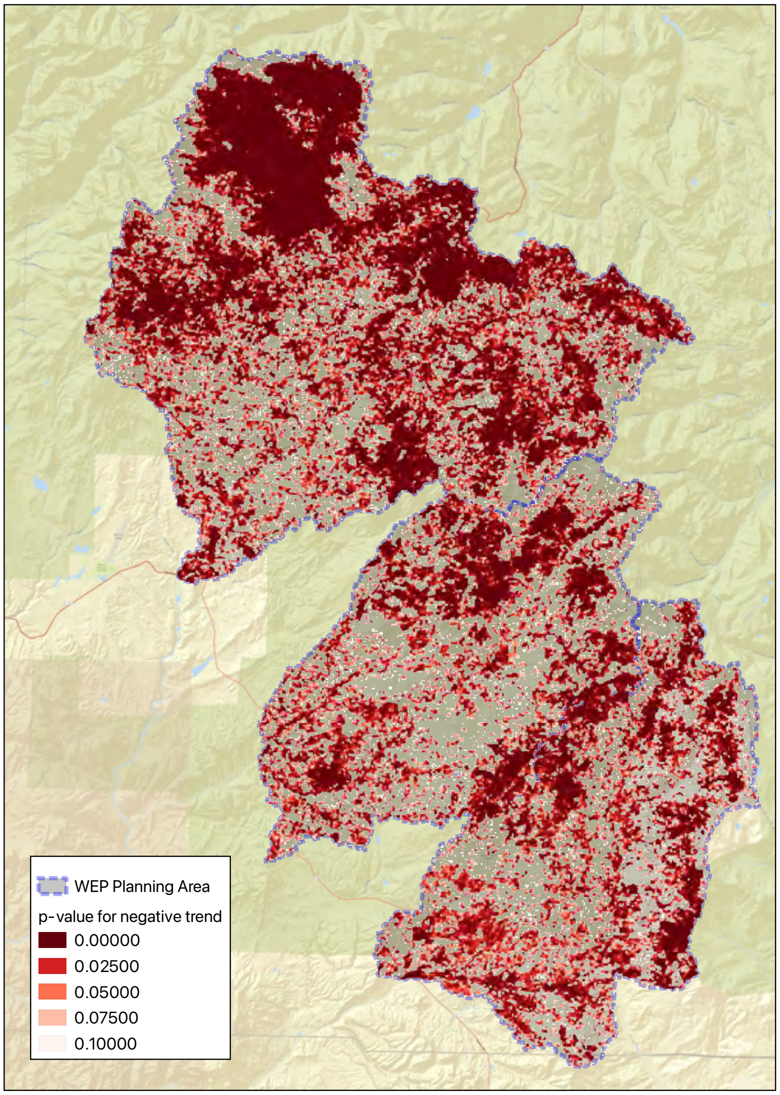

Figure 23. Mann-Kendall test results for trends in NDWI. All significant results indicated above are associated with a decreasing trend slope, indicating a progressive drying of the forest canopy over the observation period (1999-2020). A p-value less than or equal to 0.05 indicates results are significant at the 95% confidence level, etc. The effect of the West Fork Complex Fire on forest wetness is readily observed in the upper portion of the planning area.

The mechanism driving the progressive drying of the forest canopy cannot be derived directly from the data and, thus, must be inferred. Drying may be a result of the feedback between vegetative growth and soil moisture. Reduced snowpack depth and earlier melt times may be lengthening the growing season, increasing cumulative evapotranspiration and leading to a depletion of soil moisture earlier in the year. If this is the primary mechanism at work, streamflows would be expected to fall with decreasing NDWI and soil moisture. The observed drying trend may also reflect the impact of wildfire (e.g., West Fork Complex fire) and/or pine and spruce beetles on widespread tree mortality. Recent work by the Colorado Water Institute indicates that, if beetle-kill is the primary mechanism at work, declining evapotranspiration rates should be followed by a modest increase in streamflows.[43] It is likely that the combined effects of snowpack/snowmelt characteristics, vegetative water use, wildfire, and beetle-kill are at work in many areas of the WEP planning area. We are unable to attribute which of these mechanisms is the main driver or compounding factor affecting streamflow behavior at this time.

2.4 Wildfire, Hillslope Erosion, and Landslides

As a drying climate increases the risk for high-severity wildfire across the planning area, the risk for increased erosion and transport of hillslope soils to the river channel also increases. Drainages that experience high-severity fires are expected to produce large yields of sediment in the years following the fire.[44] This may be particularly relevant in areas like the San Juan mountains where the risk of high-severity fire is relatively high and high-intensity monsoonal rainstorms are a common occurrence. Sediment mobilized by precipitation events can quickly move downslope to streams and rivers where it can cause rapid aggradation of the stream channel, changes in the alignment of the river, and significant damage to transportation infrastructure, water diversion infrastructure, homes, and businesses. Increased suspended sediment loads in streams and rivers can also create major problems for municipal water treatment facilities and significantly degrade aquatic habitats.

The observed trend toward increasingly dry forest canopies in many areas of the WEP planning area may increase the likelihood of large, destructive wildfires in the coming years. Wildfire risk characterization in the San Juan watershed was performed previously by the San Juan Headwaters Forest Health Partnership.[45] This effort was expanded during the WEP Phase II assessment to include more recent fire hazard mapping and risk assessment results. A variety of fire behavior maps were retrieved from the Colorado Forest Service (COFS) Risk Reduction Planner (Appendix D).[46] These maps communicate fire characteristics using data and modeling tools that consider surface fuels, canopy cover, weather, historical fire occurrence, and topography. The Extreme Weather Fire Type mapping layer was selected for use in the WEP planning effort (Figure 24). This layer indicates four fire types likely to occur under extreme weather conditions: No Fire, Surface Fire, Passive Canopy Fire, and Active Canopy Fire. Extreme weather conditions are the conditions most likely to produce highly-destructive crown fires. Approximately 43% of the WEP planning area is mapped as Surface Fire, 29% as Passive Canopy Fire, and 27% as Active Canopy Fire. Much of the Active Canopy Fire is mapped across mid- and high-elevation mixed-conifer and spruce-fir forests. It's important to note that the COFS mapping products do NOT consider any of the trends analysis results presented here regarding changing forest canopy wetness, soil moisture, etc. Instead, they are relatively static snapshots of the current forest condition. Areas mapped under a given fire type are subject to change as forests respond to changing climate, insect infestations and undergo natural forest succession.

Stakeholders to the WEP planning effort hoped to understand how potential future fire activity may impact rates of hillslope erosion and sediment delivery to area streams. To meet this need, Extreme Weather Fire Type burn classifications were used as a proxy for post-fire Soil Burn Severity (SBS) delineations.[47] Areas mapped as

[43] https://watercenter.colostate.edu/wp-content/uploads/sites/33/2020/03/CR236.pdf

[44] Sankey, J.B., Kreitler, J., Hawbaker, T.J., McVay, J.L., Miller, M.E., Mueller, E.R., Vaillant, N.M., Lowe, S.E. and Sankey, T.T., 2017. Climate, wildfire, and erosion ensemble foretells more sediment in western USA watersheds. Geophysical Research Letters, 44(17), pp.8884-8892.

[45] http://sanjuanheadwaters.org/wp-content/uploads/2016/02/Watershed-Risk-Handout-20151112.pdf

[46] https://coloradoforestatlas.org

[47] https://www.fs.fed.us/rm/pubs/rmrs_gtr243.pdf

Surface Fire were classified as Low Burn Severity, areas mapped as Passive Canopy Fire were classified as Moderate Burn Severity, and areas mapped as Active Canopy Fire were classified as High Burn Severity. These SBS delineations (Figure 24) were used as a primary input to Disturbed Watershed Erosion Prediction Project (Disturbed WEPP), a modeling tool developed by U.S. Forest Service for predicting the impact of land disturbance and fire on rates of hillslope erosion.[48]

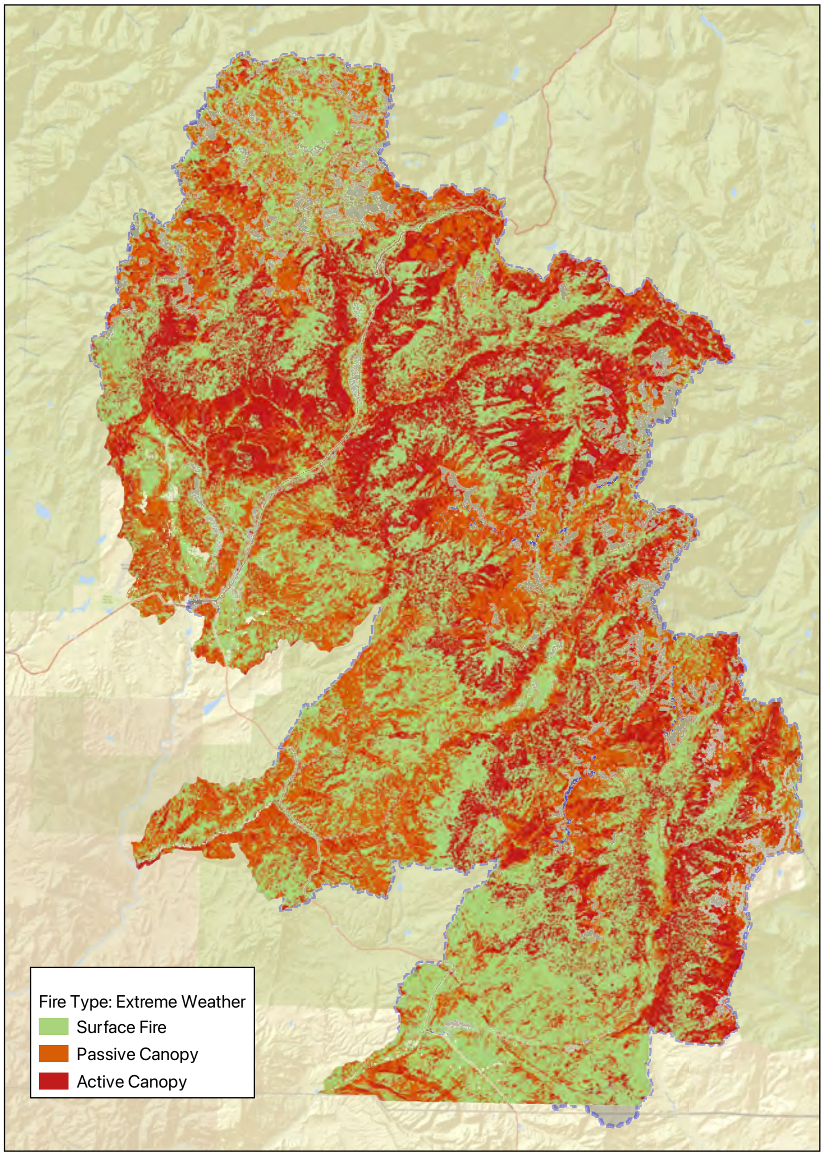

Figure 24. COFS mapping of Extreme Weather Fire Types across the WEP planning area. Approximately 43% of the WEP planning area is mapped as Surface Fire, 29% as Passive Canopy Fire, and 27% as Active Canopy Fire. Much of the Active Canopy Fire is mapped in mid- and high-elevation mixed-conifer and spruce-fir forests. Mapped fire types were used as a proxy for Soil Burn Severity in Disturbed WEPP model runs.

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[48] https://www.fs.usda.gov/ccrc/tool/watershed-erosion-prediction-project-wepp

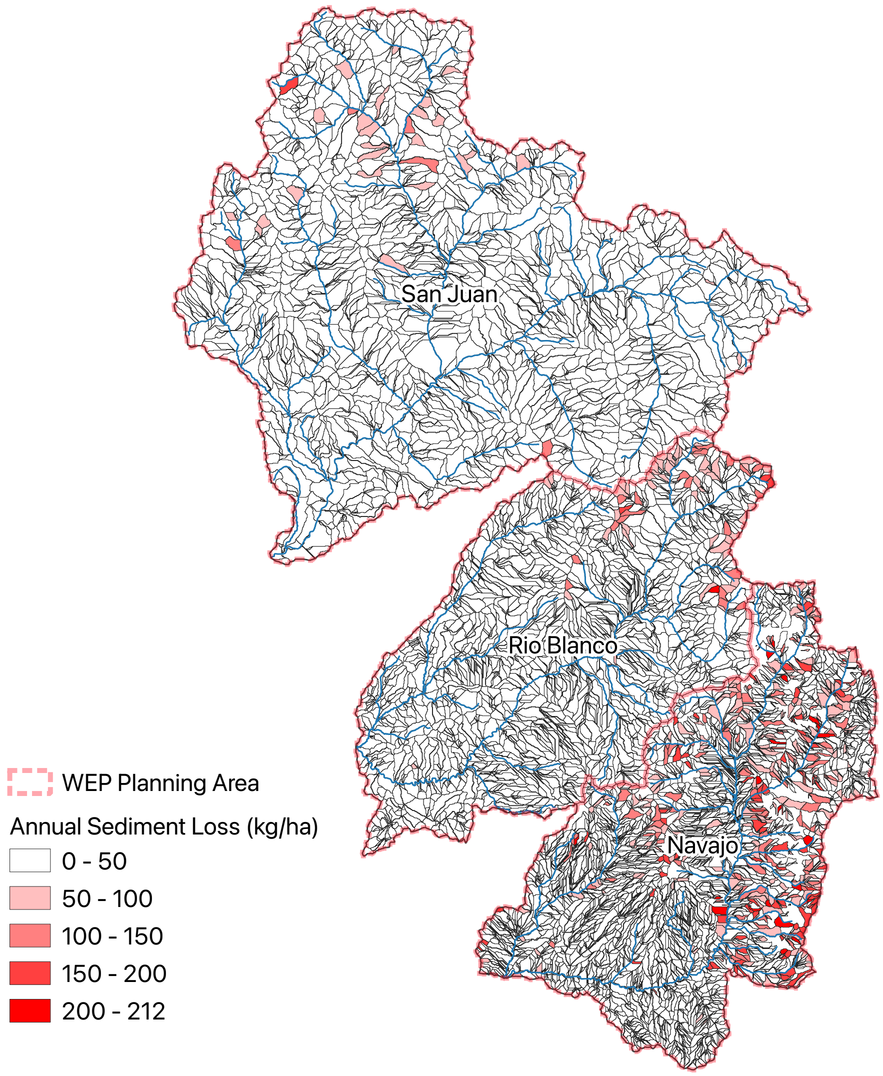

Figure 25. Baseline rates of hillslope erosion estimated by the Disturbed WEPP model prior to incorporation of fire.

Inputs to the Disturbed WEPP model included terrain characteristics, drainage area mapping, soil characteristics, landcover, and a time series of precipitation and temperature. Terrain characteristics and drainage areas were generated from 30-meter Digital Elevation Models (DEMs). Soil characteristics were retrieved from the STATSGO[49] or SSURGO[50] databases. Landcover was retrieved from the National Landcover Database (NLCD). The meteorological time series used by the model reflected likely climate conditions between 2006-2099, based on CMIP5[51] climate model ensembles. Two Disturbed WEPP model runs were performed. The first run did not incorporate the proxy SBS mapping and, thus, was used to characterize baseline rates of hillslope erosion across the planning area (Figure 25). The highest rates of erosion

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[49] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053629

[50] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

[51] https://esgf-node.llnl.gov/projects/cmip5/

were predicted in the Navajo River watershed—a result that is supported by qualitative observations of high sediment yields in the Navajo River at the Oso Diversion Dam.

A second Disturbed WEPP run included the proxy-SBS mapping and functioned as an indicator of the potential for increases or decreases to hillslope erosion following Extreme Weather Fire Types. Fire-driven increases in hillslope erosion were assessed by overlaying results from the two Disturbed WEPP model runs and quantifying the change in the annual average erosion rate. The greatest increases in erosion tend to follow the patterns of mapped Active Canopy Fire from the Extreme Weather Fire Type layer, but also reflect divergent terrain, soil, and landcover characteristics across the planning area. The largest increases in potential sediment loss occurred in the Navajo River watershed. Increases were also observed in the steep, upper reaches of the Rio Blanco and the southern tributaries to the East Fork San Juan River—areas falling within the Volcanic Subalpine Forest Ecoregion.

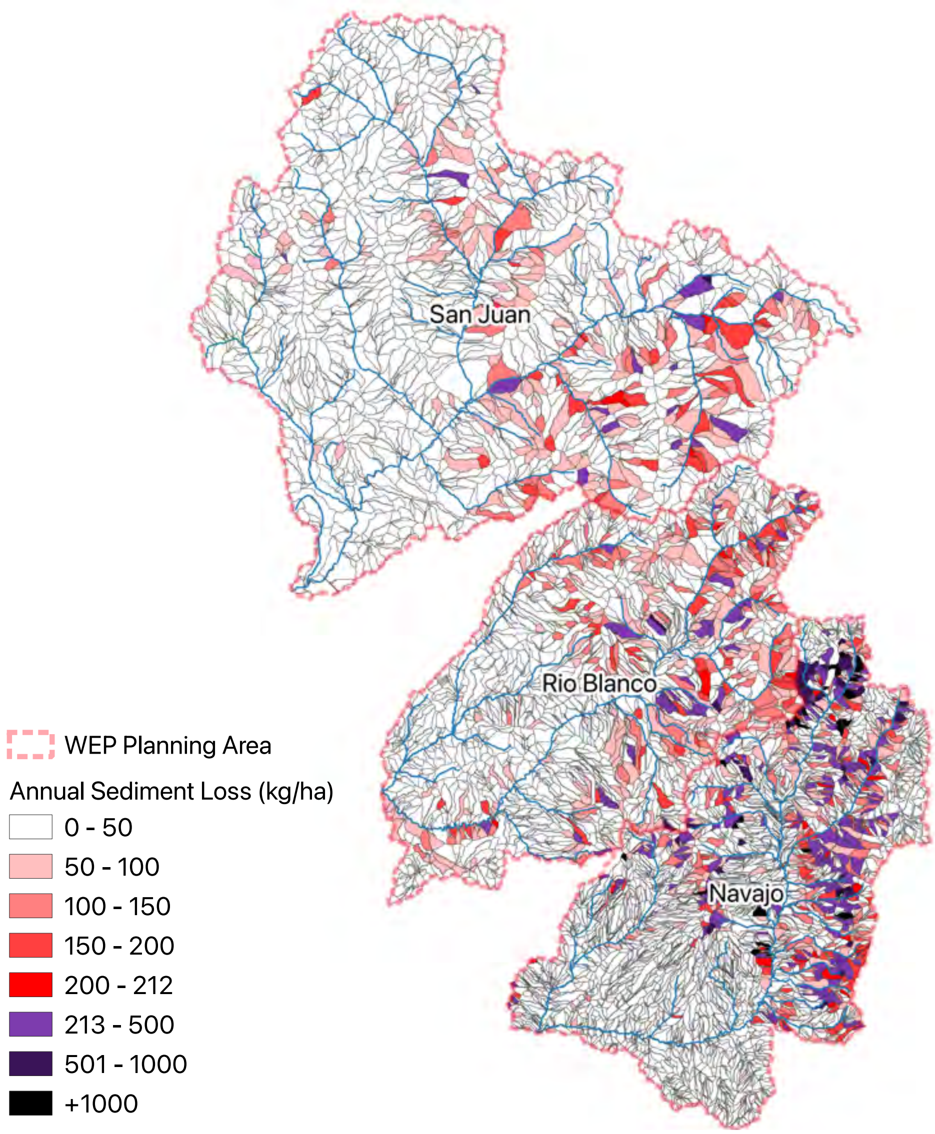

Figure 26. Rates of hillslope erosion estimated by the Disturbed WEPP model when the mapped Extreme Weather Fire type mapping provided by COFS is used as a proxy for SBS classification.

The Disturbed WEPP model predicts that the combined effects of steep terrain and the generally-erosive soils in the Volcanic Subalpine Forest Ecoregion elevate the likelihood of post-fire sheet and rill hillslope erosion. These same factors are expected to contribute to landslide hazards as well. Future investigations may elect to assess the potential for post-wildfire landslides associated with varying rainfall intensities and durations using standard methods developed by the U.S. Geological Survey (USGS).[52] The Disturbed WEPP model outputs generated here may also be used in subsequent planning phases to investigate the potential impact of various fire intensities on erosion predictions from one or more sub-catchments. Such an approach may be used to iteratively evaluate the effectiveness of various forest treatments aimed at reducing rates of post-fire hillslope erosion. The cost of forest treatment can then be weighed against the potential risk reduction for downstream infrastructure, etc.

2.4.1 Critical Landscape Elements

Areas of low-gradient, wide or unconfined floodplain downstream from canyons or steep stream segments are generally considered channel response zones. Upstream drainages with steep hillslopes and stream channel bed slopes may be capable of producing and transporting large volumes of sediment to these areas (e.g., during heavy thunderstorms and debris-flow events). As slope decreases where the stream channel enters a response zone, water velocities decrease and sediment settles out of the water column or ceases to roll along the streambed. Sediment deposition is the defining feature of channel response zones. Stream channels in these zones may be prone to episodic or persistent aggradation, bank avulsion, and abrupt shifts in lateral channel alignment or cross-sectional geometry. They also represent critical natural buffer areas that can reduce downstream impacts from increased hillslope erosion and channel sediment transport.

Assessments of aerial imagery, limited field investigations, and use of terrain processing algorithms were used to delineate channel response zones across the WEP planning area. Overlay analysis was performed in a Geographic Information System (GIS) to count both the number of mapped structures and sum the total road miles that fall within each channel response zone. Structure counts and road miles are intended to serve as proxies for valuable human infrastructure that be at higher risk to large flood events and/or debris flows that follow large destructive wildfires. It's critical to note here that no hydraulic modeling was employed to delineate channel response zones, and so they cannot be interpreted to mean the same thing as, for example, 100-year floodplains delineated by the Federal Emergency Management Administration (FEMA). The channel response zones delineated here more closely follow the methods used to delineate Fluvial Hazard Zones (FHZs).[53] Future planning efforts may benefit from a formal FHZ mapping effort in the high-risk areas identified here.

Five, large channel response zones were identified by this analysis: two on the West Fork San Juan, one on the East Fork San Juan, and one each on the Rio Blanco and Navajo River (Figure 27). Several small response zones exist along each mainstem river. The uppermost response zone on the West Fork sits at the base of Wolf Creek Pass and includes the confluences with Wolf Creek and Fall Creek. The next downstream response zone occupies the floodplain and riparian areas within the Boot Jack Ranch. Numerous structures, ranch roads, and USFS roads fall within each of these response zones. A notable channel response zone also exists on the East Fork between Quartz Creek and Sand Creek. Aside from a USFS road that parallels the river, very little infrastructure exists in this area and, thus, elevated sediment delivery following a wildfire poses little risk to human property. However, significant investment in physical stream restoration and fisheries enhancements have been made in this location in the past, which may warrant some consideration during subsequent management discussions.

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[52] http://dx.doi.org/10.3133/ofr20161106

[53] https://www.coloradofhz.com

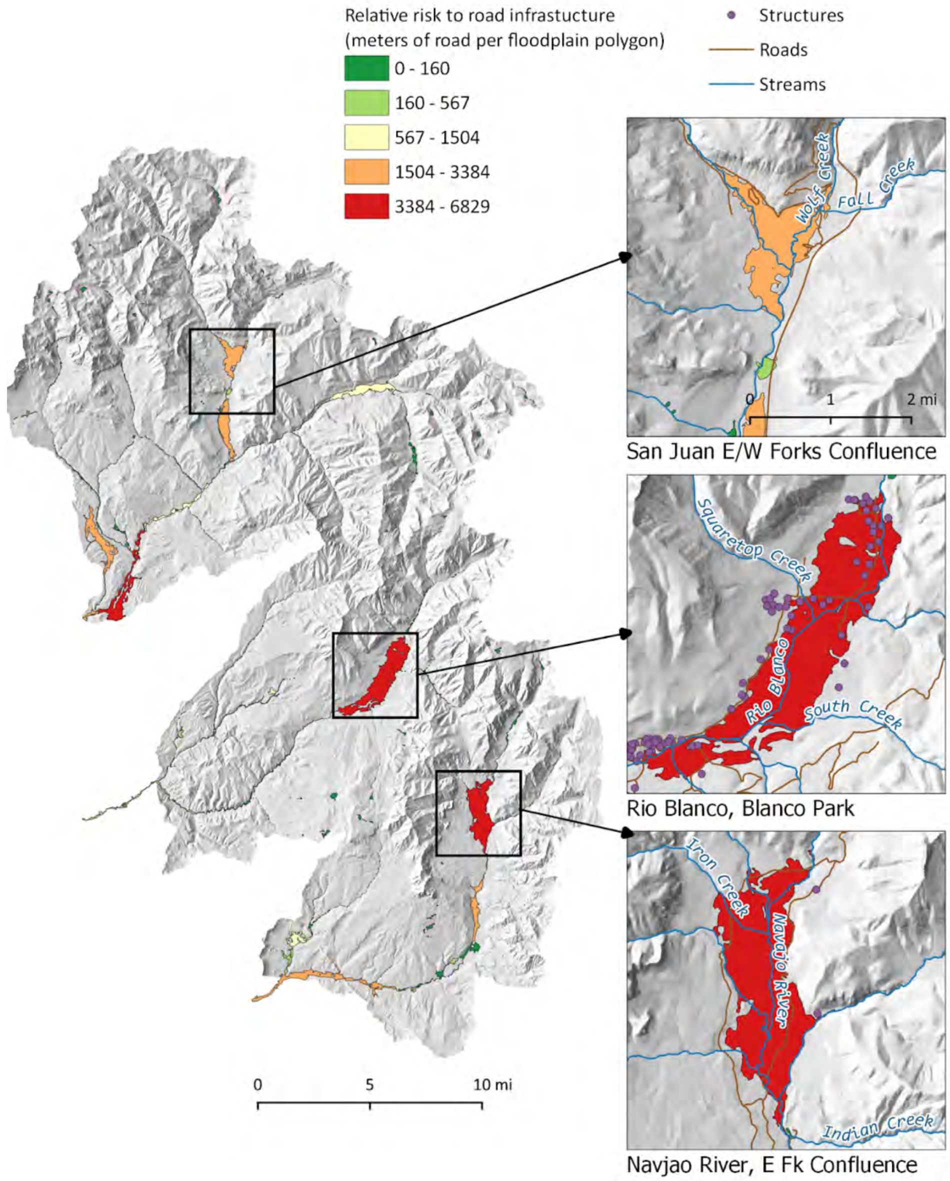

Figure 27. Channel response zones delineated throughout the WEP planning area. These areas may be susceptible to flooding, debris flows, or rapid changes in channel alignment and/or geometry. Response zones are symbolized according to the number of road miles that fall within them. No weighting was applied to road type (i.e., forest roads were weighted as heavily as highways).

The most notable response zone exists in the Blanco Basin near the Rio Blanco's confluences with Squaretop Creek and South Creek. The river parallels Blanco Basin Rd. (Co 326) through this area. Some river segments through this area appear to be artificially straightened. The reach of the Rio Blanco below the Fish Creek confluence may be particularly vulnerable to rapid channel responses following wildfire and increased sediment loads. Multiple structures exist in the channel margins in this area. Although they may be elevated enough to avoid estimated impacts from traditional flood modelling (i.e., FEMA Special Flood Hazard Zone), significant post-wildfire fluvial hazard likely exists in these locations. Risks to homes, roads, and other structures may currently be underestimated.

The broad floodplains adjacent to the Navajo River and East Fork of the Navajo River in the vicinity of the confluences with Fall Creek and Indian Creek appear to be high risk for post-wildfire channel response.

Disturbed WEP modelling indicated that the drainages contributing flows to this area score high-risk ratings for post-fire sediment generation. Unlike some locations identified on the upper San Juan River and Rio Blanco, the floodplain adjacent to the Navajo River in this channel response zone is characterized by a meandering multi-threaded form and little to no development has encroached on the floodplain. This area appears more resilient to the effects of post-wildfire sediment delivery.

2.4.2 Management Implications

Channel response zones may be subject to rapid shifts in channel location following intense wildfire and heavy precipitation events. Existing floodplain mapping techniques and delineations may significantly underestimate flood or debris flow risks to infrastructure, including residential structures, roads, and diversion structures. These areas are geomorphologically active on relatively short timescales and applying conservative planning principles (i.e., avoiding new development in these zones) and allowing the river adequate space for lateral movement is likely to be the most cost-effective and successful long-term risk-reduction. This concept is particularly relevant in the response zones along the West Fork/East Fork San Juan and in the upper Navajo River where little near-stream development has yet occurred. Practical engineering solutions for reducing post-fire sediment delivery risks in densely populated response zones by altering the floodplain or stream channels may not exist. Historical methods like stiffening streambanks with rocks or wood may be incapable of achieving ecosystem preservation goals or protecting local residences and road infrastructure. As evidenced by the 2013 Front Range flooding events, even infrastructure specifically engineered to accommodate floods can fail (sometimes spectacularly) during low-probability events like intense rainfall on burn scars. In locations like Blanco Park, where infrastructure and dwellings already in place may face elevated post-fire fluvial hazard risks, the best strategy for risk reduction may require forest treatments and other mitigations measures to help lower the probability of high-severity wildfire. Even this option, however, may be stymied by the extensive amounts of forest that exist within designated wilderness boundaries in the upper Blanco Basin. Concerted thinking by a diverse group of local landowners, county government, and federal resource managers in subsequent planning phases will be required to identify any feasible risk-mitigation strategies for this area.

2.5 Anticipating Hydrological Futures

Shifts in climate or future water management activities have the potential to impact important hydrological regime characteristics, including: total annual volume, magnitude and duration of peak and low flows, the frequency of drought conditions, etc. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g., the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change.[54]

Different perspectives on future hydrological behavior and its relationship to consumptive and non-consumptive water uses are gleaned from trends analysis on historical streamflow records and scenario modeling. While trends analysis may be the best tool for understanding near-term hydrological conditions, extrapolation of historical trends out to 30- or 50-year time horizons may be an insufficient or inappropriate approach for understanding future conditions. This is especially true where historical behavior in the joint hydrological/socio-political/administrative system is not necessarily predictive of potential future behavior. Simulation models of future hydrology, water use, and water management provide a tool for evaluating the effects of various future scenarios. Scenario modeling is used extensively across Colorado for risk assessment and decision support. That approach is adopted here as well to provide local stakeholders with insights into the

[54] B. Johnson, M. Beardsley, and J. Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams.," 2016.

ways in which changes in water availability and water use may alter local waterways' ability to deliver goods and services to local communities.

The CWCB recently provided a Technical Update to the Colorado Water Plan.[55] That update includes a set of revised StateMod scenario planning models for the Southwest Basin. The models simulate the effects of several climate change and development futures (Figure 28). Results generated by the models provide a lens through which potential future conditions in the WEP planning area can be evaluated. Modeled scenarios encompass a wide range of future conditions according to the best available science and stakeholder inputs. This scenario planning approach, unlike the more simplistic low to high-stress conditions, recognizes that the future holds a degree of uncertainty where the various drivers will impact each other. The nine impact drivers considered by the Technical Update include:

- Population/Economic Growth
- Social/Environmental Values
- Climate Change/Water Supply Availability
- Urban Land Use/Urban Growth Patterns
- Energy Economics/Water Demand
- Level of Regulatory Oversight/Constraint
- Agricultural Economics/Water Demand
- Municipal and Industrial Water Demands
- Availability of Water-Efficient Technologies

Each of the planning scenarios presented in the Technical Update reflects a possible future state, which depends on a variety of environmental and social drivers. The differentiating components of the planning scenarios are listed below:

Baseline – Current Conditions

- Current irrigated acreages and irrigation practices
- Historical Irrigation Water Requirement (IWR)
- Historical hydrology

Scenario A – Business as Usual

- Some reduction of irrigated acreage near Pagosa Springs due to expansion of residential development
- Modest improvements to irrigation efficiency
- Climate is similar to conditions observed in the 20th century

Scenario B – Weak Economy

- Reduction of irrigated acreage near Pagosa Springs
- Economy struggles, slow population growth
- Climate is similar to conditions in the 20th century
- Little change in social values, levels of water conservation, urban land use patterns, and environmental regulations

[55] "Technical Update to the Colorado Water Plan," Colorado Water Conservation Board, Volume 1., 2019.

Scenario C – Cooperative Growth

- Reduction of irrigated acreage
- 20% increase to IWR due to a moderately warming climate
- Population growth consistent with current forecasts
- Increased water and energy conservation
- Emergence of water-saving technology
- Water development more restrictive, requiring high efficiency as well as environmental/recreational benefits
- Moderate warming of the climate increasing water demands in all sectors (Ag + M&I)

Scenario D – Adaptive Innovation

- Much warmer climate
- Adoption of technological innovations to address associated socio-environmental problems
- Population growth higher than current projections
- Reduction of irrigated acreage, but less than other scenarios due to demand for locally produced food
- 31% IWR increase due to a warming climate
- 10% IWR reduction due to improved technology or efficiency (i.e., lower water use by crops)
- 10% system efficiency increase offsets water use in a warmer climate

Scenario E – Hot Growth

- Much warmer climate with significantly increased population
- Population growth higher than current projections
- Rapid transition of agricultural lands to urban and suburban land uses near Pagosa Springs
- Earlier snowmelt runoff
- 31% IWR climate factor due to a warming climate

The predictions for changes in hydrological regime behavior, water use, and water management made in the Technical Update to the Colorado Water Plan were used to explore risks for alteration of ecosystem conditions and the delivery of important ecosystem goods and services to local communities. Those risk assessments, along with a characterization of existing conditions, are discussed in subsequent sections.

The scenario models included in the Technical Update run on a monthly timestep. For the purposes of evaluating impacts of climate change, population growth, etc., on ecological characteristics of the upper San Juan watershed, a daily timestep was required. Monthly simulation results were disaggregated to daily results using a method of fragments approach. The validity of the disaggregation approach was initially assessed by comparing 107 computed metrics of annual streamflow behavior (e.g.,7-day minimum flow, average September flow, 3-day maximum flow, etc.) for Baseline simulation results representing the San Juan River at Pagosa Springs to the same metrics computed on observed streamflow data from those locations using a Wilcox Rank Sum test. Results indicate no statistically significant difference in the computed metrics between the simulation results and observation data for most metrics at this location. We found these results encouraging and, generally, supportive of our intention to use scenario modeling results to characterize changes in annual flow characteristics between scenarios. Modeling results should not be interpreted as precise predictions of baseline or future conditions, particularly at locations where no existing or historical streamflow gauges exist to support model validation.

Drivers	A Business as Usual	B Weak Economy	C Cooperative Growth	D Adaptive Innovation	E Hot Growth
A. Economy/ Population					
B. Urban Land use	No change	No change	Higher density	Higher density	Lower density
C. Climate Status/ Water Supply	Same as 20th century observed	Same as 20th century observed	Between hot and dry and 20th century observed	Hot and dry	Hot and dry
D. Energy Water Needs	Low (no oil shale)	Moderate (no oil shale)	Low (no oil shale)	Low (no oil shale)	High (oil shale)
E. Agricultural Conditions	Total ag water demands slightly higher • Decrease in irrigated acres due to urbanization • Ag exports and demands lower • Ag is less able to compete with urban areas for water	Total ag water demands decrease • Decrease in irrigated acres due to urbanization • Ag exports and demands constant • Ag is less able to compete with urban areas for water	Total ag water demands slightly higher • Slight decrease in irrigated acres due to urbanization • Ag exports down and local demands up • Ag is better able to compete with urban areas for water • Increased ET due to climate change	Total ag water demands slightly higher • Slight decrease in irrigated acres due to urbanization • Ag exports down and local demands up • Ag is better able to compete with urban areas for water • Increased ET due to climate change	Total ag water demands higher • Significant decrease in irrigated acres due to urbanization • Ag exports and demands high • Ag is better able to compete with urban areas for water • Increased ET due to climate change
F. Availability of New Water Efficiency Technology	• M&I Moderate • Ag: Efficiencies are increased	• M&I Moderate • Ag: Efficiencies are increased	• M&I High • Ag: Efficiencies are increased	• M&I High • Ag: Much higher efficiencies are implimented	• M&I Moderate • Ag: Efficiencies are increased
G. Social/ Environmental Values	No change	No change	• Increased awareness • Increased willingness to protect environment and stream recreation	• Increased awareness • Increased willingness to protect environment and stream recreation	• Full use of resources • Low willingness to protect environment and stream recreation
H. Regulatory Constraints	Regulation / Deregulation No change	Regulation / Deregulation No change	Regulation / Deregulation Increased	Regulation / Deregulation Increased but expedited	Regulation / Deregulation Reduced
I. M&I Water Demands	Lowest of the five scenarios	Middle of the five scenarios	Second lowest of the five scenarios	Second highest of the five scenairos	Highest of the five scnarios

Figure 28. Climate change and development scenarios included in Technical Update to the Colorado Water Plan.

Comparison of the various climate change and population growth scenario simulation results to the baseline simulation result indicate a shift toward earlier peak runoff and lower total annual runoff volumes associated with increasingly warm climate futures (Figure 29, Figure 30, Figure 31, Figure 32). These patterns are typical of predictions elsewhere on Colorado's western slope and align with observed recent hydrological trends. Simulation results for the mainstem San Juan River indicate relative insensitivity to the changes from the baseline condition modeled by scenarios A and B. As a result, many of the analyses presented in subsequent sections of this report consider differences between scenarios A, C, and E only. These three scenarios effectively bracket the range of potential future conditions predicted in the entire suite of model scenarios.

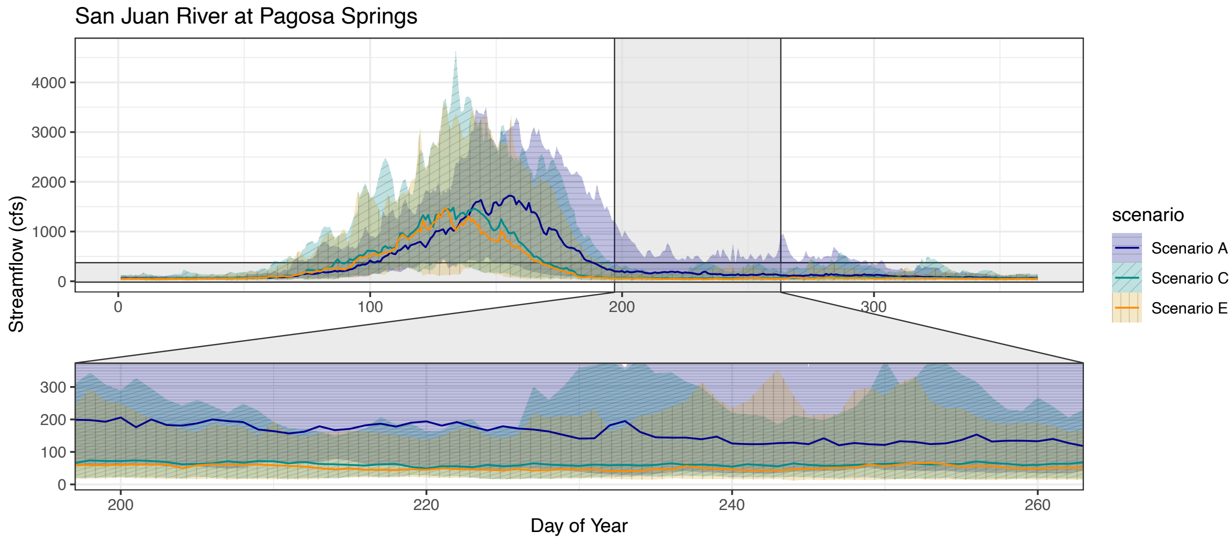

Figure 29. Hydrological regime behaviors for the San Juan River at Pagosa Springs modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

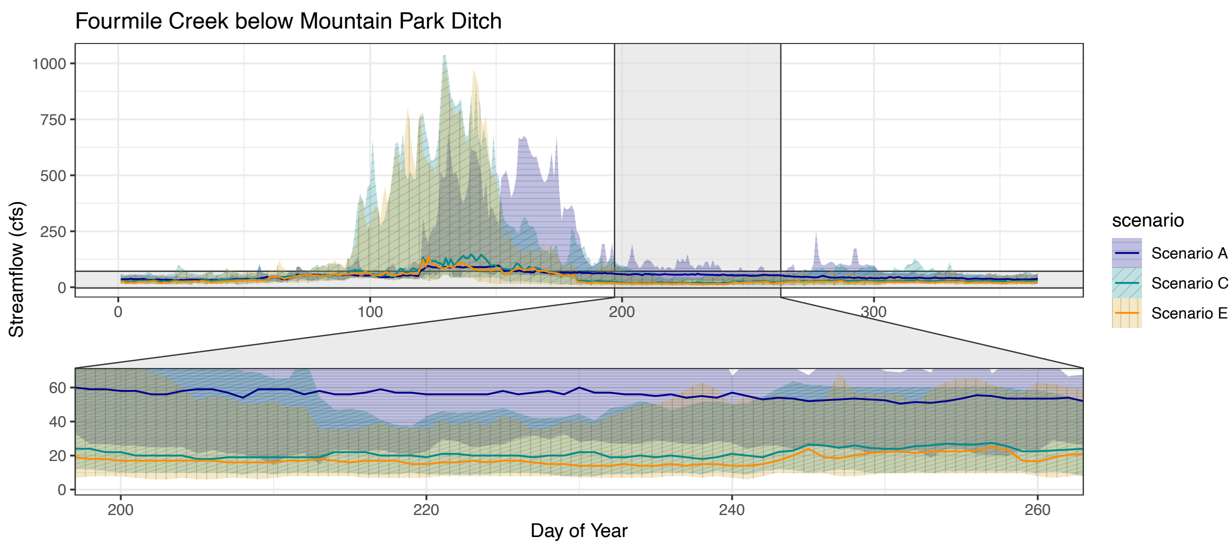

Figure 30. Hydrological regime behaviors for Fourmile Creek below Mountain Park Ditch modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

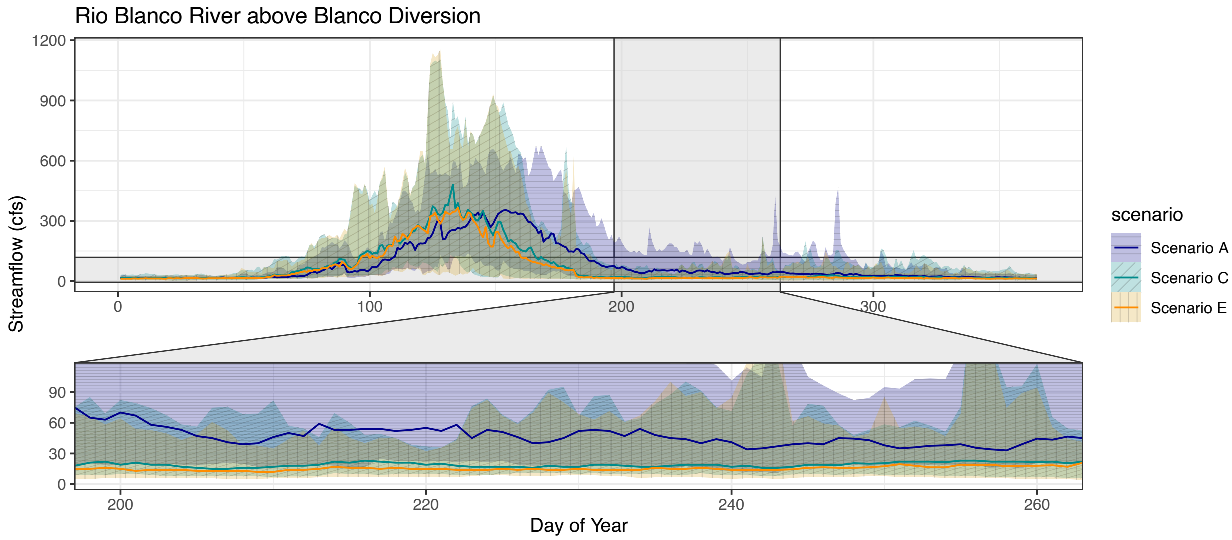

Figure 31. Hydrological regime behaviors for the Rio Blanco above the Blanco Diversion Dam modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

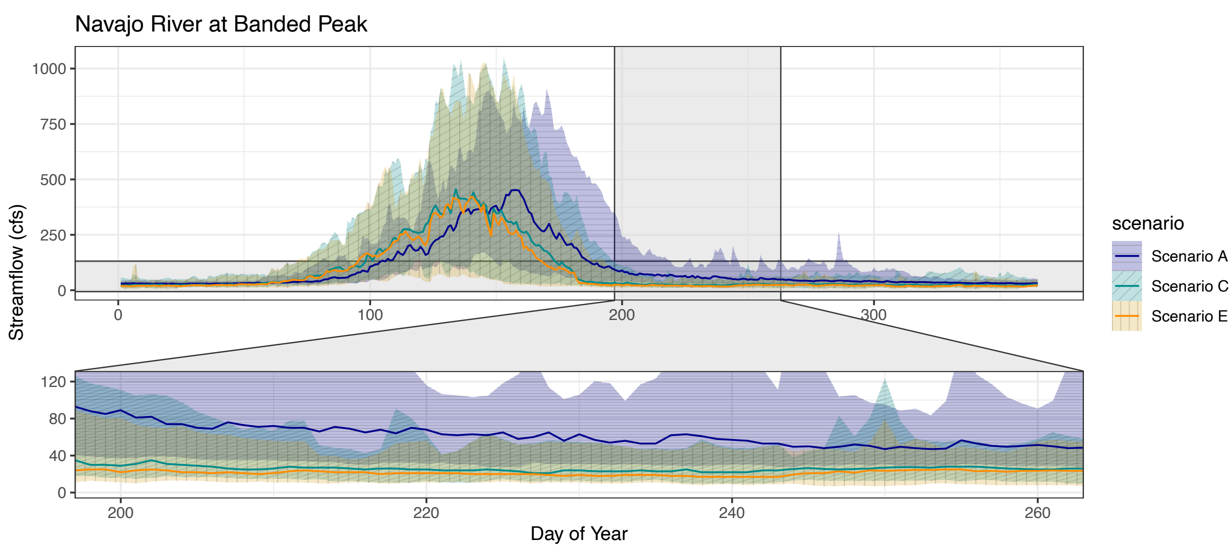

Figure 32. Hydrological regime behaviors for the Navajo River at Banded Peak modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the 40-year simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

The visual comparison of streamflow behavior predicted by the scenario models is supported by computation of various metrics of hydrological behavior (e.g., median July flow, annual 3-day minimum flow). Metrics were computed for each year in the 40-year simulation time series provided for each scenario. Then, the annual metric values were summarized for each scenario by computing the 25th, 50th, and 75th percentiles in the range. A subset of those results deemed most relevant for subsequent discussions of values-at-risk are included here in tabular form (Table 4, Table 5, Table 6).

Table 4. Predicted changes in streamflow behavior for the San Juan River at Pagosa Springs as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [56].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	1777	0	0	-18	-33	-33
	50th	cfs	2303	0	0	-9	-13	-13
	75th	cfs	3349	0	0	-8	-17	-19
75pct Total Yield	25th	doy	174	0	0	-11	-13	-13
	50th	doy	181	0	0	-11	-13	-13
	75th	doy	188	0	0	-10	-5	-4
April Max	25th	cfs	854	0	0	12	-10	-11
	50th	cfs	1014	0	0	55	34	33
	75th	cfs	1488	0	0	37	27	27
May Max	25th	cfs	1701	0	0	-17	-36	-36
	50th	cfs	2053	0	0	-4	-15	-16
	75th	cfs	2497	0	0	24	12	9
June Max	25th	cfs	1508	0	0	-55	-65	-67
	50th	cfs	2085	0	0	-38	-49	-49
	75th	cfs	2904	0	0	-27	-39	-44
July Max	25th	cfs	373	2	2	-75	-82	-80
	50th	cfs	655	0	0	-73	-81	-81
	75th	cfs	1110	0	0	-63	-73	-75
July Min	25th	cfs	75	1	1	-60	-72	-72
	50th	cfs	123	2	2	-55	-67	-70
	75th	cfs	204	0	0	-64	-69	-70
August Min	25th	cfs	55	4	4	-53	-72	-68
	50th	cfs	93	13	13	-57	-66	-63
	75th	cfs	124	6	6	-58	-56	-63
September Min	25th	cfs	54	0	0	-59	-72	-72
	50th	cfs	75	1	1	-38	-49	-49
	75th	cfs	107	0	0	-36	-25	-27
October Min	25th	cfs	56	-7	-7	-60	-73	-71
	50th	cfs	72	0	0	-33	-42	-42
3-day Min	75th	cfs	52	0	0	-31	-52	-49
	25th	cfs	30	0	0	-50	-68	-64
	50th	cfs	43	2	2	-41	-69	-63
7-day Min	25th	cfs	32	1	1	-52	-68	-63
	50th	cfs	45	0	0	-38	-65	-58
	75th	cfs	54	0	0	-27	-49	-44
30-day Min	25th	cfs	43	0	0	-51	-70	-64
	50th	cfs	51	0	0	-36	-59	-52
	75th	cfs	63	0	0	-29	-41	-40

[56] "Technical Update to the Colorado Water Plan."

Table 5. Predicted changes in streamflow behavior for Fourmile Creek below Mountain Park Ditch as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [57].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	150	0	0	47	25	85
	50th	cfs	298	0	0	73	4	4
	75th	cfs	641	0	0	32	27	26
75pct Total Yield	25th	doy	228	0	0	-29	-33	-31
	50th	doy	247	0	0	-24	-26	-26
	75th	doy	258	0	0	3	2	0
April Max	25th	cfs	83	0	0	33	22	27
	50th	cfs	97	0	0	143	113	218
	75th	cfs	105	0	0	399	314	313
May Max	25th	cfs	112	0	0	42	1	42
	50th	cfs	197	0	0	33	36	32
	75th	cfs	336	0	0	136	87	83
June Max	25th	cfs	73	0	0	17	-14	-32
	50th	cfs	116	0	0	28	1	26
	75th	cfs	348	0	0	-45	-56	-48
July Max	25th	cfs	72	-1	1	-68	-78	-76
	50th	cfs	88	0	0	-66	-75	-70
	75th	cfs	171	0	0	-63	-76	-77
July Min	25th	cfs	39	0	0	-69	-78	-77
	50th	cfs	51	0	0	-71	-76	-75
	75th	cfs	58	0	0	-53	-66	-69
August Min	25th	cfs	35	-3	0	-74	-77	-77
	50th	cfs	42	0	0	-69	-71	-74
	75th	cfs	52	1	1	-62	-63	-68
September Min	25th	cfs	29	0	0	-64	-68	-66
	50th	cfs	35	0	0	-54	-54	-57
	75th	cfs	49	0	0	-43	-47	-50
Octobr Min	25th	cfs	29	0	0	-52	-61	-59
	50th	cfs	36	0	0	-44	-58	-58
3-day Min	75th	cfs	28	0	0	-60	-65	-60
	25th	cfs	18	0	0	-54	-66	-66
	50th	cfs	26	0	0	-65	-69	-66
7-day Min	25th	cfs	21	0	0	-58	-70	-69
	50th	cfs	28	0	0	-61	-69	-67
	75th	cfs	30	0	0	-60	-63	-62
30-day Min	25th	cfs	25	0	0	-58	-72	-70
	50th	cfs	31	0	0	-59	-69	-66
	75th	cfs	34	0	0	-50	-65	-63

[57] "Technical Update to the Colorado Water Plan."

Table 6. Predicted changes in streamflow behavior for the Rio Blanco above the Blanco Diversion as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [58].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	482	0	0	-2	-18	-19
	50th	cfs	579	0	0	5	-1	-1
	75th	cfs	705.5	0	0	18	16	16
75pct Total Yield	25th	doy	181	0	0	-14	-17	-17
	50th	doy	189	0	0	-15	-16	-16
	75th	doy	207	0	0	-3	-13	-13
April Max	25th	cfs	217	0	0	13	21	21
	50th	cfs	278	0	0	42	23	23
	75th	cfs	386	0	0	42	37	36
May Max	25th	cfs	381.5	0	0	0	-12	-13
	50th	cfs	518	0	0	16	3	3
	75th	cfs	633.5	0	0	31	28	28
June Max	25th	cfs	319.5	0	0	-54	-67	-63
	50th	cfs	498	0	0	-41	-52	-53
	75th	cfs	612.5	0	0	-16	-34	-36
July Max	25th	cfs	115.5	0	0	-80	-82	-82
	50th	cfs	169	0	0	-75	-81	-83
	75th	cfs	239.5	0	0	-70	-75	-76
July Min	25th	cfs	20.5	0	0	-51	-66	-66
	50th	cfs	29	0	0	-59	-59	-62
	75th	cfs	48.5	0	0	-62	-67	-67
August Min	25th	cfs	18	0	0	-42	-56	-58
	50th	cfs	24	0	0	-42	-50	-54
	75th	cfs	34	0	0	-47	-56	-54
September Min	25th	cfs	18	0	0	-43	-61	-61
	50th	cfs	26	0	0	-40	-52	-50
	75th	cfs	35	0	0	-41	-46	-46
October Min	25th	cfs	15	0	0	-45	-60	-60
	50th	cfs	18	0	0	-22	-31	-28
3-day Min	75th	cfs	12	0	0	-26	-40	-47
	25th	cfs	9	0	0	-54	-67	-67
	50th	cfs	10	0	0	-37	-50	-50
7-day Min	25th	cfs	9.07	0	0	-49	-67	-67
	50th	cfs	10.86	0	0	-30	-54	-54
	75th	cfs	12.29	0	0	-16	-37	-40
30-day Min	25th	cfs	11.8	0	0	-42	-67	-66
	50th	cfs	13	0	0	-31	-51	-50
	75th	cfs	16.38	0	0	-24	-40	-35

[58] "Technical Update to the Colorado Water Plan."

Table 7. Predicted changes in streamflow behavior for the Navajo River at Banded Peak as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [59].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	484.5	0	0	-13	-20	-20
	50th	cfs	665	0	0	-6	-14	-14
	75th	cfs	852	0	0	5	-5	-4
75pct Total Yield	25th	doy	182	0	0	-13	-15	-14
	50th	doy	189	0	0	-13	-14	-14
	75th	doy	200	0	0	-11	-13	-12
April Max	25th	cfs	201.5	0	0	44	31	25
	50th	cfs	259	0	0	56	48	48
	75th	cfs	346	0	0	40	36	36
May Max	25th	cfs	408	0	0	0	-11	-12
	50th	cfs	511	0	0	18	11	11
	75th	cfs	678.5	0	0	25	18	18
June Max	25th	cfs	441	0	0	-47	-65	-66
	50th	cfs	568	0	0	-30	-36	-36
	75th	cfs	780	0	0	-12	-27	-28
July Max	25th	cfs	123.5	0	0	-72	-80	-79
	50th	cfs	190	0	0	-69	-77	-76
	75th	cfs	311.5	0	0	-65	-77	-76
July Min	25th	cfs	40.5	0	0	-59	-70	-68
	50th	cfs	58	0	0	-62	-71	-69
	75th	cfs	73	0	0	-57	-60	-58
August Min	25th	cfs	31	0	0	-58	-68	-63
	50th	cfs	40	0	0	-55	-62	-62
	75th	cfs	57	0	0	-57	-62	-63
September Min	25th	cfs	33	0	0	-57	-63	-69
	50th	cfs	38	0	0	-46	-53	-49
	75th	cfs	45	0	0	-35	-43	-43
October Min	25th	cfs	27.25	0	0	-50	-66	-66
	50th	cfs	32.5	0	0	-42	-52	-52
3-day Min	75th	cfs	27	0	0	-46	-59	-59
	25th	cfs	21.5	0	0	-60	-69	-68
	50th	cfs	23.67	0	0	-58	-68	-66
7-day Min	25th	cfs	21.93	0	0	-60	-69	-68
	50th	cfs	25.57	0	0	-53	-69	-68
	75th	cfs	27.43	0	0	-40	-58	-57
30-day Min	25th	cfs	23.22	0	0	-50	-62	-61
	50th	cfs	27.63	0	0	-49	-63	-62
	75th	cfs	30.38	0	0	-37	-56	-55

[59] "Technical Update to the Colorado Water Plan."

Simulation results representing the potential effects of climate change were produced by applying adjustment factors to historical hydrology and, thus, do not effectively demonstrate potential or expected changes in precipitation intensity produced by a warming climate. Characterizing the effects of increasingly severe rainfall events on flows in the San Juan and its tributaries requires some consideration of all the potential locations of such events across the entire watershed, the relative intensity and duration of any given event, and the effects of flow routing on flood waves propagating along the stream network—not a trivial task. The reader should take note that such changes were not captured by simulation modeling results that form the basis for scenario comparisons in this effort.

Increasing atmospheric moisture content and an associated increase in extreme rainfall event frequency and/or severity might produce short-duration flood pulses during the summer monsoon period. A simplistic approach to accounting for increasing summer monsoon activity is included here. The potential impact of increased late summer precipitation can be approximated by applying a 3.5% increase per degree Fahrenheit of future warming (as per Colorado Dam Safety Office proposed Rule 7.2.4) to observed July-September peak flows observed on the San Juan River at Pagosa Springs between 1990 and 2020 (Table 8). Peak flows observed during this period are generally associated with high-intensity rainfall events. Similar outputs computed for the Navajo River and Rio Blanco show similar patterns but were not included here for brevity. Increased flood magnitude on any of these three large mainstem rivers may pose a hazard for roads, homes, and other infrastructure located in floodplains and valley bottoms.

Table 8. Predicted increases in late summer (Jul – Oct) peak streamflow events on the San Juan River in Pagosa Springs produced by three different warming scenarios. Events during this period are generally driven by monsoonal rainstorms. A peak flow event with a 1-in-10-year return interval has a 1-in-10 chance of occurring in any given year.

Return Interval (years)	**Peak Flow (cfs)**			
	Historical Conditions	**+1°F**	**+3°F**	**+5°F**
2	833	862	920	979
4	1400	1449	1548	1646
5	1575	1630	1741	1851
10	2103	2177	2324	2471
20	2613	2705	2888	3071
25	2774	2871	3066	3260
50	3263	3378	3606	3834
100	3737	3867	4129	4391
250	4338	4489	4793	5097
500	4773	4940	5275	5609

The intersection between hydrology and other environmental and recreational attributes of the San Juan River and its tributaries is explored in greater detail in the sections below.

2.6 Sediment Transport Along Channels

The potential for cascading impacts between alteration of hydrology or sediment supplies, channel morphology, and habitat quality for native species make sediment transport characteristics an area of specific management concern to local stakeholders. Sediment transport analysis is a typical approach used to characterize the potential impact of changing hydrology on channel form and behavior. Coarse sediment supply and transport in rivers is critical in maintaining channel geometry and is a critical variable in riverine habitat formation, flood inundation, and riparian condition. Here, we discuss the typical sediment transport characteristics of the large streams and rivers in the WEP planning area. This is a different dimension of sediment transport to the discussion provided previously regarding large, post-fire, sediment delivery events.

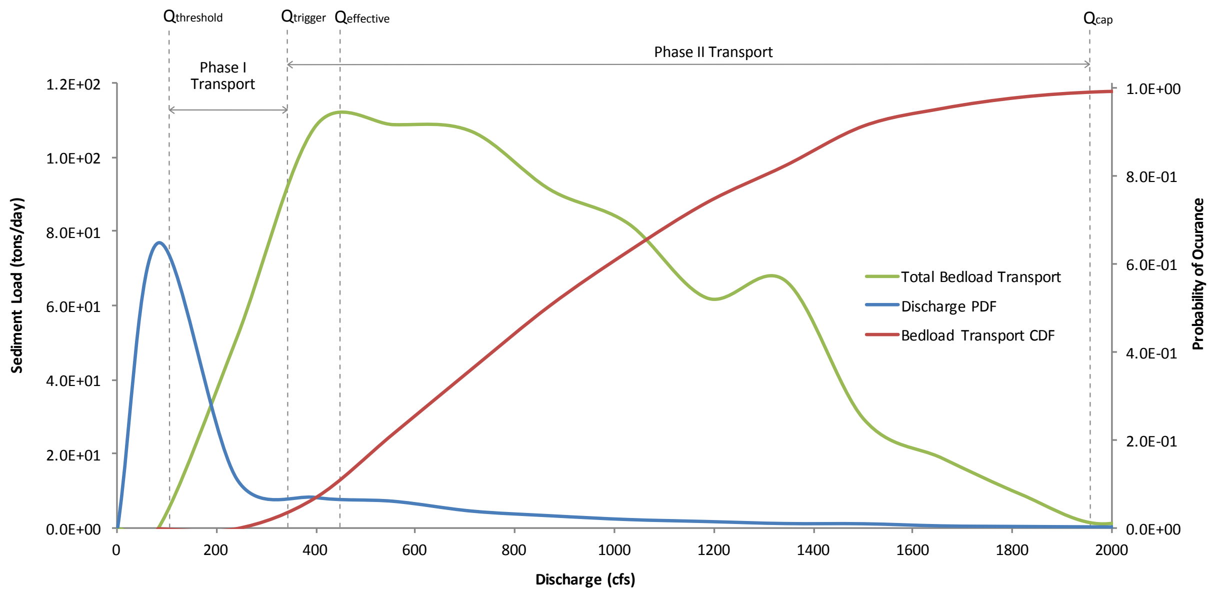

Figure 33. Example magnitude-frequency plot estimating the mass of sediment transported through a channel cross-section across a range of discharges. Total bedload transport results are a function of the hydraulic characteristics of the cross section and the probability of occurrence of various flow states along the interval.

Channel geometry, sediment particle size, and water discharge control two dominant phases of sediment transport in alluvial river reaches (areas with unconfined floodplains): Phase I transport includes fine-grained particles such as sand and fine gravel; Phase II transport mobilizes all particle sizes in the stream bed including large gravel, and cobbles (Figure 33). We estimated the threshold for Phase II transport initiation as the streamflow capable of mobilizing all particle sizes measuring up to 7 inches along the B-axis.

Variability of thresholds for initial motion between stream reaches can be high, especially in reaches where river morphology is highly variable. Some characteristic differences in sediment transport behavior were observed between sampled locations on the Navajo River below the Oso Diversion Dam, on the Blanco River below the Blanco Diversion Dam, and locations on the mainstem San Juan River. However, sediment discharge rating curves developed for the mainstem San Juan River in Pagosa Springs and near the confluence with Fourmile Creek showed very similar patterns of sediment transport as modeled flows increased. Estimates for Phase II transport initiation produced here are ~1450 cfs for the San Juan above Pagosa Springs, ~1225 cfs for the San Juan through Pagosa Springs, ~110 cfs for the Navajo River below Oso Diversion Dam, and ~265 cfs for the Rio Blanco below the Blanco Diversion Dam. Notably, the particle size distributions collected on the Rio Blanco and Navajo River skewed toward the small clast sizes. A thick layer of silt and sand covering the bed and much of the larger material was observed at both locations. This characteristic is likely the result of the extensive sediment removal activities that occur annually above each of the San Juan Chama Project diversion structures (Figure 34, Figure 35). These activities mobilize large quantities of fine sediment during periods when flows are particularly low. These mobilized sediments make their way downstream of the diversion structures where they settle out onto the streambed and, likely, remain in place until the following year's peak runoff. This inundation of fine particles is expected to degrade habitat quality for aquatic macroinvertebrates, trout, and native warm-water fish species.

Figure 34. Evidence of sediment removal activities on the upstream side (image-right) of the Oso Diversion Dam on the Navajo River.

Figure 35. Evidence of sediment removal activities (image-center) on the upstream side of the Blanco Diversion Dam on the Rio Blanco.

The bedload transport rating curve from each site was applied to the hydrologic records available from current or historical USGS streamflow gauging stations in order to complete a sediment transport magnitude-frequency analysis. Computation of the flows responsible for transporting the majority (i.e., modal 80%) of sediment at the sites on each river can be useful when considering the implications of various management actions or climate change scenarios on sediment transport characteristics. Here, we treat the flow associated with the 50th percentile of the cumulative sediment transport curve as the effective discharge.

The flow responsible for Phase II transport initiation and the effective discharge provide useful reference points for flow management. Flows exceeding the Phase II transport flow should occur, on average, for 30 or more days each year in order to maintain existing sediment transport characteristics. Three-day peak flow events exceeding the effective discharge should occur at a frequency of ~2 years to help maintain historical and existing rates of channel change and bedload mobilization on a given section of river. These management targets assume no significant alteration of land cover characteristics or alterations in sediment supply.

Table 9. Sediment transport characteristics for sites on the mainstem San Juan River, Rio Blanco, and Navajo River.

Location	Phase II Transport Threshold (cfs)	Effective Discharge (cfs)
San Juan River below Fourmile Creek	1450	2250
San Juan River in Pagosa Springs	1225	2410
Rio Blanco below Blanco Diversion Dam	265	502
Navajo River below Blanco Diversion Dam	110	490

The hydrological scenario modeling conducted as part of this planning process yielded predictions for flood recurrence intervals at locations across the watershed under a variety of planning scenarios. The Baseline modeling results indicate that flood events exceeding the effective discharge occur approximately once every 2-years on the San Juan mainstem (both sites), once every 10-years on the Rio Blanco below the Blanco Diversion Dam, and once every 2-years on the Navajo River below the Oso Diversion Dam. These results are somewhat confounded on the Rio Blanco and Navajo River sites by the presence of excessive silt and sand on the streambed. Readers are advised to treat numbers provided for those sites with caution. They likely provide a very conservative set of management targets and/or indicators of sediment mobilization. It is likely that the flows indicated above are effective at mobilizing fine sediment but ineffective at mobilizing the underlying armored cobble layer. Collection of additional bed sediment samples on both rivers below the San Juan – Chama Project diversions immediately following snowmelt runoff and prior to sediment removal activities may provide more reliable estimates of sediment transport characteristics.

Scenario modeling also provides a means to predict the potential impacts of climate change. Scenarios A and B do not diverge significantly from baseline (i.e., current conditions). Scenarios C, D, and E indicate varying degrees of departure from current conditions at locations on the mainstem San Juan River, Rio Blanco, and Navajo River. However, impacts of climate change on peak flow magnitude and frequency are most evident on the mainstem San Juan River. The peak flow magnitude with a 2-year recurrence frequency at both sites on the San Juan River mainstem was estimated at 2465 cfs under the Baseline scenario, 2220 cfs under Scenario C (a -10% change from Baseline), and 1920 cfs under Scenario E (a -22% change from Baseline). Under Scenario E, floods exceeding the effective discharge shift from a 2-year recurrence interval to a 4-year recurrence interval. As sediment transporting flows become less frequent, the channel of the San Juan River below Fourmile Creek may become more sensitive to episodic or transient inputs of sediment (e.g., sediment loading produced by wildfire).

2.6.1 Risks Posed by Wildfire and Climate Change

A warming climate may increase the frequency and severity of fire in the WEP planning area.[60] Wildfires are known to increase rates of hillslope erosion and sediment delivery to stream networks for several years after fire occurs.[61] Rapid increases in the rate and volume of suspended and bedload sediment delivered to the streams and rivers in the planning area may result in rapid sediment accumulation in pocket floodplains, side channels and backwaters. Without corresponding high flows to remobilize this sediment and transport it downstream, newly created bars and depositional surfaces may become vegetated and stabilized, reducing measures of channel complexity though the planning area. In the event that a large wildfire in the San Juan, Rio

[60] Rocca, M. E., Brown, P. M., MacDonald, L. H., & Carrico, C. M. (2014). Climate change impacts on fire regimes and key ecosystem services in Rocky Mountain forests. Forest Ecology and Management, 327, 290-305.

[61] Moody, J. A., & Martin, D. A. (2001). Initial hydrologic and geomorphic response following a wildfire in the Colorado Front Range. Earth Surface Processes and Landforms: The Journal of the British Geomorphological Research Group, 26(10), 1049-1070.

Blanco, or Navajo River watersheds, quick action to stabilize soils or revegetate burn scars may be necessary to prevent significant deleterious effects on channel characteristics, especially in the Navajo and Rio Blanco where significant hydrological modification by the San Juan – Chama project already impacts sediment transport regimes. It is also important to note that climate futures that change the composition and extent of riparian communities may alter the way that riparian vegetation interacts with channel hydraulics to mediate channel form and movement. The potential impact of a changing climate and hydrological regime on riparian communities is discussed in the next section.

2.7 Riparian Forests

Riparian areas are both rare and critical ecosystems. These landscape elements act as transitional zones from the riverbed to drier uplands and provide important habitat for wildlife. Riparian area extent and function is largely a function of landscape position, local hydrology, and development activities in the floodplain. Despite their relatively small total land coverage in the WEP planning area and elsewhere in Colorado, riparian zones produce outsized contributions to biological diversity and abundance, as well as strong controls on water quality, aquatic habitat, and physical channel dynamics. Riparian lands consist of less than 3 percent of the total area of western Colorado, but 72 percent of reptile species, 77 percent of amphibian species, 80 percent of mammal species, and 90 percent of all bird species use riparian areas "for food, water, cover, or migration routes." [62] Readers interested in a detailed characterization of wetlands and riparian areas in Archuleta County are directed to the Survey of Critical Wetlands and Riparian Areas in Archuleta County.[63]

Riparian vegetation communities exist in a dynamic state both physically (between the river and its floodplain) and in time (between periods of snowmelt runoff and late-season baseflows). Occasional scouring of overbank areas provides the necessary habitat for the germination of many riparian plant species. Active channel migration in wide floodplains provides a particularly conducive disturbance regime for promoting diverse riparian communities. Following germination on scoured or newly created surfaces (e.g., point-bars), seedlings require a relatively slow reduction in water table height over the progression of the growing season. Rapid water table elevation reductions or late season water table heights that drop below the maximum rooting depth of cottonwoods and other riparian plants can stress vegetation and can lead to seedling mortality. Changes in channel and floodplain structure, channel alteration designed to limit lateral migration, or adjustments in the magnitude, timing or frequency of peak flows and baseflows may, therefore, limit the establishment of younger plants and lead to decadent stands of vegetation[64] (Figure 36).

Flow recommendations for support of existing riparian communities reflect the assessment peak flow hydrology present on the alluvial sections of the San Juan River and the expectation that existing riparian extents will be partially maintained through overbanking conditions that scour streambanks, mid-channel bars, and other floodplain features. Hydrological simulation modeling suggests a reduction in peak snowmelt runoff magnitudes under scenarios that represent a warming climate. While limited data on historical riparian condition makes it difficult to establish causality between changes in hydrological regime behavior and reductions in riparian area, first principles of riparian ecology suggest that reductions in the magnitude of flows occurring at 5- or 10-year return intervals may limit the aerial extent of active riparian recruitment, thereby reducing riparian forest widths over time. Riparian area disturbances, in turn, may impact aquatic habitat and may produce

[62] Rare Earth Science, LLC, "Baseline Documentation Report: Silt River Preserve Conservation Easement." at 7.

[63] Freeman, K., March, M., and Culver, C. 2006. Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program

[64] Mahoney and Rood, "A Device for Studying the Influence of Declining Water Table on Poplar Growth and Survival."

negative secondary impacts including elevated water temperatures and increased sediment loading from streambanks.[65]

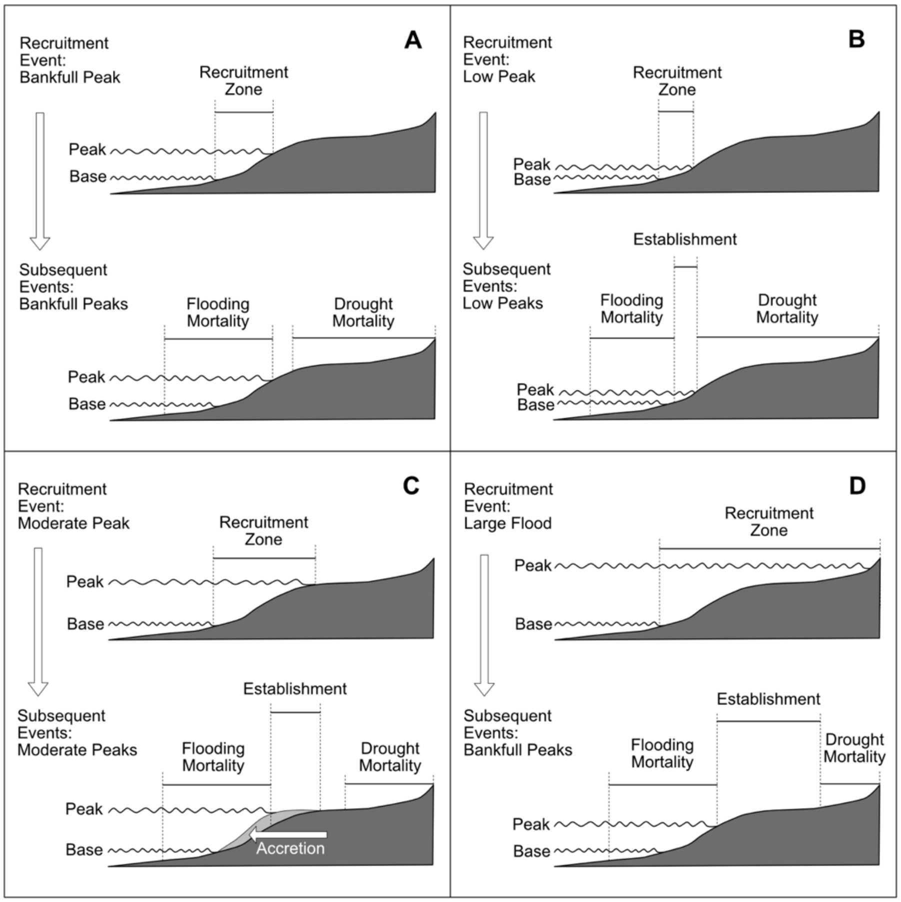

Figure 36. Riparian recruitment dynamics on alluvial reaches are largely governed by flood disturbances. A) Where inter-annual variability in flow is low, little or no pioneer recruitment occurs. B) Long-term drought or management-induced reductions in peak flows leads to narrowing of the riparian zone as new recruits establish on former channel beds. C) Meandering channels support pioneer recruitment of on accreting point bars. D) Infrequent large floods enable recruitment on higher floodplain surfaces.[66]

Colorado Natural Heritage Program (CNHP) designates numerous areas within the WEP planning bounds as Potential Conservation Areas (PCAs) (Figure 37). These PCAs should receive special management focus for limiting the impact of future development and land-use change. See Appendix E for additional discussion, including biodiversity characteristics and management needs, specific to each PCA. CHNP includes hydrological modifications, stream bank stabilization projects, historical land uses (e.g., logging and gravel pits),

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[65] White River National Forest, "Five-Year Monitoring and Evaluation Report: October 2002 - September 2007." at 8.

[66] Auble, Gregor T., J. M. Friedman, and M. L. Scott, "Relating Riparian Vegetation to Present and Future Streamflows," Ecol. Appl., vol. 4, no. 3, pp. 544–554, 1994.

transportation corridors, grazing, OHV recreation, and non-native plants as the primary factors that diminish the vitality and function of biotic communities in the PCAs. Development of transportation corridors and historical gravel mining operations along the San Juan River over the last half-century directly reduced the extent of riparian areas in several locations along the river corridor above Pagosa Springs. The most frequently noted hydrological impacts to riparian and wetland areas are related to grazing activities.

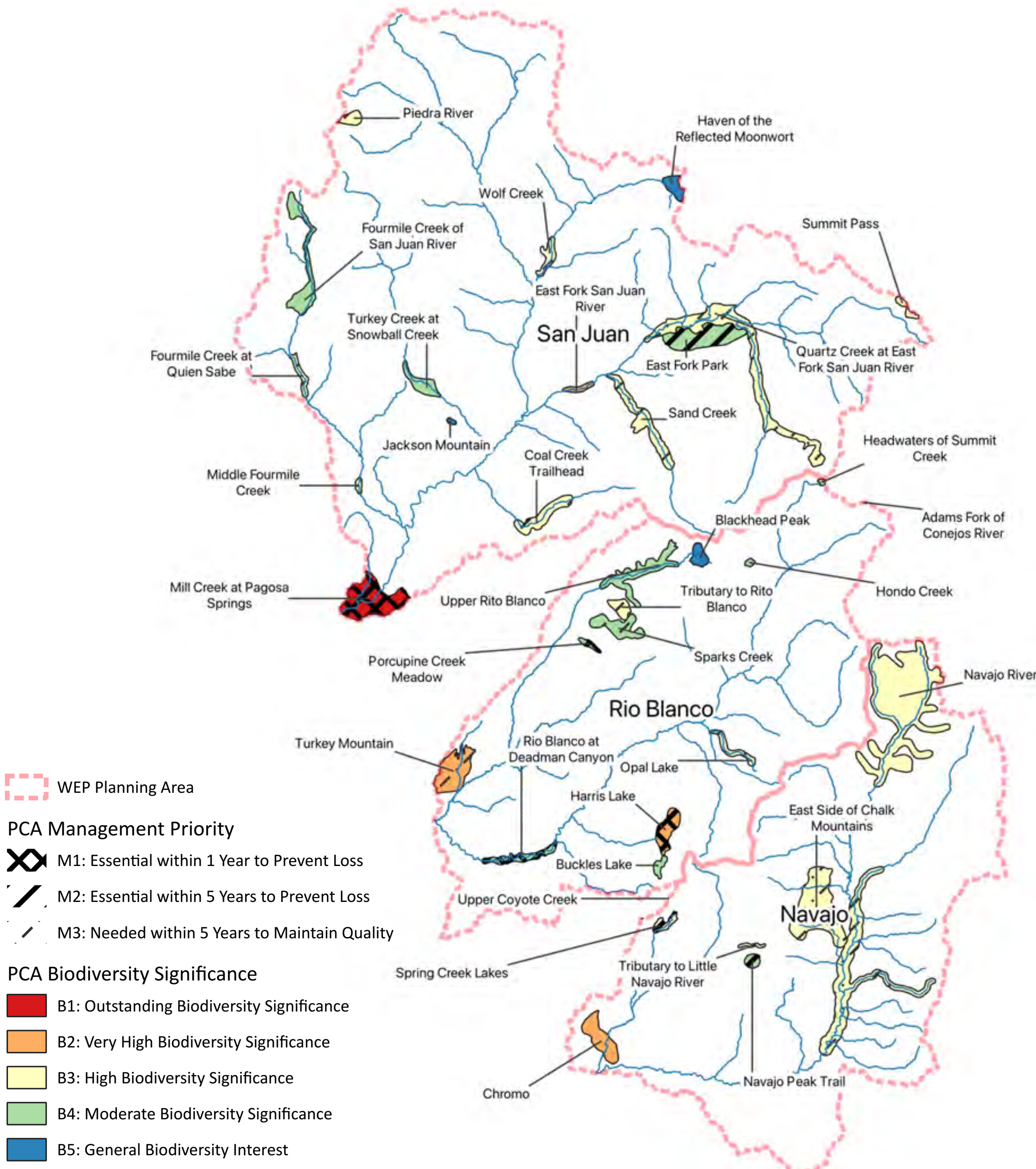

Figure 37. CNHP delineated Potential Conservation Areas falling within the WEP planning area.

The hot springs wetlands in Pagosa Springs are designated by CNHP as a Site of Local Significance. These wetlands are home to rare and unique plant communities supported by outflows from the Pagosa Hot Springs. Threats to the function and quality of these wetlands include modification of the timing and quantity of flows received by the hot springs, development and urban runoff from adjacent lands, and invasive plant species. The unique characteristics and management needs for these wetlands are also presented by Pagosa Wetland Partners.[67] Preservation of this unique wetland complex may require the development of a long-term agreement between the Town of Pagosa Springs and the private entity that manages return flows from the Pagosa Hot Springs. Such an agreement would need to ensure that the wetlands receive an adequate supply of geothermal water to maintain the existing community structure. Determination of the timing, quantity, and frequency of water deliveries to the wetlands may require a detailed, site-specific study. Stakeholders may benefit from focused consideration of these opportunities in the next phase of planning.

Figure 38. A view of the Town of Pagosa Springs Wetlands, one of the most unique riparian wetlands in the WEP planning area. (Photo credit: Brenda Breding)

2.7.1 Restoration Opportunities

CNHPs delineation of PCAs reflects management needs for existing wetlands and riparian areas. They do not, however, identify long-degraded areas on the landscape that may benefit from some variety of structural or functional restoration. In response to this data gap, a cursory investigation was performed in the WEP Phase II assessment to identify stream reaches and riparian areas that exist in a degraded functional state. Specifically, we endeavored to identify areas where management interventions designed to elevate groundwater elevations and promote re-establishment of woody and herbaceous riparian plant communities would 1) be likely to succeed and 2) provide some local benefit to aquatic/terrestrial habitat, water quality, etc.

Wetland communities are found in many locations in the wetter, high-elevation zones of the WEP planning area. In the lower-elevation bands, however, shallow water tables capable of supporting riparian and wetland vegetation tend to exist only in close proximity to streams, rivers, and, in some cases, irrigation canals/ditches. The geographic constraints on soil moisture sufficient to support most wetland species make riparian zones particularly important ecosystems in the lower portions of the planning area. Longitudinal gradients in riparian vegetation density and indicators of channel incision along smaller tributaries tend to reflect grazing patterns.

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[67] Riverwalk Wetlands Preservation 2020. Pagosa Wetland Partners.

Stream banks where grazing is active are often devoid of vegetation. The lack of vegetation allows the stream channel to down-cut. Streambeds in many of these areas now exist at a much lower elevation than they did historically. As streambed elevations decline, so too does the water table. At some point, the depth of the water table may exceed the rooting depth of riparian plants and it becomes extremely difficult to reestablish those communities on meaningful human timescales without some type of management intervention.

The investigation conducted here was restricted to consideration of small tributary streams in the San Juan watershed. Integrated results from an analysis approach that included GIS-based terrain analysis, examination of historical aerial imagers, and limited rapid site surveys indicate that several reaches along Mill Creek and McCabe Creek may benefit most from the application of low-cost process-based restoration techniques.[68] Most, if not all, of these locations exist on private land. Therefore, it may be appropriate for stakeholders to contemplate an outreach strategy to landowners whose property includes candidate stream reaches during future phases of the WEP planning effort.

2.8 Biota

The San Juan watershed is also home to many aquatic, avian, amphibian, and mammalian species that inhabit stream channels and riparian areas. Notable indicator species of overall river health include cutthroat trout, macroinvertebrates, bald eagles, river otters, Lewis woodpecker, and great blue heron. Just as characterizing the extent and condition of terrestrial and avian species throughout the watershed can promote understanding of physical and biological processes that promote or degrade ecosystem resilience, so too can examination of the presence and condition of key aquatic species.

Fish and macroinvertebrates are the two most frequently referenced groups of organisms in efforts to assess biological conditions in Colorado rivers and streams. Both groups are readily observed and sampled. A wide array of methodologies is available to assess characteristics of populations or individuals to evaluate the quality and availability of aquatic habitat. Aquatic macroinvertebrates help scientists and state regulatory agencies gauge trends in stream health and water quality. Macroinvertebrates are sensitive to pollutants (including temperature) and streamflow, and their relative immobility, short lifespans, and easy observation make them a great yardstick for overall stream health. Many species of fish are iconic species that have special recreational value for sportsman and special ecosystem value to conservationists.

The fisheries supported by streams and rivers throughout the WEP planning area are typically broken into two basic classifications: warm-water and cold-water. Both fishery classifications include native and non-native fish and several state or federally-listed species of concern. The planning area provides important habitat to support several native warm-water fish species, including flannelmouth sucker, roundtail chub, and bluehead sucker. All three species are classified as Tier 1 Species of Greatest Conservation Need in the state of Colorado. Native cold-water fish in the San Juan, Rio Blanco, and Navajo River watersheds include Colorado cutthroat trout, mottled sculpin and speckled dace. Non-native cold-water species in the San Juan watershed comprise the main sport fishery and include rainbow trout, brown trout, and brook trout.

Warm-water fish species typically reside in the San Juan River mainstem and its tributaries below Fourmile Creek. These species may also use the mainstem and tributaries above this point for spring spawning migration. Of the native warm-water species, the bluehead sucker is expected to range highest in the basin, as this species prefers steeper, faster streams than the flannelmouth sucker. Species success is dependent on adequate base

[68] DOI:10.13140/RG.2.2.19590.63049/2

flows and the availability of high-quality of riffle habitat.[69] Bluehead suckers prefer rocky-bottomed streams with moderately cool temperatures (~68° F). Spawning is triggered by a critical water temperature (~60° F) and, therefore, starts earlier for fish residing at lower elevations in the watershed. Young bluehead suckers prefer slow-moving water close to streambanks. They move to deeper, covered areas away from streambanks as they progress into juvenile and adult life stages. Feeding preferences mirror habitat preferences: larval fish find vertebrates in the deep rocky pools and riffles near shore, and older fish feast on algae, plant detritus and invertebrates in their covered pools and riffles further away from streambanks.[70] Documented heavy use of an intermittent tributary in the Gunnison River basin by spawning bluehead suckers demonstrates that tributaries provide important habitat for this species.[71]

Like the bluehead sucker, the flannelmouth sucker is also dependent on adequate base flows and the quality of riffle and run morphology.[72] Flannelmouth suckers generally inhabit unvegetated murky pools or riffle/run areas in gravel, rock, sand, or mud bottomed streams. Younger fish seek out shallow riffles and eddies near the shore, migrating towards the deeper riffles and runs in adulthood. Larval flannelmouth suckers prey on invertebrates, transitioning to a variety of algae, detritus, plant debris and invertebrates in later life stages. This species will migrate long distances in the spring to find suitable spawning habitat.[73] Documented heavy use of an intermittent tributary in the Gunnison River basin by spawning flannelmouth suckers demonstrates that tributaries provide important habitat for this species.[74]

Roundtail chub are habitat generalists; however, the species remains sensitive to baseflow reductions.[75] Roundtail chub prefer slow-moving, deep pools for cover and feeding but will inhabit streams with a variety of substrate types -- silt, sand, gravel -- and occur in both murky and clear water. Preferred habitat varies by life stage. Juveniles and young-of-year seek out pools and quiet backwaters, while adults gravitate towards eddies and pools adjacent to strong currents. Spawning is triggered by water temperatures, beginning in June or early July when temperatures have reached 65° F. Roundtail chub are carnivorous, opportunistically feeding on available insects, fish, snails, crustaceans, algae and sometimes lizards. They are more likely to be limited by available food resources than by habitat.[76]

Habitats suitable for cold-water and warm-water fish overlap in some portions of the San Juan, Rio Blanco, and Navajo River watersheds. In these areas, it may be possible to find species belonging to both groups. The confluence of the San Juan River and Fourmile Creek is generally considered the dividing line between the expected ranges for cold-water and warm-water fish species on the San Juan mainstem. The Blanco Diversion Dam on the Rio Blanco and the Oso Diversion Dam on the Navajo River also sit at or near the dividing line

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69 Kowalski, "Native and Sport Fish of the San Juan and Dolores Rivers."

70 "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker."

71 Hooley-Underwood, Z.E., S.B. Stevens, N.R. Salinas, and K.G. Thompson. 2019. An intermittent stream supports extensive spawning of large-river native fishes. Transactions of the American Fisheries Society 148:426–441.

72 Kowalski, "Native and Sport Fish of the San Juan and Dolores Rivers."

73 "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker."

74 Hooley-Underwood, Z.E., S.B. Stevens, N.R. Salinas, and K.G. Thompson. 2019. An intermittent stream supports extensive spawning of large-river native fishes. Transactions of the American Fisheries Society 148:426–441.

75 D. Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers," 15-Dec-2010.

76 "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker." Utah Department of Natural Resources, Sep-2006.

for warm and cold-water fish. However, CPW believes that some warm-water fish would move higher in each river to spawn in the spring, if they could pass through or over the diversion structures. Overlapping habitat among native warm-water fish and piscivorous non-native, stocked sport fish like brown trout may suppress native fish populations in some reaches during some periods of the year.

Cold-water native fish species, including Colorado cutthroat trout, mottled sculpin, and speckled dace occur at higher elevations on the San Juan River mainstem and its tributaries. The Colorado cutthroat trout is designated a Colorado Species of Concern. Cutthroat trout lost much of their original habitat range across Colorado and experienced significant population reductions due to impacts from water diversion, stocking of non-native fish species, logging, and mining. Vulnerability to population declines in the future persists due to a significant reduction in range [77]. Cutthroat trout tend to occupy lower order streams and alpine lakes. Occurrence in these streams is correlated to habitat characteristics unfavorable to non-native fish. Populations of cutthroat persist in many areas of the San Juan watershed but receive special management consideration in Himes Creek, Wolf Creek, and the upper Navajo River.

Seasonal migration of native cold-water trout to smaller perennial streams for spawning is triggered by increased flow from spring runoff. Once in spawning habitat, cutthroat wait until water temperatures reach 44-50° F and peak runoff subsides before depositing redds and returning to their stream of origin. The extent of movement between spawning grounds and streams of origin is largely dictated by stream network connectivity. After emergence, fry move to shallow, slow-moving areas near spawning zones before migrating to larger streams. Juveniles and adults favor covered, slow-moving pools and protected areas for feeding in the summer and deep pools, beaver ponds and groundwater upwelling zones during the winter.[78]

The dominant non-native cold-water species in the San Juan watershed include brown trout, rainbow trout and brook trout. These species occupy similar ecological niches to Colorado cutthroat trout, and have become important keystone species and indicators of overall health of riverine ecosystems. Additionally, USFS considers them a Management Indicator Species. Non-native trout populations in the East Fork San Juan are considered stable, but natural reproduction rates are low. These populations are stocked, managed and promoted by CPW as a sports fishery. Rainbow trout are stocked regularly on the East Fork and on the San Juan River in Pagosa Springs. Brown trout are less successful on the San Juan River but are stocked only occasionally. Ecological concerns regarding the impact of brook trout on the viability of Colorado cutthroat trout populations significantly influence management decisions regarding sport fish.

Both brook and brown trout prefer clear streams that support robust and diverse riparian vegetative cover. Brook trout can exist in high population densities, thriving in beaver ponds and other confined areas. Brown trout prefer slightly deeper, slower and warmer water, undercut banks and covered bankside areas, and can tolerate lower quality habitat. Rainbow trout are habitat generalists, but often occupy mid-channel areas. Rainbow and brook trout feed mainly on insects, while brown trout are piscivorous, surviving mainly on other fish [79]. Non-native trout need warmer water temperatures than native cutthroat trout. Of the three non-native species, brook trout tolerates the coldest water temperatures (~57° F). Rainbow trout prefer warmer water temperatures (~70° F), and brown trout need the warmest water temperatures of the three, (~65-75° F) and are, therefore, generally found in the lowest elevations. Spawning and incubation periods for all non-native trout species are partially queued by and dependent on photoperiods and water temperatures. Brook and brown

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[77] "State of the San Juan Watershed 2014"; Lyon and Sovell, "A Natural Heritage Assessment: San Juan and Western Montrose Counties, Colorado"; Kowalski, "Native and Sport Fish of the San Juan and Dolores Rivers."

[78] Young, "Colorado River Cutthroat Trout."

[79] Dare, Carrillo, and Speas, "Common Trout Species and Conservation Assessment for the Grand Mesa, Uncompahgre, and Gunnison National Forests."

trout spawn in the late fall (September-November) when days get shorter and water temperatures fall. Rainbow trout spawn in the spring when water temperatures begin to rise (March-May). Both spring and fall spawning periods fall on the shoulders of the irrigation season when water is diverted from the San Juan River and its tributaries to support agricultural, municipal, and industrial uses. Fall spawning species are probably most impacted by surface water divisions in the San Juan as this is a period of acute water depletion on some stream segments.

Both native cold-water and warm-water fisheries exhibit significant alteration due to historic human management activities. Fishery health in both the San Juan River and the upper reaches of the Rio Blanco and Navajo River watersheds (e.g., above the San Juan – Chama Project diversions) is supported by a relatively natural hydrological regime. Primary challenges to native fishery health across the planning area include habitat fragmentation and competition/hybridization between native and non-native species. These issues are likely to persist into the future and may be further complicated by changes to flow brought about by population growth and/or climate change.

Conservation opportunities for native fishes in the WEP planning area arise from addressing limitations: increasing or protecting flood and summer streamflows; installing fish screens in diversions; providing for fish passage for all resident fish species around or through any man-made structures, particularly during key times of movement (e.g., spawning, seasonal migrations to more-optimal habitat); managing non-native species; improving water quality; controlling or eliminating invasive fish species, and supporting native-fish stocking efforts.

2.8.1 Habitat Fragmentation

Connectivity refers to the physical and biological linkages between stream segments throughout the watershed, as well as linkages between streams and the upland landscape. Longitudinal connectivity relates to upstream-downstream travel of aquatic species and downstream transport of sediment, nutrients, and woody debris. In the management context, stream network connectivity most often relates to the ability of fish and other aquatic species to move throughout a stream network and utilize a range of habitats within a basin or watershed. For many species, unimpeded upstream-downstream movement is vital to spawning success and migration. Wide-ranging native fish species may be particularly sensitive to reductions in network connectivity. Connections between large and small streams in different geomorphological settings allows organisms to locate and utilize refugia during short-term stressful events (e.g., summer temperature warming events). The degree of network connectivity may also dictate how biota within the physical system are able to respond to the long-term land-use changes or the effects of climate change. Protecting and expanding stream network connectivity can, thus, reduce long-term risks for fish and other aquatic organisms created by a changing environment by maximizing opportunities for the use of various habitat types at different points in a given year or season.

Barriers to longitudinal connectivity include all channel-spanning structures such as weirs, large dams and small impoundments, push-up dams or other water delivery infrastructure, culverts, flow-depleted stream reaches too shallow for fish and other organisms to traverse, natural features such as waterfalls or extended steep cascades, and recreational whitewater features. The significance of different features varies by species. Some fish, such as brook and cutthroat trout, can ascend very steep and powerful headwaters reaches. Other warm-water species endemic to the mainstem and lower tributaries may experience greater difficulty navigating around or through such obstacles.

A GIS and limited field-reconnaissance of existing barriers to passage along mainstem rivers and tributary streams in the planning area identified several candidate diversion structures, highway culverts, and other structures for fish passage projects. Critically, the parallel investigation of agricultural infrastructure conducted by SJCD provided critical information about many area diversion structures (Appendix B). Several of the identified structures were reviewed with CPW staff and a preliminary prioritization of needs for reducing habitat fragmentation and increasing network connectivity was developed. The primary causes of habitat fragmentation in the WEP planning area are the San Juan – Chama Project diversion structures. These large, channel-spanning features preclude almost all upstream passage of aquatic organisms on the Rio Blanco, Little Navajo River and Navajo River. Fish passage through these structures would benefit native fish[80]. It's possible that these aging diversion structures will require some upgrades in the near future. It is also possible that opportunity exists to work with U.S. Bureau of Reclamation (USBR) on a significant redesign of these diversions that would simultaneously allow for a more effective passage of aquatic organisms and downstream transport of sediment—potentially reducing maintenance requirements for these structures by a significant margin. Subsequent planning phases should work to engage USBR staff to discuss these concepts.

Increasing connectivity between the mainstem rivers and tributary streams (particularly in the lower 0.5-1.0 miles of those tributaries) throughout the planning area is expected to benefit spawning activities of native warm-water species. The most important consideration for increasing access to tributary streams is the aging Hwy. 160 culvert over McCabe Creek. During subsequent phases of the WEP planning effort, stakeholders should discuss needs and opportunities for working with Colorado Department of Transportation to ensure that reconstruction of this culvert includes aquatic organism passage design elements.

Connectivity improvements higher in the watershed on smaller order streams may benefit cutthroat trout. However, many of the smaller diversion structures present in the watershed do not appear to preclude fish passage. It is also important to note here that increased connectivity between habitats within a stream network is not always desirable. Ensuring the long-term health and genetic purity of some cutthroat trout populations may require establishing or maintaining downstream barriers to passage for other species. Reestablishing connectivity may also allow for the transmission of diseases and parasites or invasion of undesirable non-native fishes. *Any project* aimed at enhancing stream network connectivity should proceed under close coordination with CPW aquatic biologists.

2.8.2 Climate Change Impacts

The water supply needs of cold and warm-water fisheries (sport and native) throughout the WEP planning area were characterized by analyzing relationships between river structure, streamflows, and aquatic habitat quality and extent. This characterization occurred on the mainstem San Juan River, Rio Blanco, Navajo River, and on major tributaries where fisheries were documented and where sufficient data existed to complete an analysis. Most fish species exhibit preferences for certain habitat types, and those preferences change with life-stage. Habitat quality is generally evaluated based on an examination of the way that hydraulic conditions (e.g., water depth and velocity) change with varying streamflow at different times of the year. Where and when optimal conditions exist, fish can utilize local habitat for feeding, sheltering, and reproducing. Changes in streamflow (in timing, magnitude, or frequency) may preclude the use of some stream areas and create barriers to passage for fish or other types of aquatic wildlife.

The nexus between streamflow and habitat conditions for fish is regularly established by way of hydraulic habitat models. Several methodologies exist for assessing local hydraulic conditions against the preferred conditions for various aquatic species. These methodologies include R2Cross, PHABSIM, RHABSIM, the wetted-perimeter method, the Tennant method, and others. The R2Cross methodology uses quickly obtainable hydraulic geometry data and assumes that streamflows sufficient to maintain aquatic habitat in critical riffle segments will also maintain habitat quality in other channel segments such as runs and pools. CWCB and CPW rely extensively on the R2Cross methodology[81] to describe minimum flow needs for assemblages of fish as support for the development of ISF water rights on rivers across Colorado. ISF water rights are established on

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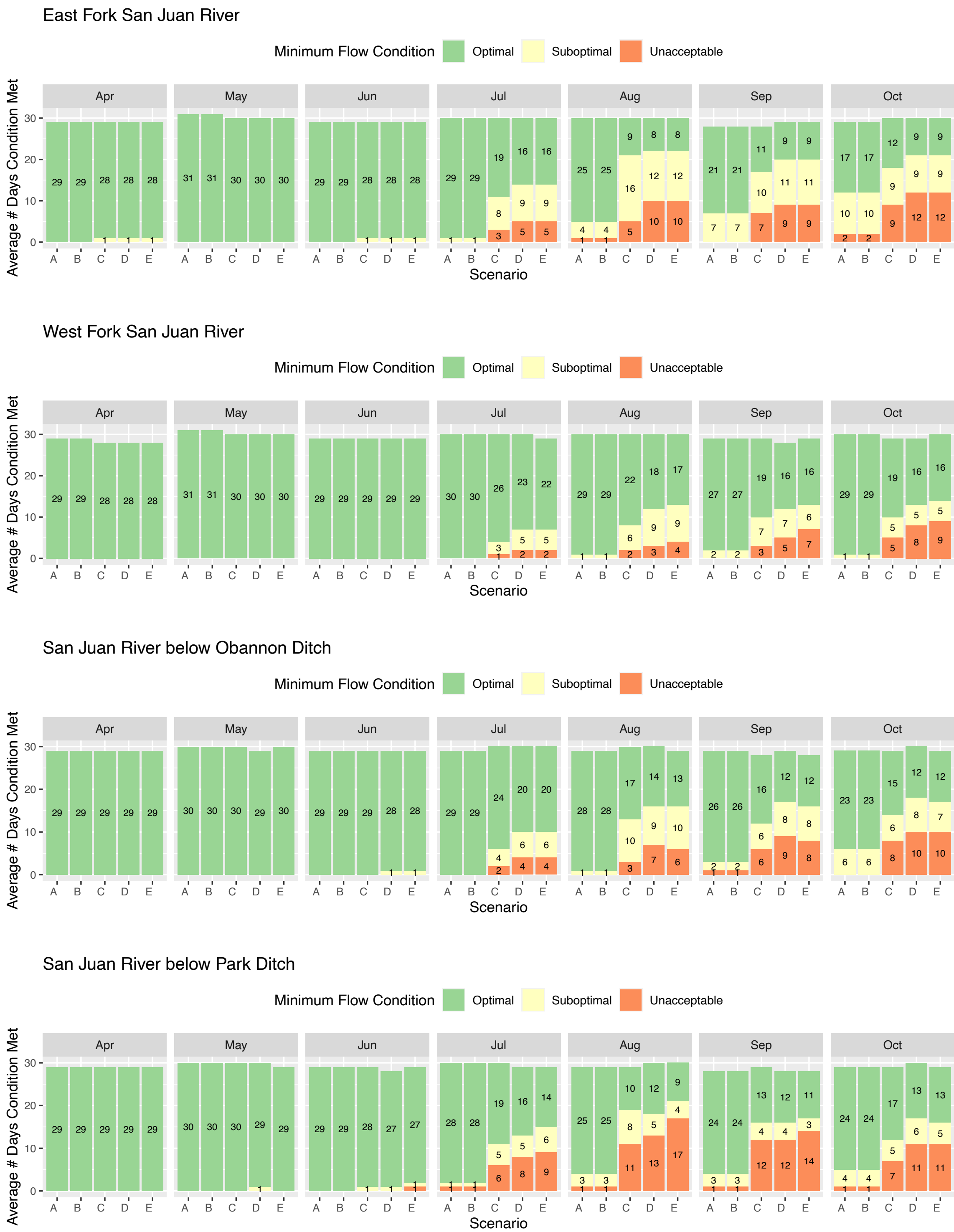
[80] Personal communications with Jim White, CPW Aquatic Biologist and Ryan Unterreinter, CPW Southwest Water Resources Specialist

[81] D. Espegren, "Development of Instream Flow Recommendations in Colorado Using R2Cross.," Colorado Water Conservation Board., Jan. 1996.

many mainstem reaches and tributaries in the planning area. Hydrological simulation models were used to assess the frequency, magnitude and duration of flows falling below ISF water rights under each of the modeling scenarios (Figure 39).



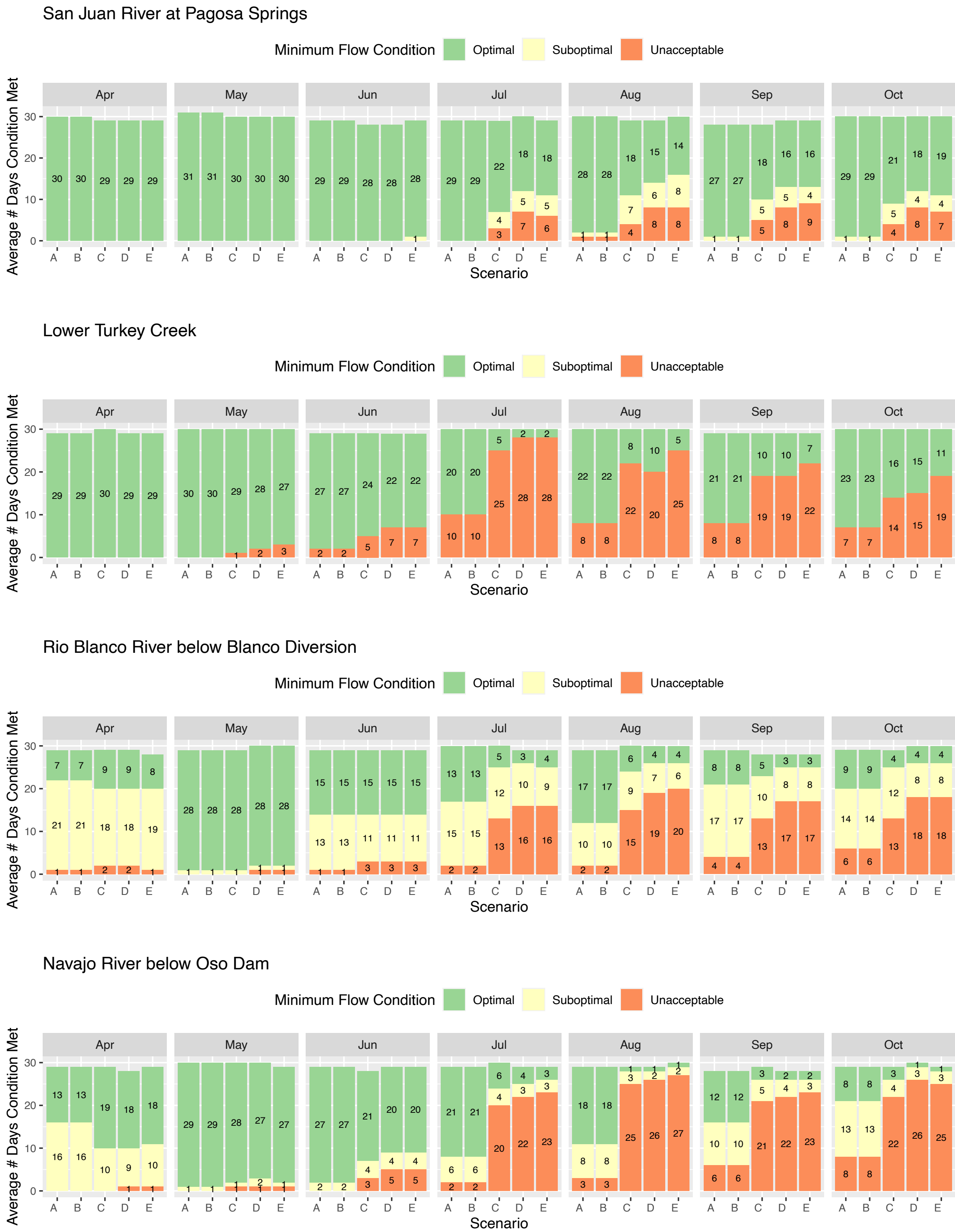


Figure 39. Changing aquatic habitat conditions predicted for stream reaches across the WEP planning area during summer months under several hydrological scenarios. Optimal flow conditions (green) correspond to periods when flows exceed 3-of-3 R2Cross criteria. Suboptimal flow conditions (yellow) correspond to periods when flows exceed 2-of-3 R2Cross criteria. Unacceptable flow conditions (orange) correspond to periods when flows are lower than 2-of-3 R2Cross criteria. Note that not all monthly totals sum to the correct number of days in each month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

Results indicate that minimum streamflow needs for habitat are generally met in the spring and early summer months (Apr-Jun) on most reaches, except the Rio Blanco and Navajo River below the San Juan – Chama Project diversions where suboptimal flows regularly occur in April and June. On all reaches, the number of days characterized as either suboptimal (2-of-3 R2Cross criteria met) or unacceptable (<2 R2Cross criteria met) in the summer and fall months (Jul-Oct) increases with an increasingly warm and dry climate. The effects of climate change on fish habitat quality appear particularly acute on the Navajo River below the Oso Diversion Dam where even a modest amount of warming (i.e., Scenario C) drastically reduced the number of acceptable minimum streamflow days for aquatic biota in the summer and fall.

On all rivers considered by this assessment, the effects of a warming climate on habitat quality (as assessed by R2Cross) is most severe in the late summer and fall. A reduction in streamflows during this period may have an outsized impact on species that spawn in that period. Brown trout may, thus, suffer the most from a warming climate.

The changes in habitat quality observed through the review of ISF flow requirements against predicted hydrological futures suggests that improving stream network connectivity on the Navajo River may be particularly important for ensuring that native fish and sport fish can adapt to changing watershed conditions by migrating to reaches that are more favorable to a particular species/life stage at various times of the year. It is possible that a warming climate produces an upstream expansion of the potential range of native warm-water fish while simultaneously degrading downstream habitat conditions for those same species. The same is likely true for the Rio Blanco and Little Navajo River.

A more nuanced evaluation of the connections between streamflows and habitat quality was developed in several reaches of the San Juan River and East Fork San Juan River. Two-dimensional representations of river flow were simulated with the USGS Flow and Sediment Transport with the Morphological Evolution of Channels (FaSTMECH) model. Model results across a range of flow conditions were used to estimate fish habitat characteristics using physical variables like water depth, velocity, and channel substrate.[82] Different indices of habitat suitability were combined to create a composite suitability index (CSI) for several fish species and life stages. Comparison of hydraulic modeling outputs across a range of flows to CSI values for each species yielded weighted usable habitat area (WUA)[83] curves for each study site. These curves reflect changes in habitat quality in a modeled reach as a function of flow (Figure 40).

Habitat modeling results indicate that WUA for native species generally increases with flows. At both San Juan River sites, habitat conditions were found to be more suitable for warm-water fish than cold-water fish at flows above 200 cfs. Relative comparisons of WUA curves between the species at each site indicate habitat conditions potentially more favorable to bluehead suckers than either flannelmouth suckers as flows increase beyond 300 cfs. WUA values for the non-native sport species indicate conditions may be more favorable to brown trout than rainbow trout at all flows. Both cold-water species seem less sensitive to changes in flow than the warm-water species. It is important to be aware that this assessment did not consider water quality characteristics, angling pressure, inter-species competition, or other factors that may partially dictate species success on a given reach. This assessment instead took a narrow view at the potential limiting effect of streamflow on habitat quality and species success on the selected reaches.

The relationship between streamflow and habitat suitability metrics (described by WUA values) is most useful for river management decision-making when considered within the context of historical hydrology and potential future hydrology changes. Comparing WUAs for each species under the baseline hydrology scenario to the

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[82] https://iric-gui-user-manual.readthedocs.io/en/latest/01_introduction.html.

[83] https://www.ars.usda.gov/ARSUserFiles/60600510/Topashaw/aquatic_habitat_suitability.pdf

range of hydrologic regimes described by other planning scenarios allows stakeholders to predict potential aquatic habitat impacts associated with each of those scenarios. For example, on the San Juan River near Fourmile Creek median August minimum flows are expected to decrease by 63% when shifting from Baseline conditions to conditions proposed under Scenario E. This change in flows corresponds to a greater than 25% decrease in habitat suitability for adult brown trout and a greater than 35% decrease in habitat suitability for adult rainbow trout. Tabular representations of the WUA curves are provided in Appendix F. These tabular results may be used during subsequent WEP planning phases in order to evaluate the impact of changing streamflows at a particular time of year on a given species or life stage. Changing streamflows may be contemplated as a consequence of climate change, reservoir development, water conservation measures, streamflow restoration projects, etc.

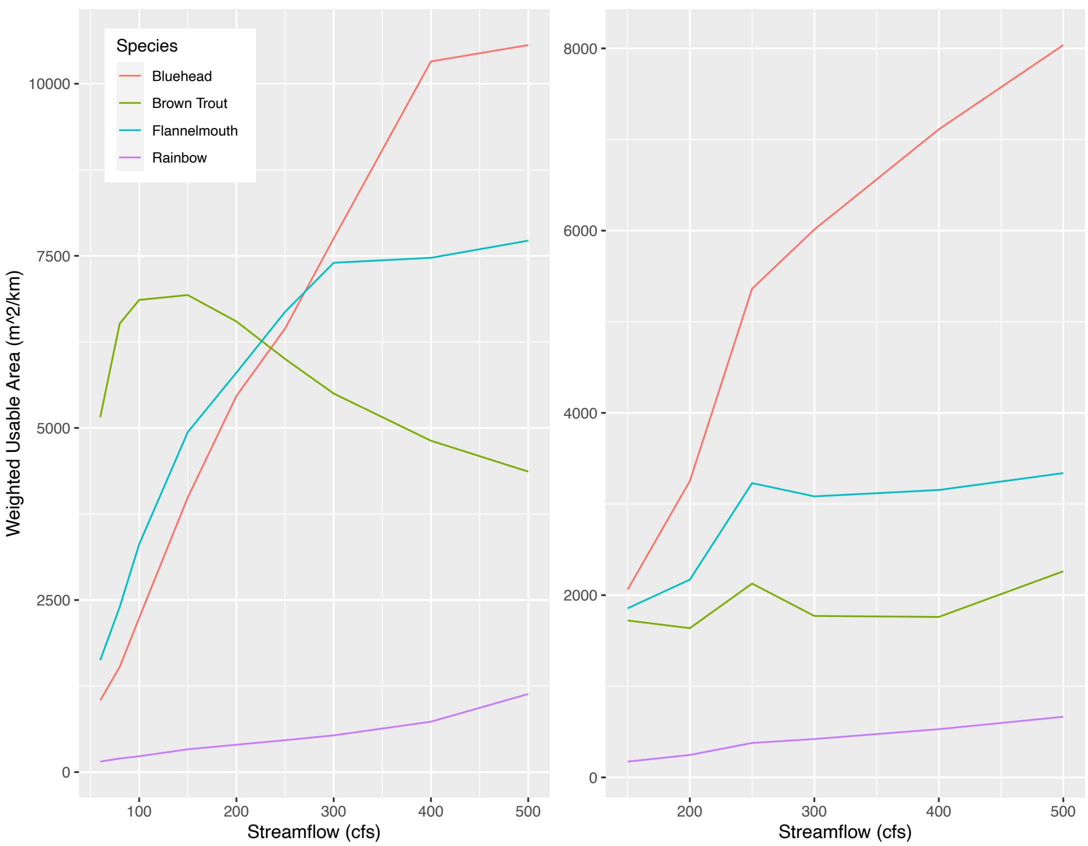


Figure 40. WUA curves generated for adult life-stages of four species in the San Juan near Fourmile Creek (left) and the San Juan at Pagosa Springs (right)

2.9 Recreation

Participation in water-based outdoor recreation activities by residents and nonresidents leads to significant consumer spending and economic activity. Two primary types of river/stream recreational activities were considered by the WEP in this assessment: whitewater boating and angling.

2.9.1 Whitewater Boating

The economic impact of whitewater boating recreation (i.e., canoeing/kayaking, rafting, standup paddle-boarding) by the state of Colorado is estimated at ~$1.5 billion[84]. The state of Colorado estimates that each participant in whitewater boating activities contributes $245 of trip-related spending to the local economy per participation day and spends approximately $434 per year on equipment. These activities are an important contribution to the local economies in the San Juan watershed.

Whitewater boating activity in the San Juan watershed is concentrated on the mainstem San Juan River. Excellent whitewater boating opportunities exist on the East Fork San Juan River and on the mainstem San Juan River between the East Fork and Mesa Canyon below Pagosa Springs. These section features consistent gradients and Class II-III whitewater. Whitewater boating use in the San Juan typically starts in the spring as snowmelt begins and continues through peak runoff and mid-summer until flows get too low to float. The best boating conditions occur during peak runoff (May-June). Private boaters tend to concentrate usage in these time periods. Commercial usage coincides with the tourism season, June-August, and periods when flows are sufficiently high for floating rafts and dories.

Recreational users enjoy whitewater boating in a variety of crafts: canoes, kayaks, duckies, rafts, and stand-up paddle boards. The enjoyment and challenges experienced by users at different flow levels can vary significantly by skill level and by craft. Boaters need enough streamflow to move their craft of choice downriver. However, at lower flows, rapids become more technical. Higher flows increase wave size making rapids more interesting and challenging to navigate. Very high flows can wash out rapids or make them too difficult for safe passage, decreasing boating enjoyment. Very low flows make it impossible to move the craft downstream. Variability in flow, watercraft type, and user experience level produce a wide range in user preferences for flows on various segments of the river. Notably, whitewater features in the Town of Pagosa Springs and several bridges and weirs below Pagosa can make navigation in whitewater craft difficult at some flow levels. Whether or not a given flow is suitable for recreational use is a matter of opinion and is dependent on skill level, local river knowledge, etc.

Recreational user flow preference thresholds for whitewater boating and angling activities were collected from a small focus group of local experts during the WEP Phase II planning effort (Table 10) (Appendix G). Focus group participants included business owners, outfitters, and private users. The solicitation for user preference feedback generally followed the survey approaches implemented by American Whitewater (AW). User flow-preference assessment feedback was provided through an online flow evaluation survey. Participants responded to a series of questions at specific measured flows in each reach, that, when compiled, describe how flows affect recreation quality and identify the range of flows that provide optimal and suboptimal recreation opportunities for several reaches of river. The user survey targeted four reaches in the WEP planning area: 1) East Fork San Juan between the First Bridge and the USFS Campground 2) San Juan River between the East Fork Confluence and Pagosa Springs, 3) the Pagosa Springs town run, 4) and Mesa Canyon.

The availability of recreational use potential on various segments of the East Fork and the San Juan River was quantified by calculating a Boatable Days metric developed by AW. This metric reflects the number of days that optimal, acceptable, and unacceptable use conditions exist under different hydrological conditions. If the streamflow on a particular day fell within a given flow range described as optimal or acceptable, then that day counted as a Boatable Day, regardless of whether or not users actually engaged in recreational activities on that day [85]. A Boatable Days analysis was completed for every day of the simulation period across three hydrological

[84] https://www.americanwhitewater.org/content/Wiki/stewardship:recreation_economics

[85] Fey, "Assessing Boatable Days to Describe Stream-Flow Influenced Recreational Attributes."

year types: moderate-wet, average, and moderate-dry on all reaches designated by stakeholders as important recreational use areas.

Characterization of the number of days falling within various user preference categories, as per the Boatable Days methodology, allows for evaluation of changes in streamflow mediated recreational opportunities between reaches on the San Juan River and on a given reach across months and under different hydrological scenarios. This assessment indicated that most opportunities for recreational boating occur in May and June in the upper and middle watershed. Scenario modeling indicates reductions in the number of "Optimal" and "Low Acceptable" days for those scenarios that include the impacts of climate change (i.e., C, D, and E). The impacts of climate change are most significant in the months of June and July and some shifting of Boatable Days to earlier in the year (i.e., Apr-May) is apparent on all reaches.

Table 10. User preferences for recreational whitewater uses on reaches of the East Fork and the San Juan River.

			User Preference (cfs)				
River	**Reach Description**	**Activity**	**Minimum Navigable**	**Lower Acceptable**	**Lower Optimal**	**Upper Optimal**	**Upper Acceptable**
East Fork	First Bridge to USFS Campground	Rafting	400	450	800	2500	3500
		Kayaking	200	250	600	3000	3500
San Juan	East Fork to River Center	Rafting	400	400	800	2500	3000
		Kayaking	200	250	600	3000	3500
		SUP	250	300	600	1500	2000
	Town Run	Rafting	200	250	500	2500	3500
		Kayaking	150	200	500	3000	3500
		Tubing	0	30	100	250	400
		SUP	150	200	400	2500	3500
	Mesa Canyon	Rafting	300	300	800	2500	3500
		Kayaking	250	300	600	3000	2500
		SUP	300	400	800	500	3500

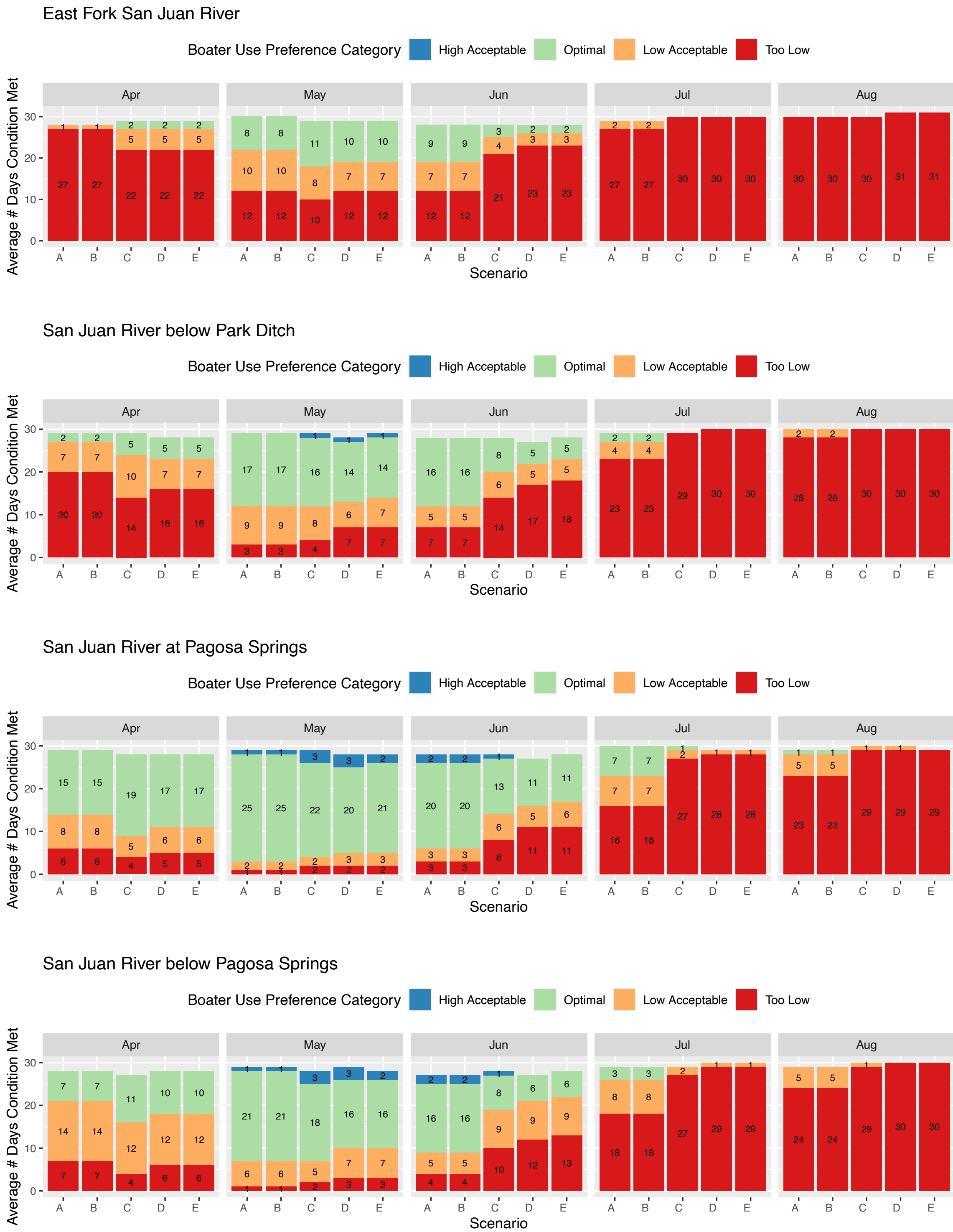


Figure 41. Distribution of boatable days supporting rafting activities across the summer recreation season under a variety of potential future hydrological scenarios on the East Fork and the San Juan River. Note that not all monthly totals sum to the correct number of days in each month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

2.9.2 Angling

The state of Colorado estimates that angling activities generate $120 million in annual economic output in the southwestern portion of the state[86]. River angling activity in the San Juan watershed is concentrated in public access areas along the mainstem San Juan River through Pagosa Springs, along the East Fork of the San Juan, and in Mesa Canyon when conditions are conducive to float fishing. Smaller channels, smaller fish and difficult terrain limit angling activity on most tributary streams. Other mainstem reaches fall largely within private property.

Anglers typically seek out non-native trout (i.e., rainbow, brown and brook trout) on the San Juan River mainstem during the spring, summer and fall seasons. However, some limited angling activities continue on these reaches through the winter months. The region offers exceptional Colorado River cutthroat trout fishing opportunities for individuals willing to trek a bit further from road-accessible streams. High elevation lakes like Quartz Lake and Crater Lake boast robust cutthroat fisheries in spectacular alpine settings. Anglers from around the region regularly travel to the Pagosa Springs region to seek out these emblematic fish.

The availability of recreational use potential on various segments of the San Juan River was quantified by calculating a Fishable Days metric. This metric reflects the number of days that optimal, acceptable, and unacceptable use conditions exist under different hydrological conditions. Angler preferences for various flow conditions along the mainstem San Juan River and for various types of angling (e.g., wade-fishing, bank-fishing, float fishing) were collected via an online survey (Table 11) (Appendix G). The hydrological scenario models were then used to evaluate how angling opportunities change when moving between reaches of the San Juan River. These models were also used to evaluate how those opportunities change under potential population growth and climate change futures.

Critically, the Fishable Days metric does not reflect social or biological constraints on angling activities. For example, climate change scenarios may produce elevated water temperatures that limit angling opportunities or quality before flow conditions do. Additionally, the interactions between the condition and characteristics of the fishery and angler preferences may also limit certain types of angling in some locations and/or during some times of the year. For example, a trend toward warming air temperatures may allow warm-water fish to become the dominant species in many sections of the San Juan River near Pagosa Springs. Anglers may prefer to seek out cold-water species in smaller tributaries if this occurs, even if flow conditions on the San Juan mainstem are suitable for various angling activities. Nonetheless, use of hydrological scenario modeling to characterize the relationship between angler preferences and potential water futures is useful for understanding one of the potential future controls on angling activities on several stream reaches within the WEP planning area.

Table 11. User preferences for recreational angling uses on reaches of the East Fork and the San Juan River.

River	Reach Description	Activity	User Preference (cfs) Minimum Tolerable	Lower Acceptable	Lower Optimal	Upper Optimal	Upper Acceptable
San Juan	East Fork to River Center	Float Fishing	300	400	1250	1500	2000
		Bank Fishing	30	50	100	1000	1500
		Wade Fishing	30	50	100	600	1250
	Town Run	Float Fishing	250	300	400	1250	1500
		Bank Fishing	100	100	200	1250	2500
		Wade Fishing	30	100	150	800	1250
	Mesa Canyon	Float Fishing	200	250	500	1250	2000

[86] https://cpw.state.co.us/Documents/Trails/SCORP/2017EconomicContributions_SCORP.pdf

Scenario modeling results for the San Juan River mainstem display distinct spatial and temporal patterns in Fishable Days that reflect flow-related constraints on the different types of angling. All three use types are most constrained during late summer and fall when flows are low. As flows drop after snowmelt runoff in the early and mid-summer, conditions become more suitable for use. The shift in peak flow timing that characterizes the climate change scenario models tends to increase the number of preferable days for angling in April and May while decreasing the number of days in the optimal preference category in early summer and fall. Decreased late-season flows associated with the climate change scenarios tend to decrease the number of optimal and acceptable days for all angling activities in the Jul-Oct. period.

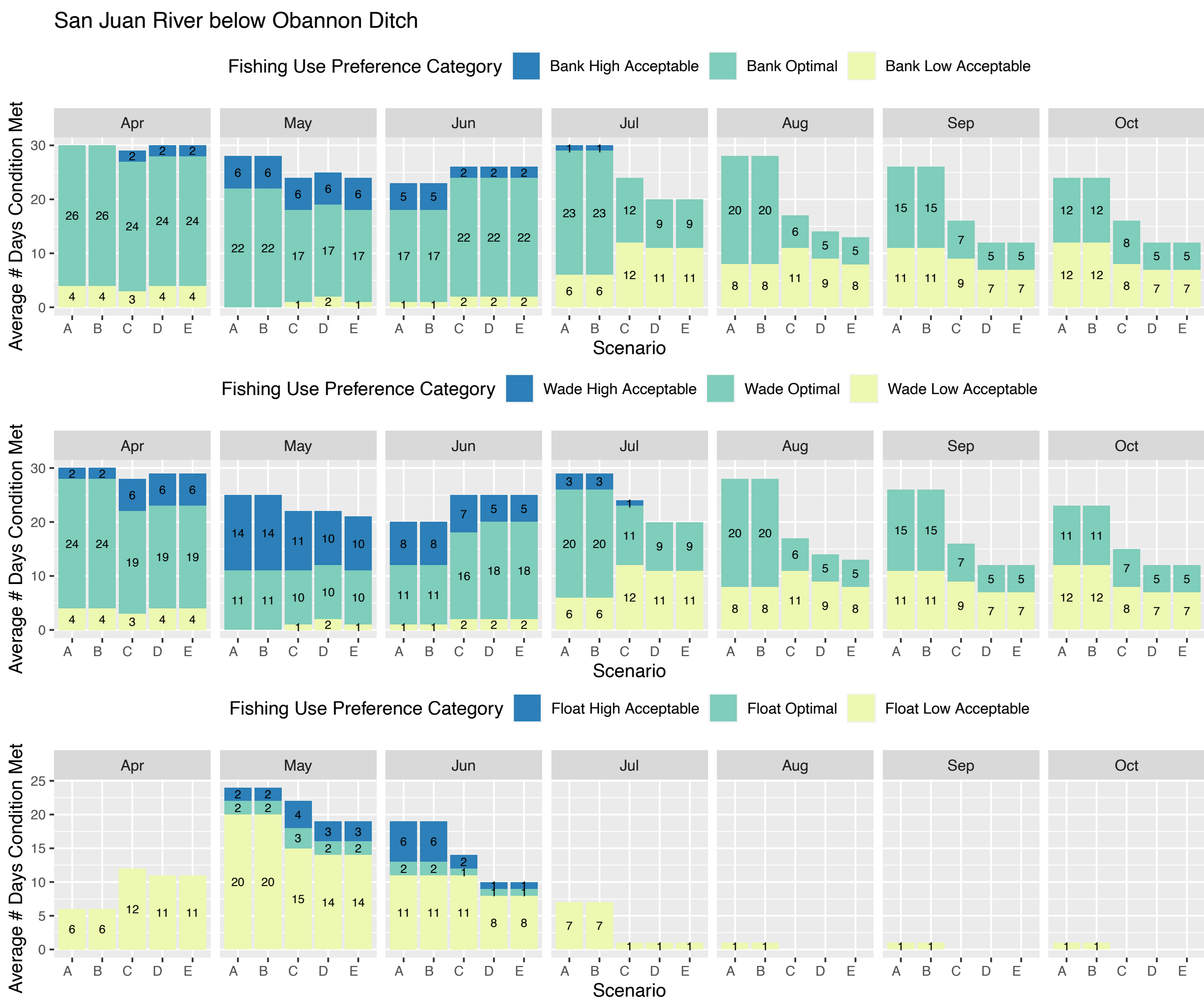


Figure 42. Distribution of the average number of days in each month falling in bank fishing (top), wade fishing (middle), and float fishing (bottom) use preference categories on the San Juan River above Pagosa Springs under a variety of potential future hydrological scenarios. Note that some monthly totals may sum to a greater number of days than are present in a given month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

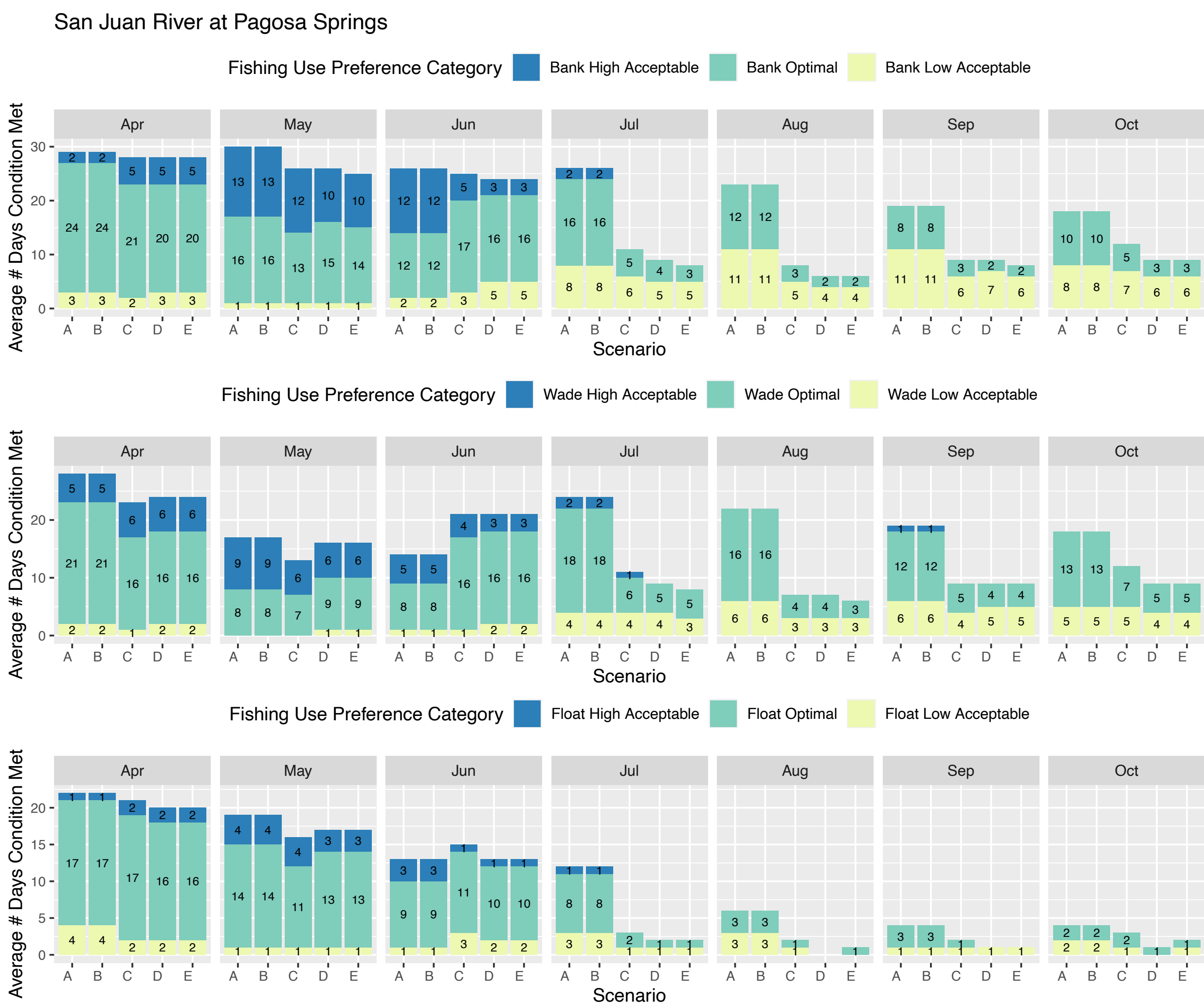


Figure 43. Distribution of the average number of days in each month falling in bank fishing (top), wade fishing (middle), and float fishing (bottom) use preference categories on the San Juan River in Pagosa Springs under a variety of potential future hydrological scenarios. Note that some monthly totals may sum to a greater number of days than are present in a given month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

2.9.3 Management Implications

The climate change shift in the timing of snowmelt runoff to earlier in the year reapportions "Optimal" and "Acceptable" user preference days between months and/or between disparate recreational activities. For example, a reduction in mean streamflow in July may reduce the number of optimal days available for rafting. However, those days may become available for rafting in April or May where they would not have appeared otherwise. That same reduction in flows that reduced the number of optimal days for rafting in July may improve conditions for tubing and increase the number of days available for that activity (Figure 44).

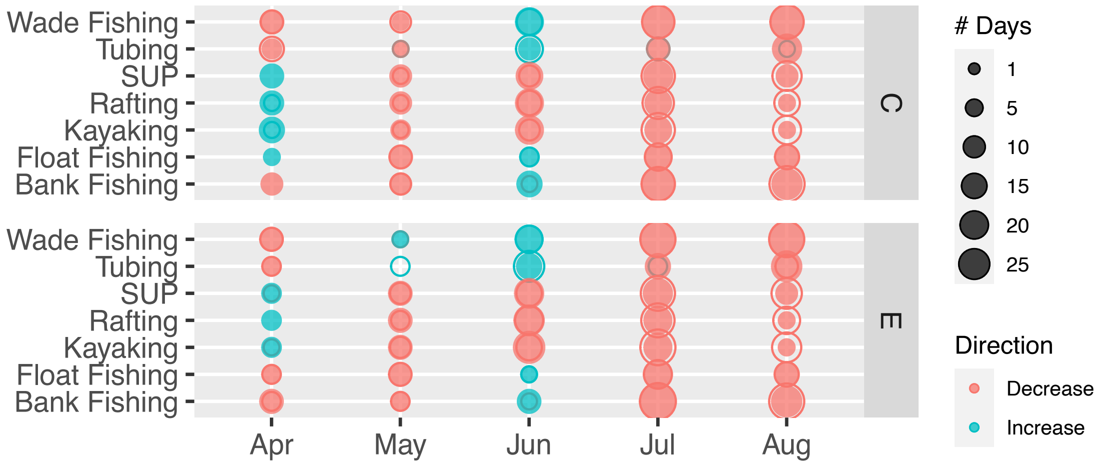


Figure 44. Potential climate change scenarios lead to a reallocation of acceptable and optimal days between various recreational use activities on the San Juan River in Pagosa Springs.

Recreational uses of the San Juan River are currently focused in and below the Town of Pagosa Springs. Use of upstream segments is limited by river characteristics and limited public access. If climate change predictions bear out, the number of days supportive of whitewater and angling activities on the San Juan River through town in any given year will decline. During Phase III, WEP stakeholders may want to contemplate opportunities to "recapture" some of these lost opportunities for the local economy by expanding opportunities for recreational users to take advantage of favorable conditions earlier in the year on river segments upstream of Pagosa Springs. Ideal user access facilities will be supportive of a wide variety of use activities by facilitating trailered boat launches, hand boat launches, and, perhaps, bank, wade, and ADA angling access.

3 NEXT STEPS

The flows in the San Juan River are largely unaltered compared to other western U.S. rivers. However, some segments of the mainstem Rio Blanco, Little Navajo River, and Navajo River and several tributaries are heavily utilized for municipal and agricultural use. The high-level analyses presented here indicate that E&R gaps do exist for the maintenance of riparian and fishery health on some segments. Forest health assessment indicates a trend toward drying forest canopies and an elevated risk of wildfire and subsequent debris flows and sediment transport to stream channels. Hydrological scenario modeling indicates significant potential for changes to hydrological behavior due to climate change and corresponding impacts to the environmental and recreational attributes that streamflows support. The specific impacts to E&R needs associated with climate change vary depending on the attribute of interest, the location in the watershed, and the time of year. Reductions in stream network connectivity caused by the San Juan – Chama Project diversions and the Hwy. 160 road crossing over McCabe Creek may limit access to important habitat for some native and sport fish at some times of the year. Improving stream network connectivity may be a crucial action for ensuring that native and sport fisheries can respond and adapt to changing environmental conditions brought about by climate change. Recreational use opportunities may also be affected by changing streamflow behavior under warmer climate futures. Ensuring no net loss in angling and whitewater activities (and the economic benefits of those activities) on the San Juan River may require the development of new recreational access facilities along the river above Pagosa Springs.

The next phase of the WEP planning effort considers these issues in an effort to identify projects, processes, and collaborative management opportunities (collectively termed "cooperative measures") for meeting and protecting existing consumptive *and* E&R needs in the WEP planning area. Ongoing stakeholder dialog will help ensure that planning activities remain aligned with local and regional perspectives. The planning process will continue to refine its focus and direction through community input on questions including, but not limited to, the following:

1. What are our water use and forest health management priorities?

2. What aspects of fishery and recreational use management are we most concerned about?

3. What kind of water future do we envision for our children growing up in the San Juan watershed?

4. Which water use and management strategies are best suited to avoiding the most undesirable effects of potential climate change?

Stakeholder groups that should be involved in the next planning phase include: agricultural producers, water administrators, representatives from county and municipal government, natural resource agency staff, local and national environmental or conservation organizations, recreational advocates, and other water rights holders. In Phase III of the WEP planning effort, stakeholders will reflect on the information presented in this report and help articulate reasonable management goals for the San Juan River, Rio Blanco, Navajo River and their collective tributaries. These goals will help guide the identification of cooperative measures and the evaluation of their outcomes. Cooperative measures considered by the WEP planning group may include market-based water use/conservation programs, ditch efficiency upgrades, diversion structure reconstruction, phreatophyte control, water storage projects, and channel modifications, process-based stream restoration, recreational access development, among others. Stakeholders will then help evaluate the relative effectiveness and feasibility of each identified cooperative measure. The final planning outcome will be a prioritized list of recommendations for action in the WEP planning area.

3.1 Setting Goals

Surveys, meetings, one-on-one meetings and other approaches will be used to characterize local values related to water uses that support human communities and the environment. Those interactions will help describe a set of planning goals that reflect high-priority issues warranting focused consideration. Goals will respond to the location, behavior, condition, and/or function of the primary attribute(s) of interest to local stakeholders. Planning goals will be used to guide the selection of management alternatives. They also provide a benchmark for evaluating progress toward or away from desired outcomes after some action is taken.

3.2 Identifying and Evaluating Opportunities

Water is a limited resource and balancing consumptive and non-consumptive use needs generally involve tradeoffs. This is certainly the case in the San Juan watershed where the most acute impacts on E&R needs are tied to surface water storage and diversion for agricultural and municipal use. The responses of physical and legal water demands to hydrological conditions determine the allocation of water among the various uses present in the system. For agriculture, the infrastructure used to convey water, the irrigation application method, and the distance of fields from stream systems all influence the timing and location of surface and groundwater return flows. Interaction between water availability and use efficiencies can conspire to create demand shortages at different locations over the course of a year.

Understanding the location, magnitude, and frequency of water use shortages affecting the environment, agriculture, municipal use, and recreation can be useful for identifying locations and times when an opportunity exists for implementing cooperative measures. Understanding water use shortages affecting a diversity of users also assists in identifying those locations and times where and when water availability and other constraints may limit the feasibility or effectiveness of cooperative measures. The first phase of the WEP planning effort included analysis of forest health, streamflow characteristics, and conditions for aquatic biota and riparian areas, and the intersection between streamflow behavior and recreational use opportunities. An assessment performed by SJCD detailed the need for improvements to agricultural water use infrastructure. These data sets and tools provide stakeholders with a framework for evaluating the existence of degraded conditions as they are affected by different hydrological conditions. Furthermore, these tools can be used in a predictive manner to determine whether water supply gaps are likely to increase or decrease following the implementation of various cooperative measures.

It is unlikely that any single management alternative will represent a panacea for improving forest health while, simultaneously, optimizing water use and management between consumptive and environmental and recreational water needs. Rather, each alternative will likely represent a unique set of environmental, capital, and social costs and benefits. Stakeholders will be asked to consider these factors and help prioritize implementation of identified cooperative measures over the short, medium, and long-term.

3.3 Appropriate Use of Assessment Results

This WEP planning effort aims to bring together scientific and engineering evaluations and local stakeholder values/concerns to produce a list of high-priority cooperative measures that produce multiple water-use benefits in the upper San Juan, Rio Blanco and Navajo River watersheds. The first phase of the WEP planning effort relied heavily on existing data sets, studies, and research to evaluate conditions across the San Juan watershed. This report details work completed during Phase II. The evaluations and results presented here represent appraisal level assessments that intend to characterize historical and current conditions at a relatively coarse level across the entire 575 square mile planning area. In some areas data remains scarce and the types of assessment activities that could be completed within the scope of this project were limited. These data limitations produce some uncertainty in results. Understanding the limitations of this assessment is critical for appropriate contextualization of the information presented here during future planning processes and discussions.

In most cases, this document does not contain assessment results of sufficient detail to support new water rights filings or take the place of 1041 permit application review or any component of the National Environmental Policy Act (NEPA) process that may be required for a new water development project. Instead, this document should be used only as foundational information in support of planning-level discussions that identify high-priority projects, processes and management actions that help support a diversity of water uses. Subsequent planning phases are expected to include more detailed, site-specific evaluations.

3.4 Expected Outcomes

The completion of the WEP planning effort will yield a list of projects, processes, and management actions that enjoy a broad base of community support, exhibit limited legal/political/administrative constraints, have identifiable champions for implementation, and present logical funding sources. This list of prioritized actions will guide future action in the upper San Juan, Rio Blanco and Navajo River watersheds and may be used by the SWBRT to describe IPPs during the next update to the Southwest Basin Implementation Plan.

APPENDIX A: MAPS AND GEOSPATIAL DATA

ArcGIS Online Webmap URL for data layers used in report maps and analyses

Access to many of the data layers of interest to stakeholders in the WEP planning area can be found at the following link: https://arcg.is/1GTj8y2

Figures 1 and 2 describe the process for turning individual layers on and off in one of two map viewers. Presentation of data in this format allows stakeholders to review information and create new maps not otherwise included in the main report or appendices.

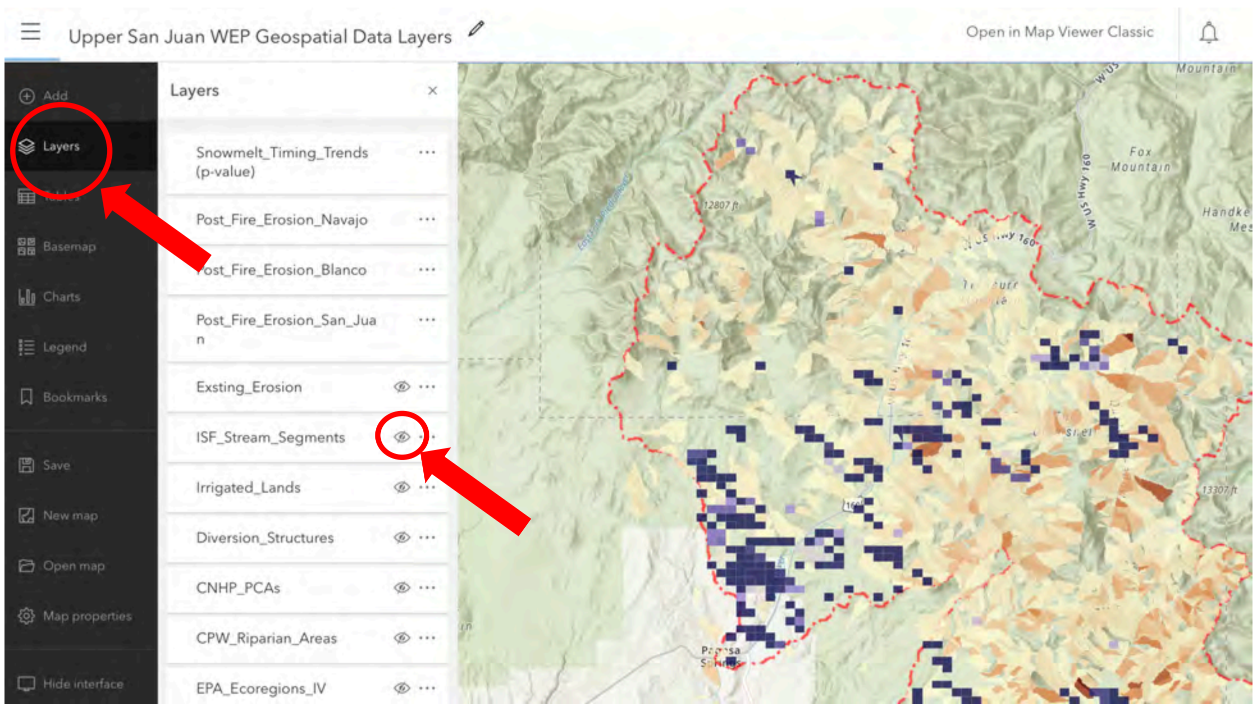


Figure 1. New map viewer option. A subset of the data layers is turned on by default. Explore the entire set of data layers by selecting the "Layers" option from the top of the left sidebar and then clicking on the "eye" icons to toggle layer visibility on and off.

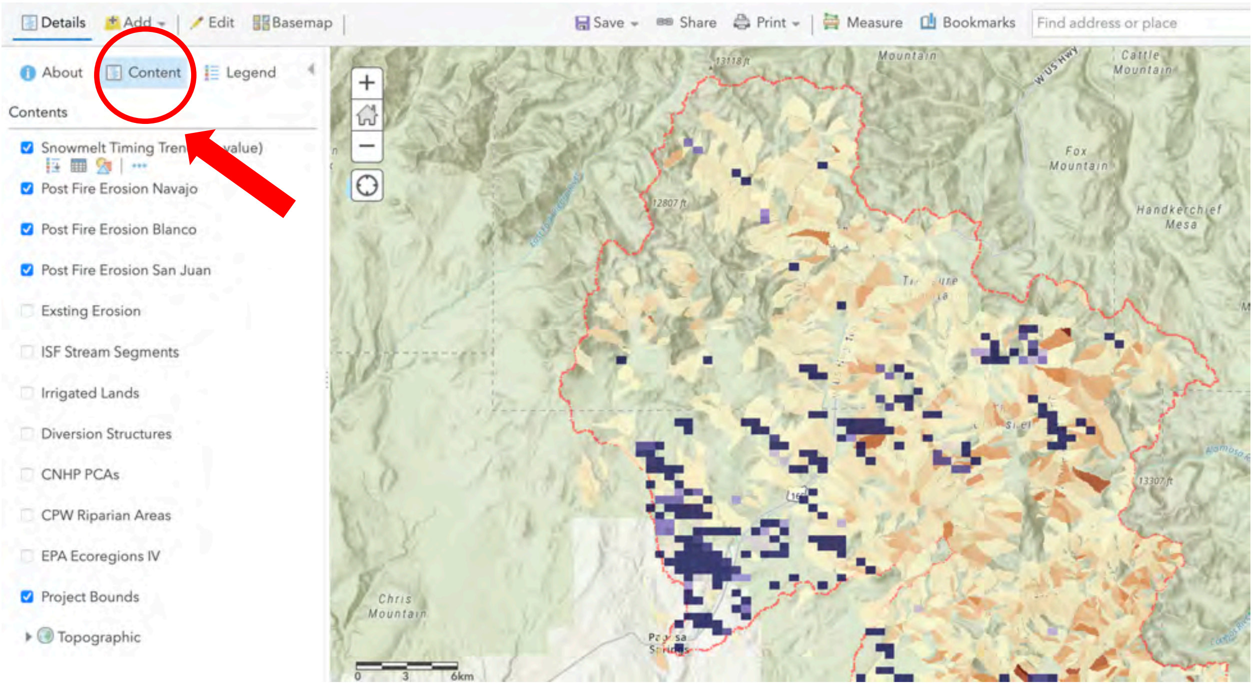


Figure 2. Old map viewer option. A subset of data layers is turned on by default. Explore the entire set of data layers by selecting the "Content" option from the top of the left sidebar and then clicking on the checkboxes next to each layer to toggle layer visibility on and off.

APPENDIX B: AGRICULTURAL INFRASTRUCTURE EVALUATION

San Juan CONSERVATION DISTRICT

The San Juan Conservation District (SJCD), in cooperation with Mountain Studies Institute, conducted field surveys to inventory current conditions of irrigation systems and agricultural water use for the Upper San Juan River. This analysis is to be incorporated into Lotic Hydrological's watershed assessment and modeling for the San Juan Basin.

As drought is becoming a more frequent issue in our area, water availability has become an increasing concern. Compounding this issue is the increased demand for other uses of water. This situation has created a need to find balance for all water uses including irrigation, domestic, recreational, and environmental. We believe conservation is the best alternative to achieve this balance. Also, with increased development, ditch maintenance becomes more difficult and overflow/seepage from these ditches can and has impacted the adjacent residences and infrastructure. This project addressed the efficient delivery of water to critical ditches on the San Juan River and subsequently the individual water users along them with best management practices.

SJCD worked with agricultural water users, appropriate ditch representatives and water right holders to inventory current conditions of irrigation systems and agricultural water use with the project area. The ditches inventoried included Snowball, Mesa, Four Mile, Echo, Highline, Park, Snook, Earl Adams, Colton Montroy, Valley View, Dutton, Hershey, Horse Gulch, and Hidden Valley. On farm irrigation conditions that receive their water from the above ditches were also evaluated. See Attachment 1 for maps of each ditch and on farm parcel irrigation method.

SJCD georeferenced the location of each ditch and all structures or points of interest along each ditch. Each structure/point was marked, the existing structure/condition was noted, and photos were taken. This data was then used to develop cost estimates to address the deficiencies on each ditch.

Inventoried Ditch Length, Miles (Approximate)

Echo, Echo North and Echo South Ditches	12.9
Earl Adams Ditch	1.9
Valley View Ditch	2.9
Mesa Ditch	6.1
Park Ditch	12.8
Snowball Ditch	6.2
Fourmile Ditch	8.5
Horse Gulch Ditch	2.3
Dutton Ditch	8.1
Highline Ditch	3.0
Snooks Lateral	1.7
Colton Montroy	2.0
Hershey Lateral	2.1
Hidden Valley	0.9
TOTAL:	**71.4 miles**

Structure/Inventory Points

Echo, Echo North and Echo South Ditches	49
Earl Adams Ditch	29
Valley View	11
Mesa Ditch	70
Park Ditch	133
Snowball Ditch	90
Fourmile Ditch	39
Horse Gulch Ditch	11
Dutton Ditch	25
Highline Ditch	12
Snooks Lateral	13
Colton Montroy Ditch	14
Hershey Lateral	7
Hidden Valley	5

TOTAL STRUCTURES/POINTS: 508 consisting of the below:

- Division Box
- Headgate
- Diversion (ft)
- Irrigation Pipeline (ft)
- Structure for Water Control - Inlet (no)
- Structure for Water Control - Diversion (no)
- Structure for Water Control - Measuring (no)
- Structure for Water Control – Check Dam (no)
- Structure for Water Control - Culvert (no)
- Earthen Ditch

Approximate # of Irrigators – Total: 160 consisting of 322 irrigated fields (5,374 total acres)

SJCD also contacted each property owner that irrigated with water received from the inventoried ditches. They were offered a free evaluation of their current irrigation system with suggestions for improvement along with cost estimates. Their current irrigation method was mapped (as reflected in Attachment 1). The on farm irrigated fields were broken out into one of three irrigation types: ditch, gated pipe, or sprinkler. Within the project area the total acreage and percent efficiency for each irrigation method is shown below:

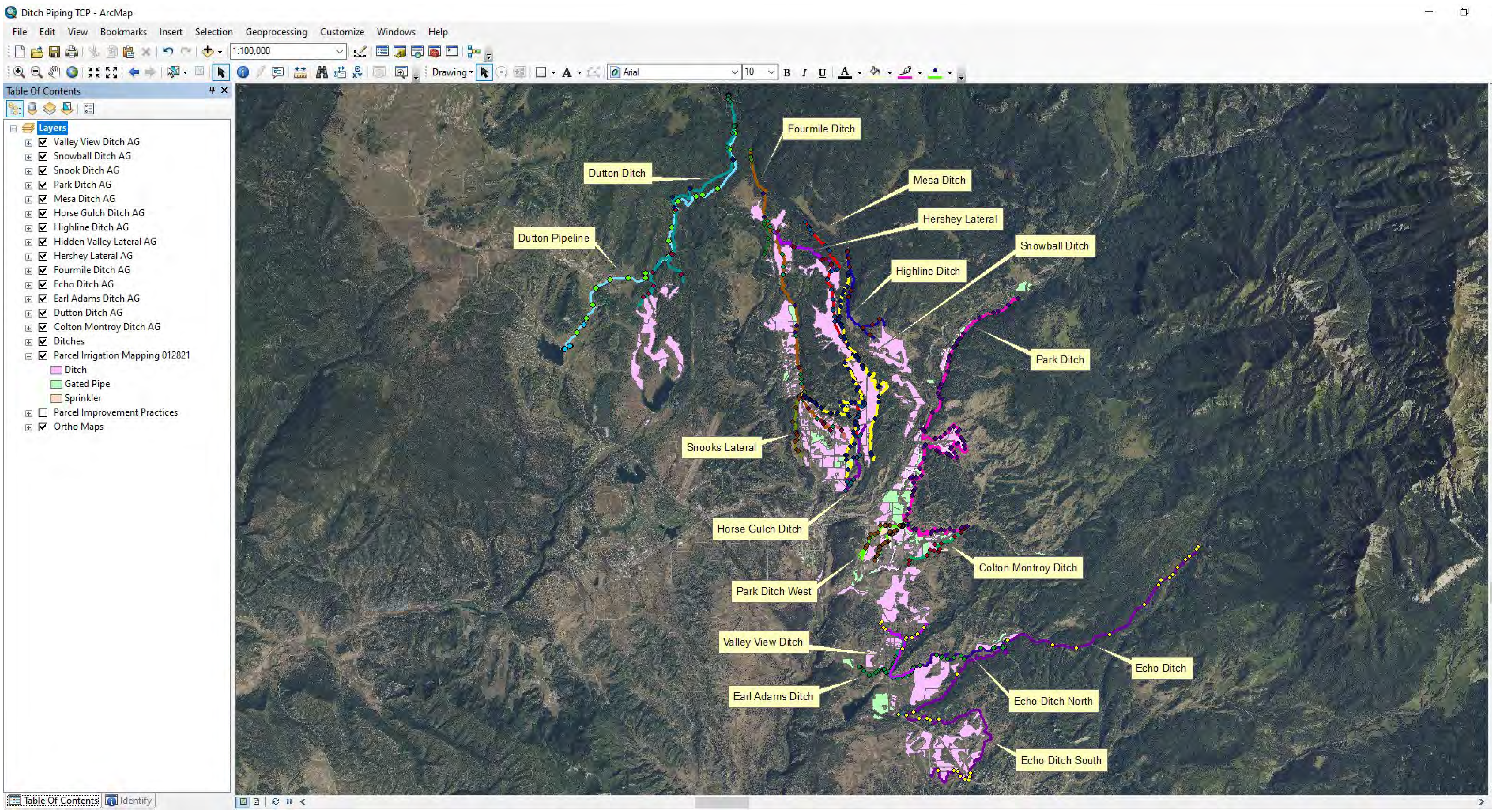
Irrigation Method	Acreage	Percent Efficiency
Ditch	4,664 acres	30%-50%
Gated Pipe	683 acres	50%-60%
Sprinkler	27 acres	70%-75%

Cost estimates were developed to improve each irrigated field to its highest potential efficiency. In most cases this was moving from a ditch irrigation method to gated pipe. There were only a few instances where a sprinkler was suitable. The table below shows the total estimated cost (in descending order from most expensive to the least) for ditch improvements and on farm improvements.

Ditch	Ditch Improvements		On Farm Improvements (OFI)
Snowball	$ 1,141,120.98		
Mesa	$ 1,028,709.10		
Four Mile	$ 1,007,938.80		
Echo South/SW	$ 818,085.90		
Highline	$ 603,220.00		
Park	$ 390,401.82		
Snook	$ 99,540.00		
Snowball West	$ 86,474.80		
Earl Adams	$ 62,127.20		
Park West	$ 60,084.10		
Colton Montroy	$ 46,226.00		
Valley View/West	$ 38,239.62		
Dutton	$ 30,591.20		
Hershey	$ 16,528.00		
Mesa East	$ 12,072.40		
Horse Gulch	$ 7,041.44		
Echo Ditch North	$ 6,923.00		
Snowball Southwest	$ 6,834.30		
Earl Adams West	$ 5,829.52		
Hidden Valley	$ 2,222.00		
Snowball South	$ -		
Echo OFI			$ 795,011.20
Four Mile OFI			$ 611,684.00
Mesa OFI			$ 549,211.30
Colton Montroy OFI			$ 520,650.40
Snowball OFI			$ 302,808.90
Park OFI			$ 288,192.60
Park West OFI			$ 149,590.00
Dutton OFI			$ 100,819.45
Horse Gulch OFI			$ 14,271.60
TOTALS	**$ 5,470,210.18**		**$ 3,332,239.45**
GRAND TOTAL FOR ALL IMPROVEMENTS			**$ 8,802,449.63**

The agriculture water system map and results will be presented to each ditch lead/representative to get feedback on their priorities vs the inventory findings. We will gauge interest in moving forward with installing improvement practices and what level of funding is needed from grants to accomplish the goals of each ditch. We will then seek funding to implement improvements! As the information contained in this inventory is private and confidential, the actual data will only be shared with its respectful owners or representatives. See Attachment 2 for a sample of the data that was collected.

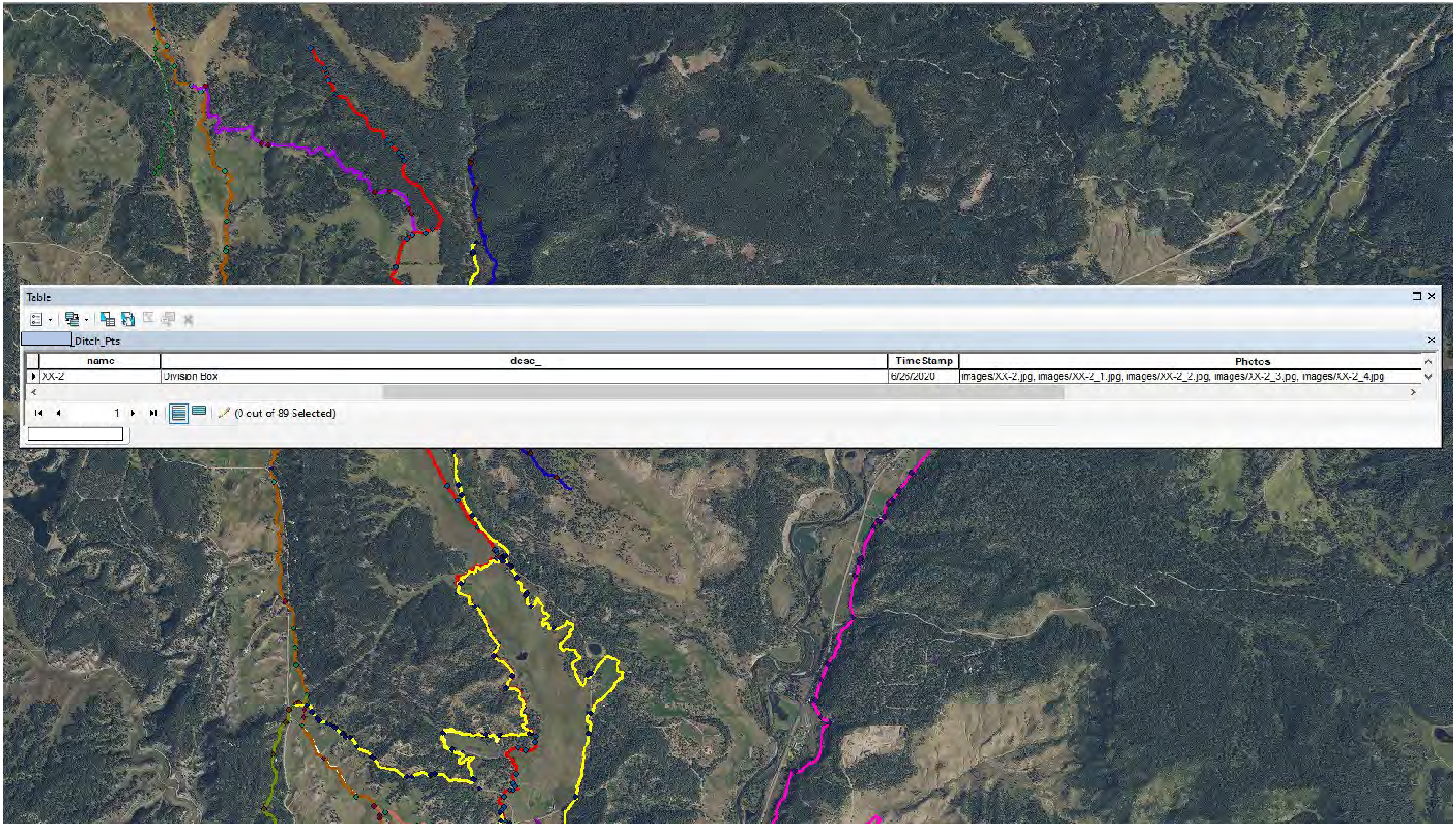
ATTACHMENT 1



ATTACHMENT 2

The data collected for each ditch and on farm irrigation condition is depicted in the sample below.

Sample Point that denotes the structure along ditch and photos taken:



Photos that correspond to above Sample Point:

Division Box Photos

XX-2

XX-2_1

XX-2_2

XX-2_3

XX-2_4

Spreadsheet entry that corresponds to sample point with improvement practices and cost estimate:

	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	**Point Name**	**Photo(s) Taken**	**Existing Infrastructure**	**Existing Infrastructure Size: LxWxH; Feet; Acres**	**Condition Rating**	**Existing Infrastructure Notes**	**Improvement Practice 1**	**Quantity 1**	**Units 1**	**Unit Cost 1**	**Estimate 1**	**Improvement Practice 1 Notes**
3	**XX-2**	**Yes**	**Division Box**	**14' L x 5' W x 3' D, with 5' W wasteway to east**	**Fair - Functioning with major defects**	**Steel box with wood slide gate on main channel, flash boards for wasteway. Bank thin directly downstream of box**	**Division Box**	**1**	**no**	**23870**	**$ 23,870.00**	**replace with similar steel structure, 1/4" steel plate, 16' L x 5' W x 3' H main box with slide gate, east extension 8' L x 5' W x 3' H with 2' drop, flashboard controlled, see sketch, 5031 lbs steel**

XX Ditch | XX Ditch Parcel Improv. | Field Lists | Field Sheet

Continuation of spreadsheet entry that corresponds to sample point with alternative improvement practice:

	AE	AF	AG	AH	AI	AJ	AW	AX	AY	AZ	BA	BB	BC	BD
1	Improvement Practice 2	Quantity 2	Units 2	Unit Cost 2	Estimate 2	Improvement Practice 2 Notes	Total Cost	Priority	Comments	WGS 84 13 N Easting	Northing			
3	Division Box	1	no	22728	$ 22,728.00	concrete box, same dimensions as steel box alternative, 8" thick, 12 cubic yards concrete	$ 23,870.00		working in spite of age and condition of metal and wood, but could be replaced	322656	4134634			
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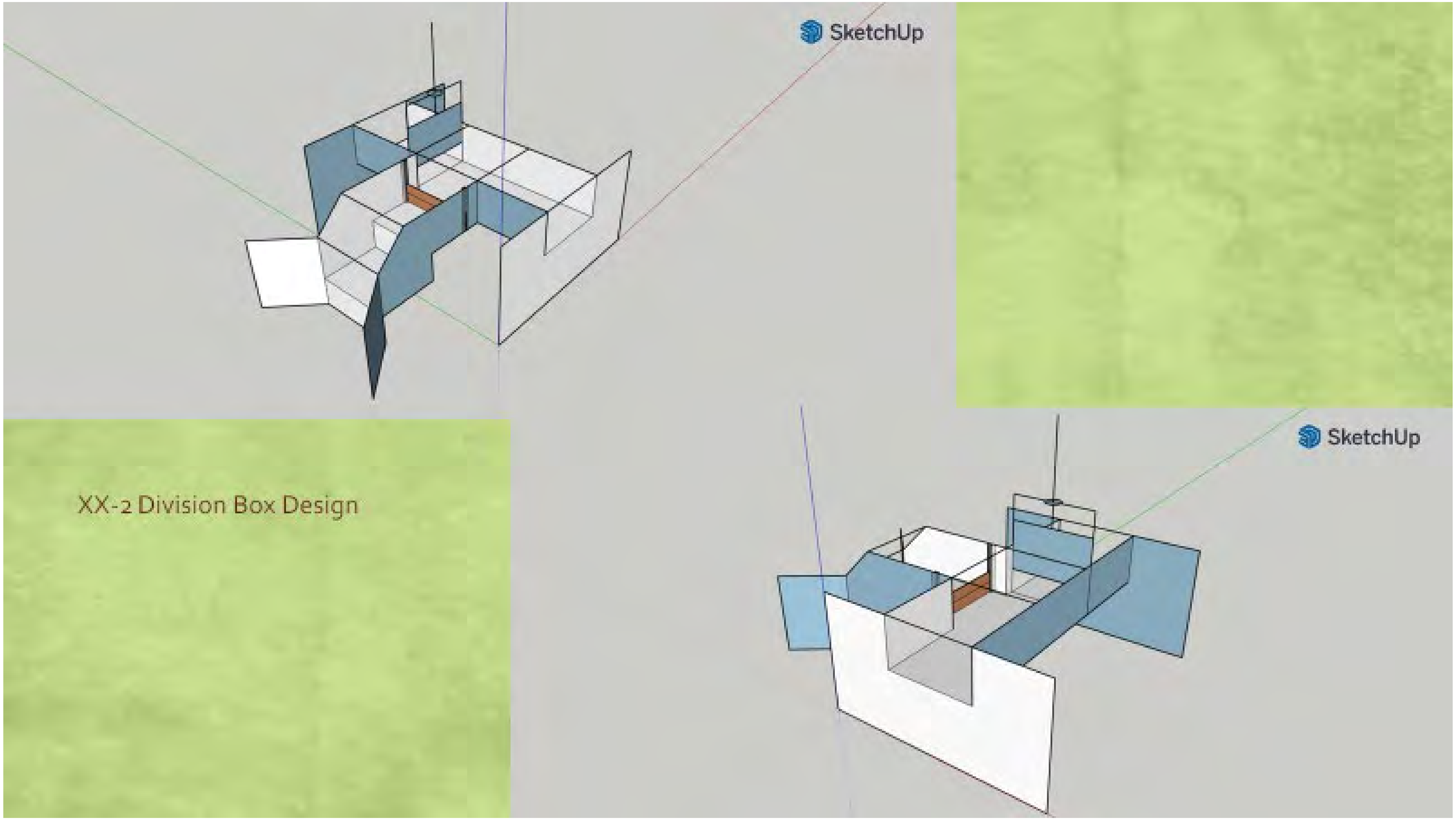
XX Ditch | XX Ditch Parcel Improv. | Field Lists | Field Sheet

The total cost depicted is the most expensive alternative prescribed for the condition.

Design that corresponds to improvement practice in above spreadsheet (dimensions are listed in spreadsheet description):



Once the agricultural inventory has been presented to each ditch leader, the improvement practices will be prioritized.

APPENDIX C: HYDROLOGICAL ASSESSMENT METHODOLOGIES AND RESULTS

Hydrological Assessment Methods & Results

1 Introduction

Effective water management and future planning require robust analyses of how the hydro-climatic system is, or is not, changing. In many snowmelt dominated systems across the western US decreasing snowfall and increasing temperatures are stressing water demands (CITE), and leading to increased attention directed at water use planning under an uncertain and changing future. In situations where trends in hydroclimatic data are detected (e.g., decreasing streamflow), these trends can be projected into the future, or climate model forecasts can be utilized to predict potential conditions in the coming decades. In this analysis we used analysis of historic trends in streamflow and scenario modeling of future hydro-climatic regimes to help facilitate conversations focused on potential management strategies. This document summarizes the methodologies and primary results produced by the following activities in the WEP planning area:

- Hydrological trends analysis at historical streamflow gauges;
- Validation of hydrological simulation modeling results produced by disaggregating monthly StateMod simulation results to daily time series; and
- Hydrological scenario analysis characterizing future potential impacts of population growth and climate change

2 Hydrological Trends Analysis

Trend analysis is a common approach to evaluating time-series of hydrological (e.g., streamflow) or climatological (e.g., precipitation) data. In general, it is recommended to use a 30-year period of data for hydro-climatological trend analysis, as this is the period of data used to compute climate "normals". Hydrological and climatological normals are long-term (i.e., 30-year) averages and are updated by state and federal agencies every 10 years.

We performed a trend analyses for streamflow data from eight gauges in the study region (see Table 1). We used a minimum period of 30-years of streamflow data at each site to evaluate trends, but also used a period beyond 30-years, when available, to determine how trend significance changed, or remained the same, as the window size of observation varied. The Mann-Kendall trend test is a non-parametric statistical evaluation to determine whether a parameter of interest (e.g., peak annual flow) is changing over time. This statistical test provides p-values that can be used to identify significant or non-significant trends. In this analysis we defined p-values of less than 0.05 as significant. We computed the Thiel-Sen's slope to characterize the slope of a significant trend in a hydro-climatological parameter over time. The units of the slope depend on the parameter. For example, if the analysis evaluates peak annual streamflow, the units will be in terms of flow (e.g., cubic feet per second, cfs) per year. All computations were performed in the R statistical computing environment.

One-hundred seven statistical metrics (Table 2) of streamflow behavior were computed for each year in a period of record for a given stream gauge. The computed metrics of streamflow behavior included annual means, maximums, medians, and minimums as well as information on seasonal flow values and monthly flow values. Annual values were computed for each metric at each station for each year in the period of record. The time series was pre-whitened to remove lag-1 autocorrelations and a Mann-Kendall trend tests was performed on the resultant time series of annual values. The Theil-Sen slope was also computed.

Four of the eight gauges used in this analysis are currently active and accordingly are more reflective of current conditions and trends in streamflow (see Table 1). As such, we present the most relevant information derived from analysis of the active stream gauges in the subsequent sections.

Table 1. Stream gauges used in historical streamflow trend analysis.

Gauge name	Gauge ID	Agency	Period of record	Active: Y/N
San Juan River at Pagosa Springs	09342500	USGS	10/1/1935-current	Y
Navajo River at Banded Peak Ranch	09344000 (NAVBANCO)	USGS (CDWR)	10/1/1936-9/29/1995 (7/22/1991-current)	Y
Navajo River below Oso Diversion Dam	09344400 (NAVOSOCO)	USGS (CDWR)	3/1/1971-9/29/1998 (4/15/1985-current)	Y
Little Navajo below Oso Diversion Dam	LITOSOCO	CDWR	12/6/1996-current	Y
West Fort San Juan River near Pagosa Springs	09341500	USGS	10/1/1935-9/29/1998	N
Navajo River above Chromo	09344300	USGS	10/1/1956-9/29/1970	N
East Fork San Juan River above Sand Creek	09339900	USGS	10/1/1956-9/29/2003	N
Rio Blanco below Blanco Diversion Dam	09343300	USGS	3/1/1971-9/29/1998	N

Table 2. List of 107 streamflow statistics that were tested for trend using a Mann-Kendall trend test and computation of the Thiel-Sen slope.

Statistic	**Description**	**Units**	**Units Abbrv.**
Annual_Maximum	Annual Maximum	cubic feet per second	cfs
Annual_Mean	Annual Mean	cubic feet per second	cfs
Annual_Median	Annual Median	cubic feet per second	cfs
Annual_Minimum	Annual Minimum	cubic feet per second	cfs
Annual_P10	Annual 10th Percentile	cubic feet per second	cfs
Annual_P90	Annual 90th Percentile	cubic feet per second	cfs
Apr_Maximum	April Maximum	cubic feet per second	cfs
Apr_Mean	April Mean	cubic feet per second	cfs
Apr_Median	April Median	cubic feet per second	cfs
Apr_Minimum	April Minimum	cubic feet per second	cfs
Apr_P10	April 10th Percentile	cubic feet per second	cfs
Apr_P20	April 20th Percentile	cubic feet per second	cfs
Apr-Jun_Volume_ft3	April-June Volume	cubic feet	cf
Apr-Jun_Yield_in	April-June Yield	inches	in
Apr-Sep_Volume_ft3	April-September Volume	cubic feet	cf
Apr-Sep_Yield_in	April-September Yield	inches	in
Aug_Maximum	August Maximum	cubic feet per second	cfs
Aug_Mean	August Mean	cubic feet per second	cfs
Aug_Median	August Median	cubic feet per second	cfs
Aug_Minimum	August Minimum	cubic feet per second	cfs
Aug_P10	August 10th Percentile	cubic feet per second	cfs
Aug_P20	August 20th Percentile	cubic feet per second	cfs
Days_Above_Normal	Days Above Normal	days	days
Days_Below_Normal	Days Below Normal	days	days
Days_Outside_Normal	Days Outside Normal	days	days
Dec_Maximum	December Maximum	cubic feet per second	cfs
Dec_Mean	December Mean	cubic feet per second	cfs
Dec_Median	December Median	cubic feet per second	cfs
Dec_Minimum	December Minimum	cubic feet per second	cfs
Dec_P10	December 10th Percentile	cubic feet per second	cfs
Dec_P20	December 20th Percentile	cubic feet per second	cfs
DoY_25pct_TotalQ	Day of Year 25% of Total Flow Volume	days	days
DoY_33pct_TotalQ	Day of Year 33% of Total Flow Volume	days	days
DoY_50pct_TotalQ	Day of Year 50% of Total Flow Volume	days	days
DoY_75pct_TotalQ	Day of Year 75% of Total Flow Volume	days	days
Feb_Maximum	February Maximum	cubic feet per second	cfs
Feb_Mean	February Mean	cubic feet per second	cfs

Feb_Median	February Median	cubic feet per second	cfs
Feb_Minimum	February Minimum	cubic feet per second	cfs
Feb_P10	February 10th Percentile	cubic feet per second	cfs
Feb_P20	February 20th Percentile	cubic feet per second	cfs
Jan_Maximum	January Maximum	cubic feet per second	cfs
Jan_Mean	January Mean	cubic feet per second	cfs
Jan_Median	January Median	cubic feet per second	cfs
Jan_Minimum	January Minimum	cubic feet per second	cfs
Jan_P10	January 10th Percentile	cubic feet per second	cfs
Jan_P20	January 20th Percentile	cubic feet per second	cfs
Jan-Jun_Volume_ft3	January-June Volume	cubic feet	cf
Jan-Jun_Yield_in	January-June Yield	inches	in
Jan-Mar_Volume_ft3	January-March Volume	cubic feet	cf
Jan-Mar_Yield_in	January-March Yield	inches	in
Jul_Maximum	July Maximum	cubic feet per second	cfs
Jul_Mean	July Mean	cubic feet per second	cfs
Jul_Median	July Median	cubic feet per second	cfs
Jul_Minimum	July Minimum	cubic feet per second	cfs
Jul_P10	July 10th Percentile	cubic feet per second	cfs
Jul_P20	July 20th Percentile	cubic feet per second	cfs
Jul-Dec_Volume_ft3	July-December Volume	cubic feet	cf
Jul-Dec_Yield_in	July-December Yield	inches	in
Jul-Sep_Volume_ft3	July-September Volume	cubic feet	cf
Jul-Sep_Yield_in	July-September Yield	inches	in
Jun_Maximum	June Maximum	cubic feet per second	cfs
Jun_Mean	June Mean	cubic feet per second	cfs
Jun_Median	June Median	cubic feet per second	cfs
Jun_Minimum	June Minimum	cubic feet per second	cfs
Jun_P10	June 10th Percentile	cubic feet per second	cfs
Jun_P20	June 20th Percentile	cubic feet per second	cfs
Mar_Maximum	March Maximum	cubic feet per second	cfs
Mar_Mean	March Mean	cubic feet per second	cfs
Mar_Median	March Median	cubic feet per second	cfs
Mar_Minimum	March Minimum	cubic feet per second	cfs
Mar_P10	March 10th Percentile	cubic feet per second	cfs
Mar_P20	March 20th Percentile	cubic feet per second	cfs
May_Maximum	May Maximum	cubic feet per second	cfs
May_Mean	May Mean	cubic feet per second	cfs
May_Median	May Median	cubic feet per second	cfs
May_Minimum	May Minimum	cubic feet per second	cfs
May_P10	May 10th Percentile	cubic feet per second	cfs
May_P20	May 20th Percentile	cubic feet per second	cfs
Min_1_Day	Minimum 1-Day	cubic feet per second	cfs
Min_1_Day_DoY	Minimum 1-Day Day of Year	days	days
Min_3_Day	Minimum 3-Day	cubic feet per second	cfs
Min_3_Day_DoY	Minimum 3-Day Day of Year	days	days
Min_30_Day	Minimum 30-Day	cubic feet per second	cfs
Min_30_Day_DoY	Minimum 30-Day Day of Year	days	days
Min_7_Day	Minimum 7-Day	cubic feet per second	cfs
Min_7_Day_DoY	Minimum 7-Day Day of Year	days	days
Nov_Maximum	November Maximum	cubic feet per second	cfs
Nov_Mean	November Mean	cubic feet per second	cfs
Nov_Median	November Median	cubic feet per second	cfs
Nov_Minimum	November Minimum	cubic feet per second	cfs
Nov_P10	November 10th Percentile	cubic feet per second	cfs
Nov_P20	November 20th Percentile	cubic feet per second	cfs
Oct_Maximum	October Maximum	cubic feet per second	cfs
Oct_Mean	October Mean	cubic feet per second	cfs
Oct_Median	October Median	cubic feet per second	cfs
Oct_Minimum	October Minimum	cubic feet per second	cfs
Oct_P10	October 10th Percentile	cubic feet per second	cfs
Oct_P20	October 20th Percentile	cubic feet per second	cfs
Oct-Dec_Volume_ft3	October-December Volume	cubic feet per second	cfs
Oct-Dec_Yield_in	October-December Yield	cubic feet per second	cfs
Sep_Maximum	September Maximum	cubic feet per second	cfs
Sep_Mean	September Mean	cubic feet per second	cfs
Sep_Median	September Median	cubic feet per second	cfs
Sep_Minimum	September Minimum	cubic feet per second	cfs
Sep_P10	September 10th Percentile	cubic feet per second	cfs
Sep_P20	September 20th Percentile	cubic feet per second	cfs
Total_Volume_ft3	Total Volume	cubic feet	cf
Total_Yield_in	Total Yield	inches	in

2.1 SAN JUAN RIVER AT PAGOSA SPRINGS, CO (USGS 09342500)

We identified 15 significant trends in the 1990 to 2020 flow record at the San Juan River at Pagosa Springs gauge. The period of record for this gauge extends from 10/1/1935 to 3/28/2021. Fourteen of the fifteen significant trends identified trends had a negative Thiel-Sen's slope. The only non-negative slope was Min_1_Day_DoY. July-September flow volume is decreasing and August and September flows (mean, median, minimum) are all decreasing. The August mean is decreasing by 2.9 cfs/year and the September mean is decreasing by 3.6 cfs/year. The medians are decreasing by 2 and 3 cfs/year for August and September, respectively (see Table 3).

Table 3. Trend analysis for San Juan River at Pagosa Springs (USGS gauge 09342500) showing only significant trends (i.e., p < 0.05). Explanation of headers: trend = the Thiel-Sen's slope, sig = the p-value, n_years = the number of years used in the analysis. The number of years may change between variables because the pre-whitening process removes lag-1 autocorrelation from the analysis, which provides a more conservative trend analysis.

Statistic	trend	sig	n_years	mean	median	min	max
Min_1_Day_DoY	1.3875	0.0449	32	190.34	238.50	1.00	362.00
Jul-Sep_Volume_ft3	-30620160.0000	0.0083	31	1682939111.23	1454569920.00	173449728.00	5091292800.00
DoY_25pct_TotalQ	-0.4615	0.0002	30	124.57	126.50	100.00	141.00
DoY_33pct_TotalQ	-0.3333	0.0126	30	133.30	135.00	109.00	149.00
Aug_Mean	-2.9187	0.0204	31	179.51	163.59	13.43	740.42
Aug_Median	-2.0435	0.0457	31	151.56	142.00	10.80	681.00
Aug_Minimum	-1.3091	0.0323	31	80.78	69.00	8.29	385.00
Aug_P10	-1.1800	0.0420	31	99.79	83.10	8.52	560.00
Aug_P20	-1.5300	0.0323	31	111.04	92.80	9.11	586.00
Sep_Mean	-3.5951	0.0048	31	173.04	146.12	18.85	598.27
Sep_Median	-2.9333	0.0083	31	137.81	106.00	16.10	682.00
Sep_Minimum	-0.9100	0.0204	31	67.83	56.60	8.33	251.00
Sep_P10	-1.1580	0.0168	31	77.02	64.62	8.93	309.00
Sep_P20	-1.3200	0.0224	31	87.18	71.60	9.61	364.20

2.2 Little Navajo below OSO diversion dam (CDWR LITOSOCO)

We identified 8 significant trends in the 1996 to 2020 flow record at the Little Navajo below Oso Diversion Dam. The period of record for this gauge extends from 12/06/1996 to present (as of April 2021). There are decreasing trends for April mean, median, P10 and P20 (see Table 4). There is an increasing trend in July-September volume at this location. A caveat of this gauge is that the record is only 24 years long in total and that the number of years used in the July to September volume analysis was n = 18. This decrease in years used is a consequence of the pre-whitening process that removes lag-1 autocorrelation from the trend analysis.

Table 4. Trend analysis for Little Navajo below Oso Diver Dam (CDWR LITOSOCO) showing only significant trends (i.e., p < 0.05). Explanation of headers: trend = the Thiel-Sen's slope, sig = the p-value, n_years = the number of years used in the analysis. The number of

years may change between variables because the pre-whitening process removes lag-1 autocorrelation from the analysis, which provides a more conservative trend analysis.

Statistic	trend	sig	n_years	mean	median	min	max
Jul-Sep_Volume_ft3	390960.0000	0.0294	18	23803214.40	23862816.00	6756134.40	42405120.00
DoY_50pct_TotalQ	0.3333	0.0124	16	143.19	144.50	117.00	157.00
Jan_Maximum	0.0836	0.0080	23	3.33	3.10	0.84	8.72
Apr_Mean	-0.1577	0.0131	23	6.47	6.04	4.44	13.72
Apr_Median	-0.1355	0.0484	23	5.99	5.39	4.14	13.25
Apr_P10	-0.0579	0.0034	23	4.77	4.56	3.80	7.33
Apr_P20	-0.0733	0.0007	23	5.03	4.84	3.95	8.09
Dec_Maximum	0.1256	0.0321	23	4.23	3.28	1.09	13.70

2.3 NAVAJO RIVER BELOW OSO DIVERSION DAM (USGS 09344400)

We identified 29 significant trends in the 1990 to 2020 flow record at the Navajo River below Oso Diversion Dam gauge. The period of record for this gauge extends from 3/1/1971 to 9/29/1998. This gauge has been operated by the CDWR since 1985. This record was combined with the record from the NAVOSOCO gauge, which has a period of record that extends from 4/15/1985 to 3/30/2021. These two gauge records were combined to obtain a longer duration streamflow period. Of the 29 significant trends, 28 are trending in the negative direction. Most statistics between March and September are decreasing. The means, medians, and minimum values across those months are generally decreasing. July and August median values are decreasing by 0.3 and 0.4 cfs/year, respectively. There is an even larger decrease in September median of ~1 cfs per year (see Table 5).

Table 5. Trend analysis for Navajo River below Oso diversion dam (CDWR gauge NAVOSOCO, previously USGS gauge 09344400) showing only significant trends (i.e., $p < 0.05$). Explanation of headers: trend = the Thiel-Sen's slope, sig = the p-value, n_years = the number of years used in the analysis. The number of years may change between variables because the pre-whitening process removes lag-1 autocorrelation from the analysis, which provides a more conservative trend analysis.

Statistic	trend	sig	n_years	mean	median	min	max
Annual_Median	-0.2717	0.0381	32	45.36	42.95	26.60	81.60
Min_30_Day_DoY	2.3333	0.0144	32	195.13	252.50	1.00	361.00
Mar_Maximum	-1.0000	0.0246	31	66.33	48.50	36.90	265.00
Apr_Mean	-0.1167	0.0153	31	47.80	39.99	37.31	195.28
Apr_Median	-0.0667	0.0420	31	43.89	39.10	37.05	182.00
Apr_P20	-0.0371	0.0323	31	41.32	38.50	36.60	130.40
May_Mean	-0.2891	0.0067	31	100.83	90.67	55.45	199.36
May_Median	-0.1750	0.0009	31	90.84	89.50	51.10	150.00
May_Minimum	-0.2714	0.0131	31	79.52	87.10	35.60	93.00
May_P10	-0.1308	0.0060	31	86.82	88.60	42.30	95.44
May_P20	-0.1050	0.0295	31	87.29	88.90	43.90	96.10
Jun_Minimum	-0.4857	0.0113	31	56.71	55.10	9.92	163.00
Jul_Mean	-0.3226	0.0125	31	67.90	56.04	12.57	399.26
Jul_Median	-0.3250	0.0015	31	64.95	55.90	11.30	379.00
Jul_Minimum	-0.3143	0.0246	31	48.23	51.70	8.27	174.00
Jul_P10	-0.1778	0.0113	31	50.55	54.10	9.23	182.00
Jul_P20	-0.1571	0.0113	31	52.00	55.10	9.64	200.00
Aug_Mean	-0.9574	0.0204	31	56.70	55.03	12.91	121.90
Aug_Median	-0.4000	0.0060	31	51.53	54.00	13.40	123.00
Aug_Minimum	-0.4583	0.0153	31	38.16	36.40	6.60	82.20
Aug_P10	-0.5750	0.0224	31	42.77	41.13	7.54	84.20
Aug_P20	-0.5333	0.0204	31	45.22	47.80	9.00	106.00
Sep_Mean	-0.7678	0.0010	31	50.91	49.77	18.75	114.66
Sep_Median	-0.8183	0.0008	31	46.18	49.05	16.10	78.50
Sep_Maximum	-1.8500	0.0497	31	115.93	92.20	30.50	468.00
Sep_P10	-0.6075	0.0204	31	36.73	37.59	9.66	62.44
Sep_P20	-0.7538	0.0019	31	39.20	39.88	10.55	65.56
Nov_Mean	-0.2556	0.0385	31	41.43	37.80	26.16	74.69
Nov_Maximum	-0.3947	0.0295	31	64.52	47.20	33.30	421.00

2.4 NAVAJO RIVER AT BANDED PEAK RANCH, NEAR CHROMO, CO (USGS 09344000)

We identified 15 significant trends in the 1990 to 2020 flow record at the Navajo River at Banded Peak Ranch gauge. The period of record for this gauge extends from 10/1/1936 to 9/29/1995. This record was combined with the record from the NAVBANCO gauge, which has a period of record that extends from 7/22/1991 to 3/30/2021. Fourteen out of the 15 significant trends identified at this location were in the negative direction. The one positive trend was January maximum (Jan_Maximum) flow, which is increasing at ~1 cfs/year. Most August and September flow metrics are decreasing (see Table 4).

Table 6. Trend analysis for Navajo River at Banded Peak Ranch (CDWR gauge NAVBANCO, previously USGS gauge 09344000) showing only significant trends (i.e., $p < 0.05$). Explanation of headers: trend = the Thiel-Sen's slope, sig = the p-value, n_years = the number.

Statistic	trend	sig	n_years	mean	median	min	max
Jan_Maximum	0.9440	0.0054	31	54.67	48.90	22.00	148.00
May_Mean	-3.7141	0.0420	31	303.50	272.13	69.94	595.35
May_Maximum	-6.5000	0.0353	31	493.99	459.00	84.70	1350.00
Jul_Minimum	-1.1345	0.0224	31	54.18	47.20	7.17	160.00
Jul_P10	-1.1154	0.0497	31	60.44	52.10	14.81	174.00
Aug_Mean	-1.0540	0.0168	31	62.45	57.48	19.39	128.71
Aug_Median	-0.7400	0.0420	31	55.74	55.00	15.60	119.00
Aug_Minimum	-0.4733	0.0295	31	38.86	37.40	4.87	85.00
Aug_P10	-0.5600	0.0168	31	42.52	40.70	8.38	98.00
Aug_P20	-0.6500	0.0185	31	45.35	43.10	9.56	100.00
Sep_Mean	-0.9875	0.0013	31	53.30	48.70	22.33	95.93
Sep_Median	-0.6600	0.0043	31	45.59	44.50	21.80	81.35
Sep_Minimum	-0.4458	0.0385	31	31.63	30.70	3.09	57.70
Sep_P10	-0.4988	0.0074	31	34.77	33.46	4.31	57.90
Sep_P20	-0.5100	0.0060	31	37.34	35.10	5.55	59.74
Nov_Maximum	-0.2313	0.0497	31	468.49	45.10	27.20	13000.00

2.5 Relationships between trend significance, direction, and assessment period, length

Although it is standard to use a 30-year period of record in trend analysis, we also evaluated the influence of increasing the window over which the analysis was performed. We performed a changing window analysis for the two gauges with the longest streamflow records: the San Juan River at Pagosa Springs gauge that has a record from 10/1/1935-current; and the Navajo River at Banded Peak Ranch that has a record from 10/1/1936-current.

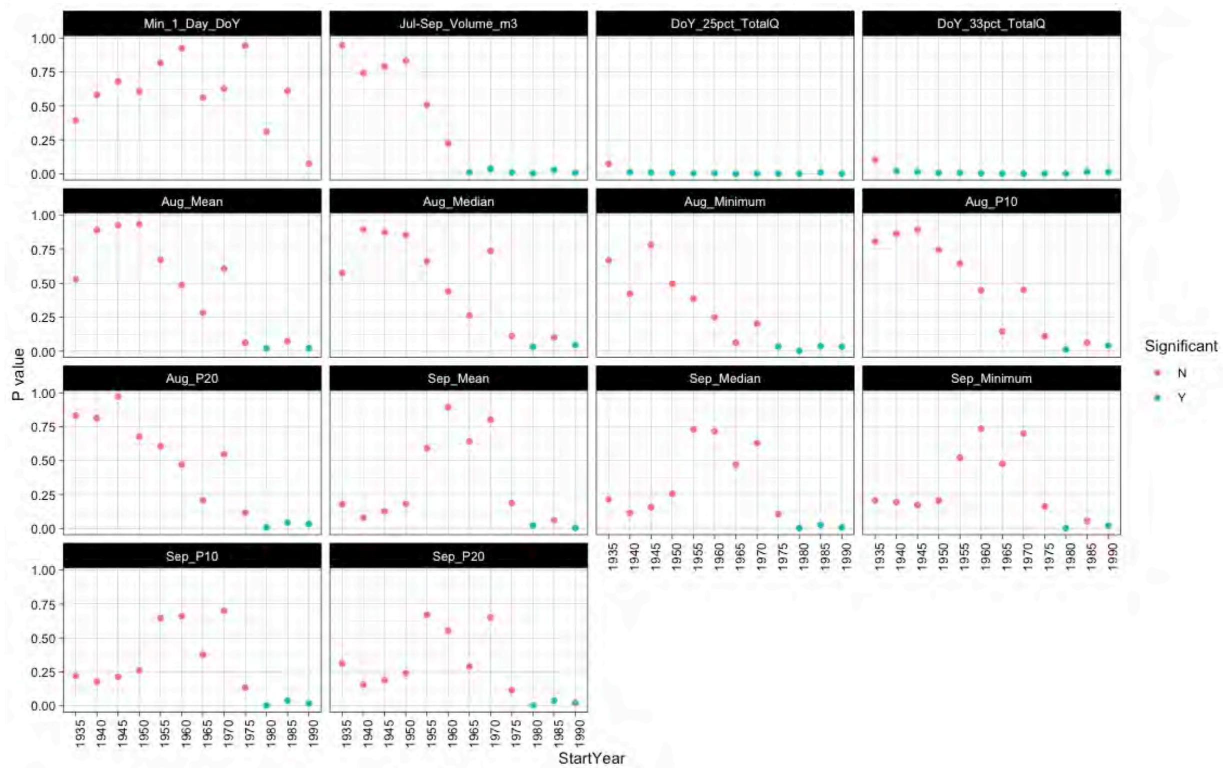


Figure 1. Results of changing window trend analysis at the San Juan River at Pagosa Springs gauge (USGS gauge 09342500). First, we performed trend analysis from 1990-2020 and then expanded the window in 5-year increments extending back to 1935 for the 14 metrics that were significant over the 1990-2020 time period. Shown here are the p-values derived from the Mann-Kendall trend analysis. The light red values are not significant and the light blue values are significant at the p < 0.05 level.

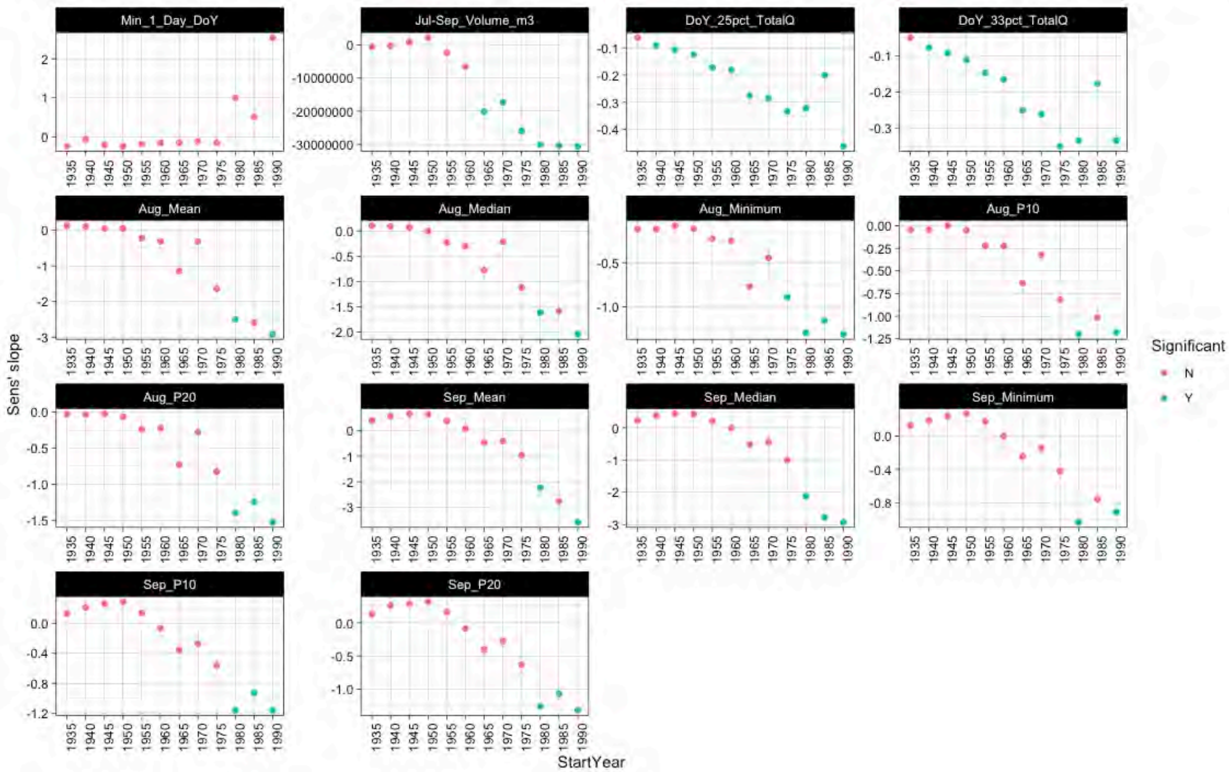


Figure 2. Results of changing window trend analysis at the San Juan River at Pagosa Springs gauge (USGS gauge 09342500). First, we performed trend analysis from 1990-2020 and then expanded the window in 5-year increments extending back to 1935 for the 14 metrics that were significant over the 1990-2020 time period. Shown here are the Sen's slopes derived from the Thiel-Sen's analysis. The light red values are not significant and the light blue values are significant at the $p < 0.05$ level.

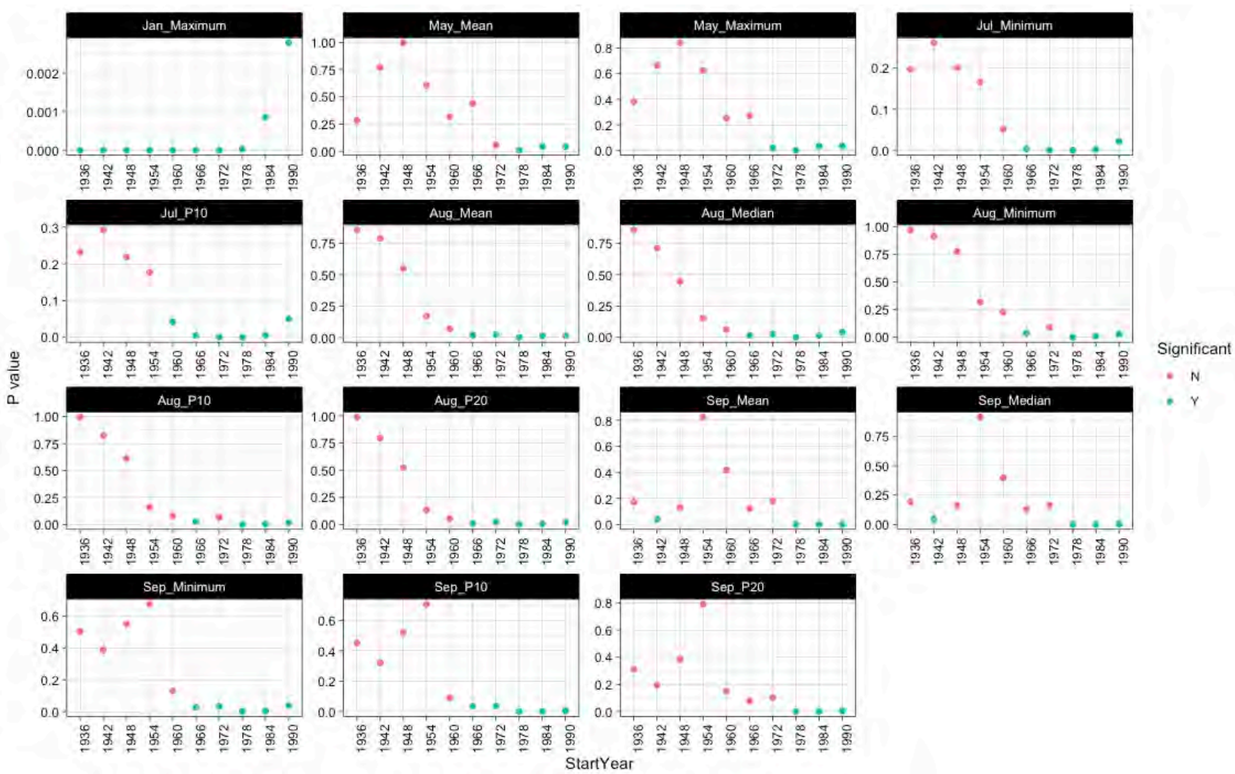


Figure 3. Results of changing window trend analysis at the Navajo River at Banded Peak Ranch gauge (USGS gauge 09344000 and CDWR NAVBANCO). First, we performed trend analysis from 1990-2020 and then expanded the window in 6-year increments extending back to 1936 for the 15 metrics that were significant over the 1990-2020 time period. Shown here are the p-values derived from the Mann-Kendall trend analysis. The light red values are not significant and the light blue values are significant at the $p < 0.05$ level.

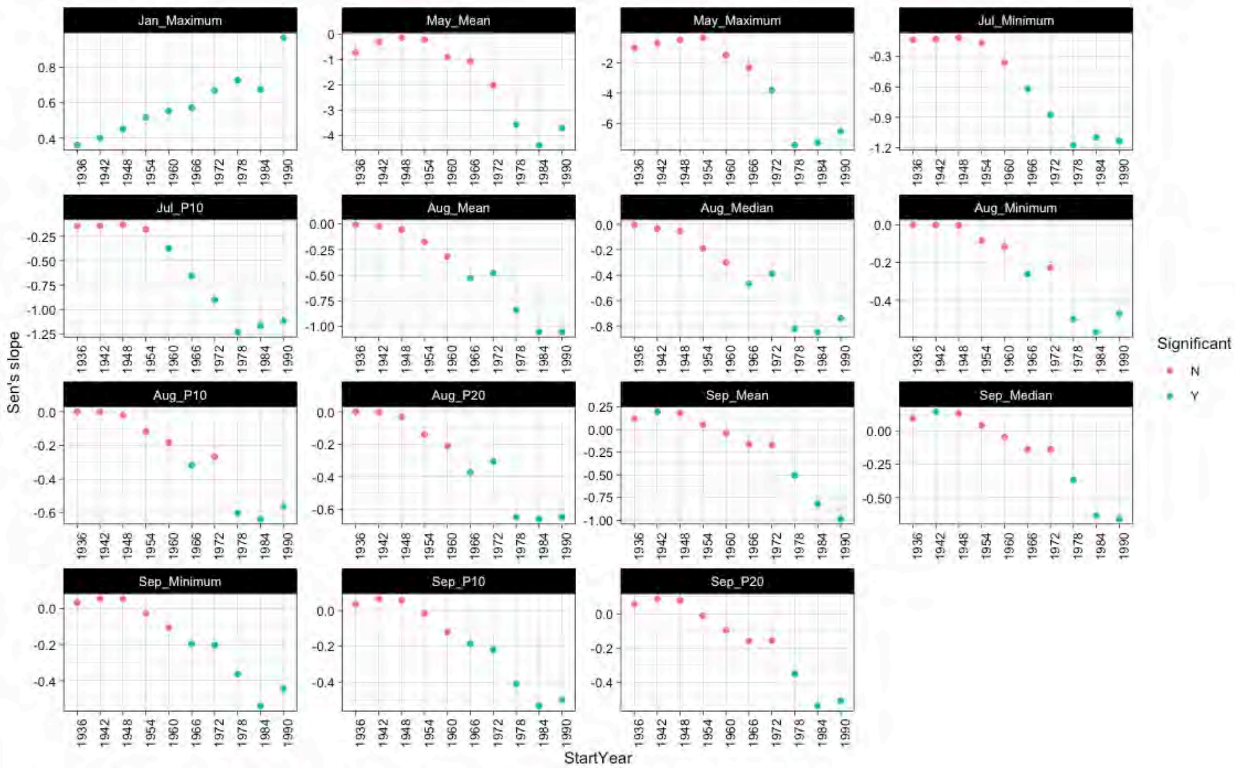


Figure 4. Results of changing window trend analysis at the Navajo River at Banded Peak Ranch gauge (USGS gauge 09344000 and CDWR NAVBANCO). First, we performed trend analysis from 1990-2020 and then expanded the window in 6-year increments extending back to 1936 for the 15 metrics that were significant over the 1990-2020 time period. Shown here are the Sen's slopes derived from the Thiel-Sen's analysis. The light red values are not significant and the light blue values are significant at the $p < 0.05$ level.

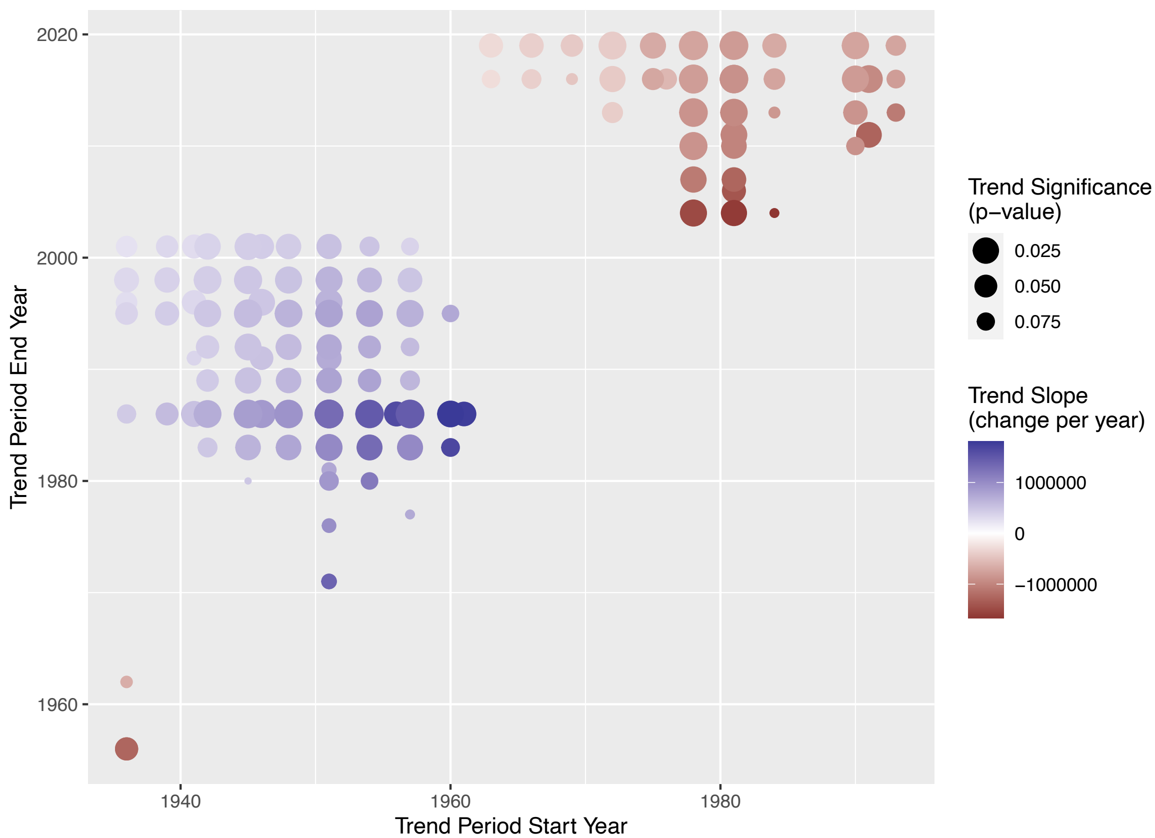


Figure 4. Trends in Jul-September volumes (trend slope values are in cubic meters) for the San Juan River at Pagosa Springs observed over various time period in the 20th century. A period of unusually large snowfall in the early 1980s drives an upward trend between the 1940s and 1980s. From the 1960s to the present, a persistent downward indicates declining runoff volumes during the summer months.

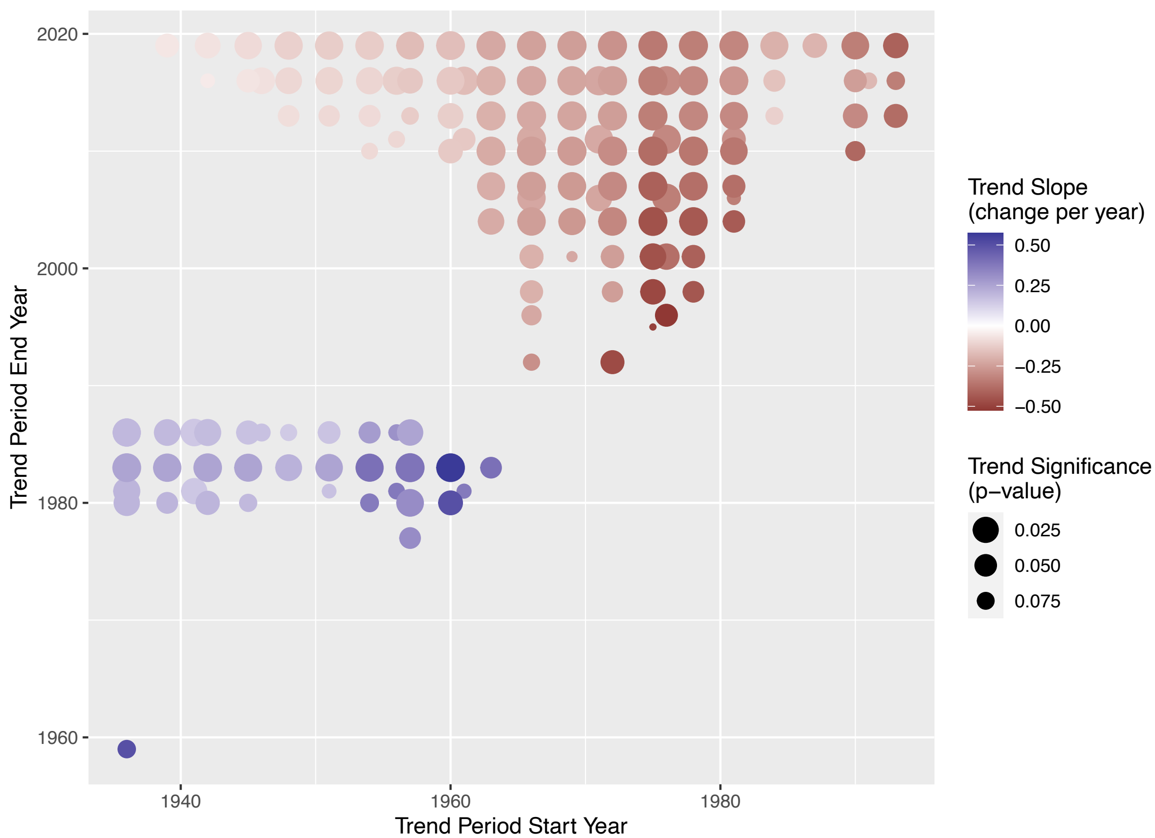


Figure 5. Trends in time to snowmelt runoff measured as Julian days to 33% of the total annual runoff for the San Juan River at Pagosa Springs observed over various time periods. The trend toward earlier snowmelt runoff strengthens over the second half of the 20th century. The trend slope calculated over the most recent 30-year period indicates snowmelt runoff is beginning ~5 days earlier each decade.

Long-term streamflow records are not available for every tributary in the San Juan watershed and historical trends assessment is limited in its ability to predict future conditions. This assessment, therefore, relied extensively on hydrological simulation modeling to estimate flow behaviors in areas without streamflow gauges and to explore the potential impacts of population growth and climate change on hydrology. These simulation models are discussed in a subsequent section.

3 Simulation Model Validation

Different perspectives on natural, existing, and future hydrological behavior and its relationship to consumptive and non-consumptive water uses can be gleaned from trends analysis on historical streamflow records and scenario modeling, as discussed above. Historical data is limited to demonstrating the behaviors that manifested after installation of a stream gauge—an event that is often preceded by water development and use in a watershed. Approximating natural hydrology in many locations, thus, requires application of modeling tools. While trends analysis may be the best tool for understanding near-term future hydrological conditions, extrapolation of historical trends out to 30 or 50-year time horizons may be an insufficient or inappropriate approach. This is especially true where potential future behavior in the joint hydrological/socio-political/administrative system is non-linear with respect to the historical condition, where rapid step changes may affect outcomes, etc.

Scenario modeling is used extensively across Colorado for risk assessment and decision support. That approach is adopted here as well to provide local stakeholders with insights into the ways in which changes in water availability and water use may alter local waterways' ability to deliver goods and services to local communities. Understanding the complex interplay between inflow hydrology and the exercise of surface water diversion rights under Colorado water law requires a water rights allocation and accounting model. Gauge records, diversion histories, and rainfall/runoff simulations provide the inputs necessary to build a functioning simulation model for local streams and rivers. Hydrological simulations for the WEP planning area were produced by modifying the State of Colorado Stream Simulation Model (StateMOD) developed by the Colorado Water Conservation Board (CWCB) for the Southwest Basin.

The CWCB recently provided a Technical Update to the Colorado Water Plan.[1] That update includes a set of revised StateMod scenario planning models for the Southwest Basin. The models simulate the effects of several climate change and development futures. Results generated by the models provide a lens through which potential future conditions in the planning area can be evaluated. Model results representing natural and existing (i.e. 'baseline') conditions provide a means for assessing the degree of hydrological alteration brought about my human activities. Modeled future scenarios encompass a wide range of future conditions according to the best available science and stakeholder inputs. This scenario planning approach, unlike the more simplistic low to high stress conditions, recognizes that the future holds a degree of uncertainty where the various drivers will impact each other. Each of the planning scenarios presented in the Technical Update reflects a possible future state, which depends on a variety of environmental and social drivers. The differentiating components of the planning scenarios are listed below:

Baseline – Current Conditions

- Current irrigated acreages and irrigation practices
- Historical IWR
- Historical hydrology

Scenario A – Business as Usual

- Includes reduction of irrigated acreage near urbanized areas
- Increased stress to streamflow and water supplies
- Climate is similar to conditions in the 20th century

Scenario B – Weak Economy

- Reduction of irrigated acreage near urbanized areas
- Economy struggles with reduced population growth
- Climate is similar to conditions in the 20th century
- Little change in social values, levels of water conservation, urban land use patterns, and environmental regulations

Scenario C – Cooperative Growth

- Reduction of irrigated acreage
- 20% in Irrigation Water Requirement (IWR) climate factor (i.e. warmer)
- Population growth consistent with current forecasts
- Increased water and energy conservation
- Emergence of water saving technology
- Water development more restrictive requiring high efficiency as well as environmental/recreational benefits
- Moderate warming of the climate increasing water demands in all sectors'

1 "Technical Update to the Colorado Water Plan," Colorado Water Conservation Board, Volume 1., 2019.

Scenario D – Adaptive Innovation

- Much warmer climate with technological innovation to address the problem
- Population growth higher than current projections
- Reduction of acreage, but lesser than other scenarios due to demand for locally produced food
- 31% IWR climate factor (i.e. warmer)
- 10% IWR reduction (i.e. lower water use by crops)
- 10% system efficiency increase to offsets water use in warmer climate

Scenario E – Hot Growth

- Much warmer climate with increased population
- Rapid transition of agricultural lands to urban
- Reduction of acreage
- Decline in streamflow and water supply
- 31% IWR climate factor

The climate scenarios included in the Technical Updates models attempt to bracket the range of future conditions predicted by a large number of climate models (Figure 6). Scenarios A and B represent climate using historical patterns of hydrology, temperature and precipitation. Scenarios D and E represent a future climate where runoff anomalies decrease (streamflows decrease) and Crop Irrigation Requirement (CIR) anomalies increase (crop water use increases). Scenario C uses positions for runoff anomalies and CIR anomalies intermediate between the historical condition and the hot-and-dry future characterized by Scenarios D and E.

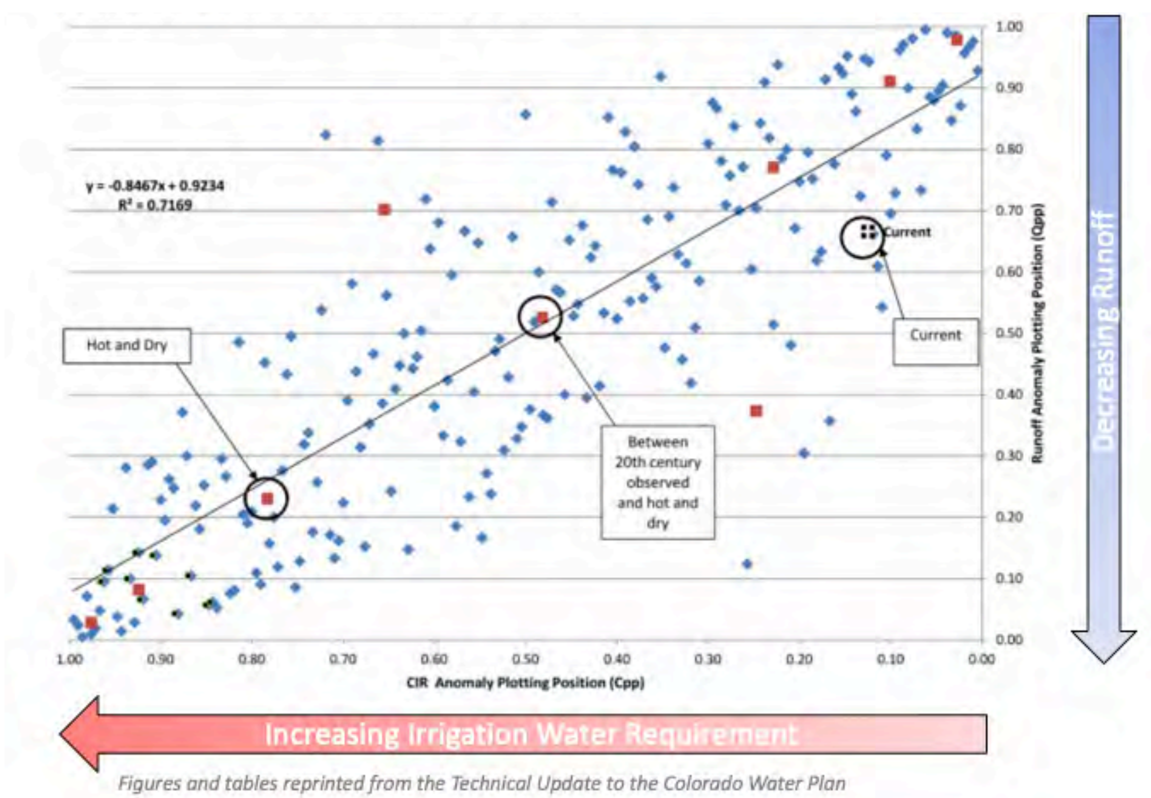


Figure 6. Three climate scenarios selected for use in the Technical Update models bracket the range of Runoff Anomalies and Crop Irrigation Requirements predicted by a large number of climate models/runs.

Streamflows are modified in the simulation models through application of climate adjustment factors that increase irrigation water demand at nodes throughout the simulation network and alter hydrograph shape and total yield at the upstream model boundaries. Increasing crop consumption is driven by increasing evapotranspiration in response to increasing temperatures. These demand increases are included to varying degrees in Scenarios C, D and E. Some of these demand increases are offset by simulation of increased water efficiency in Scenarios C and D (Figure 7). The simulation models also included changes in municipal demand to simulate population growth.

Climate change adjustments to inflow hydrographs at the upstream model boundaries generally resulted in hydrograph behavior characterized by earlier snowmelt runoff, lower late season baseflows, and reductions in annual water yield. The joint effects of population growth, increasing crop demand and altered hydrology were propagated through the simulation network over a period of 38 years.

The scenario models included in the Technical Update run on a monthly timestep. For the purposes of evaluating impacts of climate change, population growth, etc. on ecological characteristics of the streams and rivers in the planning area, a daily timestep was required. Monthly simulation results were disaggregated to daily results using a method of fragments approach.[2] The method was implemented with custom code in the R statistical computing environment. Observed daily streamflow data was retrieved from an existing USGS gauging stations throughout the planning area. The record of daily data was aggregated to monthly acre-feet volume totals. The monthly simulation results were then compared to the aggregated observed data using a three-month moving window. The three-month period from the entire series of observed data that best matched the windowed simulation data was identified using the Kline-Gupta Efficiency measure (Figure 8).

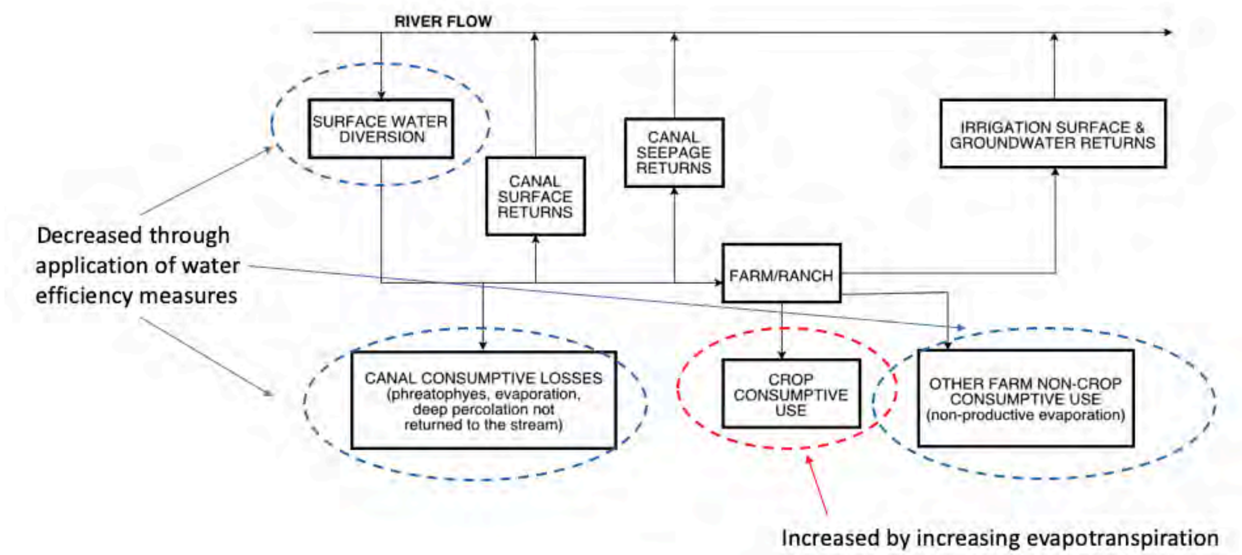


Figure 7. The climate futures represented by Scenarios C, D, and E all include increases in crop consumptive use (red circle) that drives increasing diversion from streams and rivers to satisfy agricultural use demands. Scenarios C and D include water conveyance and application efficiencies that offset this increased demand through simulated introduction of efficiency measures (blue circles).

2 Acharya, A., & Ryu, J. H. (2014). Simple method for streamflow disaggregation. Journal of Hydrologic Engineering, 19(3), 509-519.

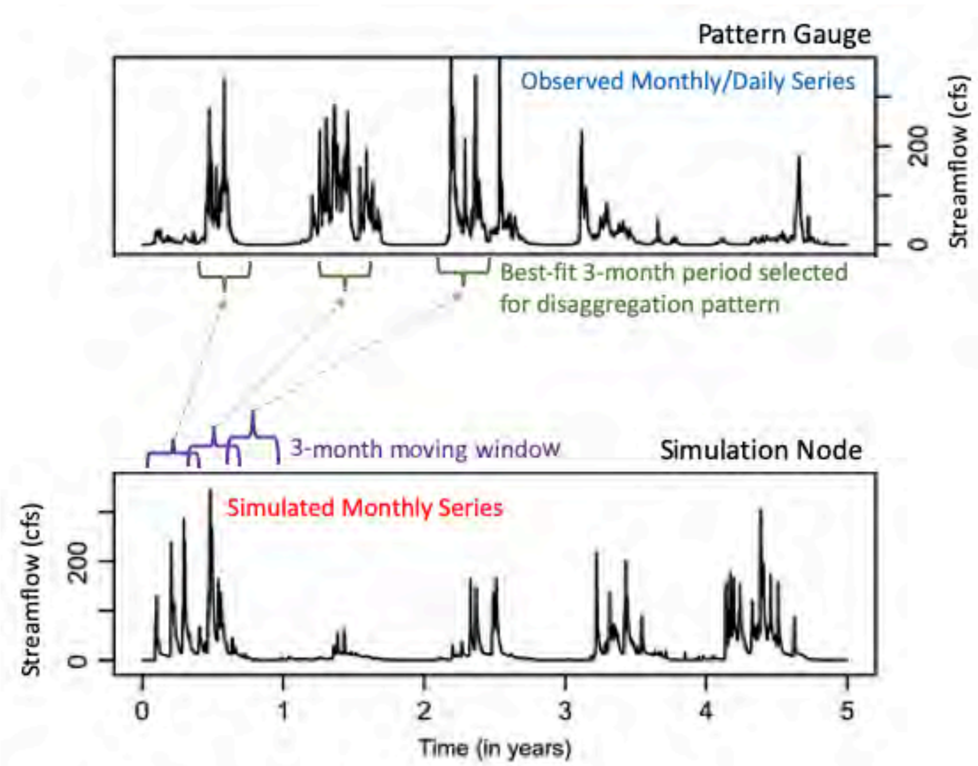


Figure 8. Visual representation of the patterning approach used for monthly-to-daily disaggregation of simulation results using observed streamflow data from nearby USGS gauging stations.

Table 7. Model nodes selected for daily disaggregation listed alongside corresponding stream reaches and target gauges.

StateMod Node/ WDID	River	Description	Reach ID	Daily Disaggregation Target Gauge
9341500	Lower West Fork San Juan River	West Fork San Juan River	WF_1	9341500
9339900	Lower East Fork San Juan River	East Fork San Juan River	EF_1	9341500
2900677	San Juan River	San Juan River below Obannon Ditch	SJ_1	9342500
9342000	Turkey Creek	Lower Turkey Creek	TK_1	9342000
2900686	San Juan River	San Juan River below Park Ditch	SJ_2	9342500
7700585	Fourmile Creek	Fourmile Creek below Mountain Park Ditch	FM_1	9342000
29_ADS002	San Juan River	San Juan River above Pagosa Springs	SJ_3	9342500
9342500	San Juan River	San Juan River at Pagosa Springs	SJ_4	9342500
9342500	San Juan River	San Juan River below Pagosa Springs	SJ_5	9342500
9343000	Blanco River	Rio Blanco River above Blanco Diversion	RB_1	9343000
9343300	Blanco River	Rio Blanco River below Blanco Diversion	BL_1	9343300
9344000	Navajo River	Navajo River at Banded Peak	NV_1	9344000
7700514	Navajo River	Navajo River below Chama Road Ditch	NV_2	9344000
9344400	Navajo River	Navajo River below Oso Dam	NV_3	9344400
7700585	Navajo River	Navajo River below Underwood Ditch	NV_4	9344400
7700576	Navajo River	Navajo River below Shahan Ditch	NV_5	9344400
9345200	Little Navajo River	Little Navajo River below Little Oso Dam	LN_1	9345200
7700559	Little Navajo River	Little Navajo River below Midland Ditch	LN_2	9345200

Once a suitable three-month observed period was identified, the daily values from the central month in the window of observed values was retrieved as used to disaggregate the central month in the window of simulation values. Disaggregation was carried out by computing the fraction of the monthly total flow occurred on each day in the observed month and then applying these ratios to each day in the simulation month. This process was carried out for each month in the simulation period. Disaggregating data is this manner is more flexible than methods traditionally applied to StateMod simulation outputs in Colorado. The method-of-fragments approach enables composition of novel simulation time series not directly observed in the historical period of record. This attribute is particularly useful for disaggregation of climate change and population growth scenarios where the assumption that future behavior will closely resemble historical hydrological behavior is not appropriate.

The validity of the disaggregation results was initially assessed by comparing 54 computed metrics of annual streamflow behavior (e.g. 7-day minimum flow, average September flow, 3-day maximum flow, etc.) for Baseline simulation results approximating historical conditions at existing streamflow gauging locations to the same metrics computed on observed streamflow data from those location using a Wilcox Rank Sum test. The goodness of fit of the disaggregated time series was also assessed with various time-series fit measures (e.g. Nash-Sutcliff Efficiency).

3.1 Results

Comparison of simulation model results to observed data provided a means for assessing the reliability of simulation results, which were then used to assess potential hydrological futures for the San Juan River, Rio Blanco, Navajo River and their various tributaries. Wilcox Rank Sum test results indicate no statistically significant difference in the computed metrics between the simulation results and observation data (Table 8). We found the disaggregation assessment results encouraging and supportive of our intention to use scenario modeling results to characterize changes in annual flow characteristics throughout the planning area.

Table 8. Wilcox rank sum test results for the San Juan River at Pagosa Springs. No significant differences were observed between characteristic behaviors of the observed and simulated daily streamflows.

Statistic	Median Simulated Value	Median Observed Vlue	Sim - Obs	p-value
Apr_Maximum	1011	1020	-9	0.905
Apr_Mean	547	547	1	0.930
Apr_Median	502	504	-1	0.921
Apr_Minimum	181	182	-2	0.921
Apr_P10	239	241	-1	0.967
Apr_P90	870	878	-8	0.926
Aug_Maximum	458	405	53	0.670
Aug_Mean	204	183	21	0.464
Aug_Median	164	156	8	0.363
Aug_Minimum	90	78	12	0.321
Aug_P10	108	96	13	0.296
Aug_P90	312	289	24	0.648
DoY_25pct_TotalQ	128	128	0	0.778
DoY_33.3pct_TotalQ	138	138	0	0.749
DoY_50pct_TotalQ	154	153	1	0.530
DoY_75pct_TotalQ	181	177	4	0.459
Jul_Maximum	636	583	53	0.582
Jul_Mean	253	235	18	0.682
Jul_Median	212	202	11	0.701
Jul_Minimum	118	111	7	0.589
Jul_P10	143	135	8	0.648
Jul_P90	440	410	30	0.685
Jun_Maximum	2070	2065	5	0.852
Jun_Mean	1195	1185	10	0.901

Jun_Median	1151	1145	6	0.967
Jun_Minimum	608	601	8	0.893
Jun_P10	668	658	10	0.909
Jun_P90	1813	1785	28	0.835
May_Maximum	2016	2040	-24	0.799
May_Mean	1256	1288	-32	0.720
May_Median	1222	1235	-13	0.783
May_Minimum	551	562	-12	0.811
May_P10	649	668	-20	0.819
May_P90	1808	1850	-43	0.831
Min_1_Day	58	52	6	0.396
Min_1_Day_DoY	266	256	10	0.306
Min_3_Day	60	55	5	0.353
Min_3_Day_DoY	268	258	10	0.238
Min_30_Day	90	77	13	0.159
Min_30_Day_DoY	270	262	8	0.783
Min_7_Day	67	59	8	0.230
Min_7_Day_DoY	270	263	7	0.723
Oct_Maximum	329	246	83	0.831
Oct_Mean	140	137	2	0.433
Oct_Median	115	98	17	0.391
Oct_Minimum	72	67	5	0.526
Oct_P10	80	73	6	0.490
Oct_P90	211	185	26	0.503
Sep_Maximum	321	456	-135	0.642
Sep_Mean	162	150	12	0.517
Sep_Median	124	109	15	0.299
Sep_Minimum	75	67	8	0.224
Sep_P10	84	76	8	0.212
Sep_P90	221	230	-9	0.931

4 Hydrological Scenario Modeling Results

Comparison of the various climate change and population growth scenario simulation results to the baseline simulation result indicate a shift toward earlier peak runoff and lower total annual runoff volumes associated with increasingly warm climate futures. These patterns are typical of predictions elsewhere on Colorado's western slope. Simulation results for the San Juan, Rio Blanco and Navajo River indicate relative insensitivity to the changes from the baseline condition included in scenarios A and B. It's worth noting that the CWCB developed each of the scenarios discussed above as representative positions along a continuum of equally probable future conditions. No weighting is provided by CWCB or by this effort regarding the "best" scenario to plan for. Instead, the reader is encouraged to consider how results associated with the full range of scenarios might inform a "no-regrets" strategy for managing conditions in the WEP planning area.

Analysis of hydrological regime behavior at locations throughout the WEP planning area considered numerous measures of streamflow behavior. Metrics characterizing flow magnitude, duration, and rate of change were derived through statistical examination of the entire simulation period at each node in the modelling network, which covered a range of wet, average, and dry hydrological conditions. Exceedance probabilities were calculated for flows simulated on each day of each calendar year to provide a pathway for building hydrological time series representative of different drought and flood conditions. The absolute values of these streamflow behavior metrics and the degree of change in each metric across planning scenarios was used in subsequent evaluations of aquatic habitat, riparian health, sediment transport, and recreational use opportunities.

Comparison of the various climate change and population growth scenario simulation results to the baseline simulation result indicate a shift toward earlier peak runoff and lower total annual runoff volumes associated with increasingly warm climate futures (Figure 9, Figure 10, Figure 11, Figure 12). These patterns are typical of predictions elsewhere on Colorado's western slope and align with observed recent hydrological trends. Simulation results for the mainstem San Juan River indicate relative insensitivity to the changes from the baseline condition modeled by scenarios A and B. As a result, many of the analyses presented in subsequent sections of this report consider differences between scenarios A, C, and E only. These three scenarios effectively bracket the range of potential future conditions predicted in the entire suite of model scenarios.

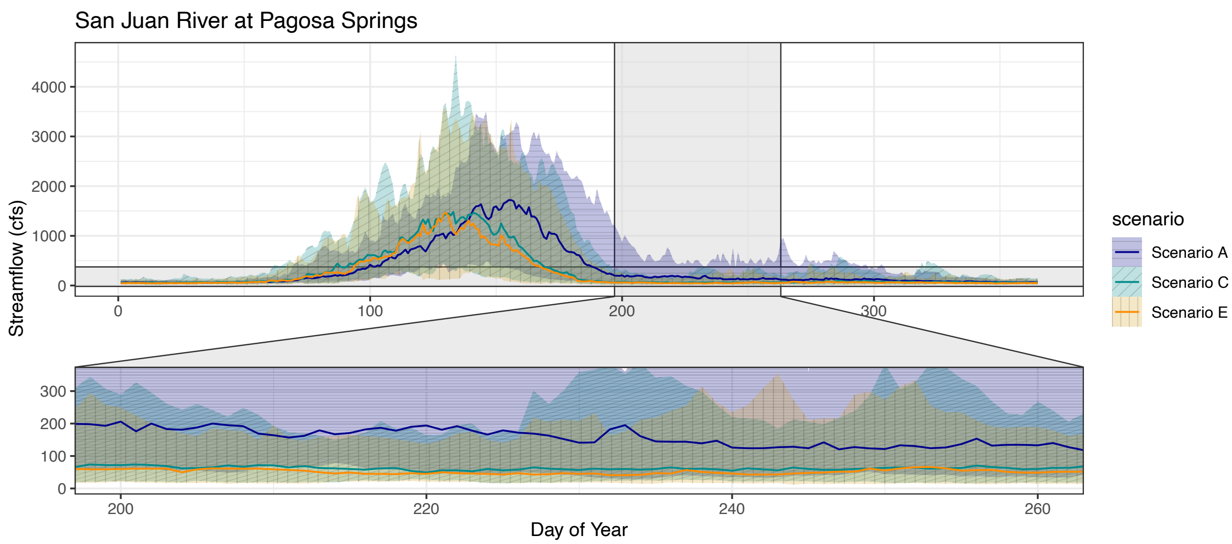


Figure 9. Hydrological regime behaviors for the San Juan River at Pagosa Springs modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

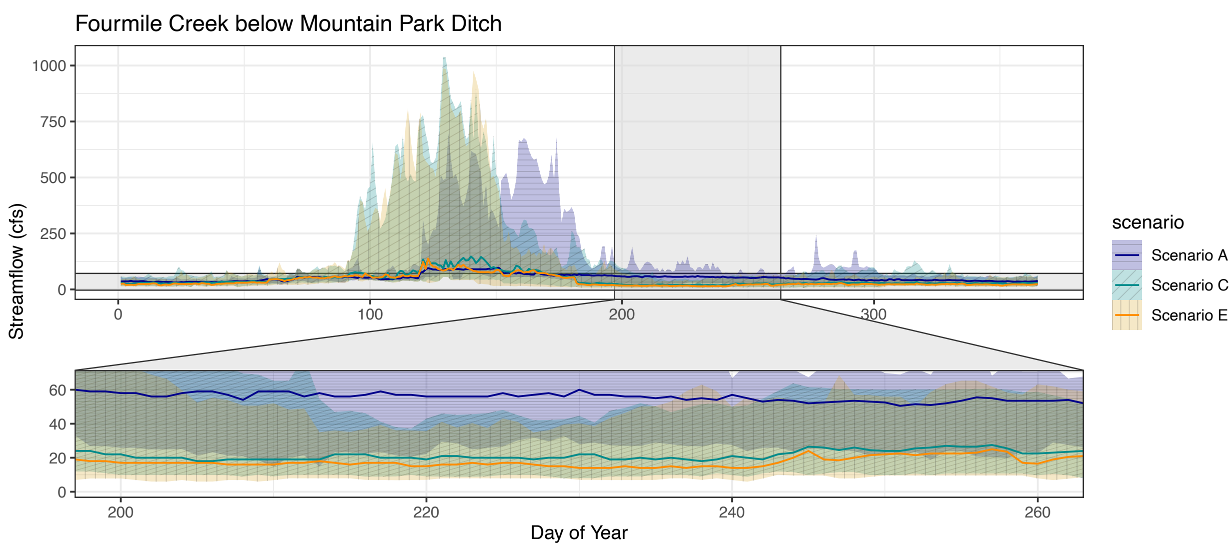


Figure 10. Hydrological regime behaviors for Fourmile Creek below Mountain Park Ditch modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

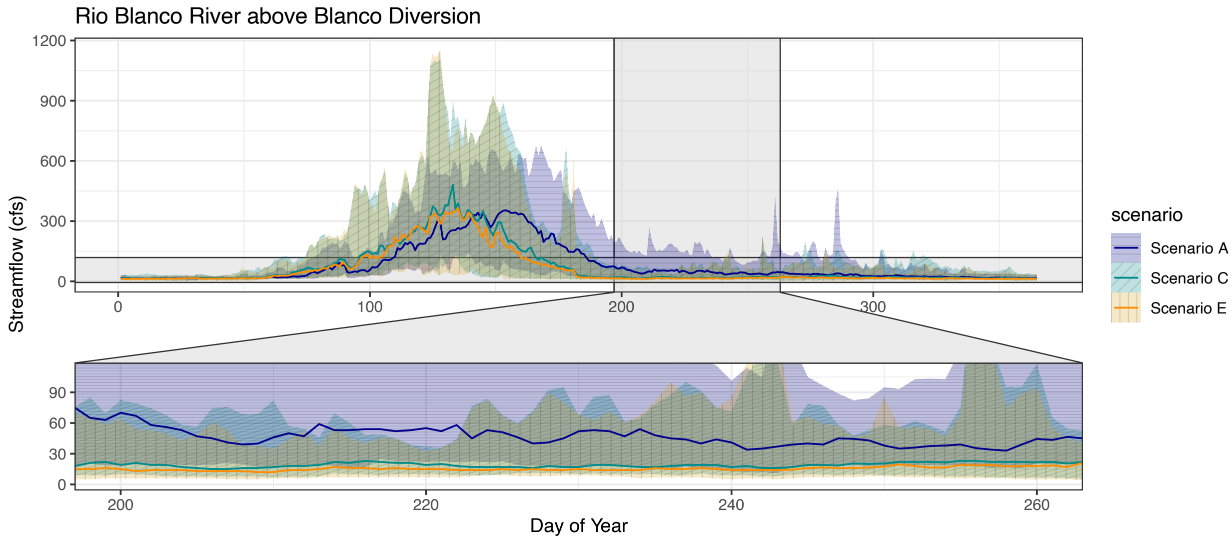


Figure 11. Hydrological regime behaviors for the Rio Blanco above the Blanco Diversion Dam modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

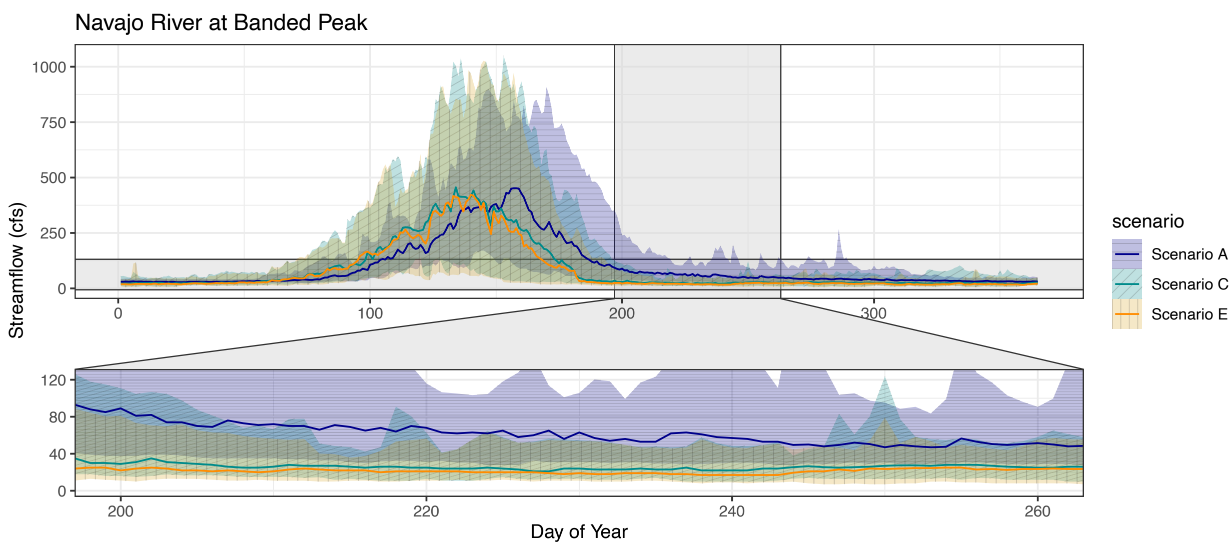


Figure 12. Hydrological regime behaviors for the Navajo River at Banded Peak modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the 40-year simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

The visual comparison of streamflow behavior predicted by the scenario models is supported by computation of various metrics of hydrological behavior (e.g., median July flow, annual 3-day minimum flow). Metrics were computed for each year in the 40-year simulation time series provided for each scenario. Then, the annual metric values were summarized for each scenario by computing the 25th, 50th, and 75th percentiles in the range. A subset of those results deemed most relevant for subsequent discussions of values-at-risk are included here in tabular form (Table 9, Table 10,

Table 11).

Table 9. Predicted changes in streamflow behavior for the San Juan River at Pagosa Springs as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [3].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	1777	0	0	-18	-33	-33
	50th	cfs	2303	0	0	-9	-13	-13
	75th	cfs	3349	0	0	-8	-17	-19
75pct Total Yield	25th	doy	174	0	0	-11	-13	-13
	50th	doy	181	0	0	-11	-13	-13
	75th	doy	188	0	0	-10	-5	-4
April Max	25th	cfs	854	0	0	12	-10	-11
	50th	cfs	1014	0	0	55	34	33
	75th	cfs	1488	0	0	37	27	27
May Max	25th	cfs	1701	0	0	-17	-36	-36
	50th	cfs	2053	0	0	-4	-15	-16
	75th	cfs	2497	0	0	24	12	9
June Max	25th	cfs	1508	0	0	-55	-65	-67
	50th	cfs	2085	0	0	-38	-49	-49
	75th	cfs	2904	0	0	-27	-39	-44
July Max	25th	cfs	373	2	2	-75	-82	-80
	50th	cfs	655	0	0	-73	-81	-81
	75th	cfs	1110	0	0	-63	-73	-75
July Min	25th	cfs	75	1	1	-60	-72	-72
	50th	cfs	123	2	2	-55	-67	-70
	75th	cfs	204	0	0	-64	-69	-70
August Min	25th	cfs	55	4	4	-53	-72	-68
	50th	cfs	93	13	13	-57	-66	-63
	75th	cfs	124	6	6	-58	-56	-63
September Min	25th	cfs	54	0	0	-59	-72	-72
	50th	cfs	75	1	1	-38	-49	-49
	75th	cfs	107	0	0	-36	-25	-27
October Min	25th	cfs	56	-7	-7	-60	-73	-71
	50th	cfs	72	0	0	-33	-42	-42
3-day Min	75th	cfs	52	0	0	-31	-52	-49
	25th	cfs	30	0	0	-50	-68	-64
	50th	cfs	43	2	2	-41	-69	-63
7-day Min	25th	cfs	32	1	1	-52	-68	-63
	50th	cfs	45	0	0	-38	-65	-58
	75th	cfs	54	0	0	-27	-49	-44
30-day Min	25th	cfs	43	0	0	-51	-70	-64
	50th	cfs	51	0	0	-36	-59	-52
	75th	cfs	63	0	0	-29	-41	-40

[3] "Technical Update to the Colorado Water Plan."

Table 10. Predicted changes in streamflow behavior for Fourmile Creek below Mountain Park Ditch as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [4].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	150	0	0	47	25	85
	50th	cfs	298	0	0	73	4	4
	75th	cfs	641	0	0	32	27	26
75pct Total Yield	25th	doy	228	0	0	-29	-33	-31
	50th	doy	247	0	0	-24	-26	-26
	75th	doy	258	0	0	3	2	0
April Max	25th	cfs	83	0	0	33	22	27
	50th	cfs	97	0	0	143	113	218
	75th	cfs	105	0	0	399	314	313
May Max	25th	cfs	112	0	0	42	1	42
	50th	cfs	197	0	0	33	36	32
	75th	cfs	336	0	0	136	87	83
June Max	25th	cfs	73	0	0	17	-14	-32
	50th	cfs	116	0	0	28	1	26
	75th	cfs	348	0	0	-45	-56	-48
July Max	25th	cfs	72	-1	1	-68	-78	-76
	50th	cfs	88	0	0	-66	-75	-70
	75th	cfs	171	0	0	-63	-76	-77
July Min	25th	cfs	39	0	0	-69	-78	-77
	50th	cfs	51	0	0	-71	-76	-75
	75th	cfs	58	0	0	-53	-66	-69
August Min	25th	cfs	35	-3	0	-74	-77	-77
	50th	cfs	42	0	0	-69	-71	-74
	75th	cfs	52	1	1	-62	-63	-68
September Min	25th	cfs	29	0	0	-64	-68	-66
	50th	cfs	35	0	0	-54	-54	-57
	75th	cfs	49	0	0	-43	-47	-50
Octobr Min	25th	cfs	29	0	0	-52	-61	-59
	50th	cfs	36	0	0	-44	-58	-58
3-day Min	75th	cfs	28	0	0	-60	-65	-60
	25th	cfs	18	0	0	-54	-66	-66
	50th	cfs	26	0	0	-65	-69	-66
7-day Min	25th	cfs	21	0	0	-58	-70	-69
	50th	cfs	28	0	0	-61	-69	-67
	75th	cfs	30	0	0	-60	-63	-62
30-day Min	25th	cfs	25	0	0	-58	-72	-70
	50th	cfs	31	0	0	-59	-69	-66
	75th	cfs	34	0	0	-50	-65	-63

[4] "Technical Update to the Colorado Water Plan."

Table 11. Predicted changes in streamflow behavior for the Rio Blanco above the Blanco Diversion as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [5].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	482	0	0	-2	-18	-19
	50th	cfs	579	0	0	5	-1	-1
	75th	cfs	705.5	0	0	18	16	16
75pct Total Yield	25th	doy	181	0	0	-14	-17	-17
	50th	doy	189	0	0	-15	-16	-16
	75th	doy	207	0	0	-3	-13	-13
April Max	25th	cfs	217	0	0	13	21	21
	50th	cfs	278	0	0	42	23	23
	75th	cfs	386	0	0	42	37	36
May Max	25th	cfs	381.5	0	0	0	-12	-13
	50th	cfs	518	0	0	16	3	3
	75th	cfs	633.5	0	0	31	28	28
June Max	25th	cfs	319.5	0	0	-54	-67	-63
	50th	cfs	498	0	0	-41	-52	-53
	75th	cfs	612.5	0	0	-16	-34	-36
July Max	25th	cfs	115.5	0	0	-80	-82	-82
	50th	cfs	169	0	0	-75	-81	-83
	75th	cfs	239.5	0	0	-70	-75	-76
July Min	25th	cfs	20.5	0	0	-51	-66	-66
	50th	cfs	29	0	0	-59	-59	-62
	75th	cfs	48.5	0	0	-62	-67	-67
August Min	25th	cfs	18	0	0	-42	-56	-58
	50th	cfs	24	0	0	-42	-50	-54
	75th	cfs	34	0	0	-47	-56	-54
September Min	25th	cfs	18	0	0	-43	-61	-61
	50th	cfs	26	0	0	-40	-52	-50
	75th	cfs	35	0	0	-41	-46	-46
October Min	25th	cfs	15	0	0	-45	-60	-60
	50th	cfs	18	0	0	-22	-31	-28
3-day Min	75th	cfs	12	0	0	-26	-40	-47
	25th	cfs	9	0	0	-54	-67	-67
	50th	cfs	10	0	0	-37	-50	-50
7-day Min	25th	cfs	9.07	0	0	-49	-67	-67
	50th	cfs	10.86	0	0	-30	-54	-54
	75th	cfs	12.29	0	0	-16	-37	-40
30-day Min	25th	cfs	11.8	0	0	-42	-67	-66
	50th	cfs	13	0	0	-31	-51	-50
	75th	cfs	16.38	0	0	-24	-40	-35

[5] "Technical Update to the Colorado Water Plan."

Table 12. Predicted changes in streamflow behavior for the Navajo River at Banded Peak as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan[6].

Metric	Percentile	Units	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	25th	cfs	484.5	0	0	-13	-20	-20
	50th	cfs	665	0	0	-6	-14	-14
	75th	cfs	852	0	0	5	-5	-4
75pct Total Yield	25th	doy	182	0	0	-13	-15	-14
	50th	doy	189	0	0	-13	-14	-14
	75th	doy	200	0	0	-11	-13	-12
April Max	25th	cfs	201.5	0	0	44	31	25
	50th	cfs	259	0	0	56	48	48
	75th	cfs	346	0	0	40	36	36
May Max	25th	cfs	408	0	0	0	-11	-12
	50th	cfs	511	0	0	18	11	11
	75th	cfs	678.5	0	0	25	18	18
June Max	25th	cfs	441	0	0	-47	-65	-66
	50th	cfs	568	0	0	-30	-36	-36
	75th	cfs	780	0	0	-12	-27	-28
July Max	25th	cfs	123.5	0	0	-72	-80	-79
	50th	cfs	190	0	0	-69	-77	-76
	75th	cfs	311.5	0	0	-65	-77	-76
July Min	25th	cfs	40.5	0	0	-59	-70	-68
	50th	cfs	58	0	0	-62	-71	-69
	75th	cfs	73	0	0	-57	-60	-58
August Min	25th	cfs	31	0	0	-58	-68	-63
	50th	cfs	40	0	0	-55	-62	-62
	75th	cfs	57	0	0	-57	-62	-63
September Min	25th	cfs	33	0	0	-57	-63	-69
	50th	cfs	38	0	0	-46	-53	-49
	75th	cfs	45	0	0	-35	-43	-43
October Min	25th	cfs	27.25	0	0	-50	-66	-66
	50th	cfs	32.5	0	0	-42	-52	-52
3-day Min	75th	cfs	27	0	0	-46	-59	-59
	25th	cfs	21.5	0	0	-60	-69	-68
	50th	cfs	23.67	0	0	-58	-68	-66
7-day Min	25th	cfs	21.93	0	0	-60	-69	-68
	50th	cfs	25.57	0	0	-53	-69	-68
	75th	cfs	27.43	0	0	-40	-58	-57
30-day Min	25th	cfs	23.22	0	0	-50	-62	-61
	50th	cfs	27.63	0	0	-49	-63	-62
	75th	cfs	30.38	0	0	-37	-56	-55

[6] "Technical Update to the Colorado Water Plan."

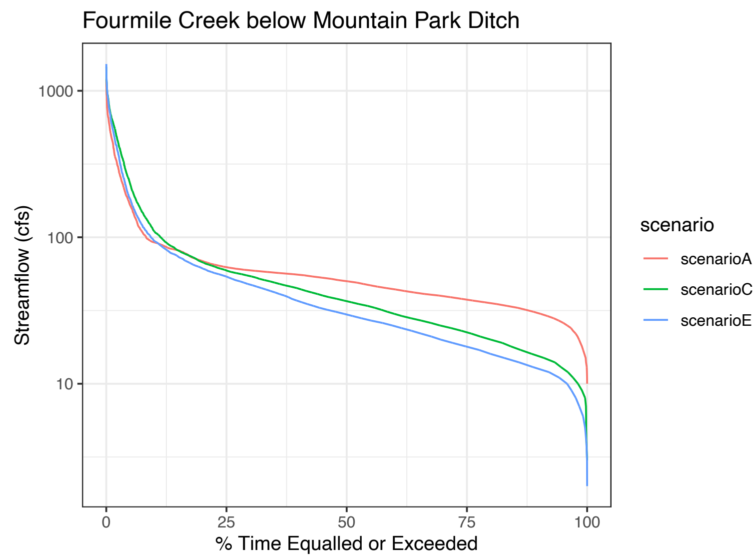


Figure 13. Flow duration curves computed for three hydrological scenarios on Fourmile Creek.

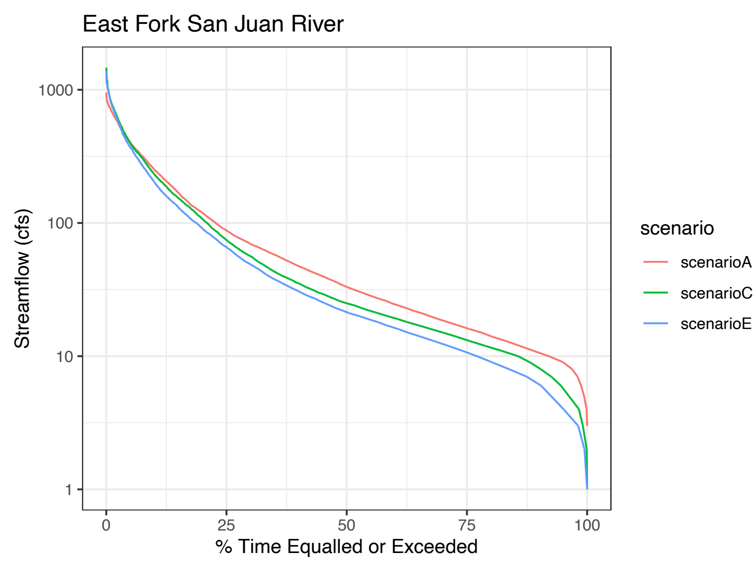


Figure 14. Flow duration curves computed for three hydrological scenarios on the East Fork of the San Juan.

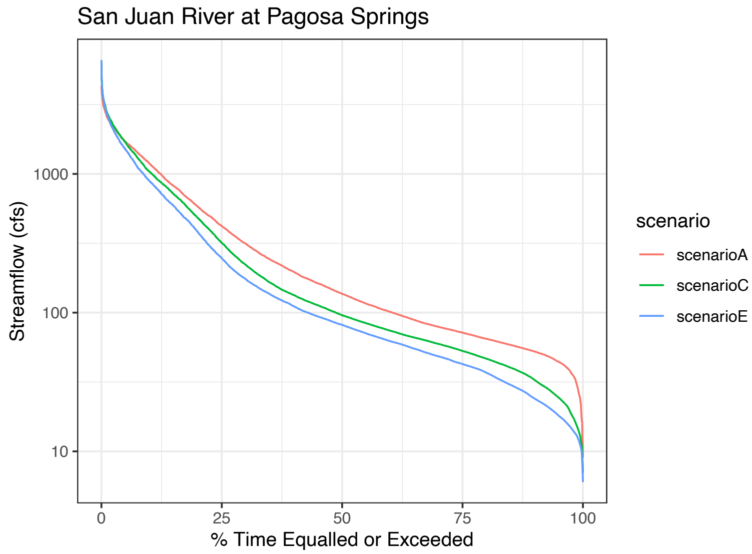


Figure 15. Flow duration curves computed for three hydrological scenarios on the San Juan River at Pagosa Springs.

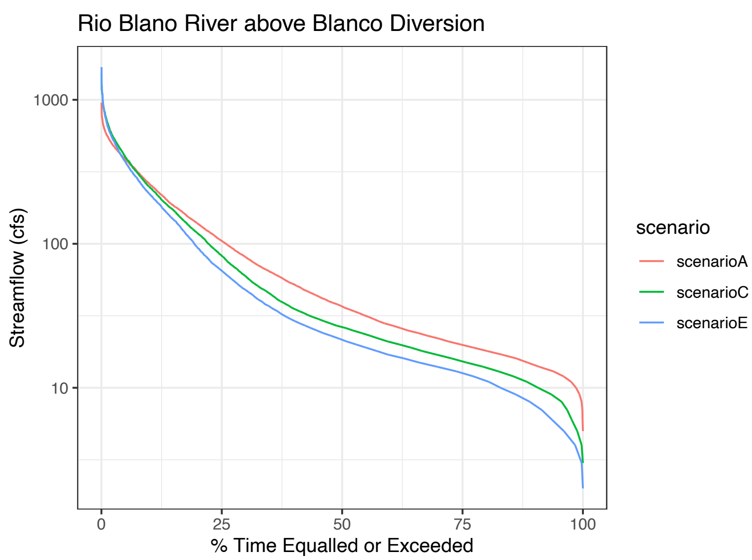


Figure 16. Flow duration curves computed for three hydrological scenarios on the Rio Blanco above the San Juan--Chama Project diversion.

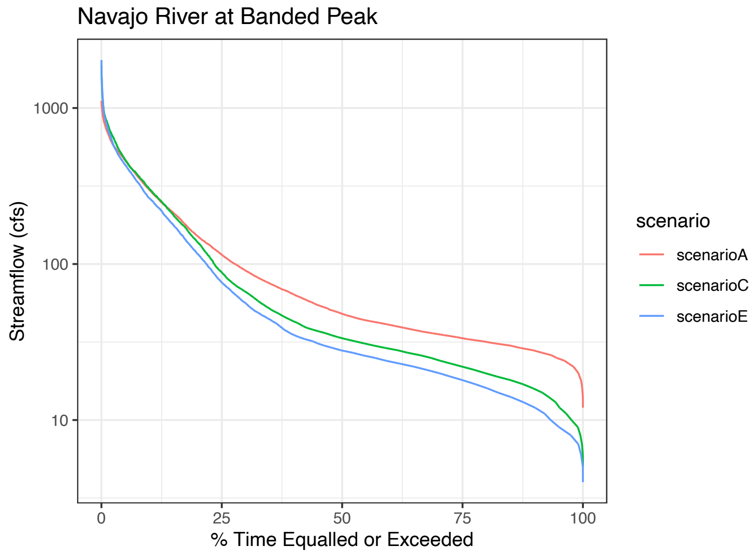


Figure 17. Flow duration curves computed for three hydrological scenarios on the Navajo River above the San Juan--Chama Project diversion.

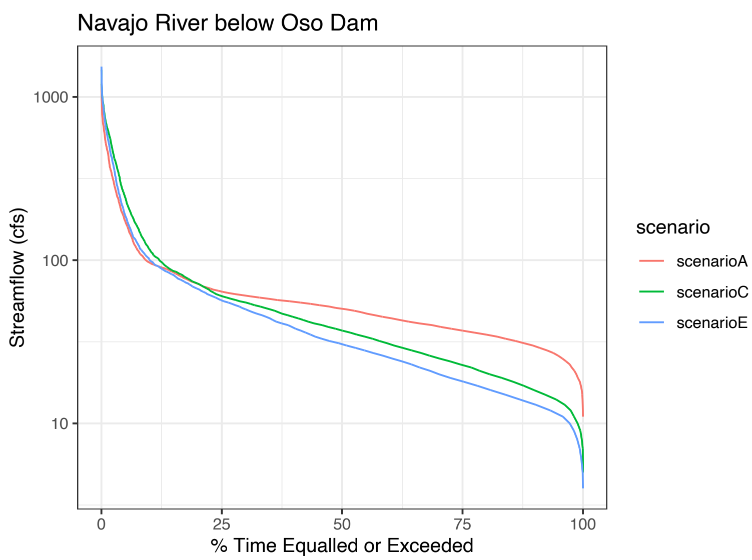


Figure 18. Flow duration curves computed for three hydrological scenarios on the Navajo River below the San Juan--Chama Project diversion.

Simulation results representing the potential effects of climate change were produced by applying adjustment factors to historical hydrology and, thus, do not effectively demonstrate potential or expected changes in precipitation intensity produced by a warming climate. Characterizing the effects of increasingly severe rainfall events on flows in the San Juan and its tributaries requires some consideration of all the potential locations of such events across the entire watershed, the relative intensity and duration of any given event, and the effects of flow routing on flood waves propagating along the stream network—not a trivial task. The reader should take note that such changes were not captured by simulation modeling results that form the basis for scenario comparisons in this effort.

Increasing atmospheric moisture content and an associated increase in extreme rainfall event frequency and/or severity might produce short-duration flood pulses during the summer monsoon period. A simplistic approach to accounting for increasing summer monsoon activity is included here. The potential impact of increased late summer precipitation can be approximated by applying a 3.5% increase per degree Fahrenheit of future warming (as per Colorado Dam Safety Office proposed Rule 7.2.4) to observed July-September peak flows observed on the San Juan River at Pagosa Springs between 1990 and 2020 (Table 13). Peak flows observed during this period are generally associated with high-intensity rainfall events.

Table 13. Predicted increases in late summer (Jul – Oct) peak streamflow events on the San Juan River in Pagosa Springs produced by three different warming scenarios. Events during this period are generally driven by monsoonal rainstorms. A peak flow event with a 1-in-10-year return interval has a 1-in-10 chance of occurring in any given year.

	Peak Flow (cfs)			
Return Interval (years)	**Historical Conditions**	**+1°F**	**+3°F**	**+5°F**
2	833	862	920	979
4	1400	1449	1548	1646
5	1575	1630	1741	1851
10	2103	2177	2324	2471
20	2613	2705	2888	3071
25	2774	2871	3066	3260
50	3263	3378	3606	3834
100	3737	3867	4129	4391
250	4338	4489	4793	5097
500	4773	4940	5275	5609

Table 14. Predicted increases in late summer (Jul – Oct) peak streamflow events on the Rio Blanco above the Blanco Diversion produced by three different warming scenarios. Events during this period are generally driven by monsoonal rainstorms. A peak flow event with a 1-in-10-year return interval has a 1-in-10 chance of occurring in any given year.

Return Interval (years)	Peak Flow (cfs)			
	Historical Conditions	**+1°F**	**+3°F**	**+5°F**
2	653	676	722	768
4	848	877	937	996
5	898	930	992	1055
10	1032	1068	1140	1213
10	1340	1387	1481	1575

Table 15. Predicted increases in late summer (Jul – Oct) peak streamflow events on the Navajo River at Banded Peak produced by three different warming scenarios. Events during this period are generally driven by monsoonal rainstorms. A peak flow event with a 1-in-10-year return interval has a 1-in-10 chance of occurring in any given year.

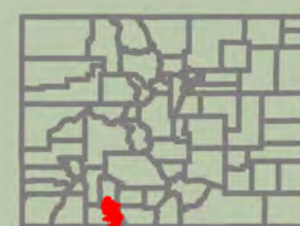
Return Interval (years)	**Peak Flow (cfs)**			
	Historical Conditions	**+1°F**	**+3°F**	**+5°F**
2	599	620	662	704
4	739	765	816	868
5	772	799	853	907
10	852	882	942	1001
100	1001	1036	1106	1176

APPENDIX C: FOREST FIRE RISK REDUCTION PLANNER

2017

Colorado Wildfire Risk Assessment Summary Report

San Juan WEP



COLORADO STATE FOREST SERVICE
COLORADO STATE UNIVERSITY

Products

Each product in this report is accompanied by a general description, table, chart and/or map. A list of available Colorado WRA products in this report is provided in the following table.

COWRA Product	Description
Wildfire Risk	The overall composite risk occurring from a wildfire derived by combining Burn Probability and Values at Risk Rating
Burn Probability	Annual probability of any location burning due to wildfire
Fire Intensity Scale	Quantifies the potential fire intensity by orders of magnitude
Wildland Urban Interface	Housing density depicting where humans and their structures meet or intermix with wildland fuel
Wildland Urban Interface Risk	Annual probability of any location burning due to wildfire
Values at Risk Rating	A composite rating of values and assets that would be adversely impacted by a wildfire by combining the four main risk outputs
Suppression Difficulty Rating	Reflects the difficulty or relative cost to suppress a fire given the terrain and vegetation conditions that may impact machine operability
Drinking Water Risk Index	A measure of the risk to Drinking Water Risk Index Areas (DWIA) based on the potential negative impacts from wildfire
Forest Assets Risk Index	A measure of the risk to forested areas based on the potential negative impacts from wildfire
Riparian Assets Risk Index	A measure of the risk to riparian areas based on the potential negative impacts from wildfire
Characteristic Flame Length	A measure of the expected flame length of a potential fire

COWRA Product	Description
Characteristic Rate of Spread	A measure of the expected rate of spread of a potential fire
Fire Type Extreme Weather	Represents the potential fire type under the extreme percentile weather category
Surface Fuels	A measure of the expected rate of spread of a potential fire
Characteristic Rate of Spread	Characterization of surface fuel models that contain the parameters for calculating fire behavior outputs
Vegetation	General vegetation and landcover types
Forest Assets	Identifies forested land categorized by susceptibility or response to fire
Riparian Assets	Forested riparian areas characterized by functions of water quantity and quality, and ecology
Drinking Water Importance Areas	A measure of quality and quantity of public surface drinking water categorized by watershed

Wildland Urban Interface

Description

Colorado is one of the fastest growing states in the Nation, with much of this growth occurring outside urban boundaries. This increase in population across the state will impact counties and communities that are located within the Wildland Urban Interface (WUI). The WUI is described as the area where structures and other human improvements meet and intermingle with undeveloped wildland or vegetative fuels. Population growth within the WUI substantially increases the risk from wildfire.

For the **San Juan WEP** project area, it is estimated that **2,570** people or **99.8 %** percent of the total project area population (2,574) live within the WUI.

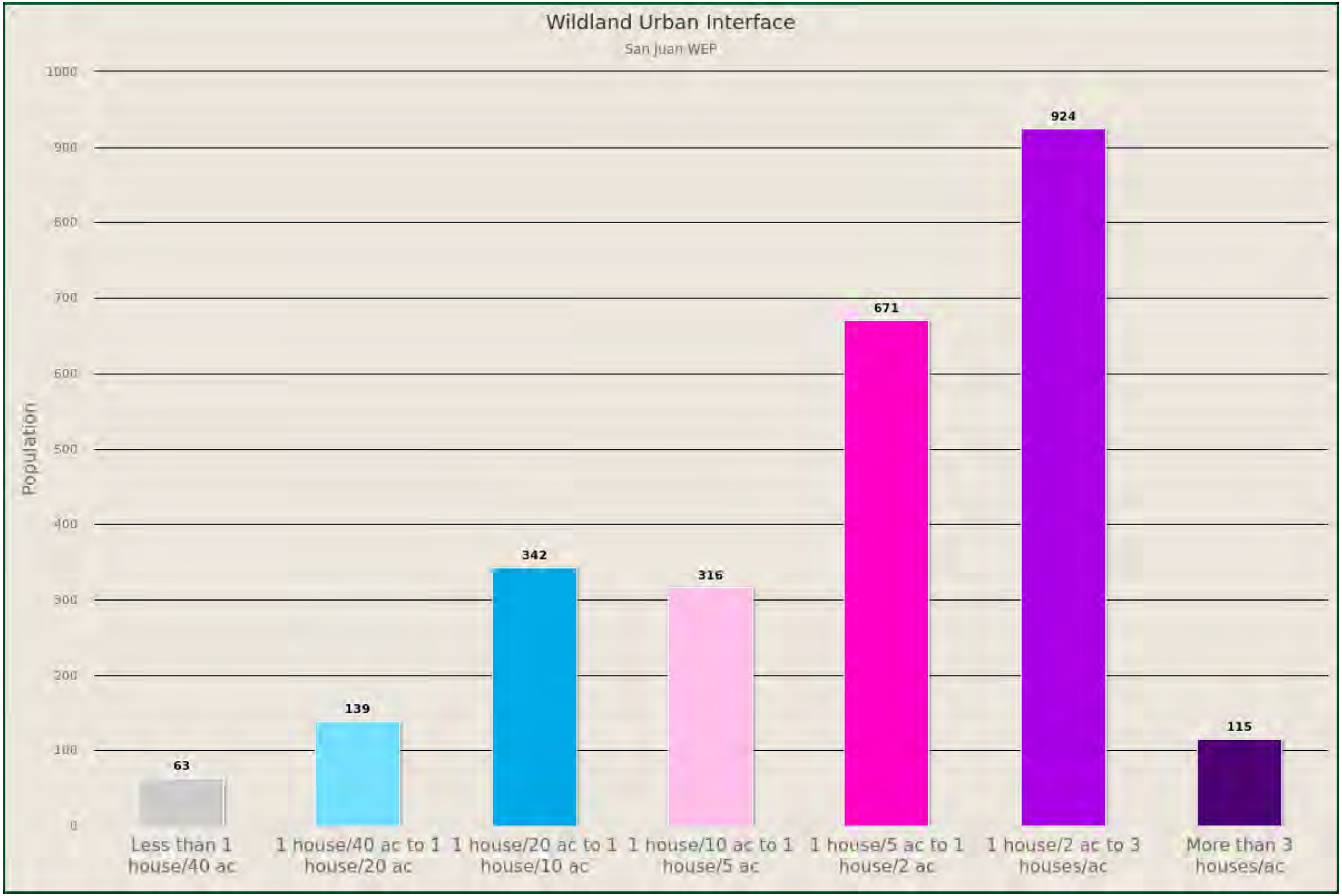
The Wildland Urban Interface (WUI) layer reflects housing density depicting where humans and their structures meet or intermix with wildland fuels. In the past, conventional wildland-urban interface datasets, such as USFS SILVIS, have been used to reflect these concerns. However, USFS SILVIS and other existing data sources did not provide the level of detail needed by the Colorado State Forest Service and local fire protection agencies.

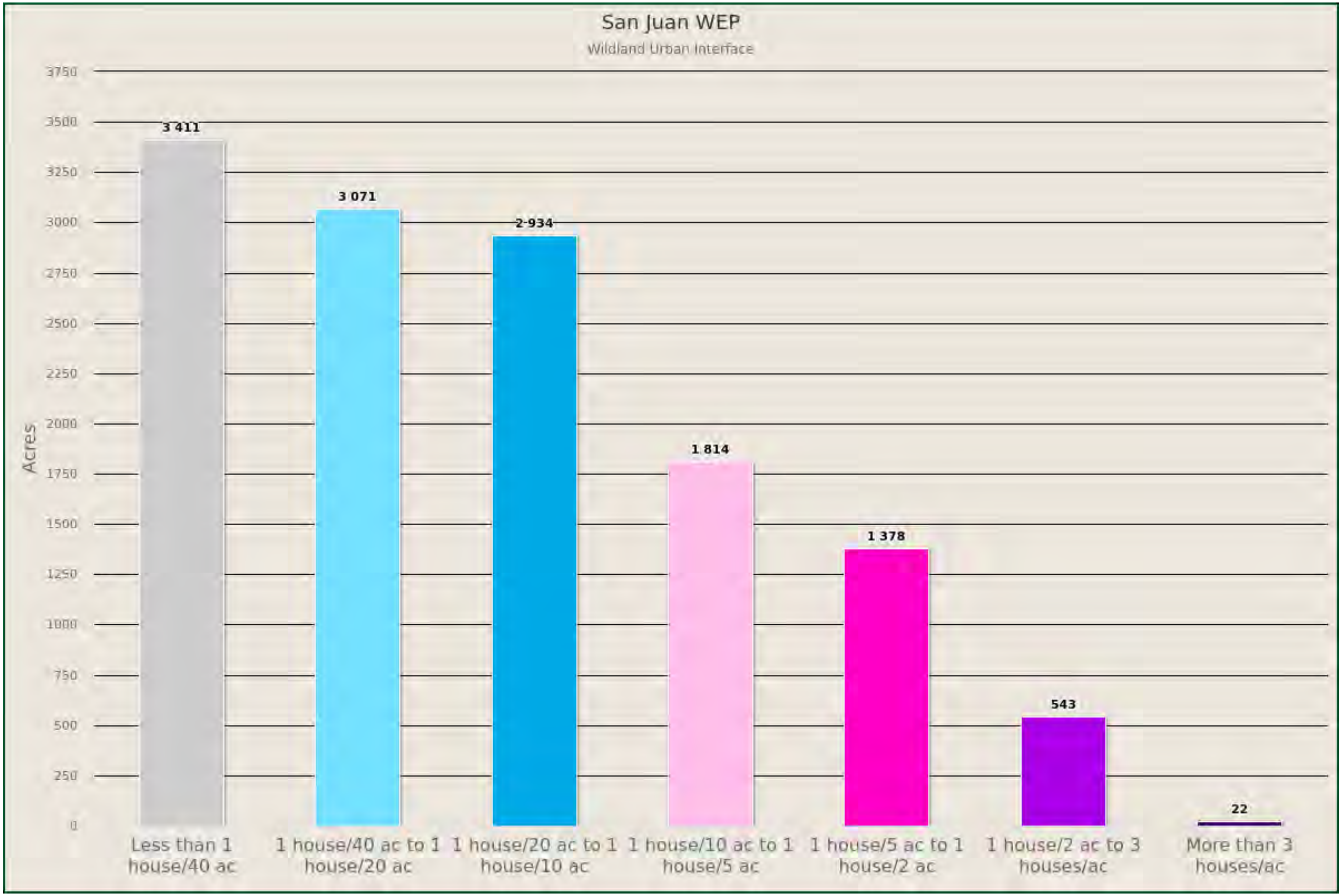
The new WUI dataset is derived using advanced modeling techniques based on the Where People Live dataset and 2016 LandScan USA population count data available from the Department of Homeland Security, HSIP dataset. WUI is simply a subset of the Where People Live dataset. The primary difference is populated areas surrounded by sufficient non-burnable areas (i.e. interior urban areas) are removed from the Where People Live dataset, as these areas are not expected to be directly impacted by a wildfire. This accommodates WUI areas based on encroachment into urban areas where wildland fire is likely to spread.

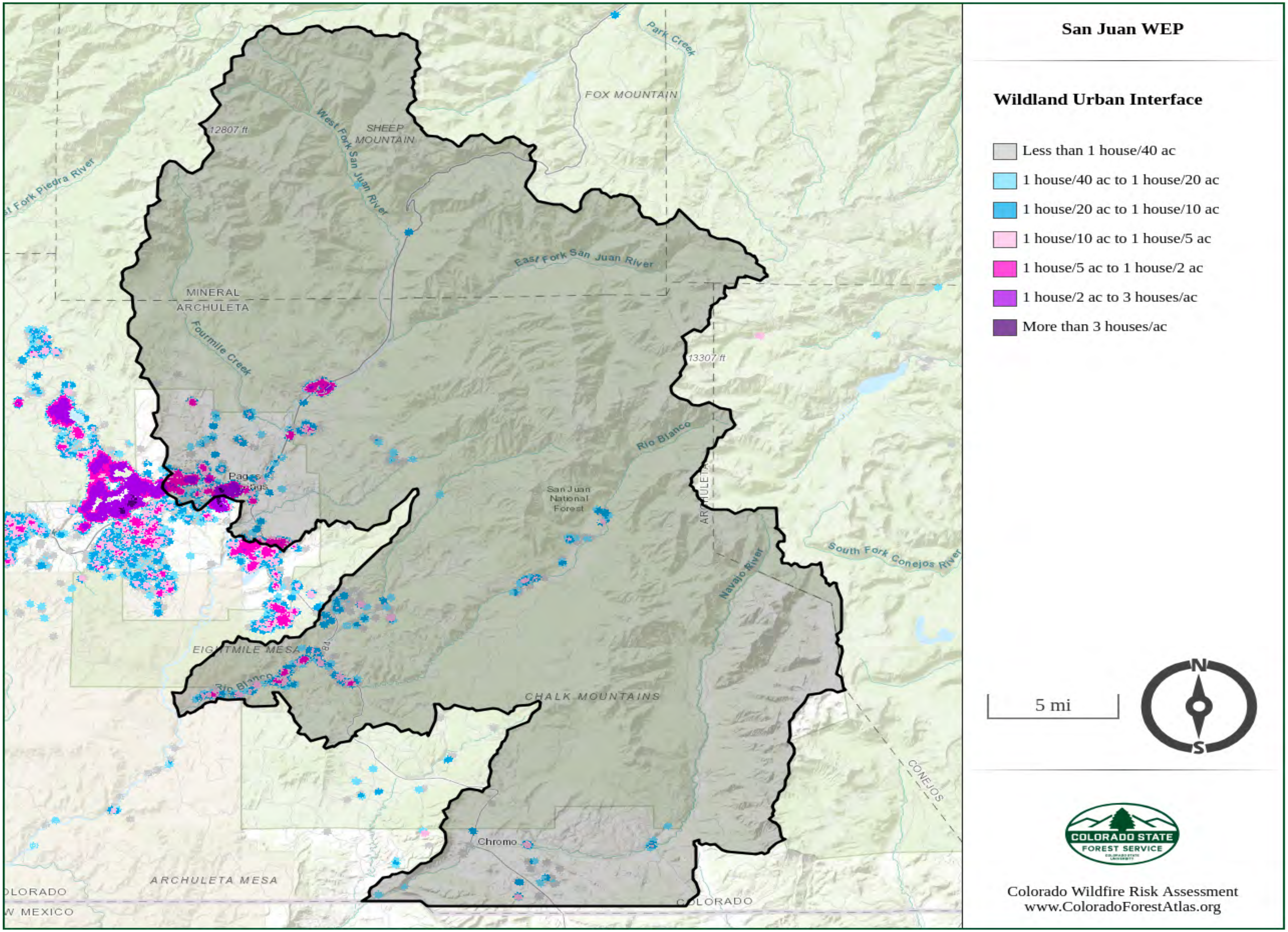
A more detailed description of the risk assessment algorithms is provided in the Colorado Wildfire Risk Assessment (Colorado WRA) Final Report, which can be downloaded from www.ColoradoForestAtlas.org.

Data are modeled at a 30-meter cell resolution (30 m2 or 900 m area per map cell), which is consistent with other Colorado WRA layers. The WUI classes are based on the number of houses per acre. Class breaks are based on densities understood and commonly used for fire protection planning.

Housing Density	WUI Population	Percent of WUI Population	WUI Acres	Percent of WUI Acres
Less than 1 house/40 ac	63	2.5 %	3,411	25.9 %
1 house/40 ac to 1 house/20 ac	139	5.4 %	3,071	23.3 %
1 house/20 ac to 1 house/10 ac	342	13.4 %	2,934	22.3 %
1 house/10 ac to 1 house/5 ac	316	12.3 %	1,814	13.8 %
1 house/5 ac to 1 house/2 ac	671	27.1 %	1,378	10.5 %
1 house/2 ac to 3 houses/ac	924	46.2 %	543	4.1 %
More than 3 houses/ac	115	7.2 %	22	0.2 %
Total	**2,570**	**100.0 %**	**13,173**	**100.0 %**


Wildland Urban Interface
San Juan WEP
Population
1000
900
800
700
600
500
400
300
200
100
0
63
139
342
316
671
924
115
Less than 1 house/40 ac
1 house/40 ac to 1 house/20 ac
1 house/20 ac to 1 house/10 ac
1 house/10 ac to 1 house/5 ac
1 house/5 ac to 1 house/2 ac
1 house/2 ac to 3 houses/ac
More than 3 houses/ac


San Juan WEP
Wildland Urban Interface
Acres
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
3 411
3 071
2 934
1 814
1 378
543
22
Less than 1 house/40 ac
1 house/40 ac to 1 house/20 ac
1 house/20 ac to 1 house/10 ac
1 house/10 ac to 1 house/5 ac
1 house/5 ac to 1 house/2 ac
1 house/2 ac to 3 houses/ac
More than 3 houses/ac


San Juan WEP
Wildland Urban Interface
Less than 1 house/40 ac
1 house/40 ac to 1 house/20 ac
1 house/20 ac to 1 house/10 ac
1 house/10 ac to 1 house/5 ac
1 house/5 ac to 1 house/2 ac
1 house/2 ac to 3 houses/ac
More than 3 houses/ac
5 mi
N
S
Colorado Wildfire Risk Assessment
www.ColoradoForestAtlas.org
Park Creek
FOX MOUNTAIN
12807 ft
SHEEP MOUNTAIN
West Fork San Juan River
East Fork San Juan River
MINERAL
ARCHULETA
Fourmile Creek
13307 ft
Rio Blanco
San Juan National Forest
South Fork Conejos River
Navajo River
CHALK MOUNTAINS
Chromo
ARCHULETA MESA
CONEJOS

Wildland Urban Interface (WUI) Risk Index

Description

The Wildland-Urban Interface (WUI) Risk Index layer is a rating of the potential impact of a wildfire on people and their homes. The key input, WUI, reflects housing density (houses per acre) consistent with Federal Register National standards. The location of people living in the wildland-urban interface and rural areas is essential for defining potential wildfire impacts to people and homes.

The WUI Risk Index is derived using a response function modeling approach. Response functions are a method of assigning a net change in the value to a resource or asset based on susceptibility to fire at different intensity levels, such as flame length.

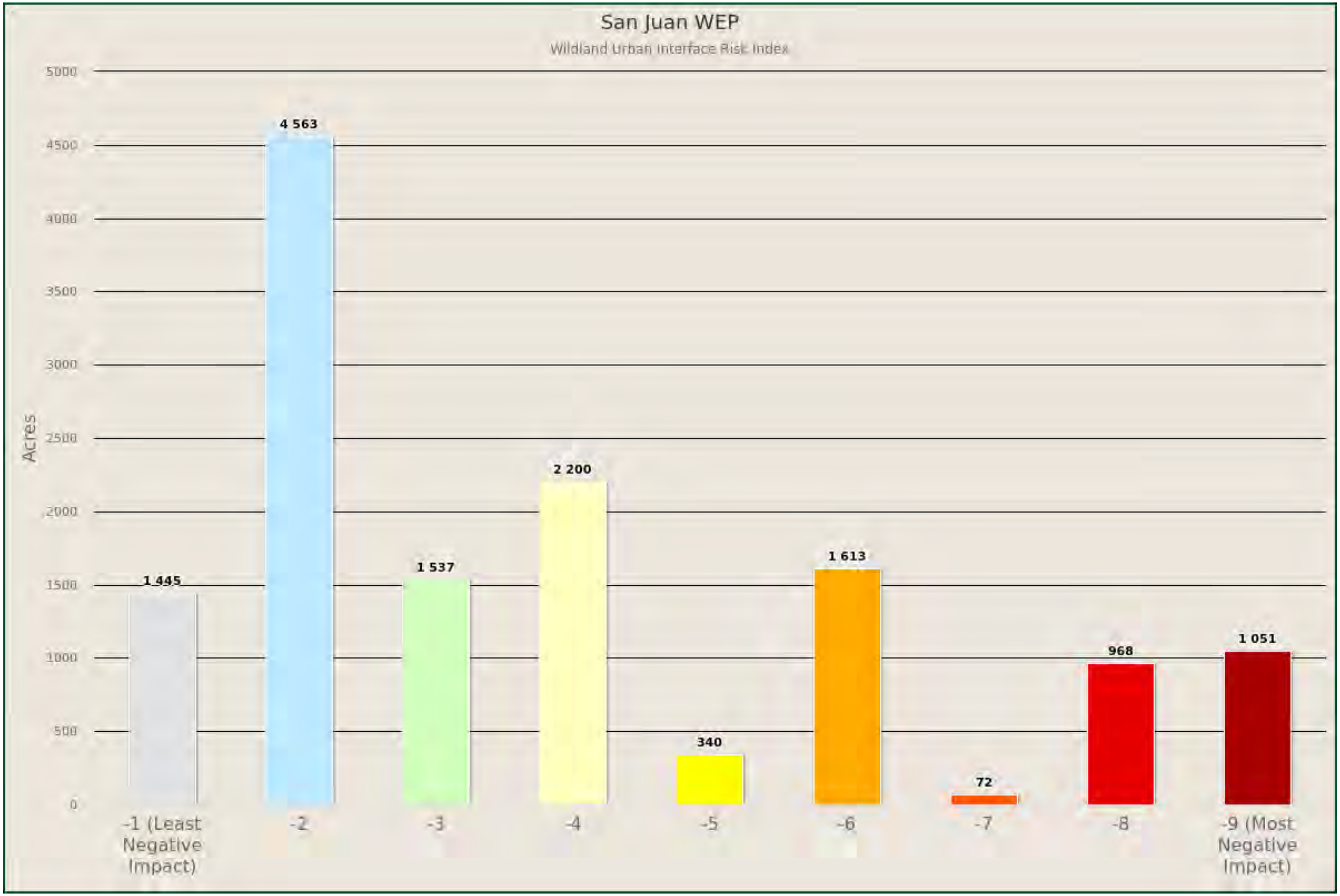
To calculate the WUI Risk Index, the WUI housing density data were combined with flame length data and response functions were defined to represent potential impacts. The response functions were defined by a team of experts led by Colorado State Forest

Service mitigation planning staff. By combining flame length with the WUI housing density data, it is possible to determine where the greatest potential impact to homes and people is likely to occur.

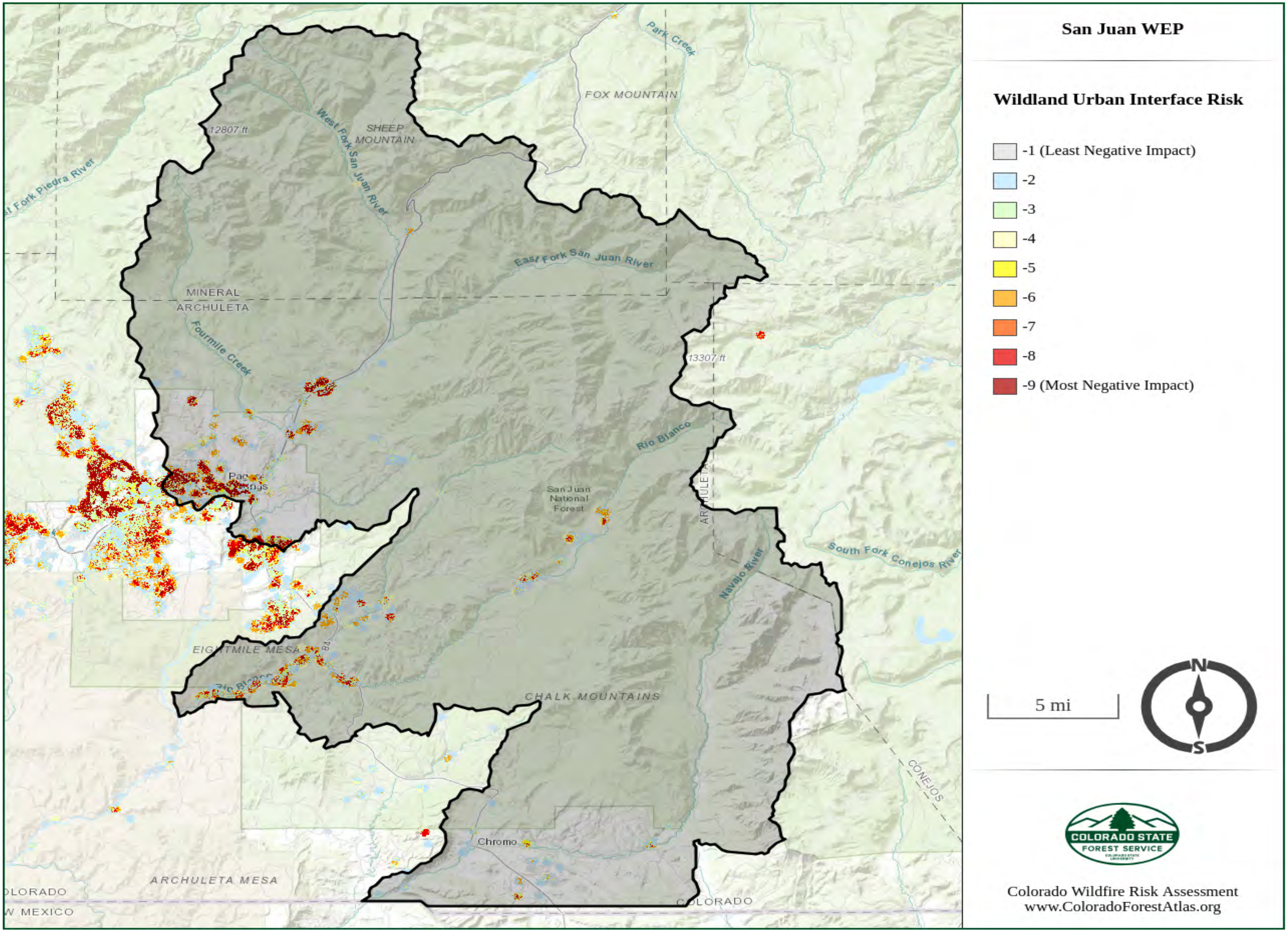
The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact. For example, areas with high housing density and high flame lengths are rated -9, while areas with low housing density and low flame lengths are rated -1.

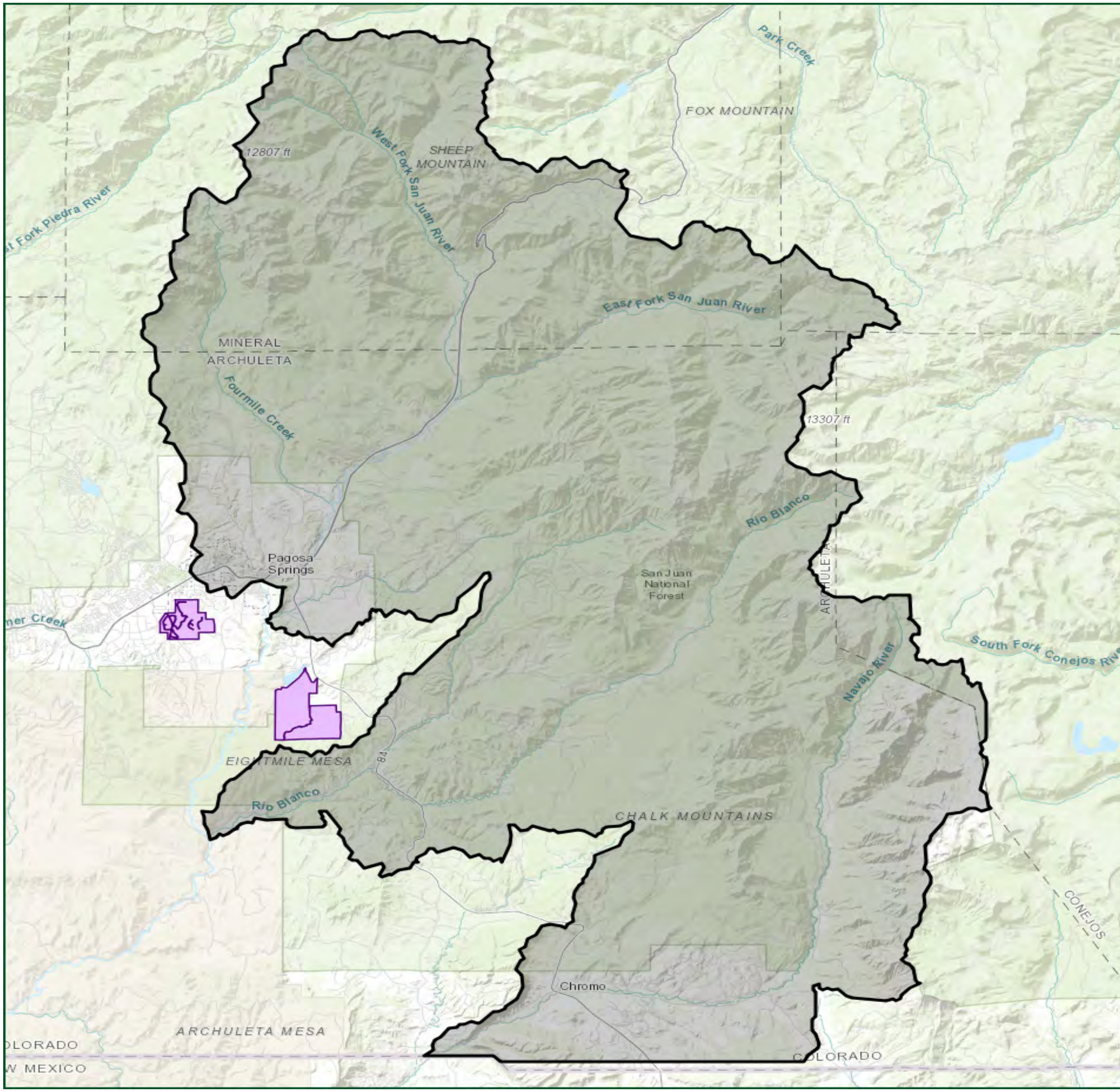
The WUI Risk Index has been calculated consistently for all areas in Colorado, which allows for comparison and ordination of areas across the entire state. Data are modeled at a 30-meter cell resolution, which is consistent with other Colorado WRA layers.

WUI Risk Class	Acres	Percent
-1 (Least Negative Impact)	1,445	10.5 %
-2	4,563	33.1 %
-3	1,537	11.1 %
-4	2,200	16.0 %
-5	340	2.5 %
-6	1,613	11.7 %
-7	72	0.5 %
-8	968	7.0 %
-9 (Most Negative Impact)	1,051	7.6 %
Total	**13,789**	**100 %**



San Juan WEP
Wildland Urban Interface Risk Index
Acres
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1 445
4 563
1 537
2 200
340
1 613
72
968
1 051
-1 (Least Negative Impact)
-2
-3
-4
-5
-6
-7
-8
-9 (Most Negative Impact)


San Juan WEP
Wildland Urban Interface Risk
-1 (Least Negative Impact)
-2
-3
-4
-5
-6
-7
-8
-9 (Most Negative Impact)
5 mi
N
S
COLORADO STATE FOREST SERVICE
Colorado Wildfire Risk Assessment
www.ColoradoForestAtlas.org
Park Creek
FOX MOUNTAIN
12807 ft
SHEEP MOUNTAIN
West Fork San Juan River
East Fork San Juan River
MINERAL
ARCHULETA
Fourmile Creek
13307 ft
Rio Blanco
San Juan National Forest
South Fork Conejos River
Navajo River
EIGHTMILE MESA
CHALK MOUNTAINS
CONEJOS
Chromo
ARCHULETA MESA
COLORADO



San Juan WEP

Fire Wise Communities

Fire Wise Communities 2018

5 mi

N S

Colorado State Forest Service

Colorado Wildfire Risk Assessment
www.ColoradoForestAtlas.org

Community Wildfire Protection Plans (CWPPs)

Description

A Community Wildfire Protection Plan (CWPP) is a document developed and agreed upon by a community to identify how the community will reduce its wildfire risk. CWPPs identify areas where fuels reduction is needed to reduce wildfire threats to communities and critical infrastructure, address protection of homes and other structures, and plan for wildfire response capability. The Colorado State Forest Service (CSFS) supports the development and implementation of CWPPs and provides resources, educational materials and information to those interested in developing CWPPs.

The CWPP dataset represents the boundaries of those areas that have developed a CWPP. Note that CWPPs can be developed by different groups at varying scales, such as county, Fire Protection District (FPD), community/subdivision, HOA, etc., and as such, can overlap. In addition, the CWPPs can be from different dates. Often a county CWPP is completed first with subsequently more detailed CWPPs done for local communities within that county or FPD. CO-WRAP provides a tool that allows the user to select the CWPP area and retrieve the CWPP document for review (PDF).

At a minimum, a CWPP should include:

- The wildland-urban interface (WUI) boundary, defined on a map, where people, structures and other community values are most likely to be negatively impacted by wildfire
- The CSFS, local fire authority and local government involvement and any additional stakeholders
- A narrative that identifies the community's values and fuel hazards
- The community's plan for when a wildfire occurs
- An implementation plan that identifies areas of high priority for fuels treatments

Community input is the foundation of a Community Wildfire Protection Plan that identfies community needs and garners community support.

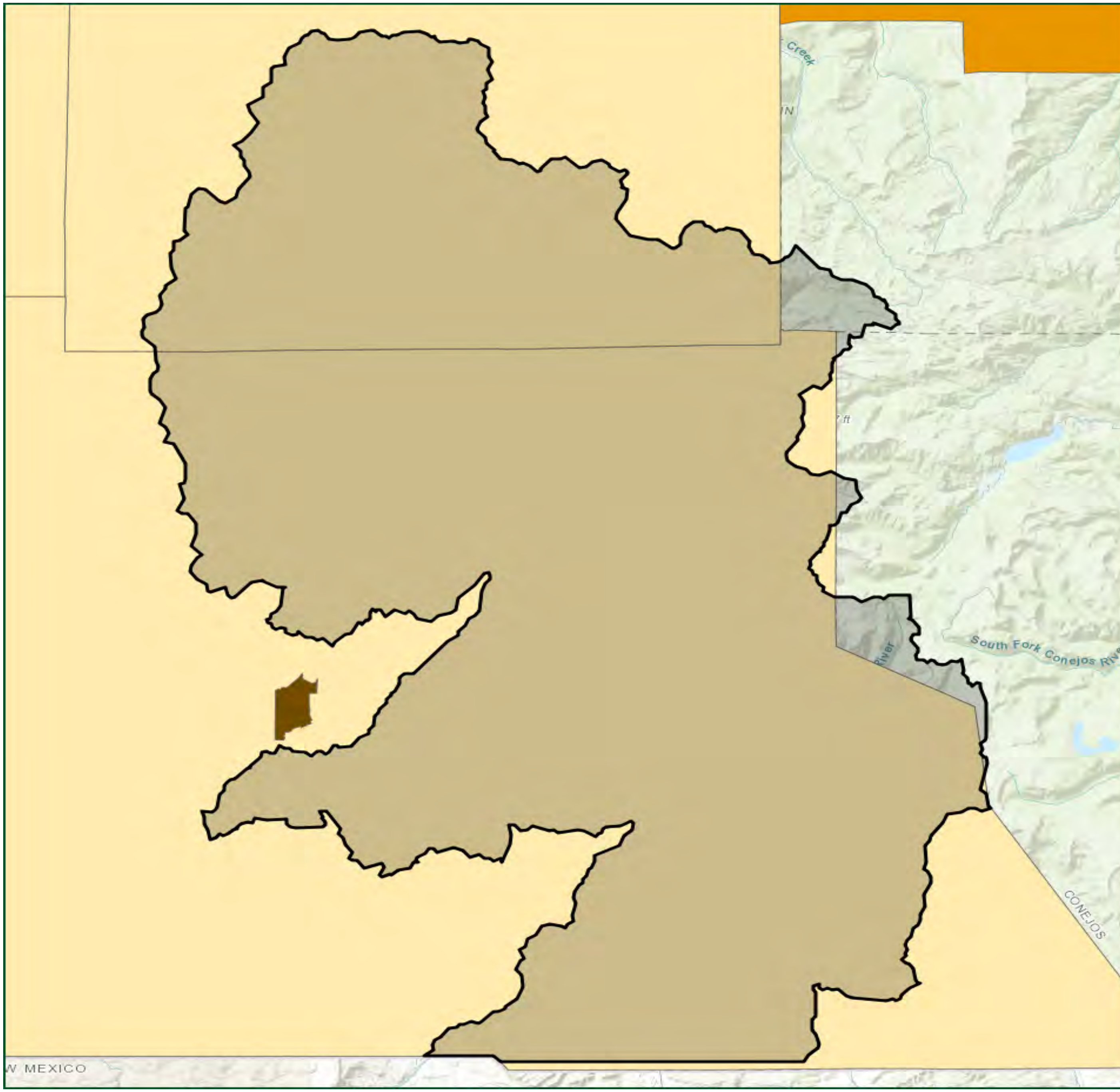
CWPPs are not shelf documents and should be reviewed, tracked and updated. A plan stays alive when it is periodically updated to address the accomplishments of the community. Community review of progress in meeting plan objectives and determining areas of new concern where actions must be taken to reduce wildfire risk helps the community stay current with changing environment and wildfire mitigation priorities.

If your community is in an area at risk from wildfire, now is a good time to start working with neighbors on a CWPP and preparing forfuture wildfires. Contact your local CSFS district to learn how to start this process and create a CWPP for your community: http://csfs.colostate.edu/pages/your-local-forester.html

For the San Juan WEP test project area, there are 2 CWPPs areas that are totally or partially in the defined project area.

Community CWPP Name	CWPP Type	CSFS District	Acres inside project area	Total Acres
Mineral County	County	Alamosa	100,338	561,715
Archuleta County	County	Durango	303,967	867,557
Total Acres			**404,305**	**1,429,273**

San Juan WEP



CWPP

- Community
- FPD
- County

5 mi

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Wildfire Risk

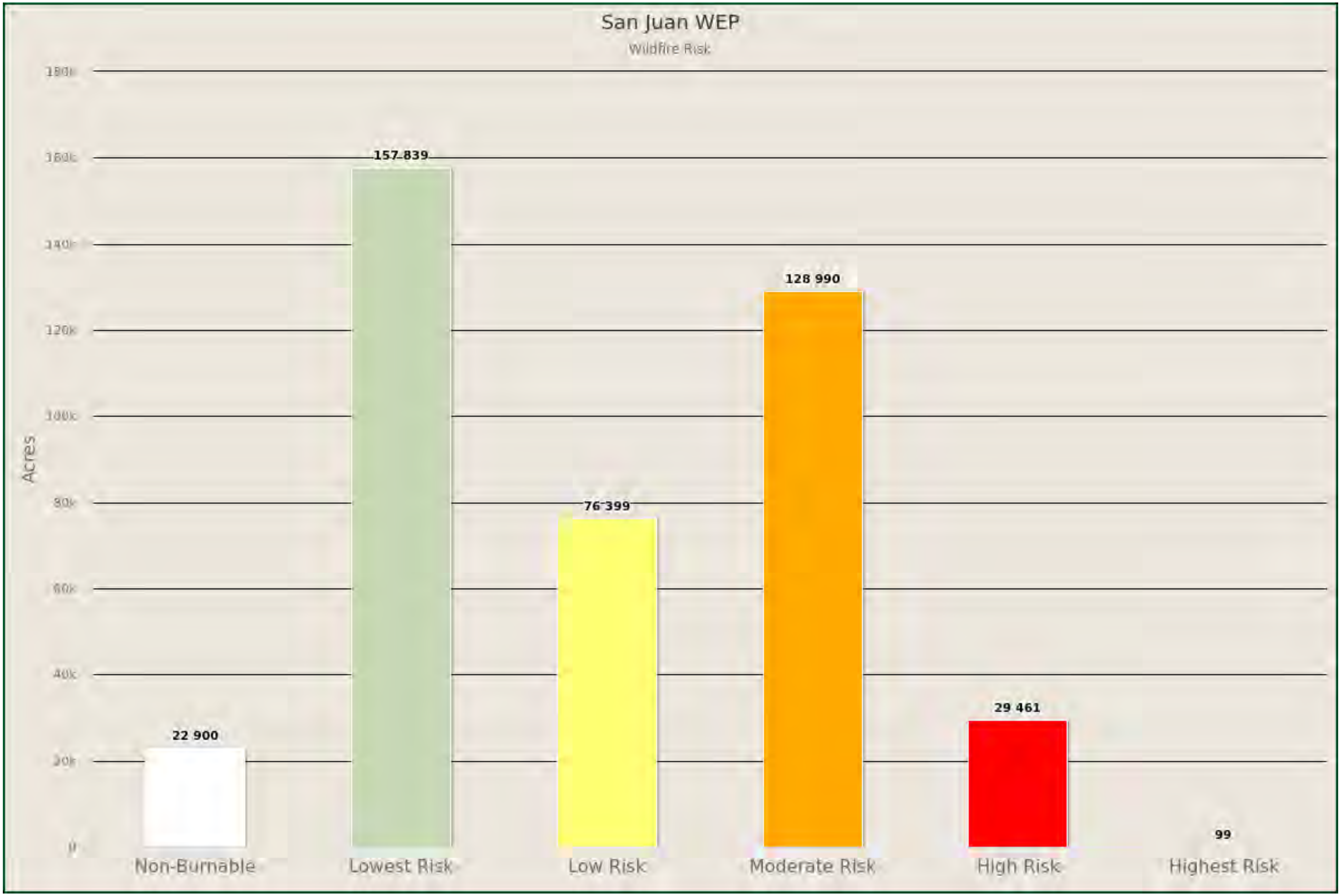
Description

Wildfire Risk is a composite risk rating obtained by combining the probability of a fire occurring with the individual values at risk layers. Risk is defined as the possibility of loss or harm occurring from a wildfire. It identifies areas with the greatest potential impacts from a wildfire – i.e. those areas most at risk - considering all values and assets combined together – WUI Risk, Drinking Water Risk, Forest Assets Risk and Riparian Areas Risk.

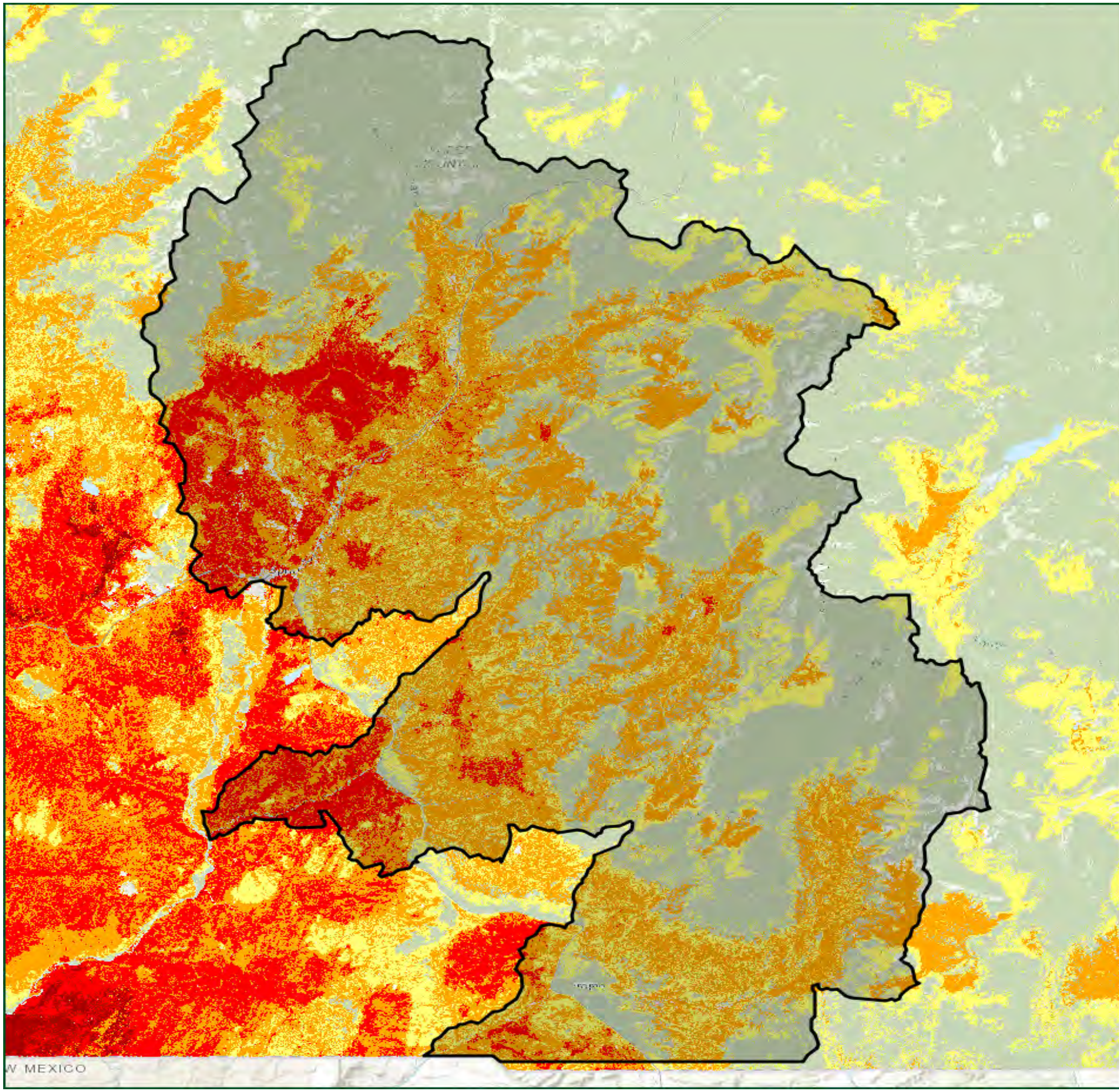
Since all areas in Colorado have risk calculated consistently, it allows for comparison and ordination of areas across the entire state. The Values at Risk Rating is a key component of Wildfire Risk. The Values at Risk Rating is comprised of several inputs focusing on values and assets at risk. This includes Wildland Urban Interface, Forest Assets, Riparian Assets and Drinking Water Importance Areas (watersheds).

To aid in the use of Wildfire Risk for planning activities, the output values are categorized into five (5) classes. These are given general descriptions from Lowest to Highest Risk.

Wildfire Risk Class		Acres	Percent
	Non-Burnable	22,900	5.5 %
	Lowest Risk	157,839	38.0 %
	Low Risk	76,399	18.4 %
	Moderate Risk	128,990	31.0 %
	High Risk	29,461	7.1 %
	Highest Risk	99	0.0 %
Total		**415,689**	**100 %**


San Juan WEP
Wildfire Risk
Acres
180k
160k
140k
120k
100k
80k
60k
40k
20k
0
157 839
128 990
76 399
29 461
22 900
99
Non-Burnable
Lowest Risk
Low Risk
Moderate Risk
High Risk
Highest Risk

San Juan WEP



Wildfire Risk

- Non-Burnable
- Lowest Risk
- Low Risk
- Moderate Risk
- High Risk
- Highest Risk

5 mi

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Burn Probability

Description

Burn Probability (BP) is the annual probability of any location burning due to a wildfire. BP is calculated as the number of times that a 30-meter cell on the landscape is burned from millions of fire simulations. The annual BP was estimated by using a stochastic (Monte Carlo) wildfire simulation approach with Technosylva's Wildfire Analyst software (www.WildfireAnalyst.com).

A total number of 3,200,000 fires were simulated across the state, including those fires outside the Colorado border which were used in a buffer area around the state, to compute BP with a mean ignition density of 8.68 fires/km2. The simulation ignition points were spatially distributed evenly every 500 meters across the state. Only high and extreme weather conditions were used to run the simulations. All fires simulations had a duration of 10 hours.

The Wildfire Analyst fire simulator considered the number of times that the simulated fires burned each cell. After that, results were weighted by considering the historical fire occurrence of those fires that burned in high and extreme weather conditions. The weighting was done by assessing the relationship between the annual historical fire ignition density in Colorado and the total number of simulated fires with varying input data in the different weather scenarios and the historical spatial distribution of the ignition points.

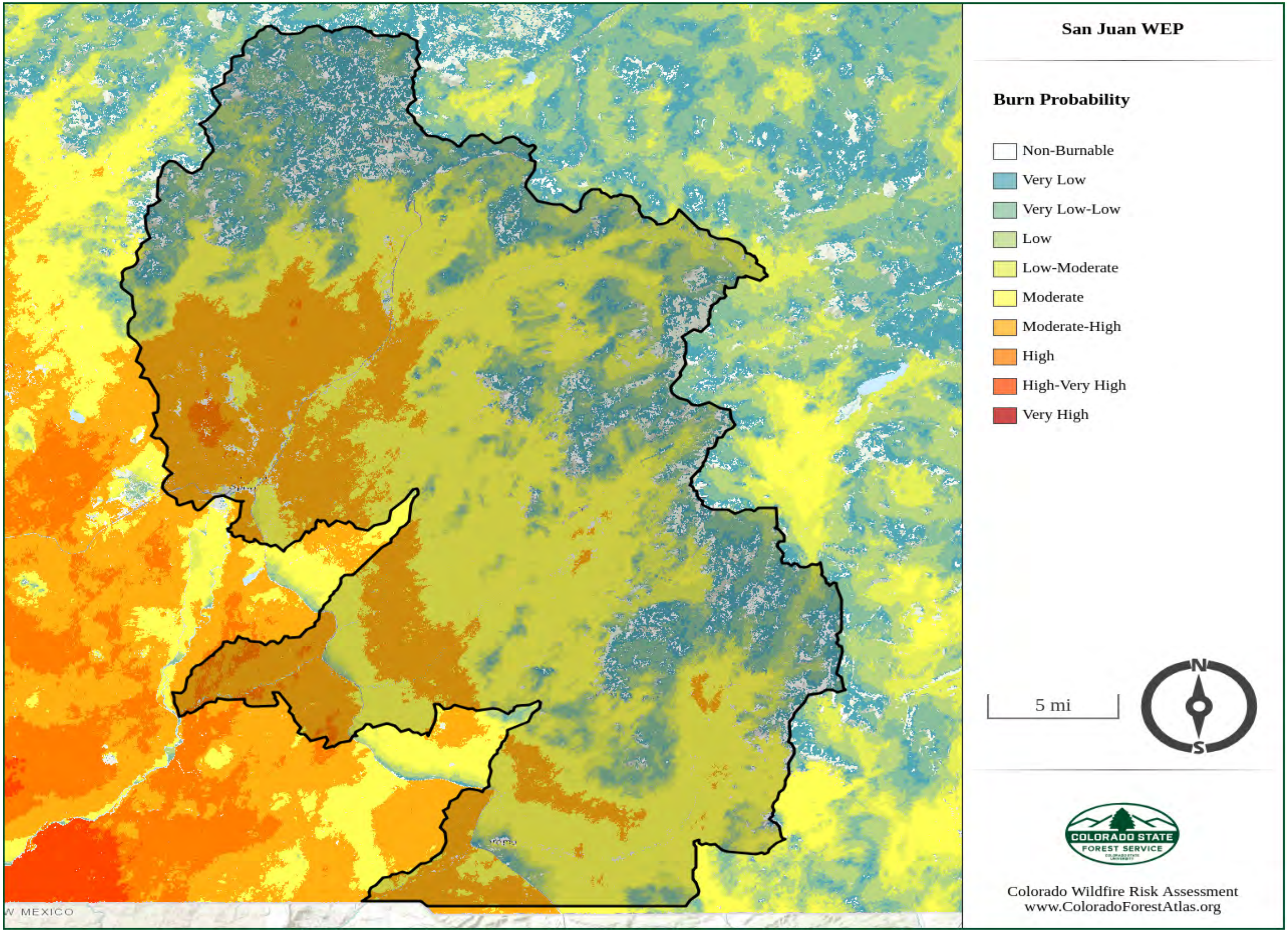
The probability map is derived at a 30-meter resolution. This scale of data was chosen to be consistent with the accuracy of the primary surface fuels dataset used in the assessment. While not appropriate for site specific analysis, it is appropriate for regional, county or local protection mitigation or prevention planning.

To aid in the use of Burn Probability for planning activities, the output values are categorized into 10 (ten) classes. These are given general descriptions from Lowest to Highest Probability.

A more detailed description of the risk assessment algorithms is provided in the Colorado WRA Final Report, which can be downloaded from www.ColoradoForestAtlas.org.

Burn Probability Class	Acres	Percent
Non-Burnable	7,765	2.0 %
Very Low	37,716	9.6 %
Very Low-Low	45,722	11.6 %
Low	41,616	10.6 %
Low-Moderate	41,980	10.7 %
Moderate	130,112	33.1 %
Moderate-High	84,430	21.5 %
High	3,486	0.9 %
High-Very High	0	0 %
Very High	0	0 %
Total	**392,827**	**100 %**


San Juan WEP
Burn Probability
Acres
140k
130k
120k
110k
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
7 765
37 716
45 722
41 616
41 980
130 112
84 430
3 486
0
0
Non-Burnable
Very Low
Very Low-Low
Low
Low-Moderate
Moderate
Moderate-High
High
High-Very High
Very High


San Juan WEP
Burn Probability
Non-Burnable
Very Low
Very Low-Low
Low
Low-Moderate
Moderate
Moderate-High
High
High-Very High
Very High
5 mi
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Values at Risk Rating

Description

Represents those values or assets that would be adversely impacted by a wildfire. The Values at Risk Rating is an overall rating that combines the risk ratings for Wildland Urban Interface (WUI), Forest Assets, Riparian Assets, and Drinking Water Importance Areas into a single measure of values-at-risk. The individual ratings for each value layer were derived using a Response Function approach.

Response functions are a method of assigning a net change in the value to a resource or asset based on susceptibility to fire at different intensity levels. A resource or asset is any of the Fire Effects input layers, such as WUI, Forest Assets, etc. These net changes can be adverse (negative) or positive (beneficial).

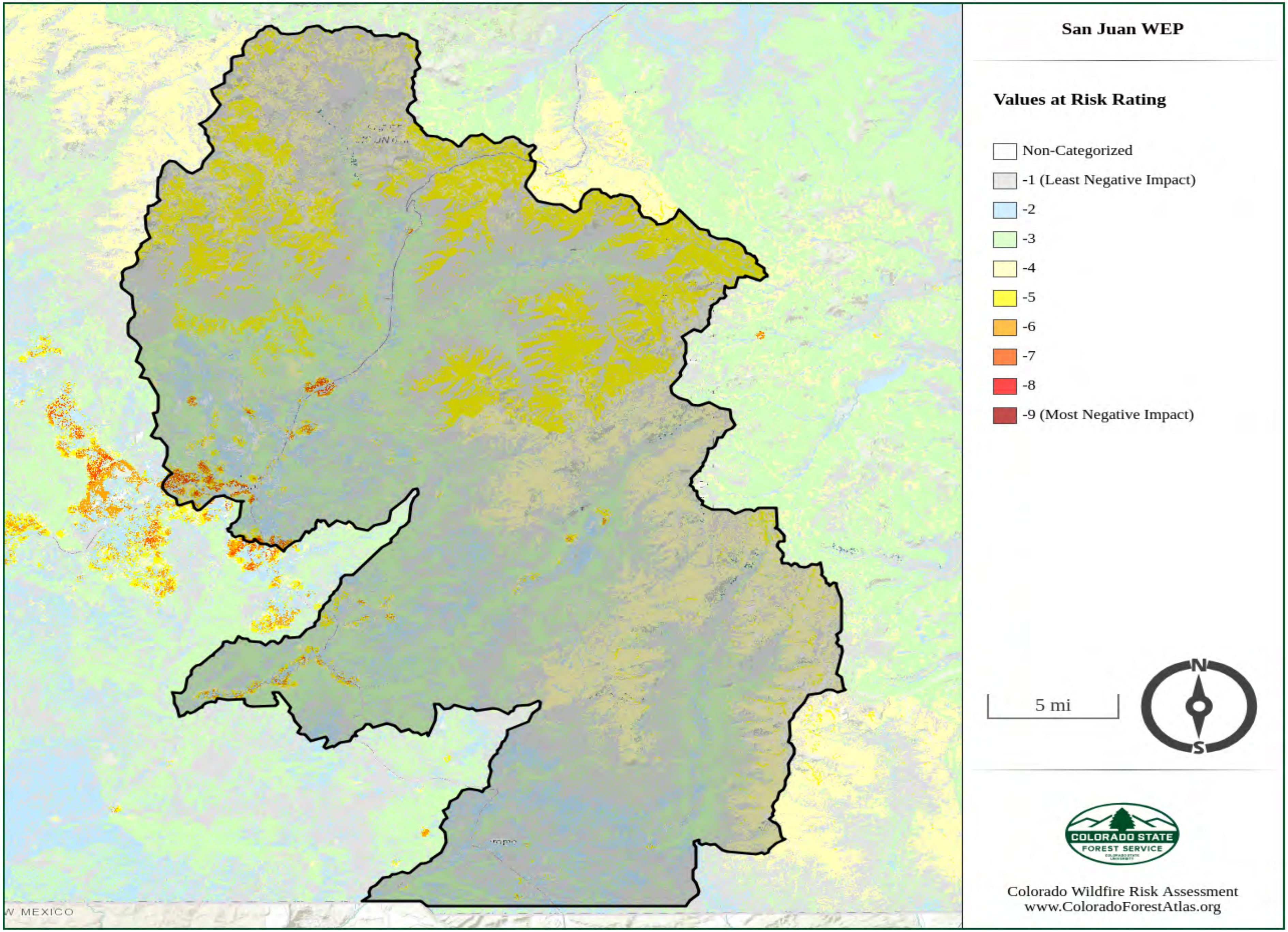
Calculating the Values at Risk Rating at a given location requires spatially defined estimates of the intensity of fire integrated with the identified resource value. This interaction is quantified through the use of response functions that estimate expected impacts to resources or assets at the specified fire intensity levels. The measure of fire intensity level used in the Colorado assessment is flame length for a location. Response Function outputs were derived for each input dataset and then combined to derive the Values Impacted Rating.

Different weightings are used for each of the input layers with the highest priority placed on protection of people and structures (i.e. WUI). The weightings represent the value associated with those assets. Weightings were developed by a team of experts during the assessment to reflect priorities for fire protection planning in Colorado. Refer to the Colorado WRA Final Report for more information about the layer weightings.

Since all areas in Colorado have the Values at Risk Rating calculated consistently, it allows for comparison and ordination of areas across the entire state. The data were derived at a 30-meter resolution.

Values at Risk Class	Acres	Percent
-1 (Least Negative Impact)	132,548	33.7 %
-2	32,499	8.3 %
-3	109,366	27.8 %
-4	71,391	18.1 %
-5	45,693	11.6 %
-6	1,336	0.3 %
-7	525	0.1 %
-8	0	0 %
-9 (Most Negative Impact)	0	0 %
Total	**393,358**	**100 %**


San Juan WEP
Values at Risk Rating
140k
120k
100k
80k
60k
40k
20k
0
Acres
132 548
32 499
109 366
71 391
45 693
1 336
525
0
0
-1 (Least Negative Impact)
-2
-3
-4
-5
-6
-7
-8
-9 (Most Negative Impact)


San Juan WEP
Values at Risk Rating
Non-Categorized
-1 (Least Negative Impact)
-2
-3
-4
-5
-6
-7
-8
-9 (Most Negative Impact)
5 mi
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Suppression Difficulty Rating

Description

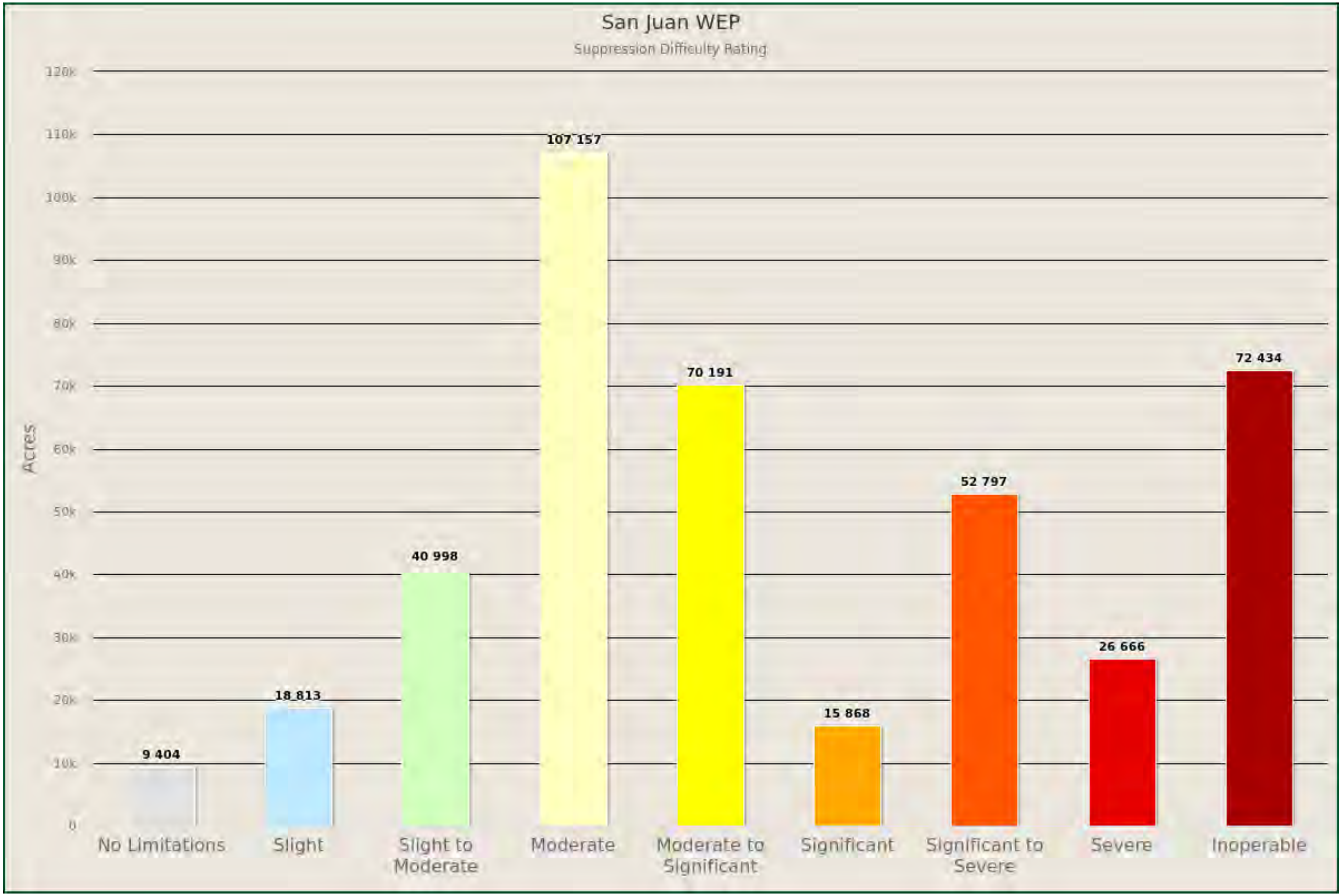
Reflects the difficulty or relative cost to suppress a fire given the terrain and vegetation conditions that may impact machine operability. This layer is an overall index that combines the slope steepness and the vegetation/fuel type characterization to identify areas where it would be difficult or costly to suppress a fire due to the underlying terrain and vegetation conditions that would impact machine operability (in particular Type II dozer).

The rating was calculated based on the fireline production rates for hand crews and engines with modifications for slope, as documented in the NWCG Fireline Handbook 3, PMS 401-1.

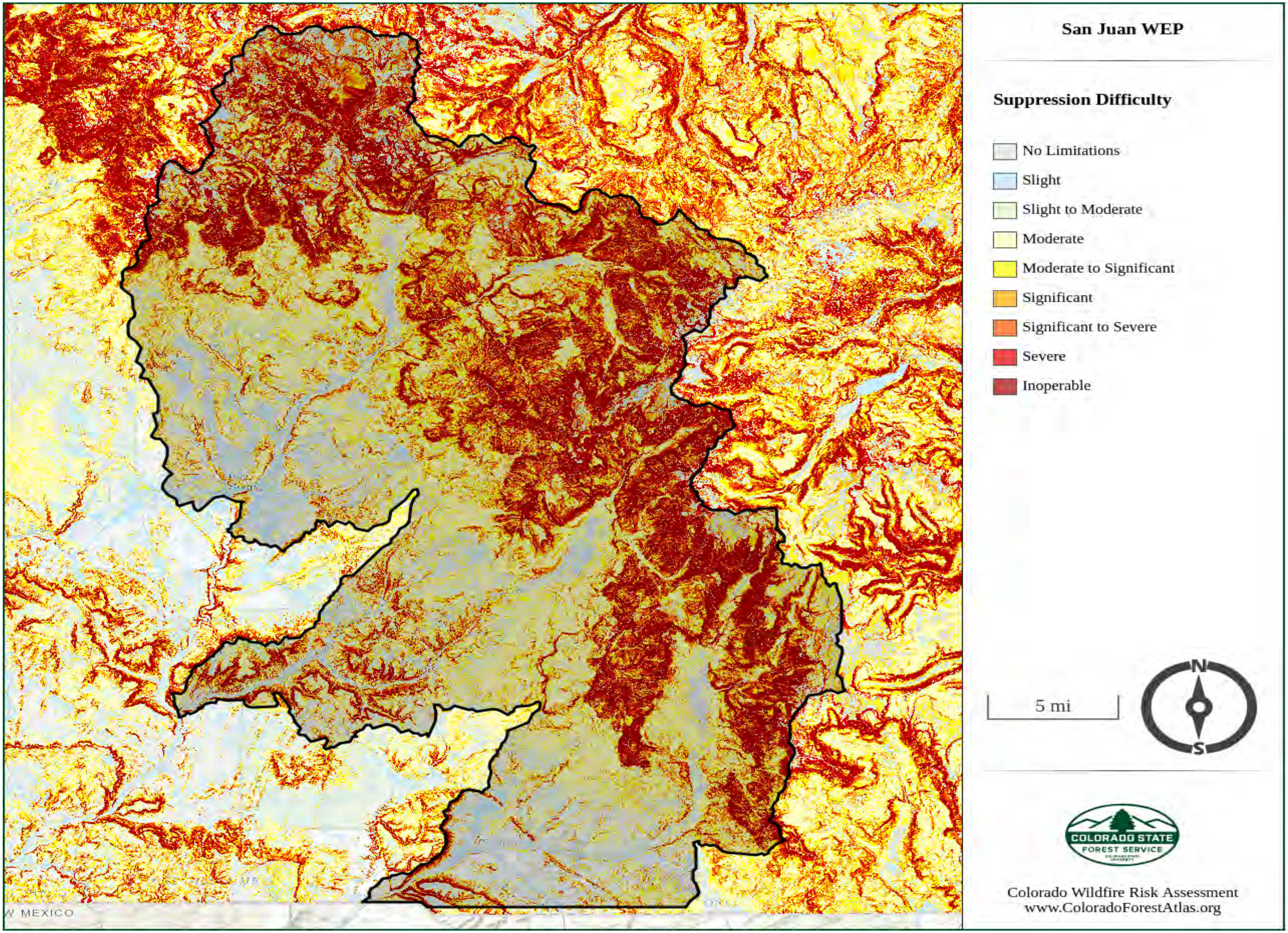
The burnable fuel models in the Colorado WRA were grouped into ten categories: Grass, Grass/Shrub, Shrub/Regeneration, Moderate Forest, Heavy Forest, Swamp/Marsh, Agriculture, Barren, Urban/Developed, Water/Ice.

Fireline production capability on six slope classes was used as the basic reference to obtain the suppression difficulty score. The response function category is assigned to each combination of fuel model group and slope category.

SDR Class	Acres	Percent
No Limitations	9,404	2.3 %
Slight	18,813	4.5 %
Slight to Moderate	40,998	9.9 %
Moderate	107,157	25.9 %
Moderate to Significant	70,191	16.9 %
Significant	15,868	3.8 %
Significant to Severe	52,797	12.7 %
Severe	26,666	6.4 %
Inoperable	72,434	17.5 %
Total	**414,329**	**100 %**



San Juan WEP
Suppression Difficulty Rating
Acres
120k
110k
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
9 404
18 813
40 998
107 157
70 191
15 868
52 797
26 666
72 434
No Limitations
Slight
Slight to Moderate
Moderate
Moderate to Significant
Significant
Significant to Severe
Severe
Inoperable


San Juan WEP
Suppression Difficulty
No Limitations
Slight
Slight to Moderate
Moderate
Moderate to Significant
Significant
Significant to Severe
Severe
Inoperable
5 mi
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Fire Occurrence

Description

Fire Occurrence is an ignition density that represents the likelihood of a wildfire starting based on historical ignition patterns. Occurrence is derived by modeling historic wildfire ignition locations to create an ignition density map.

Historic fire report data were used to create the ignition points for all Colorado fires. The compiled fire occurrence database was cleaned to remove duplicate records and to correct inaccurate locations. The database was then modeled to create a density map reflecting historical fire ignition rates.

Historic fire report data were used to create the ignition points for all Colorado fires. This included both federal and non-federal fire ignition locations.

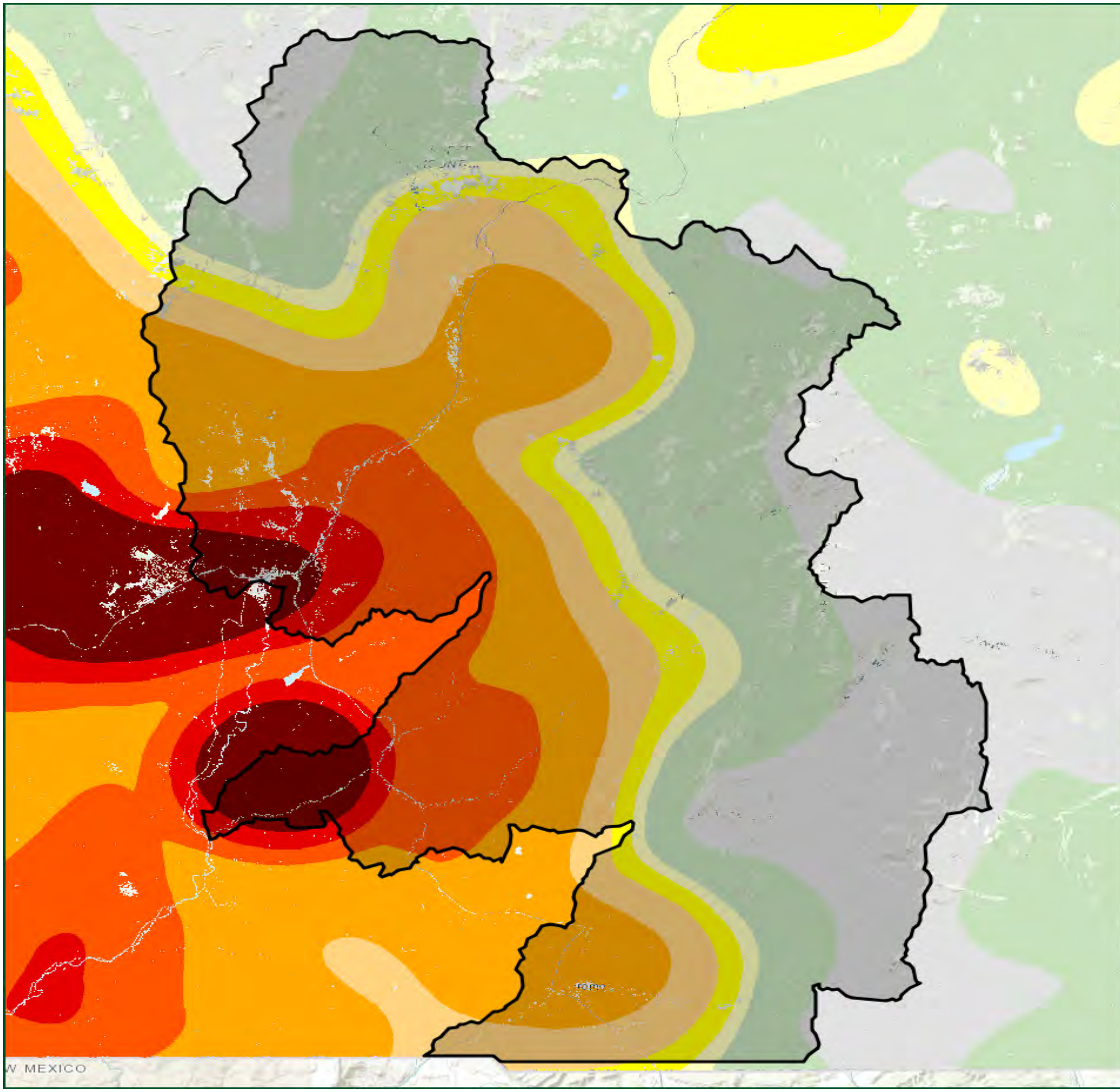
The class breaks are determined by analyzing the Fire Occurrence output values for the entire state and determining cumulative percent of acres (i.e. Class 9 has the top 1.5% of acres with the highest occurrence rate). Refer to the Colorado WRA Final Report for a more detailed description of the mapping classes and the methods used to derive these.

The Fire Occurrence map is derived at a 30-meter resolution. This scale of data was chosen to be consistent with the accuracy of the primary surface fuels dataset used in the assessment. While not sufficient for site specific analysis, it is appropriate for regional, county or local protection mitigation or prevention planning.

A more detailed description of the risk assessment algorithms is provided in the Colorado WRA Final Report, which can be downloaded from www.ColoradoForestAtlas.org.

Fire Occurrence Class	Acres	Percent
Non Burnable	22,965	5.5 %
1 (Lowest Occurrence)	56,402	13.6 %
2	94,678	22.8 %
3	20,942	5.0 %
4	29,594	7.1 %
5	53,366	12.8 %
6	74,667	18.0 %
7	40,256	9.7 %
8	10,525	2.5 %
9 (Highest Occurrence)	12,294	3.0 %
Total	**415,689**	**100 %**


San Juan WEP
Fire Occurrence
Acres
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
22 965
56 402
94 678
20 942
29 594
53 366
74 667
40 256
10 525
12 294
Non Burnable
1 (Lowest Occurrence)
2
3
4
5
6
7
8
9 (Highest Occurrence)



San Juan WEP

Fire Occurrence

- Non Burnable
- 1 (Lowest Occurrence)
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9 (Highest Occurrence)

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Fire Behavior

Description

Fire behavior is the manner in which a fire reacts to the following environmental influences:

1. **Fuels**
2. **Weather**
3. **Topography**

Fire behavior characteristics are attributes of wildland fire that pertain to its spread, intensity, and growth. Fire behavior characteristics utilized in the Colorado WRA include fire type, rate of spread, flame length and fireline intensity (fire intensity scale). These metrics are used to determine the potential fire behavior under different weather scenarios. Areas that exhibit moderate to high fire behavior potential can be identified for mitigation treatments, especially if these areas are in close proximity to homes, business, or other assets.

Fuels

The Colorado WRA includes composition and characteristics for both surface fuels and canopy fuels. Assessing canopy fire potential and surface fire potential allows identification of areas where significant increases in fire behavior affects the potential of a fire to transition from a surface fire to a canopy fire.

Fuel datasets required to compute both surface and canopy fire potential include:

1. **Surface Fuels** are typically categorized into one of four primary fuel types based on the primary carrier of the surface fire: 1) grass, 2) shrub/brush, 3) timber litter, and 4) slash. They are generally referred to as fire behavior fuel models and provide the input parameters needed to compute surface fire behavior. The 2017 assessment uses the latest 2017 calibrated fuels for Colorado.
2. **Canopy Cover** is the horizontal percentage of the ground surface that is covered by tree crowns. It is used to compute wind-reduction factors and shading.
3. **Canopy Ceiling Height/Stand Height** is the height above the ground of the highest canopy layer where the density of the crown mass within the layer is high enough to support vertical movement of a fire. A good estimate of canopy ceiling height is the average height of the dominant and co-dominant trees in a stand. It is used to compute wind reduction to mid-flame height, and spotting distances from torching trees.
4. **Canopy Base** Height is the lowest height above the ground above which sufficient canopy fuel exists to vertically propagate fire (Scott & Reinhardt, 2001). Canopy base height is a property of a plot, stand or group of trees, not an individual tree. For fire modeling, canopy base height is an effective value that incorporates ladder fuels, such as tall shrubs and small trees. Canopy base height is used to determine whether a surface fire will transition to a canopy fire.

5. **Canopy Bulk Density** is the mass of available canopy fuel per unit canopy volume (Scott & Reinhardt, 2001). Canopy bulk density is a bulk property of a stand, plot or group of trees, not an individual tree. Canopy bulk density is used to predict whether an active crown fire is possible.

Weather

Environmental weather parameters needed to compute fire behavior characteristics include 1-hour, 10-hour and 100-hour time-lag fuel moistures, herbaceous fuel moisture, woody fuel moisture and the 20-foot, 10-minute average wind speed. To collect this information, Weather data (1988-2017) from NCEP (National Center for Environmental Prediction) was used to analyse potential weather scenarios in which assessing fire behavior and spread. In particular, the North American Regional Reanalysis (NARR) product from NCEP was selected because of it provides high resolution weather data for all of Colorado. The following percentiles (97th, 90th, 50th and 25th) were analysed for each variable in each 30km NARR point to create four weather scenarios to run the fire behavior analysis: “Extreme”, “High”, “Moderate” and “Low”. After computing the weather percentiles of the NARR variables, an IDW algorithm was used to derive 30m resolution data to match the surface fuels dataset.

The four percentile weather categories are intended to represent low, moderate, high and extreme fire weather days. Fire behavior outputs are computed for each percentile weather category to determine fire potential under different weather scenarios.

For a detailed description of the methodology, refer to the 2017 Colorado Wildfire Risk Assessment Final Report at www.ColoradoForestAtlas.org.

Topography

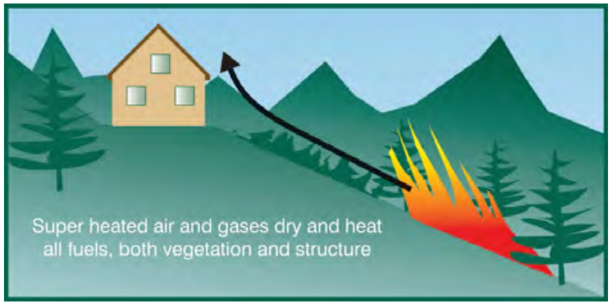
Topography datasets required to compute fire behavior characteristics are elevation, slope and aspect.

FIRE BEHAVIOR CHARACTERISTICS

Fire behavior characteristics provided in this report include:

- **Characteristic Rate of Spread**
- **Characteristic Flame Length**
- **Fire Intensity Scale**
- **Fire Type – Extreme Weather**

Characteristic Rate of Spread

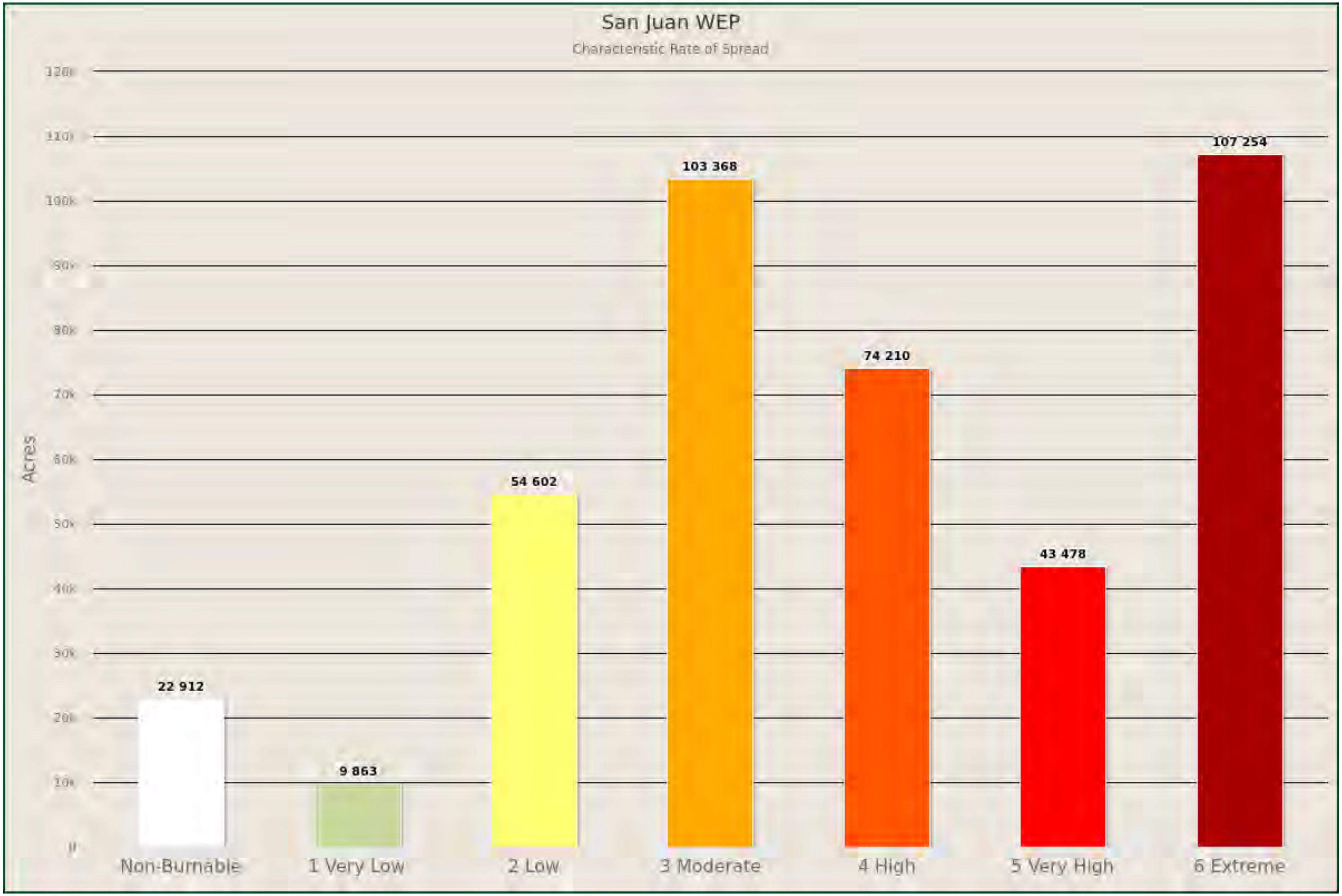


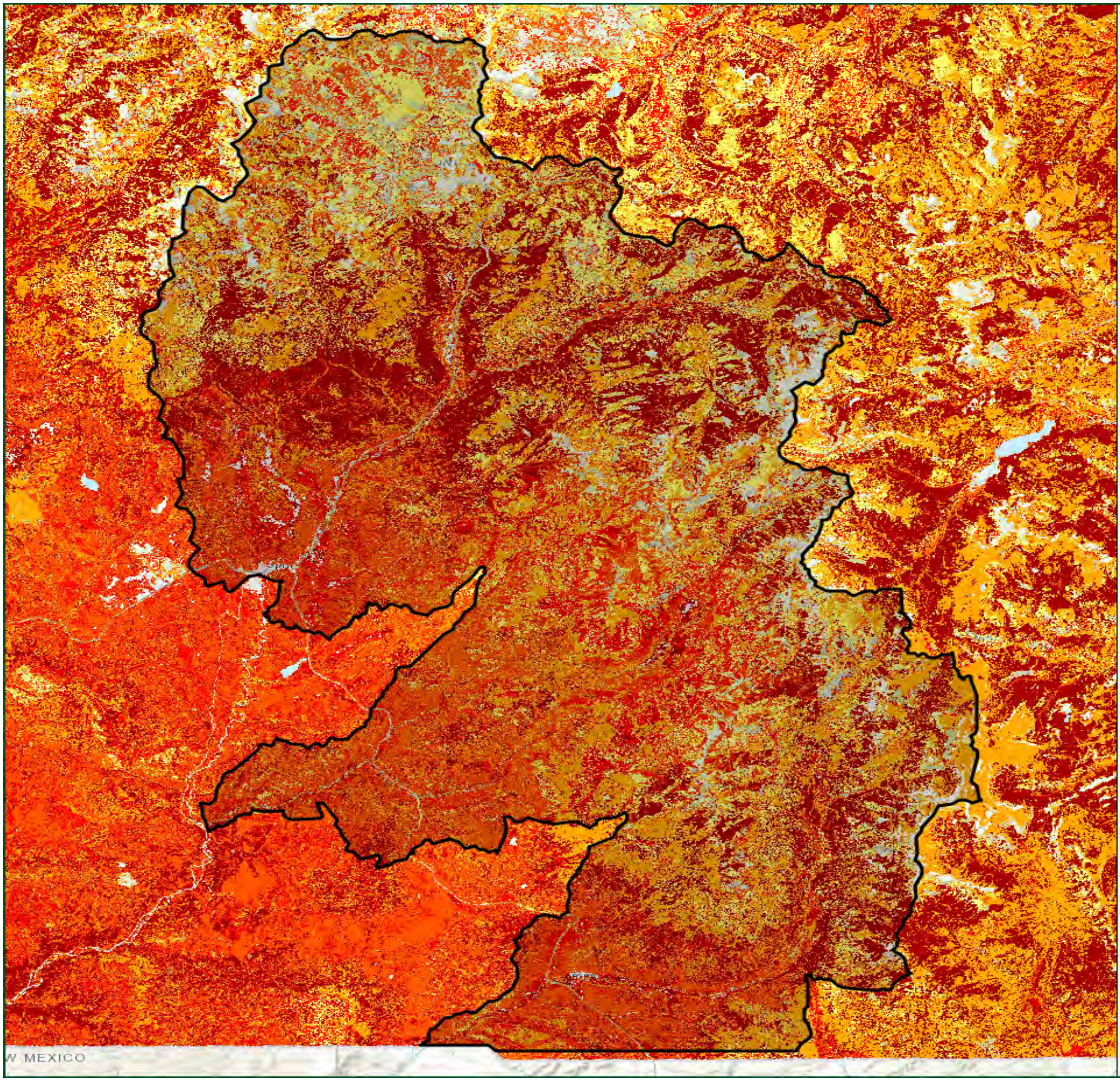
Characteristic Rate of Spread is the typical or representative rate of spread of a potential fire based on a weighted average of four percentile weather categories. Rate of spread is the speed with which a fire moves in a horizontal direction across the landscape, usually expressed in chains per hour (ch/hr) or feet per minute (ft/min). For purposes of the Colorado WRA, this measurement represents the maximum rate of spread of the fire front. Rate of Spread is used in the calculation of Wildfire Threat in the Colorado WRA.

Rate of spread is a fire behavior output, which is influenced by three environmental factors - fuels, weather, and topography. Weather is by far the most dynamic variable as it changes frequently. To account for this variability, four percentile weather categories were created from historical weather observations to represent low, moderate, high, and extreme weather days for each 30-meter cell in Colorado. Thirty (30) meter resolution is the baseline for the Colorado WRA, matching the source surface fuels dataset.

The "characteristic" output represents the weighted average for all four weather percentiles. While not shown in this report, the individual percentile weather ROS outputs are available in the Colorado WRA data.

Rate of Spread	Acres	Percent
Non-Burnable	22,912	5.5 %
1 Very Low	9,863	2.4 %
2 Low	54,602	13.1 %
3 Moderate	103,368	24.9 %
4 High	74,210	17.9 %
5 Very High	43,478	10.5 %
6 Extreme	107,254	25.8 %
Total	**415,689**	**100 %**


San Juan WEP
Characteristic Rate of Spread
Acres
120k
110k
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
22 912
9 863
54 602
103 368
74 210
43 478
107 254
Non-Burnable
1 Very Low
2 Low
3 Moderate
4 High
5 Very High
6 Extreme



San Juan WEP

Characteristic Rate of Spread

1	Very Low
2	Low
3	Moderate
4	High
5	Very High
6	Extreme

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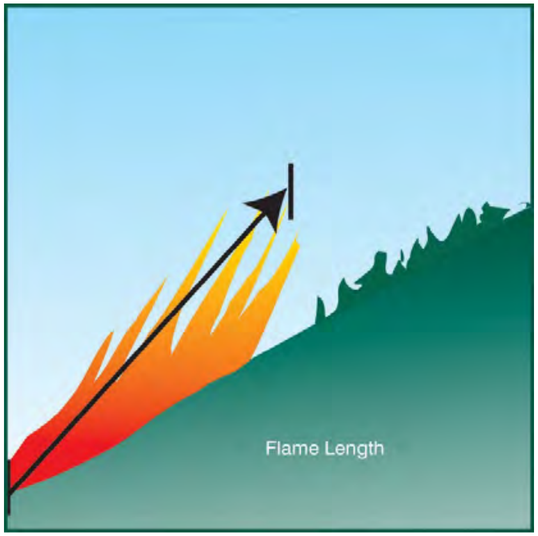
Characteristic Flame Length

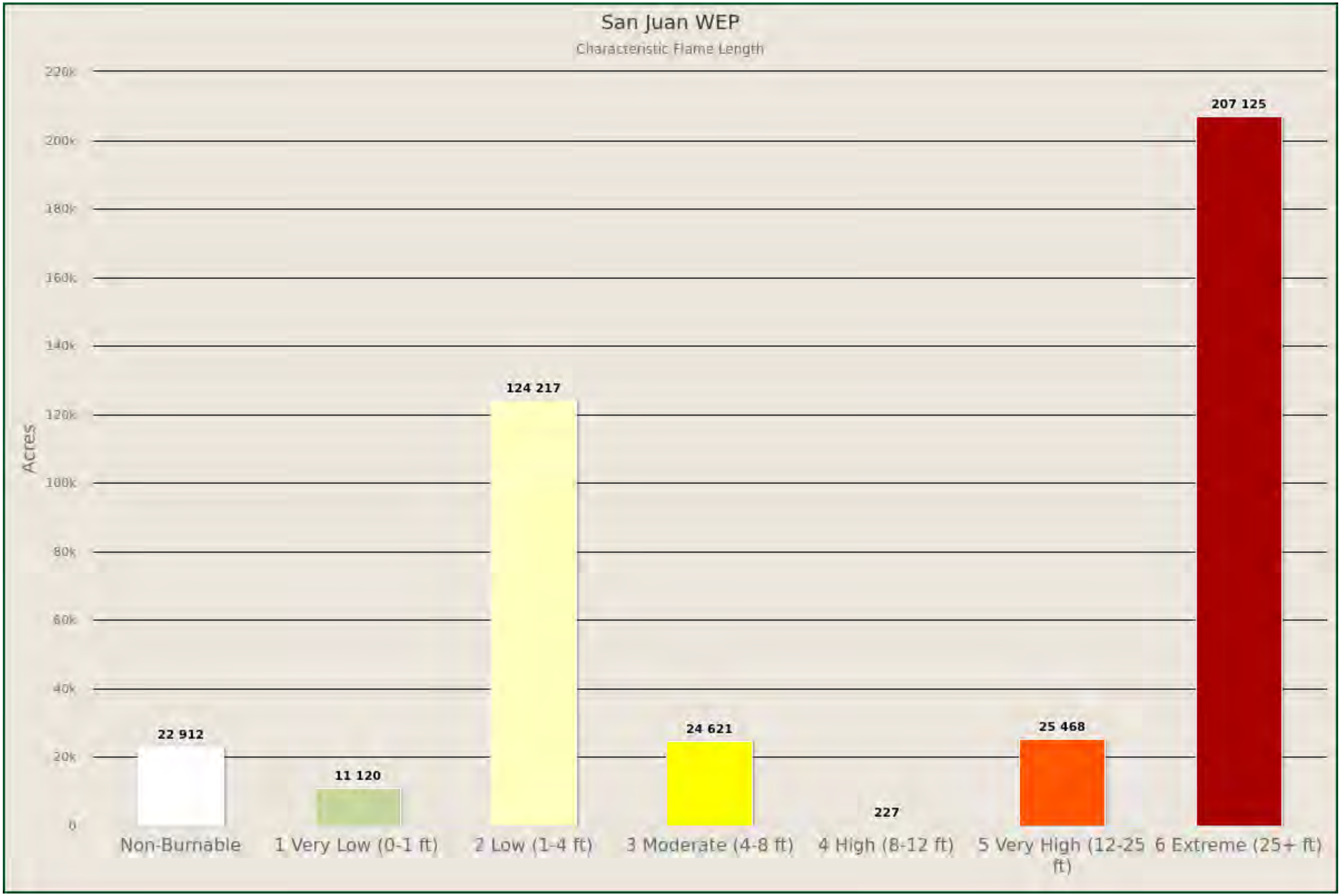
Characteristic Flame Length is the typical or representative flame length of a potential fire based on a weighted average of four percentile weather categories. Flame Length is defined as the distance between the flame tip and the midpoint of the flame depth at the base of the flame, which is generally the ground surface. It is an indicator of fire intensity and is often used to estimate how much heat the fire is generating. Flame length is typically measured in feet (ft). Flame length is the measure of fire intensity used to generate the Fire Effects outputs for the Colorado WRA.

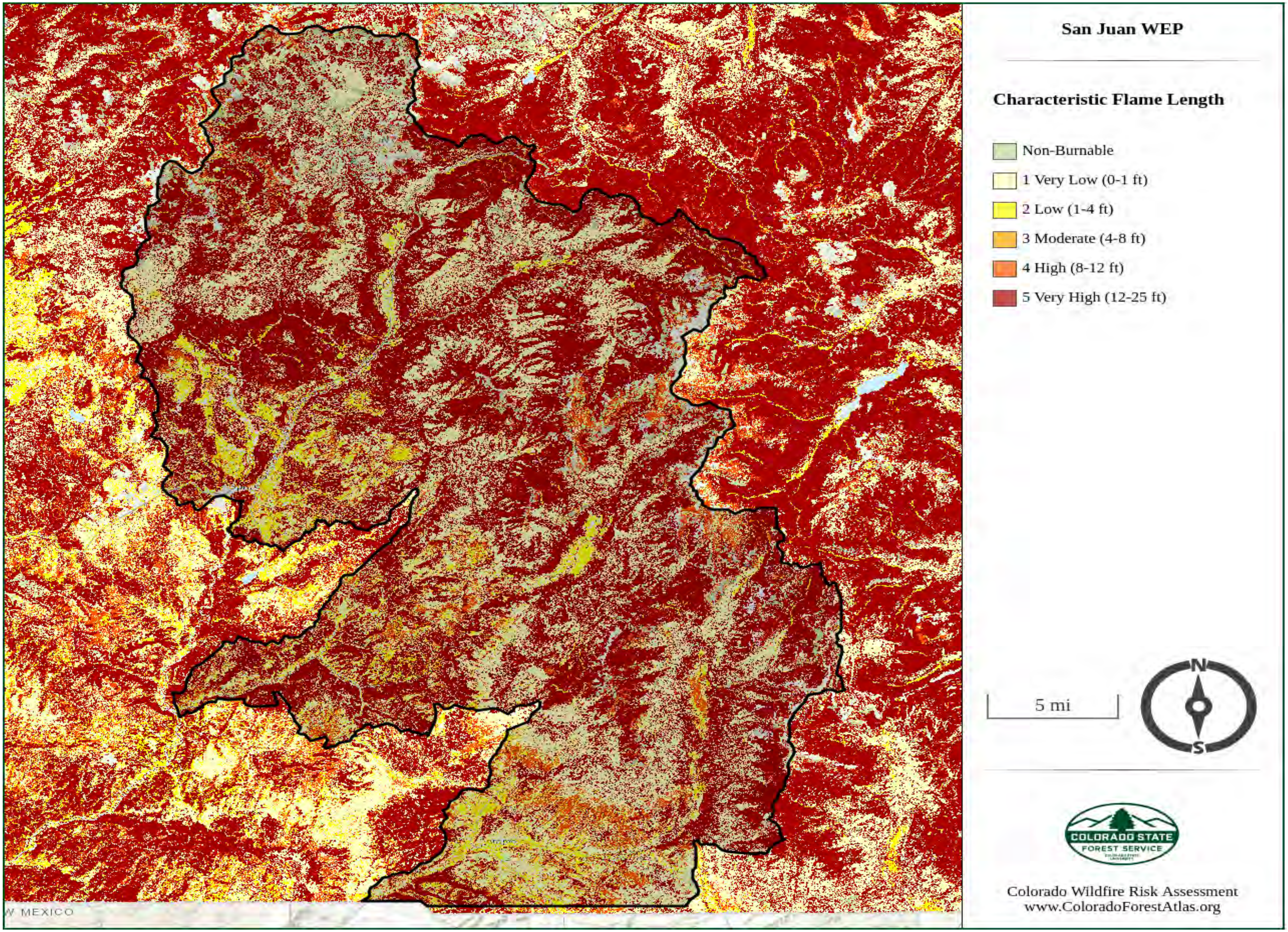


Flame length is a fire behavior output, which is influenced by three environmental factors - fuels, weather, and topography. Weather is by far the most dynamic variable as it changes frequently. To account for this variability, four percentile weather categories were created from historical weather observations to represent low, moderate, high, and extreme weather days for each 30-meter cell in Colorado.

This output represents the weighted average for all four weather percentiles. While not shown in this report, the individual percentile weather Flame Length outputs are available in the Colorado WRA data.

Flame Length	Acres	Percent
Non-Burnable	22,912	5.5 %
1 Very Low (0-1 ft)	11,120	2.7 %
2 Low (1-4 ft)	124,217	29.9 %
3 Moderate (4-8 ft)	24,621	5.9 %
4 High (8-12 ft)	227	0.1 %
5 Very High (12-25 ft)	25,468	6.1 %
6 Extreme (25+ ft)	207,125	49.8 %
Total	**415,689**	**100 %**


San Juan WEP
Characteristic Flame Length
Acres
220k
200k
180k
160k
140k
120k
100k
80k
60k
40k
20k
0
22 912
11 120
124 217
24 621
227
25 468
207 125
Non-Burnable
1 Very Low (0-1 ft)
2 Low (1-4 ft)
3 Moderate (4-8 ft)
4 High (8-12 ft)
5 Very High (12-25 ft)
6 Extreme (25+ ft)


San Juan WEP
Characteristic Flame Length
Non-Burnable
1 Very Low (0-1 ft)
2 Low (1-4 ft)
3 Moderate (4-8 ft)
4 High (8-12 ft)
5 Very High (12-25 ft)
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Fire Intensity Scale

Description

Fire Intensity Scale (FIS) specifically identifies areas where significant fuel hazards and associated dangerous fire behavior potential exist. Similar to the Richter scale for earthquakes, FIS provides a standard scale to measure potential wildfire intensity. FIS consist of five (5) classes where the order of magnitude between classes is ten-fold. The minimum class, Class 1, represents very low wildfire intensities and the maximum class, Class 5, represents very high wildfire intensities.

1. **Class 1, Lowest Intensity:**

   Very small, discontinuous flames, usually less than 1 foot in length; very low rate of spread; no spotting. Fires are typically easy to suppress by firefighters with basic training and non-specialized equipment.

2. **Class2, Low:**

   Small flames, usually less than two feet long; small amount of very short-range spotting possible. Fires are easy to suppress by trained firefighters with protective equipment and specialized tools.

3. **Class 3, Moderate:**

   Flames up to 8 feet in length; short-range spotting is possible. Trained firefighters will find these fires difficult to suppress without support from aircraft or engines, but dozer and plows are generally effective. Increasing potential for harm or damage to life and property.

4. **Class 4, High:**

   Large Flames, up to 30 feet in length; short-range spotting 1. common; medium range spotting possible. Direct attack by trained firefighters, engines, and dozers is generally ineffective, indirect attack may be effective. Significant potential for harm or damage to life and property.

5. **Class 5, Highest Intensity:**

   Very large flames up to 150 feet in length; profuse short-range spotting, frequent long-range spotting; strong fire-induced winds. Indirect attack marginally effective at the head of the fire. Great potential for harm or damage to life and property.

Burn Probability and Fire Intensity Scale are designed to complement each other. The Fire Intensity Scale does not incorporate historical occurrence information. It only evaluates the potential fire behavior for an area, regardless if any fires have occurred there in the past. This additional information allows mitigation planners to quickly identify areas where dangerous fire behavior potential exists in relationship to nearby homes or other valued assets.

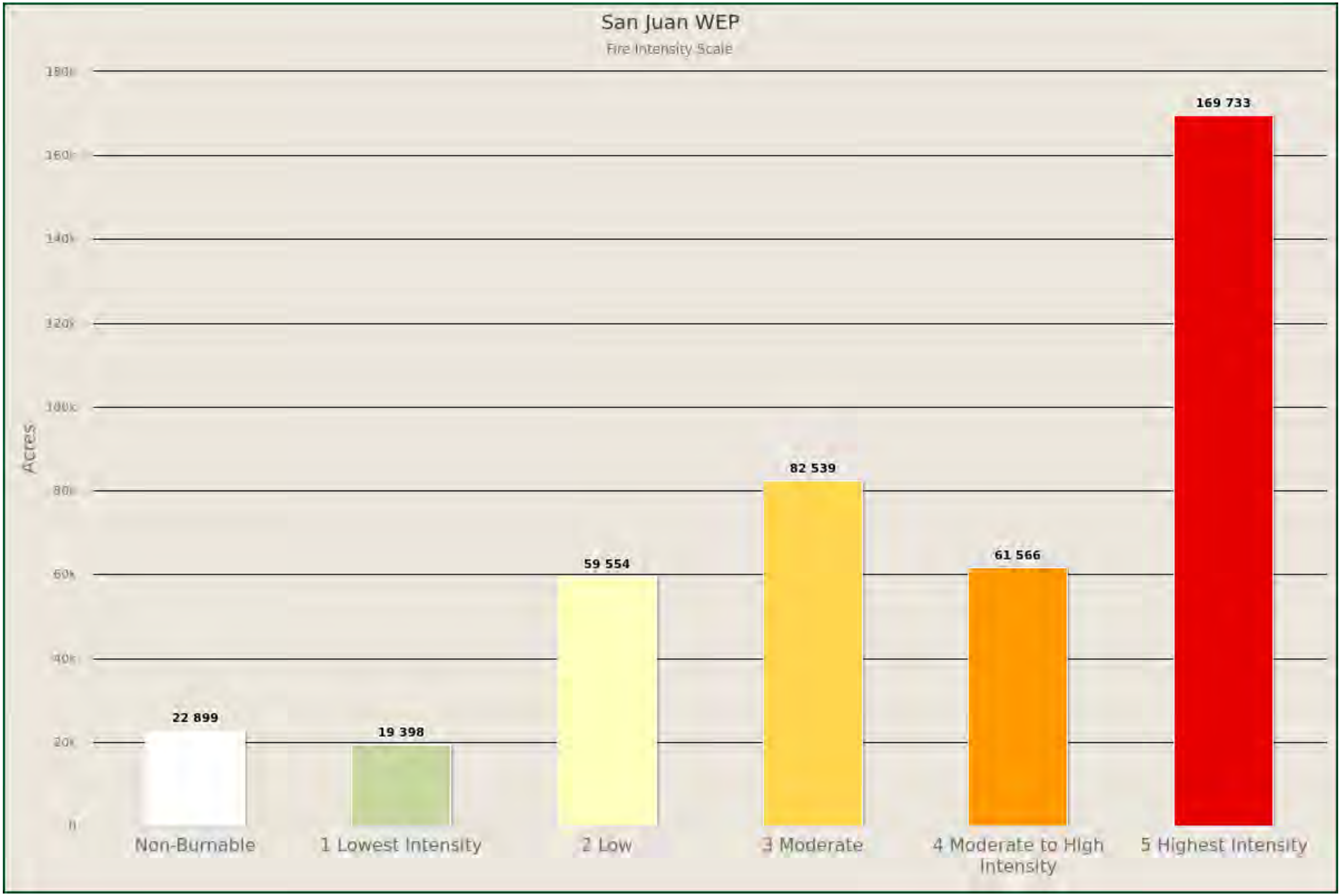
Since all areas in Colorado have fire intensity scale calculated consistently, it allows for comparison and ordination of areas across the entire state. For example, a high fire intensity area in Eastern Colorado is equivalent to a high fire intensity area in Western Colorado.

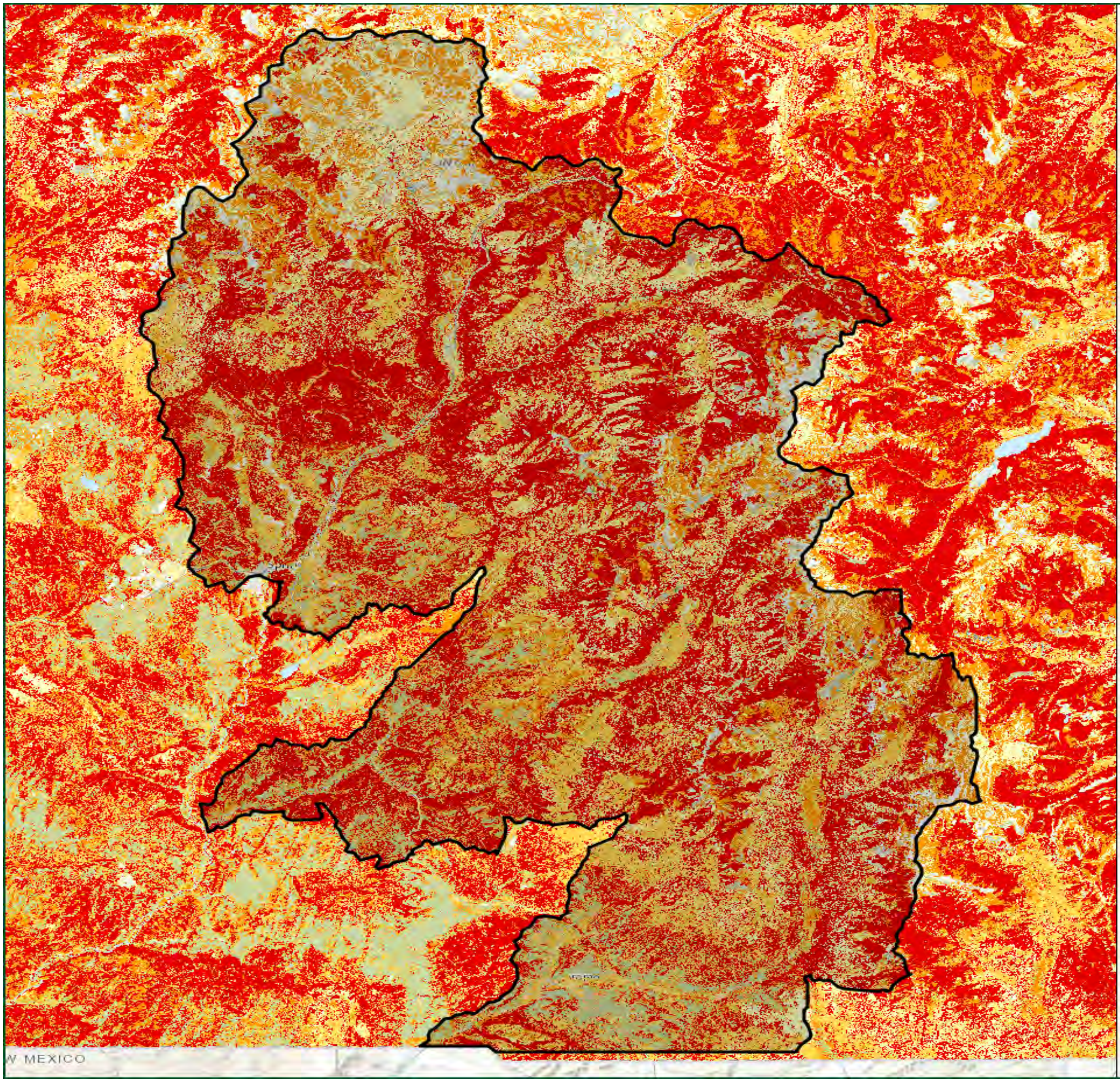
Fire intensity scale is a fire behavior output, which is influenced by three environmental factors - fuels, weather, and topography. Weather is by far the most dynamic variable as it changes frequently.

To account for this variability, four percentile weather categories were created from historical weather observations to represent low, moderate, high, and extreme weather days for each 30-meter cell in Colorado. The FIS represents the weighted average for all four weather percentiles.

The fire intensity scale map is derived at a 30-meter resolution. This scale of data was chosen to be consistent with the accuracy of the primary surface fuels dataset used in the assessment. While not appropriate for site specific analysis, it is appropriate for regional, county or local planning efforts.

FIS Class	Acres	Percent
Non-Burnable	22,899	5.5 %
1 Lowest Intensity	19,398	4.7 %
2 Low	59,554	14.3 %
3 Moderate	82,539	19.9 %
4 Moderate to High Intensity	61,566	14.8 %
5 Highest Intensity	169,733	40.8 %
Total	**415,689**	**100 %**


San Juan WEP
Fire Intensity Scale
Acres
180k
160k
140k
120k
100k
80k
60k
40k
20k
0
22 899
19 398
59 554
82 539
61 566
169 733
Non-Burnable
1 Lowest Intensity
2 Low
3 Moderate
4 Moderate to High Intensity
5 Highest Intensity



W MEXICO

San Juan WEP
Fire Intensity Scale
Non-Burnable
1 Lowest Intensity
2 Low
3 Moderate
4 Moderate to High Intensity
5 Highest Intensity
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Fire Type – Extreme Weather

Fire Type – Extreme represents the potential fire type under the extreme percentile weather category. The extreme percentile weather category represents the average weather based on the top three percent fire weather days in the analysis period. It is not intended to represent a worst-case scenario weather event. Accordingly, the potential fire type is based on fuel conditions, extreme percentile weather, and topography.

Canopy fires are very dangerous, destructive and difficult to control due to their increased fire intensity. From a planning perspective, it is important to identify where these conditions are likely to occur on the landscape so that special preparedness measure can be taken if necessary. Typically canopy fires occur in extreme weather conditions. The Fire Type – Extreme layer shows the footprint of where these areas are most likely to occur. However, it is important to note that canopy fires are not restricted to these areas. Under the right conditions, it can occur in other canopied areas.

There are two primary fire types – surface fire and canopy fire. Canopy fire can be further subdivided into passive canopy fire and active canopy fire. A short description of each of these is provided below.

Surface Fire

A fire that spreads through surface fuel without consuming any overlying canopy fuel. Surface fuels include grass, timber litter, shrub/brush, slash and other dead or live vegetation within about 6 feet of the ground.

Passive Canopy Fire

A type of crown fire in which the crowns of individual trees or small groups of trees burn, but solid flaming in the canopy cannot be maintained except for short periods (Scott & Reinhardt, 2001).

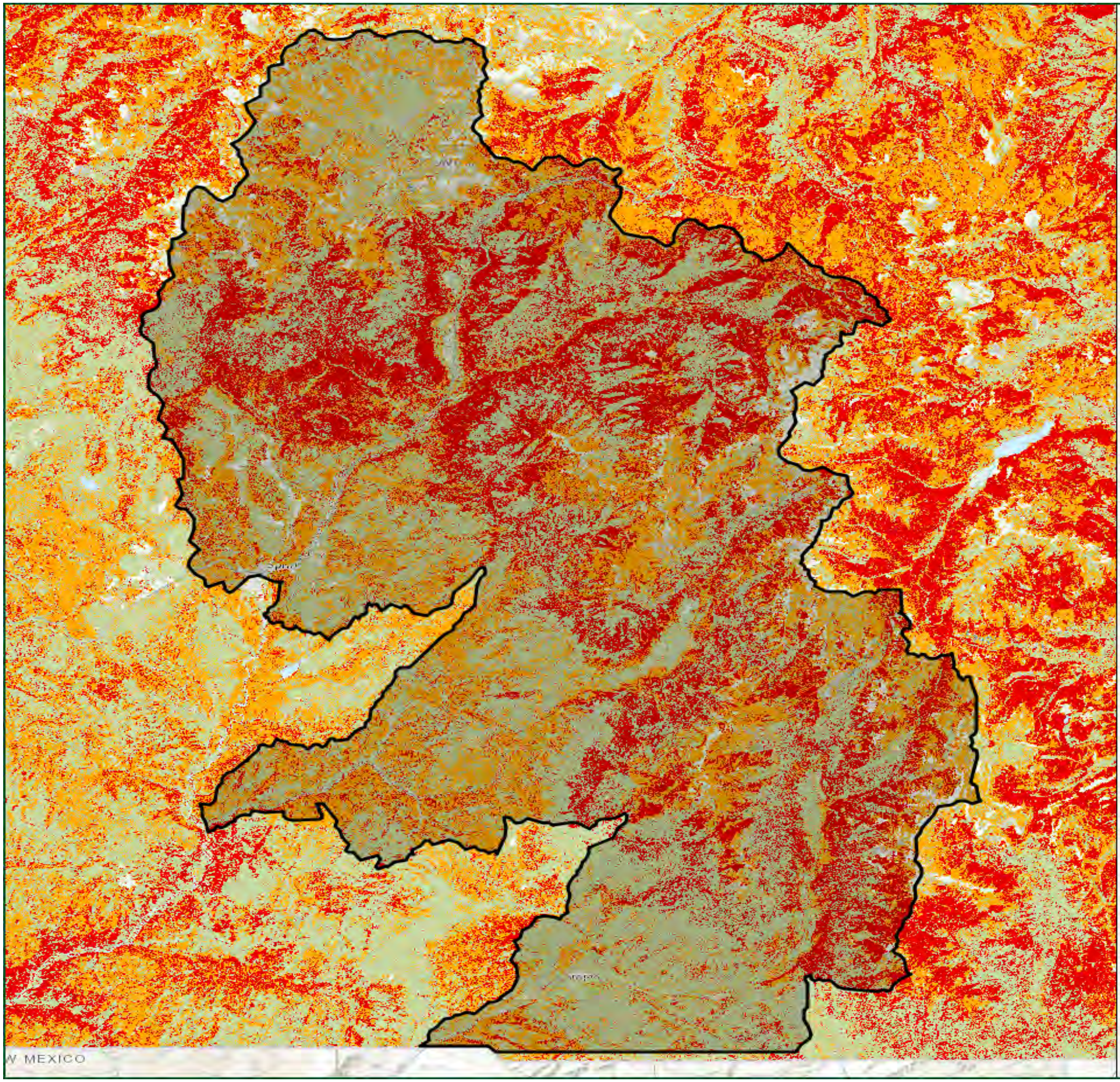
Active Canopy Fire

A crown fire in which the entire fuel complex (canopy) is involved in flame, but the crowning phase remains dependent on heat released from surface fuel for continued spread (Scott & Reinhardt, 2001).

The Fire Type - Extreme Weather map is derived at a 30-meter resolution. This scale of data was chosen to be consistent with the accuracy of the primary surface fuels dataset used in the assessment. While not appropriate for site specific analysis, it is appropriate for regional, county or local planning efforts.

Fire Type - Extreme Weather	Acres	Percent
Surface Fire	169,818	43.2 %
Passive Canopy Fire	115,220	29.3 %
Active Canopy Fire	107,751	27.4 %
Total	**392,790**	**100 %**


San Juan WEP
Fire Type - Extreme Weather
Acres
169 818
115 220
107 751
Surface Fire
Passive Canopy Fire
Active Canopy Fire



San Juan WEP

Fire Type Extreme Weather

- Surface Fire
- Passive Canopy Fire
- Active Canopy Fire

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Surface Fuels

Description

Surface fuels, or fire behavior fuel models as they are technically referred to, contain the parameters required by the Rothermel (1972) surface fire spread model to compute surface fire behavior characteristics, including rate of spread, flame length, fireline intensity and other fire behavior metrics. As the name might suggest, surface fuels account only for surface fire potential. Canopy fire potential is computed through a separate but linked process. The Colorado WRA accounts for both surface and canopy fire potential in the fire behavior outputs. However, only surface fuels are shown in this risk report.

Surface fuels typically are categorized into one of four primary fuel types based on the primary carrier of the surface fire: 1) grass, 2) shrub/brush, 3) timber litter, and 4) slash. Two standard fire behavior fuel model sets have been published. The Fire Behavior Prediction System 1982 Fuel Model Set (Anderson, 1982) contains 13 fuel models, and the Fire Behavior Prediction System 2005 Fuel Model Set (Scott & Burgan, 2005) contains 40 fuel models. The Colorado WRA uses fuel models from the 2005 Fuel Model Set.

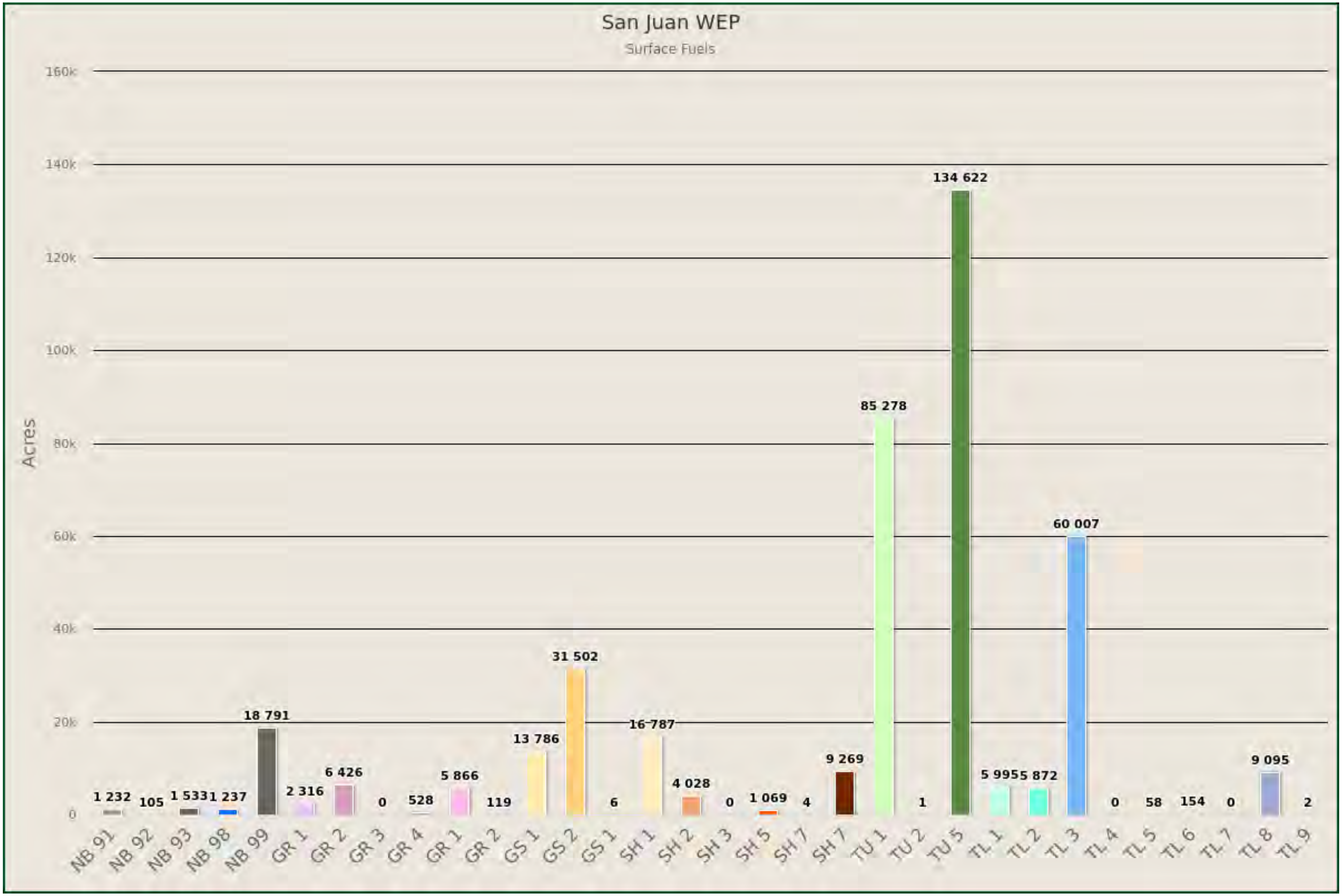
Unmanaged forest with dead and downed trees and branches

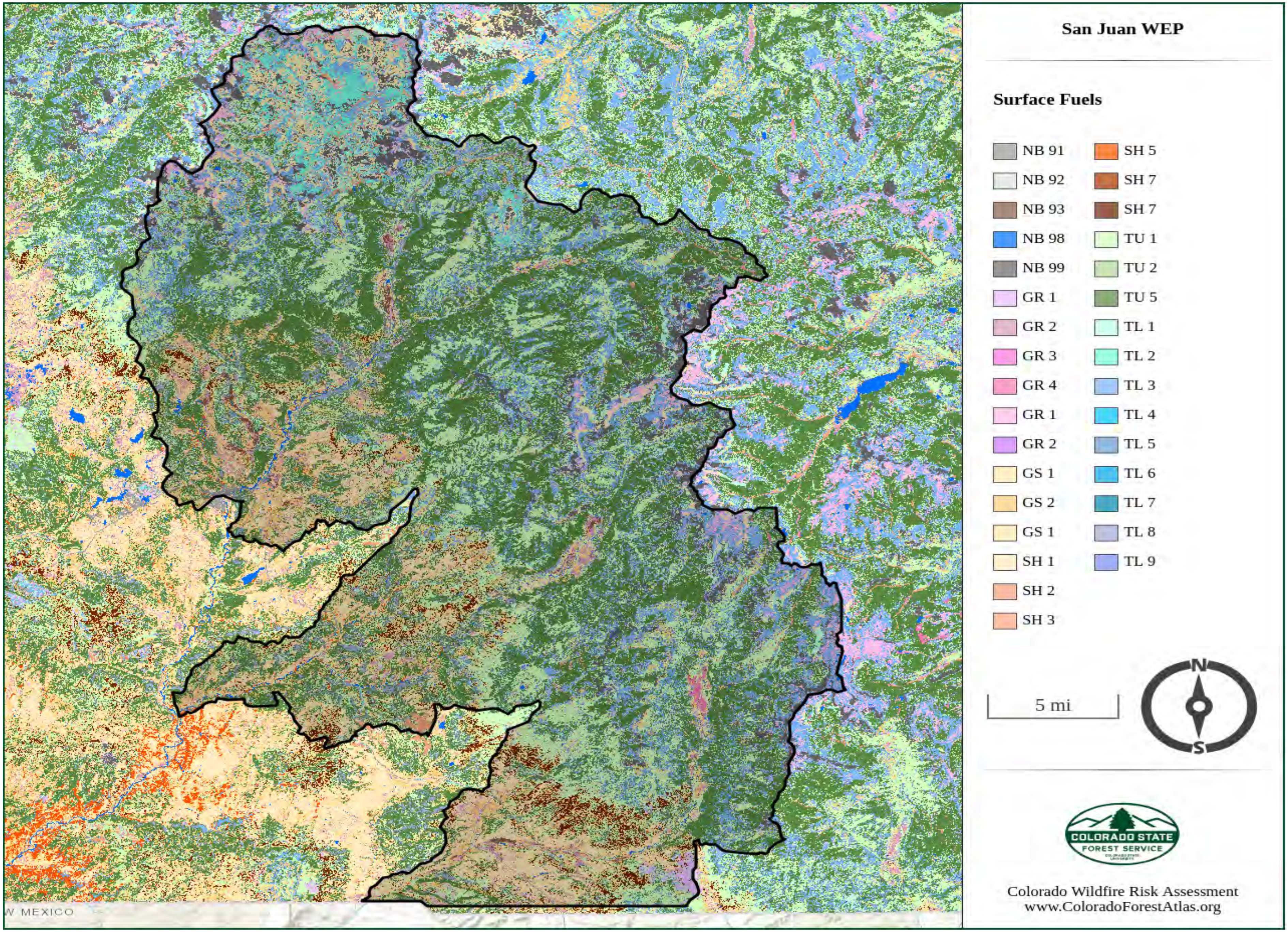
Slash on the ground indicates that forest management treatments have occurred in this area

The 2017 Colorado Surface Fuels were derived by enhancing the baseline LANDFIRE 2014 products with modifications to reflect local conditions and knowledge. A team of fuels and fire behavior experts, led by the CSFS, conducted a detailed calibration of the LANDFIRE 2014 fuels datasets. This calibration involved correcting LANDFIRE mapping zone seamlines errors; adding recent disturbances from 2013 to 2017 for fires, insect and disease, and treatments; correcting fuels for high elevations; adjusting fuels for oak-shrublands and pinyon-juniper areas; and modifying SH7 fuel designations. This calibration effort resulted in an accurate and up-to-date surface fuels dataset that is the basis for the fire behavior and risk calculations in the 2017 Colorado Wildfire Risk Assessment Update.

A detailed description of the fuels calibration methods and results is provided in the CSFS 2017 Fuels Calibration Final Report (July 2018).

Surface Fuels		Description	Acres	Percent
	NB 91	Urban/Developed	1,232	0.3 %
	NB 92	Snow/Ice	105	0.0 %
	NB 93	Agriculture	1,533	0.4 %
	NB 98	Water	1,237	0.3 %
	NB 99	Barren	18,791	4.5 %
	GR 1	Short, sparse, dry climate grass	2,316	0.6 %
	GR 2	Low load, dry climate grass	6,426	1.5 %
	GR 3	Low load, very coarse, humid climate grass	0	0 %
	GR 4	Moderate load, dry climate grass	528	0.1 %
	GR 1	GT 10,000 ft elevation	5,866	1.4 %
	GR 2	GT 10,000 ft elevation	119	0.0 %
	GS 1	Low load, dry climate grass-shrub	13,786	3.3 %
	GS 2	Moderate load, dry climate grass-shrub	31,502	7.6 %
	GS 1	GT 10,000 ft elevation	6	0.0 %
	SH 1	Low load, dry climate shrub	16,787	4.0 %
	SH 2	Moderate load, dry climate shrub	4,028	1.0 %
	SH 3	Moderate load, humid climate shrub	0	0 %
	SH 5	High load, humid climate shrub	1,069	0.3 %
	SH 7	Very high load, dry climate shrub	4	0.0 %
	SH 7	Oak Shrubland without changes	9,269	2.2 %
	TU 1	Light load, dry climate timber-grass-shrub	85,278	20.5 %
	TU 2	Moderate load, humid climate timber-shrub	1	0.0 %
	TU 5	Very high load, dry climate timber-shrub	134,622	32.4 %
	TL 1	Low load, compact conifer litter	5,995	1.4 %
	TL 2	Low load, broadleaf litter	5,872	1.4 %
	TL 3	Moderate load, conifer litter	60,007	14.4 %
	TL 4	Small downed logs	0	0 %
	TL 5	High load, conifer litter	58	0.0 %
	TL 6	Moderate load, broadleaf litter	154	0.0 %
	TL 7	Large downed logs	0	0 %
	TL 8	Long-needle litter	9,095	2.2 %
	TL 9	Very high load, broadleaf litter	2	0.0 %
Total			**415,686**	**100 %**


San Juan WEP
Surface Fuels
Acres
160k
140k
120k
100k
80k
60k
40k
20k
0
1 232
105
1 533
1 237
18 791
2 316
6 426
0
528
5 866
119
13 786
31 502
6
16 787
4 028
0
1 069
4
9 269
85 278
1
134 622
5 995
5 872
60 007
0
58
154
0
9 095
2
NB 91
NB 92
NB 93
NB 98
NB 99
GR 1
GR 2
GR 3
GR 4
GR 1
GR 2
GS 1
GS 2
GS 1
SH 1
SH 2
SH 3
SH 5
SH 7
SH 7
TU 1
TU 2
TU 5
TL 1
TL 2
TL 3
TL 4
TL 5
TL 6
TL 7
TL 8
TL 9


San Juan WEP
Surface Fuels
NB 91
NB 92
NB 93
NB 98
NB 99
GR 1
GR 2
GR 3
GR 4
GR 1
GR 2
GS 1
GS 2
GS 1
SH 1
SH 2
SH 3
SH 5
SH 7
SH 7
TU 1
TU 2
TU 5
TL 1
TL 2
TL 3
TL 4
TL 5
TL 6
TL 7
TL 8
TL 9
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Vegetation

Description

The Vegetation map describes the general vegetation and landcover types across the state of Colorado. In the Colorado WRA, the Vegetation dataset is used to support the development of the Surface Fuels, Canopy Cover, Canopy Stand Height, Canopy Base Height, and Canopy Bulk Density datasets.

The LANDFIRE 2014 version of data products (Existing Vegetation Type) was used to compile the Vegetation data for the Colorado WRA. This reflects data current to 2014. The LANDFIRE EVT data were classified to reflect general vegetation cover types for representation with CO-WRAP.

Oak shrublands are commonly found along dry foothills and lower mountain slopes, and are often situated above Piñyon-juniper.

Piñyon-juniper woodlands are common in southern and southwestern Colorado.

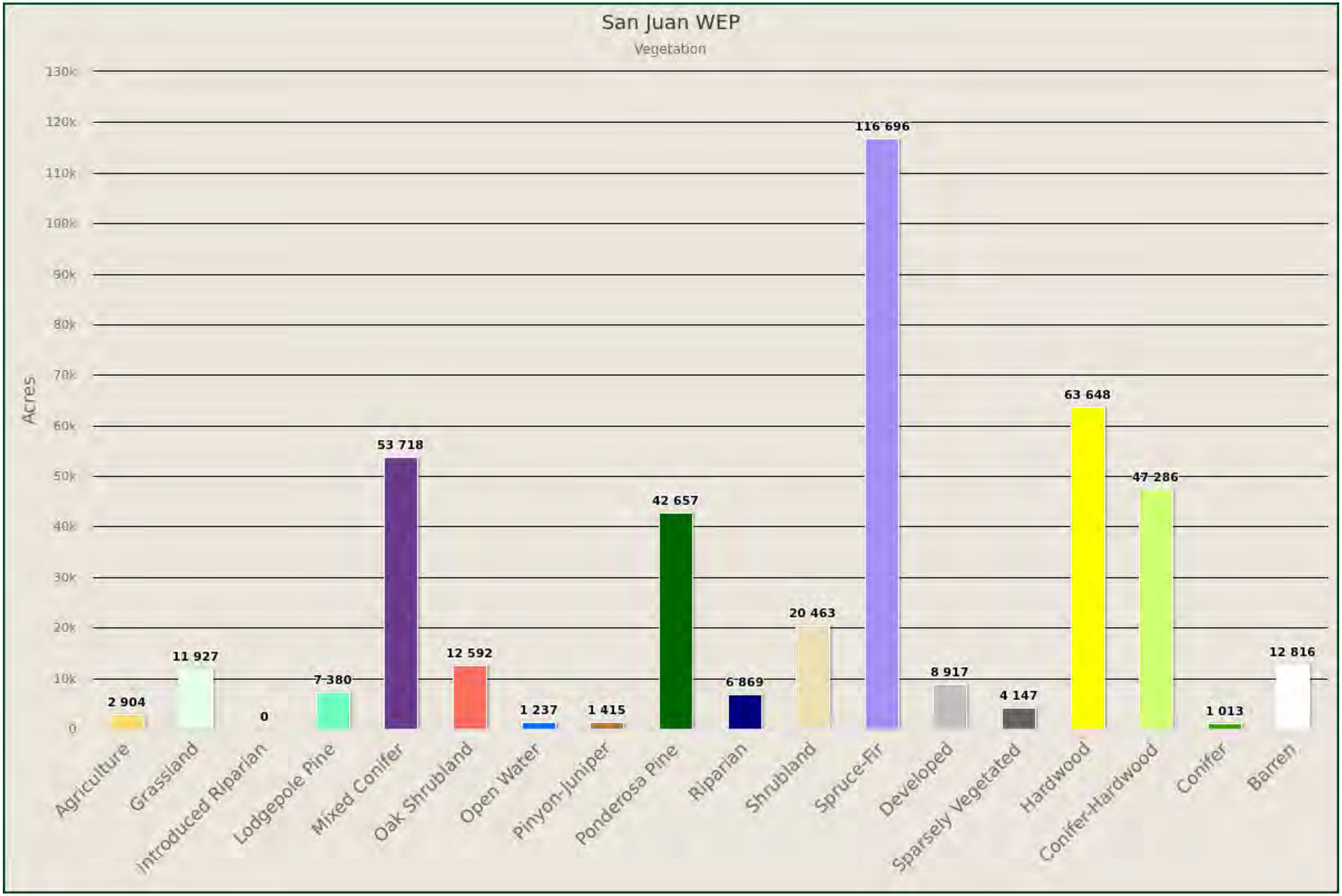
Douglas-fir understory in a ponderosa pine forest.

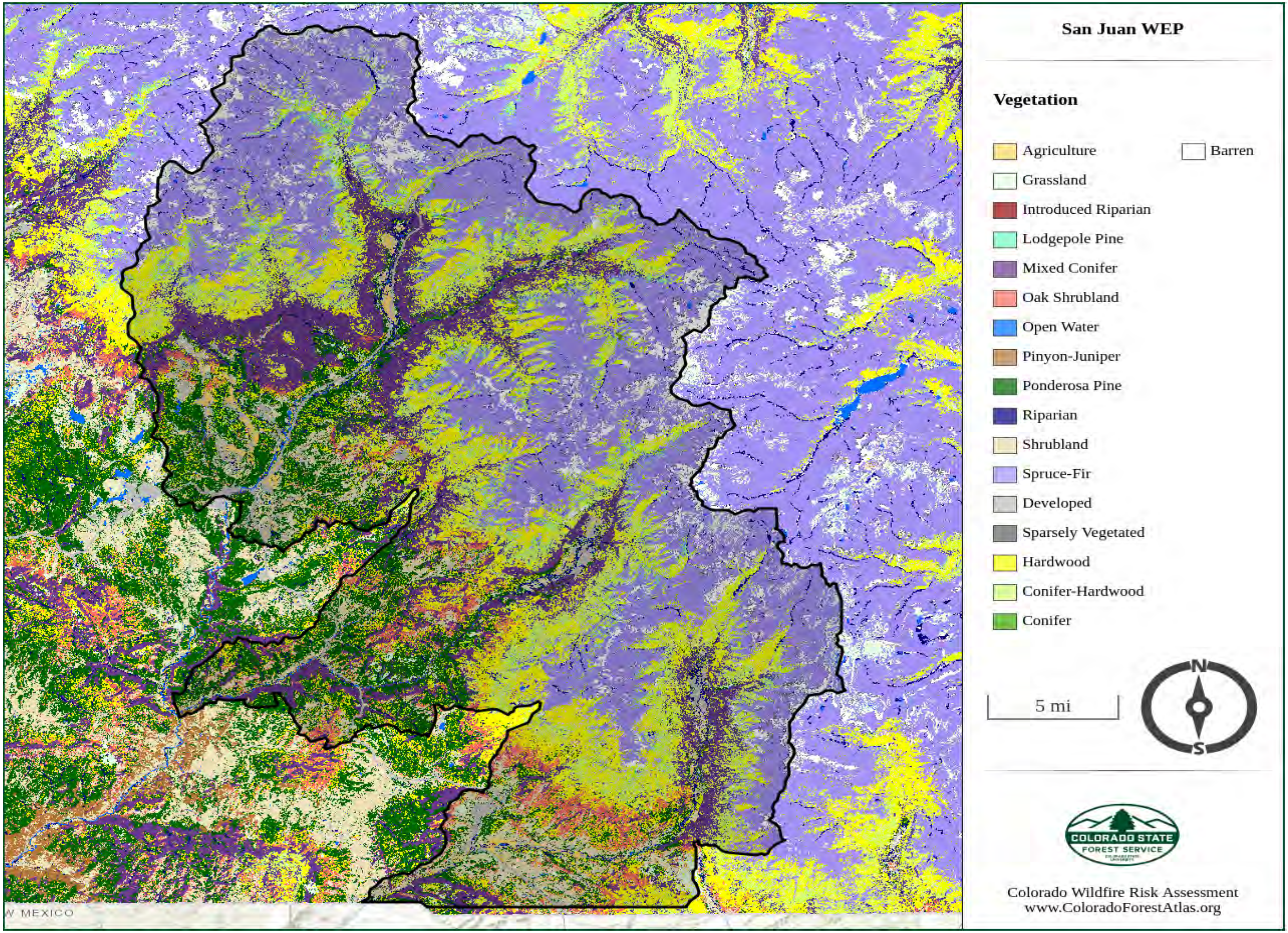
Grasslands occur both on Colorado's Eastern Plains and on the Western Slope.

Wildland fire threat increases in lodgepole pine as the dense forests grow old.

Overly dense ponderosa pine, a dominant species of the montane zone.

Vegetation Class	Acres	Percent
Agriculture	2,904	0.7 %
Grassland	11,927	2.9 %
Introduced Riparian	0	0 %
Lodgepole Pine	7,380	1.8 %
Mixed Conifer	53,718	12.9 %
Oak Shrubland	12,592	3.0 %
Open Water	1,237	0.3 %
Pinyon-Juniper	1,415	0.3 %
Ponderosa Pine	42,657	10.3 %
Riparian	6,869	1.7 %
Shrubland	20,463	4.9 %
Spruce-Fir	116,696	28.1 %
Developed	8,917	2.1 %
Sparsely Vegetated	4,147	1.0 %
Hardwood	63,648	15.3 %
Conifer-Hardwood	47,286	11.4 %
Conifer	1,013	0.2 %
Barren	12,816	3.1 %
Total	**415,686**	**100 %**


San Juan WEP
Vegetation
Acres
130k
120k
110k
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
2 904
11 927
0
7 380
53 718
12 592
1 237
1 415
42 657
6 869
20 463
116 696
8 917
4 147
63 648
47 286
1 013
12 816
Agriculture
Grassland
Introduced Riparian
Lodgepole Pine
Mixed Conifer
Oak Shrubland
Open Water
Pinyon-Juniper
Ponderosa Pine
Riparian
Shrubland
Spruce-Fir
Developed
Sparsely Vegetated
Hardwood
Conifer-Hardwood
Conifer
Barren


San Juan WEP
Vegetation
Agriculture
Barren
Grassland
Introduced Riparian
Lodgepole Pine
Mixed Conifer
Oak Shrubland
Open Water
Pinyon-Juniper
Ponderosa Pine
Riparian
Shrubland
Spruce-Fir
Developed
Sparsely Vegetated
Hardwood
Conifer-Hardwood
Conifer
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Drinking Water Importance Areas

Description

Drinking Water Importance Areas is the measure of quality and quantity of public surface drinking water categorized by watershed. This layer identifies an index of surface drinking water importance, reflecting a measure of water quality and quantity, characterized by Hydrologic Unit Code 12 (HUC 12) watersheds. The Hydrologic Unit system is a standardized watershed classification system developed by the USGS. Areas that are a source of drinking water are of critical importance and adverse effects from fire are a key concern.

The U.S. Forest Service Forests to Faucets (F2F) project is the primary source of the drinking water data set. This project used GIS modeling to develop an index of importance for supplying drinking water using HUC 12 watersheds as the spatial resolution. Watersheds are ranked from 1 to 100 reflecting relative level of importance, with 100 being the most important and 1 the least important.

Several criteria were used in the F2F project to derive the importance rating including water supply, flow analysis, and downstream drinking water demand. The final model of surface drinking water importance used in the F2F project combines the drinking water protection model, capturing the flow of water and water demand, with a model of mean annual water supply.

The values generated by the drinking water protection model are simply multiplied by the results of the model of mean annual water supply to create the final surface drinking water importance index.

Water is critical to sustain life. Human water usage has further complicated nature's already complex aquatic system. Plants, including trees, are essential to the proper functioning of water movement within the environment. Forests receive precipitation, utilize it for their sustenance and growth, and influence its storage and/or passage to other parts of the environment.

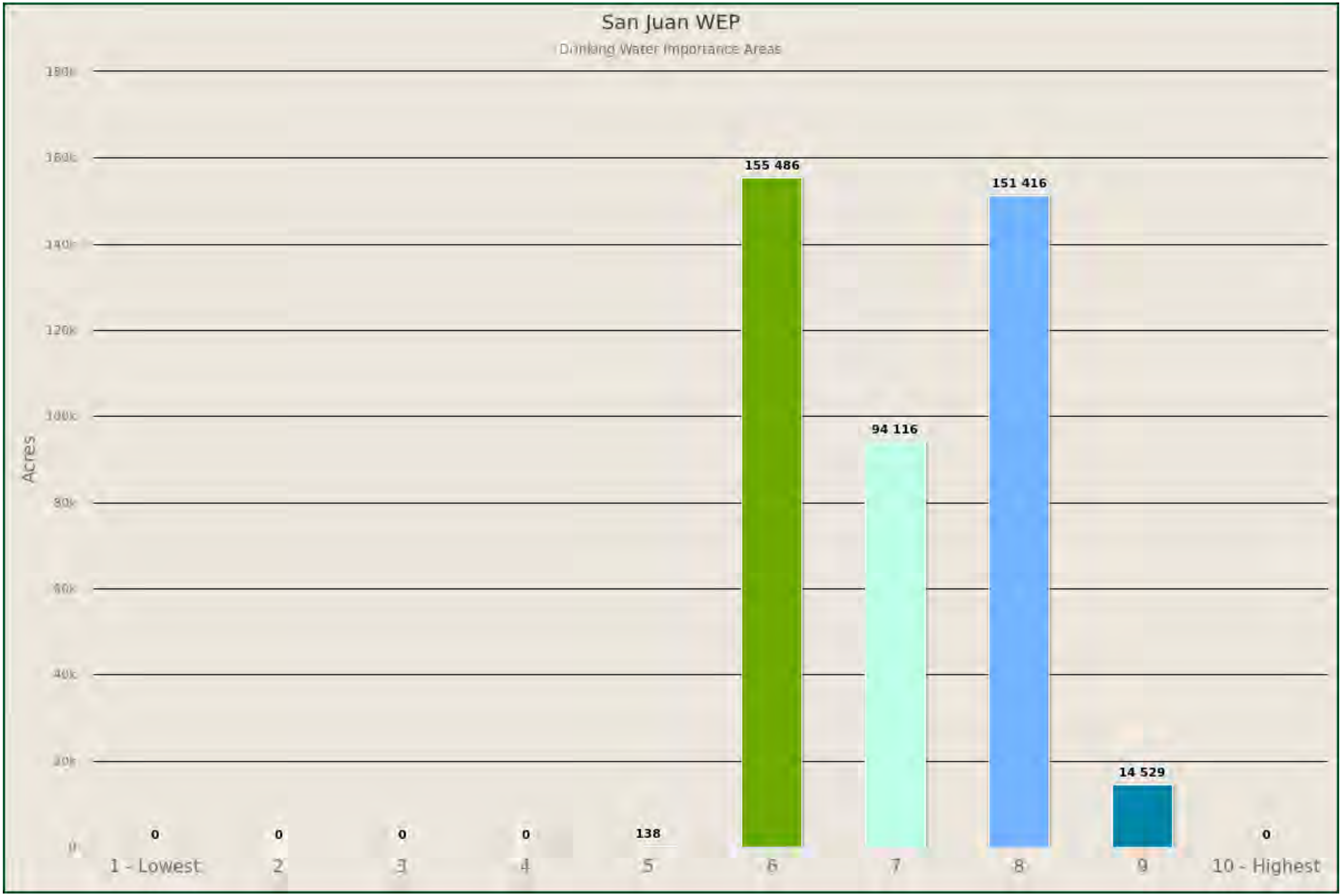
Four major river systems – the Platte, Colorado, Arkansas and Rio Grande – originate in the Colorado mountains and fully drain into one-third of the landmass of the lower 48 states. Mountain snows supply 75 percent of the water to these river systems.

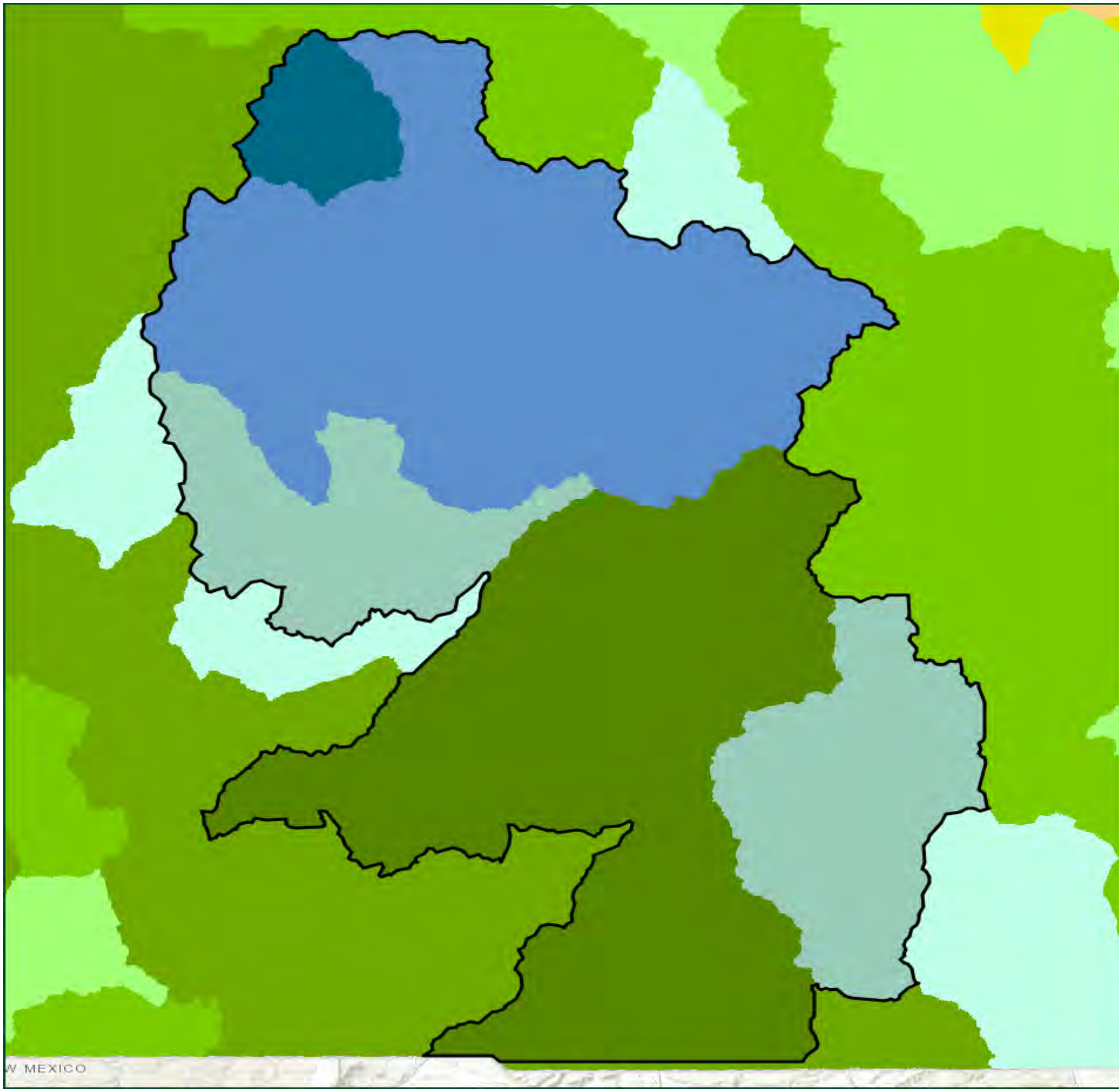
Virtually all of Colorado's drinking water comes from snowmelt carried at some point by a river.

The headwaters of the Animas River begin near Silverton, CO at elevations greater than 12,000 feet.

Approximately 40 percent of the water comes from the highest 20 percent of the land, most of which lies in national forests. National forests yield large portions of the total water in these river systems. The potential is great for forests to positively and negatively influence the transport of water over such immense distances.

Drinking Water Class		Acres	Percent
	1 - Lowest	0	0 %
	2	0	0 %
	3	0	0 %
	4	0	0 %
	5	138	0.0 %
	6	155,486	37.4 %
	7	94,116	22.6 %
	8	151,416	36.4 %
	9	14,529	3.5 %
	10 - Highest	0	0 %
Total		**415,686**	**100 %**


San Juan WEP
Drinking Water Importance Areas
Acres
180k
160k
140k
120k
100k
80k
60k
40k
20k
0
0
0
0
0
138
155 486
94 116
151 416
14 529
0
1 - Lowest
2
3
4
5
6
7
8
9
10 - Highest



San Juan WEP

Drinking Water Importance Areas

- 1 - Lowest
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Highest

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Drinking Water Risk Index

Description

Drinking Water Risk Index is a measure of the risk to DWIAs based on the potential negative impacts from wildfire.

In areas that experience low-severity burns, fire events can serve to eliminate competition, rejuvenate growth and improve watershed conditions. But in landscapes subjected to high, or even moderate-burn severity, the post-fire threats to public safety and natural resources can be extreme.

High-severity wildfires remove virtually all forest vegetation – from trees, shrubs and grasses down to discarded needles, decomposed roots and other elements of ground cover or duff that protect forest soils. A severe wildfire also can cause certain types of soil to become hydrophobic by forming a waxy, water-repellent layer that keeps water from penetrating the soil, dramatically amplifying the rate of runoff.

The loss of critical surface vegetation leaves forested slopes extremely vulnerable to large-scale soil erosion and flooding during subsequent storm events. In turn, these threats can impact the health, safety and integrity of communities and natural resources downstream. The likelihood that such a post-fire event will occur in Colorado is increased by the prevalence of highly erodible soils in several parts of the state, and weather patterns that frequently bring heavy rains on the heels of fire season.

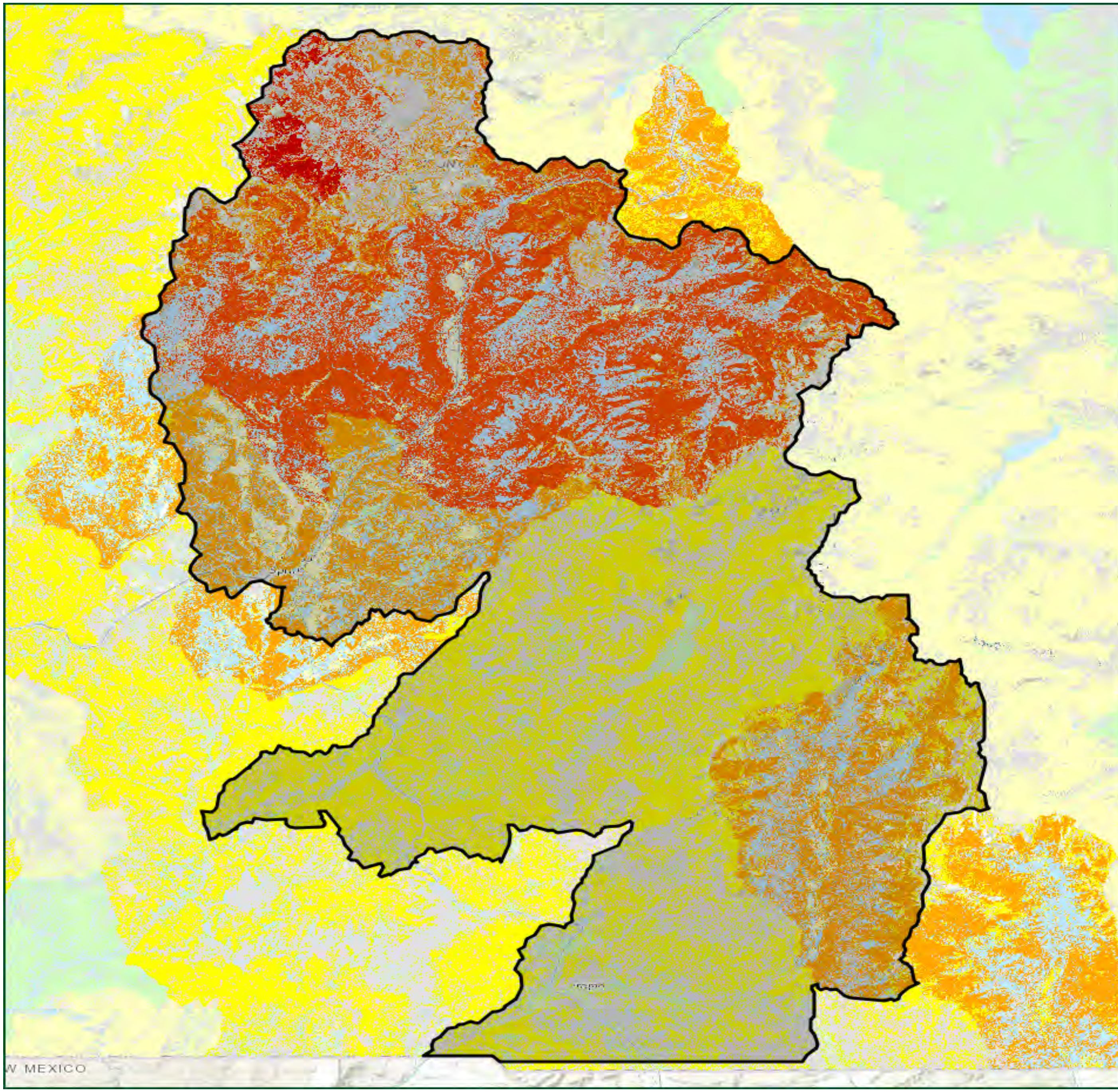
In the aftermath of the 2002 fire season, the Colorado Department of Health estimated that 26 municipal water storage facilities were shut down due to fire and post-fire impacts.

The potential for severe soil erosion is a consequence of wildfire because as a fire burns, it destroys plant material and the litter layer. Shrubs, forbs, grasses, trees and the litter layer disperse water during severe rainstorms. Plant roots stabilize the soil, and stems and leaves slow the water to give it time to percolate into the soil profile. Fire can destroy this soil protection.

The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact.

Class	Acres	Percent
-1 Least Negative Impact	97,456	24.8 %
-2	39,827	10.1 %
-3	12,300	3.1 %
-4	11,587	3.0 %
-5	91,598	23.3 %
-6	60,520	15.4 %
-7	77,126	19.6 %
-8	2,361	0.6 %
-9 Most Negative Impact	0	0 %
Total	**392,776**	**100 %**


San Juan WEP
Drinking Water Risk Index
Acres
110k
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
97 456
39 827
12 300
11 587
91 598
60 520
77 126
2 361
0
-1 Least Negative Impact
-2
-3
-4
-5
-6
-7
-8
-9 Most Negative Impact



San Juan WEP

Drinking Water Risk Index

- -1 Least Negative Impact
- -2
- -3
- -4
- -5
- -6
- -7
- -8
- -9 Most Negative Impact

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Riparian Assets

Description

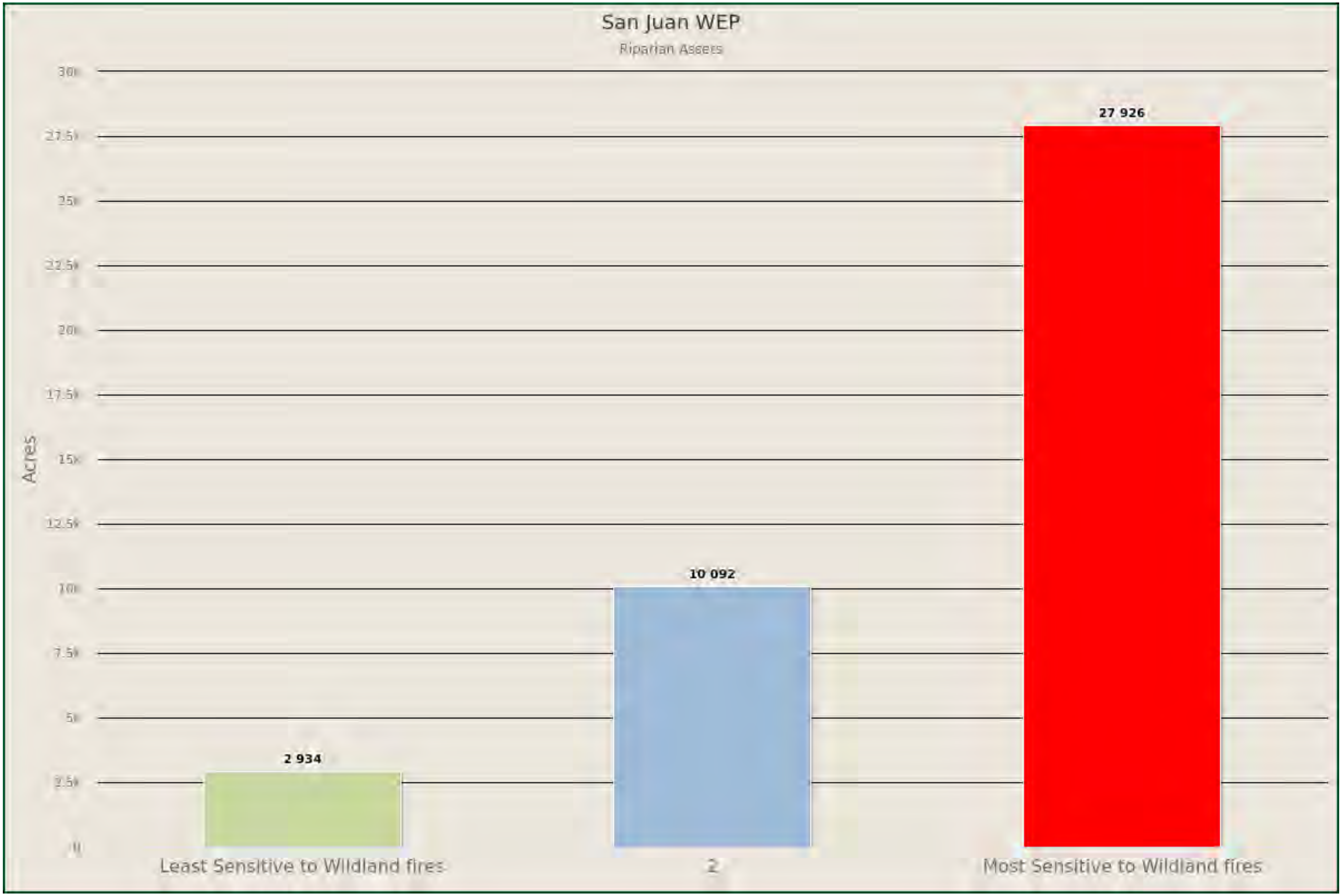
Riparian Assets are forested riparian areas characterized by functions of water quantity and quality, and ecology. This layer identifies riparian areas that are important as a suite of ecosystem services, including both terrestrial and aquatic habitat, water quality, water quantity, and other ecological functions. Riparian areas are considered an especially important element of the landscape in the west. Accordingly, riparian assets are distinguished from other forest assets so they can be evaluated separately.

The process for defining these riparian areas involved identifying the riparian footprint and then assigning a rating based upon two important riparian functions – water quantity and quality, and ecological significance. A scientific model was developed by the West Wide Risk Assessment technical team with in-kind support from CAL FIRE state representatives. Several input datasets were used in the model including the National Hydrography Dataset and the National Wetland Inventory.

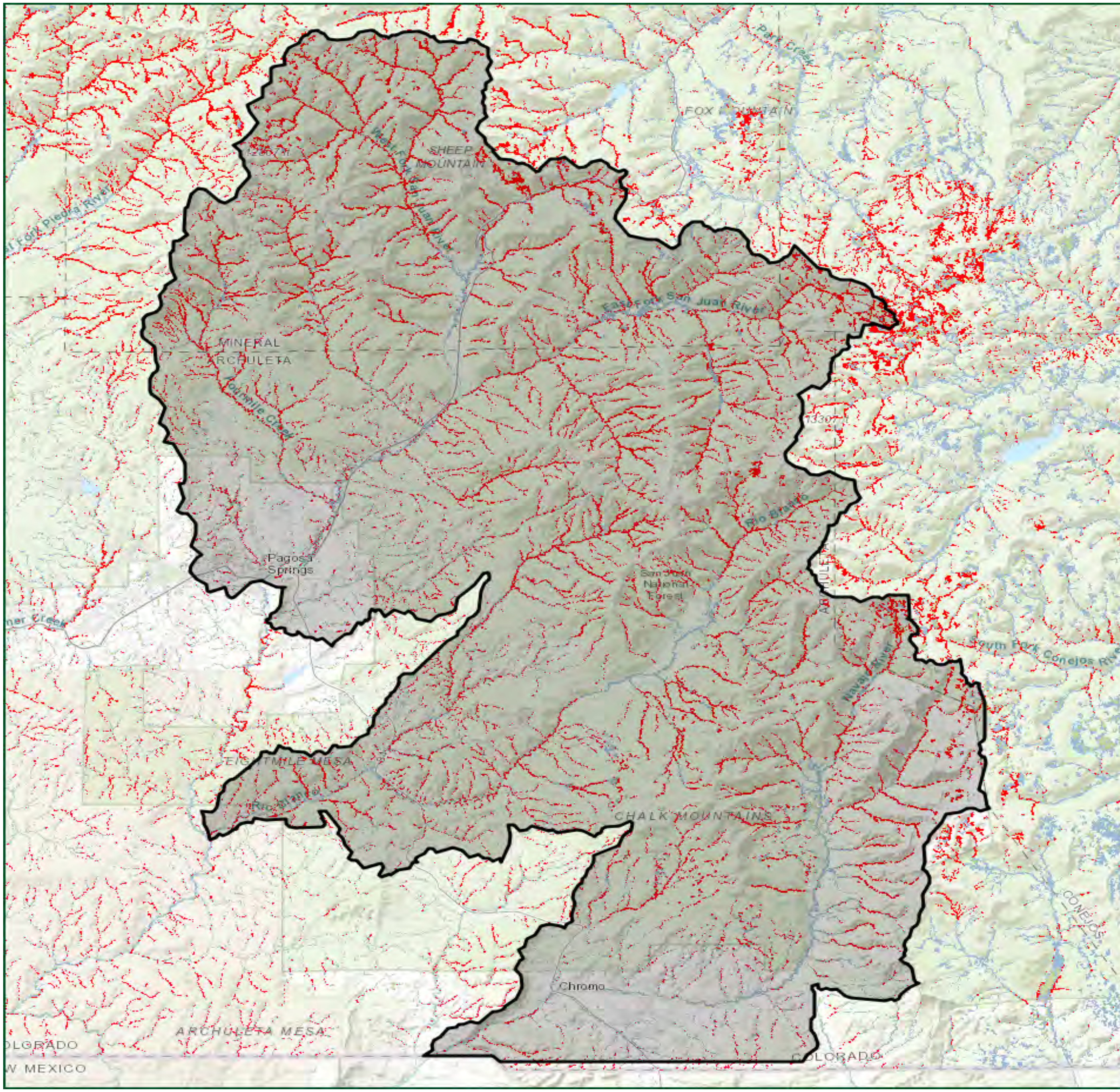
The National Hydrography Data Set (NHD) was used to represent hydrology. A subset of streams and water bodies, which represents perennial, intermittent, and wetlands, was created. The NHD water bodies dataset was used to determine the location of lakes, ponds, swamps, and marshes (wetlands).

To model water quality and quantity, erosion potential (K-factor) and annual average precipitation was used as key variables. The Riparian Assets data are an index of class values that range from 1 to 3 representing increasing importance of the riparian area as well as sensitivity to fire-related impacts on the suite of ecosystem services.

Riparian Assets Class	Acres	Percent
Least Sensitive to Wildland fires	2,934	7.2 %
2	10,092	24.6 %
Most Sensitive to Wildland fires	27,926	68.2 %
Total	**40,952**	**100 %**


San Juan WEP
Riparian Assets
Acres
2 934
10 092
27 926
Least Sensitive to Wildland fires
2
Most Sensitive to Wildland fires

San Juan WEP



Riparian Assets

- Least Sensitive to Wildland fires
- 2
- Most Sensitive to Wildland fires

5 mi

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Riparian Assets Risk Index

Description

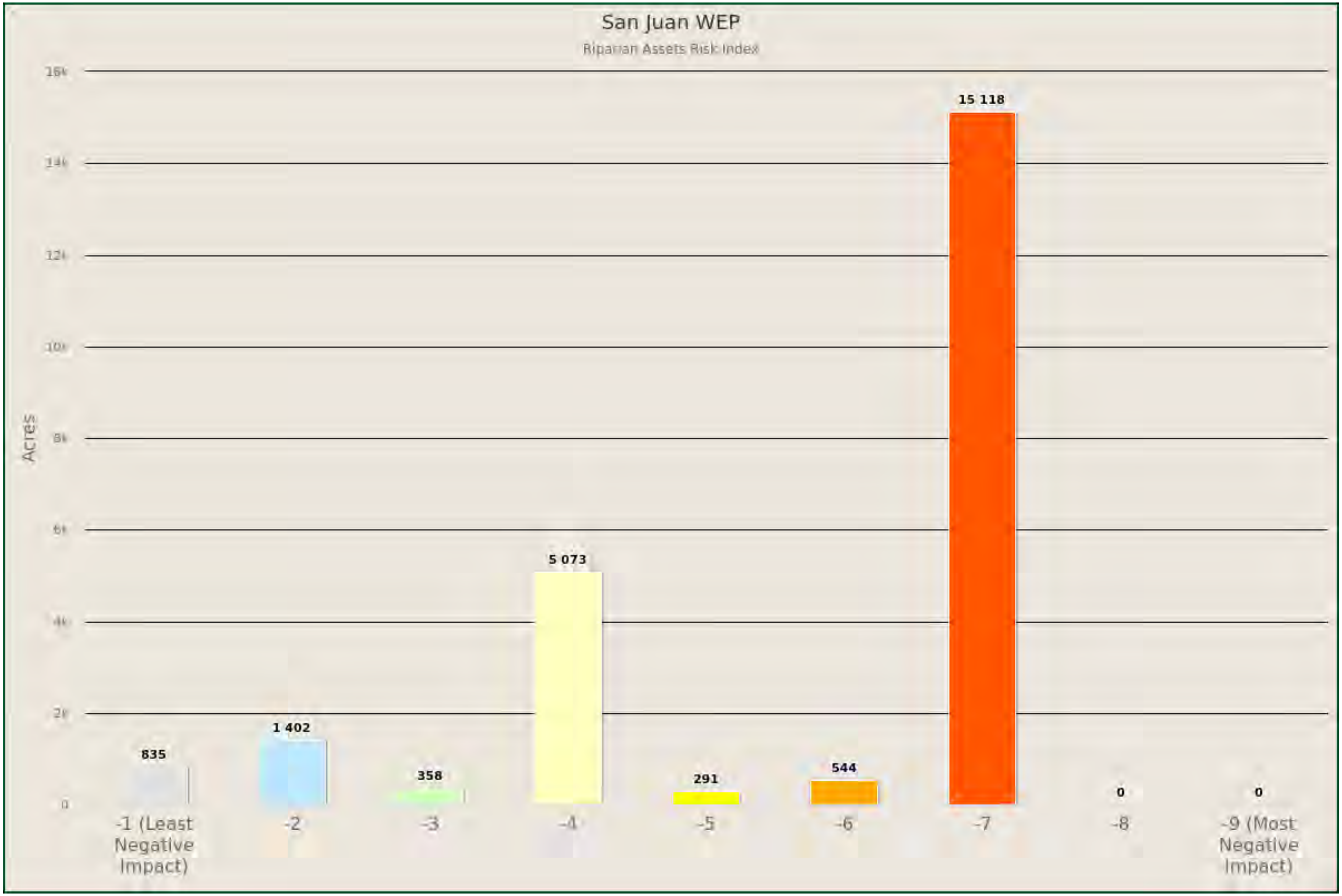
Riparian Assets Risk Index is a measure of the risk to riparian areas based on the potential negative impacts from wildfire. This layer identifies those riparian areas with the greatest potential for adverse effects from wildfire.

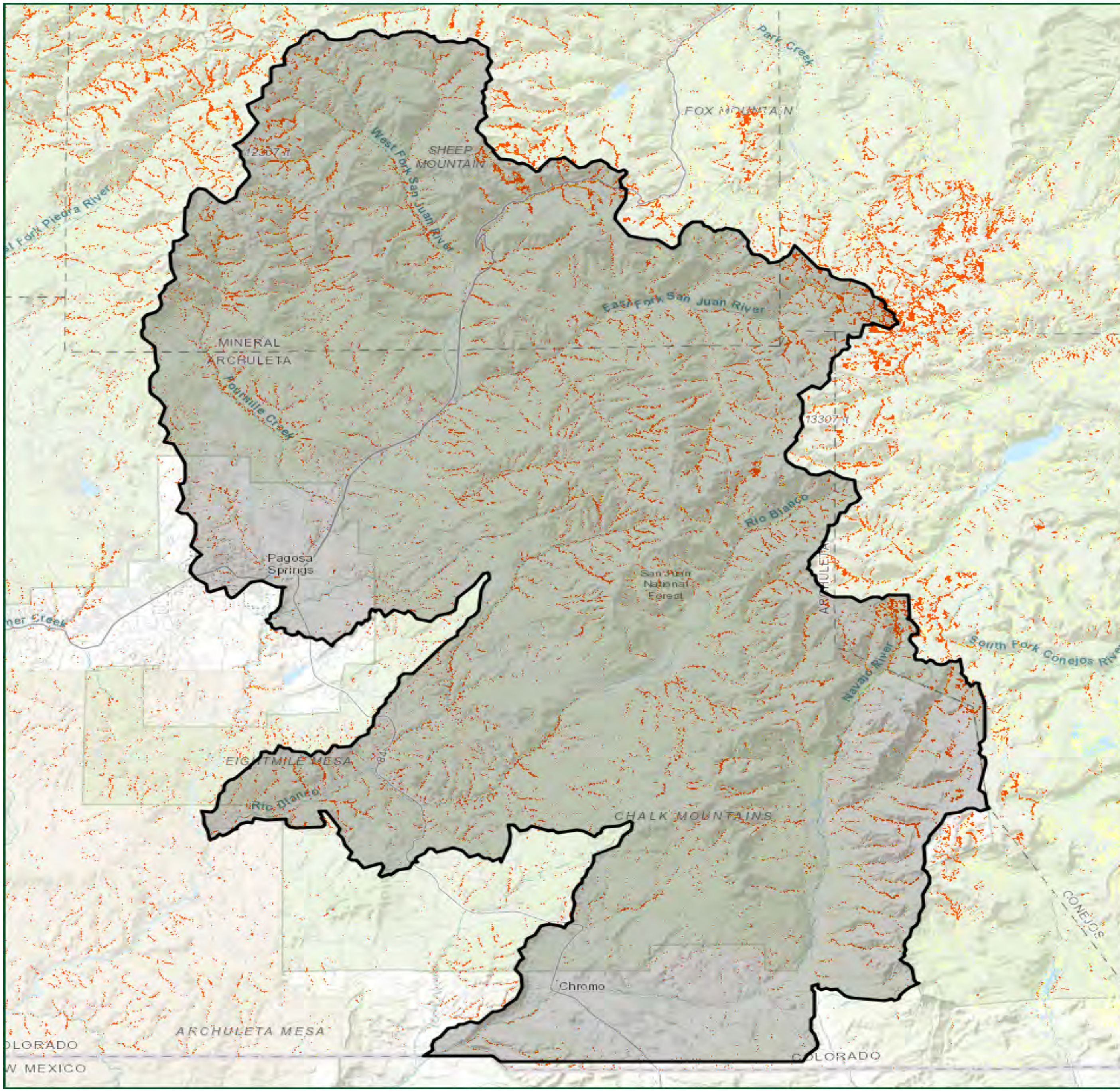
The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact.

The risk index has been calculated by combining the Riparian Assets data with a measure of fire intensity using a Response Function approach. Those areas with the highest negative impact (-9) represent areas with high potential fire intensity and high importance for ecosystem services. Those areas with the lowest negative impact (-1) represent those areas with low potential fire intensity and a low importance for ecosystem services.

This risk output is intended to supplement the Drinking Water Risk Index by identifying wildfire risk within the more detailed riparian areas.

Riparian Assets Risk Class	Acres	Percent
-1 (Least Negative Impact)	835	3.5 %
-2	1,402	5.9 %
-3	358	1.5 %
-4	5,073	21.5 %
-5	291	1.2 %
-6	544	2.3 %
-7	15,118	64.0 %
-8	0	0 %
-9 (Most Negative Impact)	0	0 %
Total	**23,622**	**100 %**


San Juan WEP
Riparian Assets Risk Index
Acres
16k
14k
12k
10k
8k
6k
4k
2k
0
835
1 402
358
5 073
291
544
15 118
0
0
-1 (Least Negative Impact)
-2
-3
-4
-5
-6
-7
-8
-9 (Most Negative Impact)



San Juan WEP

Riparian Assets Risk Index

- -1 (Least Negative Impact)
- -2
- -3
- -4
- -5
- -6
- -7
- -8
- -9 (Most Negative Impact)

5 mi

N
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COLORADO STATE FOREST SERVICE

Colorado Wildfire Risk Assessment
www.ColoradoForestAtlas.org

Forest Assets

Description

Forest Assets are forested areas categorized by height, cover, and susceptibility/response to fire. This layer identifies forested land categorized by height, cover and susceptibility or response to fire. Using these characteristics allows for the prioritization of landscapes reflecting forest assets that would be most adversely affected by fire. The rating of importance or value of the forest assets is relative to each state's interpretation of those characteristics considered most important for their landscapes.

Canopy cover from LANDFIRE 2014 was re-classified into two categories, open or sparse and closed. Areas classified as open or sparse have a canopy cover less than 60%. Areas classified as closed have a canopy cover greater than 60%.

Canopy height from LANDFIRE 2014 was re-classified into two categories, 0-10 meters and greater than 10 meters.

Response to fire was developed from the LANDFIRE 2014 existing vegetation type (EVT) dataset. There are over 1,000 existing vegetation types in the project area. Using a crosswalk defined by project ecologists, a classification of susceptibility and response to fire was defined and documented by fire ecologists into the three fire response classes.

These three classes are sensitive, resilient and adaptive.

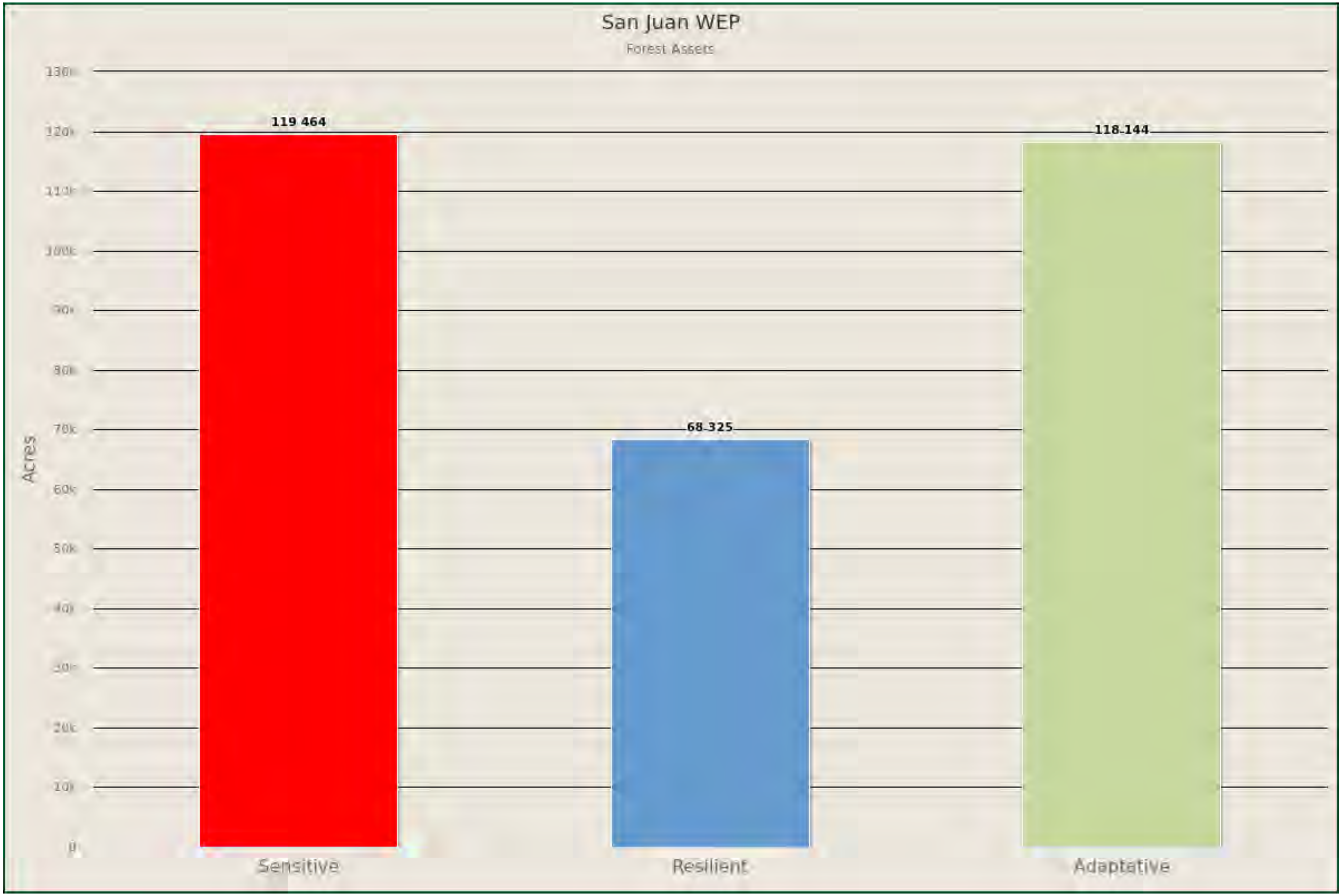
- **Sensitive** = These are tree species that are intolerant or sensitive to damage from fire with low intensity.
- **Resilient** = These are tree species that have characteristics that help the tree resist damage from fire and whose adult stages can survive low intensity fires.
- **Adaptive** = These are tree species adapted with the ability to regenerate following fire by sprouting or serotinous cones

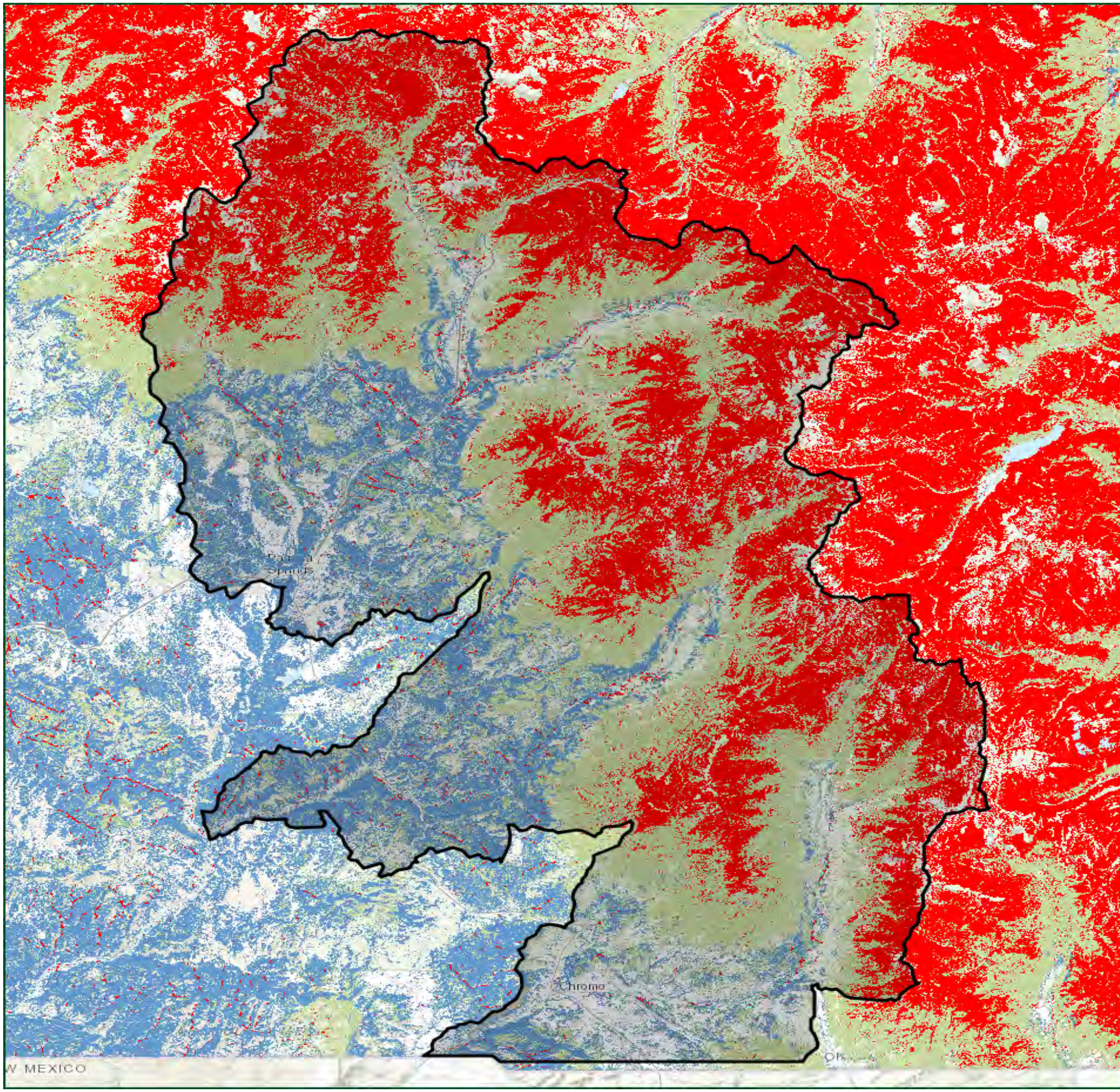
The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact.

The risk index has been calculated by combining the Forest Assets data with a measure of fire intensity using a Response Function approach. Those areas with the highest negative impact (-9) represent areas with high potential fire intensity and low resilience or adaptability to fire. Those areas with the lowest negative impact (-1) represent those areas with low potential fire intensity and high resilience or adaptability to fire.

This risk output is intended to provide an overall forest index for potential impact from wildfire. This can be applied to consider aesthetic values, ecosystem services, or economic values of forested lands.

Forest Assets	Acres	Percent
Sensitive	119,464	39.0 %
Resilient	68,325	22.3 %
Adaptative	118,144	38.6 %
Total	**305,933**	**100 %**


San Juan WEP
Forest Assets
Acres
130k
120k
110k
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
119 464
68 325
118 144
Sensitive
Resilient
Adaptative



San Juan WEP

Forest Assets

- Sensitive
- Resilient
- Adaptative

5 mi

Colorado Wildfire Risk Assessment
www.ColoradoForestAtlas.org

Forest Assets Risk Index

Description

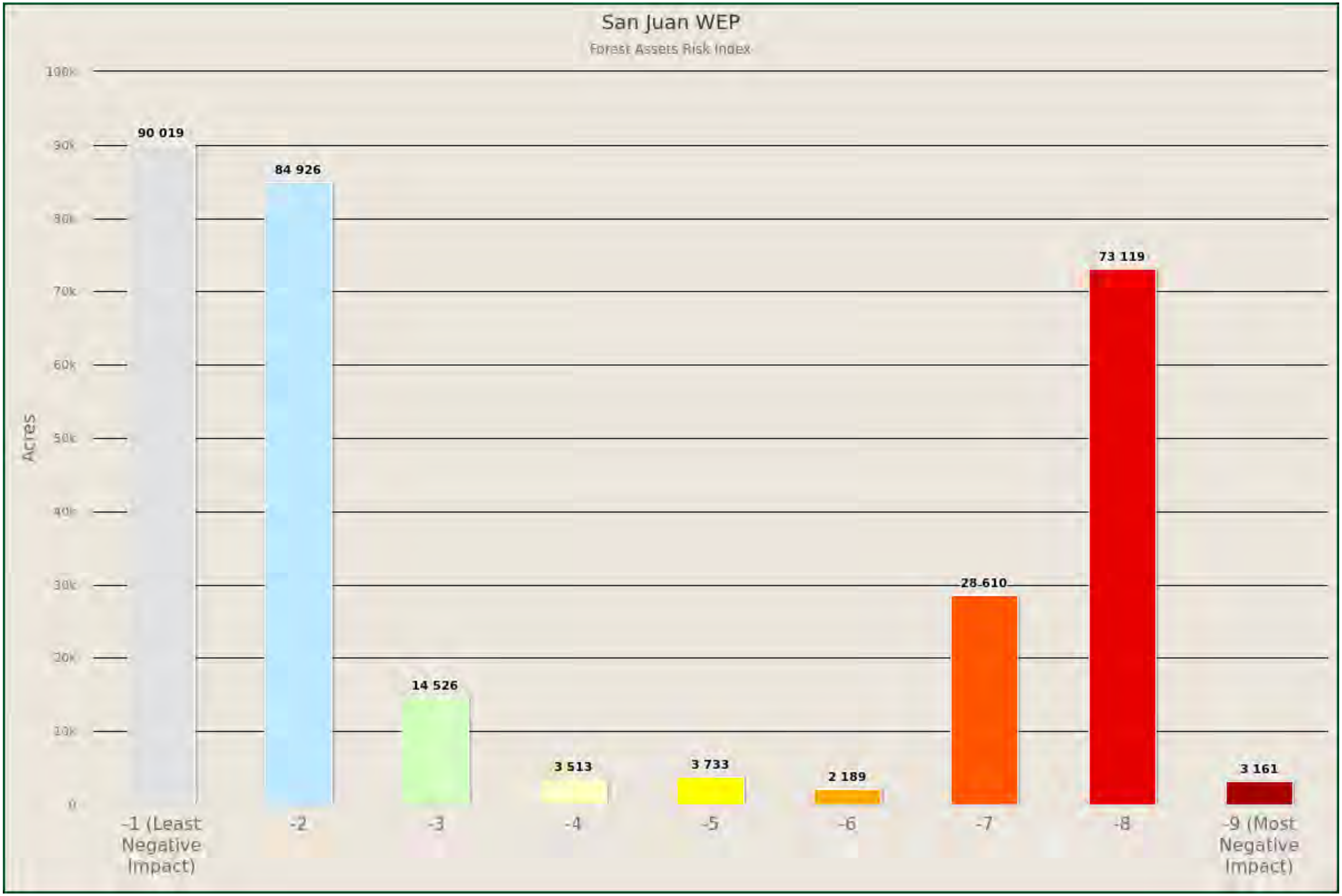
Forest Assets Risk Index is a measure of the risk to forested areas based on the potential negative impacts from wildfire. This layer identifies those forested areas with the greatest potential for adverse effects from wildfire.

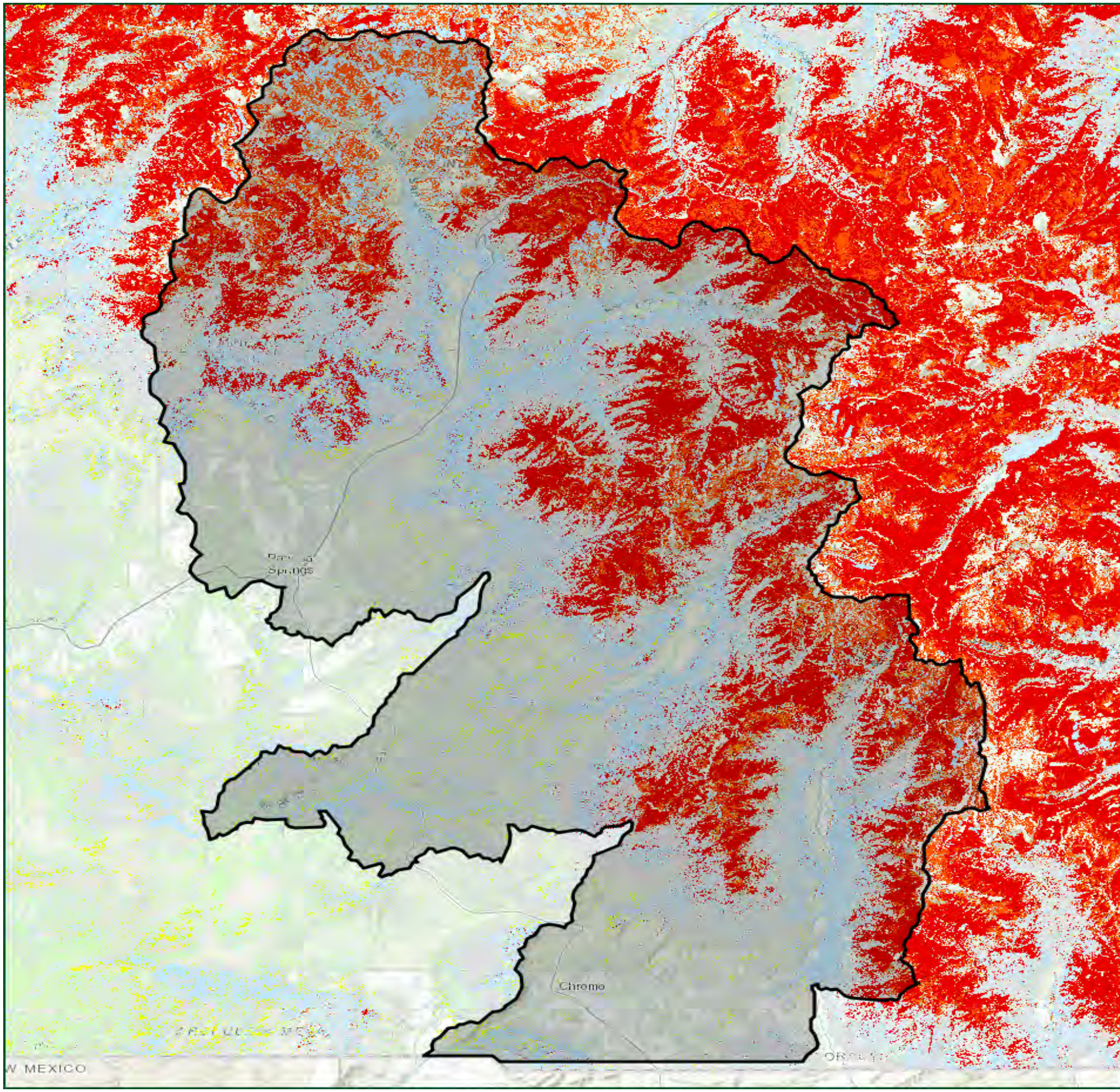
The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact.

The risk index has been calculated by combining the Forest Assets data with a measure of fire intensity using a Response Function approach. Those areas with the highest negative impact (-9) represent areas with high potential fire intensity and low resilience or adaptability to fire. Those areas with the lowest negative impact (-1) represent those areas with low potential fire intensity and high resilience or adaptability to fire.

This risk output is intended to provide an overall forest index for potential impact from wildfire. This can be applied to consider aesthetic values, ecosystem services, or economic values of forested lands.

Forest Assets Risk Class	Acres	Percent
-1 (Least Negative Impact)	90,019	29.6 %
-2	84,926	28.0 %
-3	14,526	4.8 %
-4	3,513	1.2 %
-5	3,733	1.2 %
-6	2,189	0.7 %
-7	28,610	9.4 %
-8	73,119	24.1 %
-9 (Most Negative Impact)	3,161	1.0 %
Total	**303,795**	**100 %**


San Juan WEP
Forest Assets Risk Index
Acres
100k
90k
80k
70k
60k
50k
40k
30k
20k
10k
0
90 019
84 926
14 526
3 513
3 733
2 189
28 610
73 119
3 161
-1 (Least Negative Impact)
-2
-3
-4
-5
-6
-7
-8
-9 (Most Negative Impact)



San Juan WEP

Forest Assets Risk Index

- -1 (Least Negative Impact)
- -2
- -3
- -4
- -5
- -6
- -7
- -8
- -9 (Most Negative Impact)

5 mi

N
S

Colorado Wildfire Risk Assessment
www.ColoradoForestAtlas.org

References

Anderson, H. E. (1982). Aids to determining fuel models for estimating fire behavior. USDA For. Serv. Gen. Tech. Rep. INT-122.

Colorado State Forest Service (November 2018). Colorado Wildfire Risk Assessment Final Report. A final report developed by CSFS and Technosylva Inc. (La Jolla, CA) documenting the technical methods and results for the Colorado wildfire risk assessment update project.

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Colorado State Forest Service (2012). Colorado Wildfire Risk Assessment 2012 Final Report. A final report developed by CSFS and DTS (Fort Collins, CO) documenting the technical methods and specifications for the Colorado WRA project.

National Wildfire Coordinating Group (NWCG). (2008). Glossary of Wildland Fire Terminology. Publication Management System document PMS-205.

National Wildfire Coordinating Group (2004). Fireline Handbook. NWCG Handbook 3. PMS 410-1. NFES 0065. National Interagency Fire Center. Boise, Idaho 83705.

Scott, J. H., & Burgan, R. E. (2005). Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model. Ft. Collins, CO, Rocky Mountain Research Station: USDA Forest Service, Gen. Tech. Rpt. RMRS-GTR-153.

Scott, J. H., & Reinhardt, E. D. (2001). Assessing the Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior. Ft. Collins, CO, Rocky Mountain Research Station: USDA Forest Service, Research Paper RMRS-RP-29.

COLORADO STATE FOREST SERVICE
COLORADO STATE UNIVERSITY

APPENDIX D: COLORADO NATURAL HERITAGE PROGRAM POTENTIAL CONSERVATION AREAS

Level 4 Potential Conservation Area (PCA) Report

Name Buckles Lake **Site Code** S.USCOHP*9476

IDENTIFIERS

Site ID 974 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Buckles Lake is a hydrologically manipulated lake in the southeast portion of Archuleta County, on the west slope of the Chalk Mountains. The site is mostly within the San Juan National Forest, with a portion of the north boundary privately owned. The South San Juan Wilderness boundary begins approximately one mile east of Buckles Lake and encompasses much of the watershed for the lake and its tributaries. The lake is located in a natural basin below and to the northwest of V Mountain. Runoff from numerous small drainages of the Chalk Mountains supplies water to the basin and Buckles Lake. The lake's main outlet drains through an earthen berm to the northwest, eventually joining with Big Branch Creek, a tributary to the Rio Blanco. In addition, an irrigation structure in the berm diverts an unknown percentage of the outflow to a secondary outlet (irrigation ditch), which drains directly to Harris Lake downstream. Both lakes were enhanced many years ago and are well established and support extensive native wetland and riparian plant associations. The geomorphology of the Chalk Mountains area includes landslide deposits and generally slumpy, stepped topography which often results in groundwater discharge, and therefore creates many small ponds, lakes, drainages, wetlands and several fens. These water bodies subsequently support an extraordinarily rich and diverse mosaic of wetland and riparian habitats. The western slopes of the Chalk Mountains typically have steep slopes, a dense, mature Picea spp.-Abies spp.-Populus tremuloides forest, and large rockslides and outcrops. An abundance of birds and insects occupy the basin and a trail skirts Buckles Lake on its west side. A forest service road ends within one-quarter mile of the lake and recreational use by hikers, fisherman and hunters in the basin is high. Blanco Tunnel, a major US Bureau of Reclamation subterranean water diversion in the area built in the late 1960's as part of the San Juan-Chama Project to divert water from the San Juan River Basin across the Continental Divide and into the Rio Grande River Basin (USDI no date), is mapped within the western boundary of the site, but no surficial impacts to the area were noted. A number of uncommon wetland and riparian communities are found within the site, including two types of montane wet meadow plant communities, the water sedge - beaked sedge (*Carex aquatilis - Carex utriculata*) montane wet meadow and white marsh marigold (*Caltha leptosepala*) montane wet meadow. Also occurring here are two examples of a park willow / mesic graminoid (*Salix monticola* / mesic graminoid) montane riparian willow carr. In moderately broad meadow opening east of Buckles Lake, an unnamed spring-fed tributary to the lake flows and supports a small, open-canopy willow carr dominated by park willow (*Salix monticola*) and Geyer's willow (*Salix geyeriana*), with a vigorous herbaceous graminoid understory and saturated to inundated soils. Kentucky bluegrass (*Poa pratensis*) and water sedge (*Carex aquatilis*) dominate the herbaceous layer, and the fringes of the wet meadow are occupied by shrubby cinquefoil (*Dasiphora floribunda*) and mixed graminoids such as Kentucky bluegrass and ebony sedge (*Carex ebenea*). Several rivulets run through the community, converging into one channel toward the downstream end of the community. Beaver may have historically influenced the area, but there is no current sign of active beaver. At the south end of Buckles Lake, a large, open wetland supports a mosaic of hydrophytic and mesic graminoids and forbs, punctuated by patches of willows (*Salix* spp.). Park willow and diamondleaf willow (*Salix planifolia*) occur in large, dense stands on the south and east edges of the wetland, in a narrow fringe on the west edge, and extending as a "finger" north through the center of the polygon toward but not reaching the edge of the open water. The more mesic edges, especially on the east and south edge, support good stands of thinleaf alder (*Alnus incana*). The dominant graminoids in the understory and within the open herbaceous stands are beaked sedge (*Carex utriculata*) and water sedge. Co-dominating with the sedge stands in slightly higher, less saturated soils are large patches of white marsh marigold (*Caltha leptosepala*). The herbaceous layer is minimally diverse, with these three species constituting the majority of the cover. The entire wetland is on a very slight grade, rising slowly from the edge of the open water at Buckles Lake south to the edge of the coniferous forest and beyond, providing a continuum of soil saturation levels from inundated at the edge of the open water, to moist or even dry at the southern-most, upper-most end of the wetland.

Key Environmental Factors

A large portion of the geology on the west slopes of the Chalk Mountains, including the area within the site, is mapped as Landslide Deposits (Tweto 1979), which includes areas of thick colluvial deposits. This geology seems to predispose the area to having a stepped or hummocky microtopography where the groundwater table often is intercepted, forming many small pocket lakes and ponds. Soils are mostly Castelleia loams, moderately deep and well-drained, but often limited by an underlying layer of impervious shale or sandstone. Pockets of Histic Cryaquepts occur frequently within the Castelleia matrix (USDA 1981), which appear to be directly related to locations of ponds, wetlands and fens, and correlates with the wetland communities within this site. A large pocket of Hunchback clay loams, which are deep, poorly drained and occurring on fans and toe slopes, occurs on the east side of Buckles Lake and supports a park willow (*Salix monticola*) montane riparian willow carr (USDA 1981).

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	9,500.00	**Feet**	2,896.00	**Meters**
Maximum Elevation	9,640.00	**Feet**	2,938.27	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 11/23/2005

Designer Freeman, K.M.

Boundary Justification

The boundary incorporates an area that will allow natural hydrological processes such as seasonal flooding, sediment deposition, and new channel formation to maintain a viable population of the wetland and riparian communities within the site. It includes the privately maintained earthen dam critical to providing adequate water levels in the lake to support the associated hydrophytic communities. The boundary also provides a small buffer from nearby trails and roads where surface runoff may contribute excess nutrients and sediment. It should be noted that the hydrological processes necessary to the elements are not fully contained by the site boundaries. Given that the elements are dependent on natural hydrological processes associated with runoff from the Chalk Mountains, activities such as water diversions, impoundments, and improper livestock grazing within riparian areas and along the wetland are detrimental to the hydrology within the site. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 123.41 **Acres** 49.94 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The Buckles Lake site contains a fair (C-ranked) occurrence of a park willow / mesic graminoid (*Salix monticola* / mesic graminoid) montane riparian willow carr wetland community that is globally vulnerable (G3/S3), a riparian plant community frequently occurring in areas of flooding or beaver activity. There are also fair (C-ranked) occurrences of a water sedge - beaked sedge (*Carex aquatilis - Carex utriculata*) montane wet meadow community and a white marsh marigold (*Caltha leptosepala*) montane wet meadow community, both of which are globally apparently secure (G4/S4).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank

16989	*Caltha leptosepala* Wet Meadow	Montane Wet Meadows	G4	S4	N
24585	*Salix monticola* / Mesic Graminoids Wet Shrubland	Montane Riparian Willow Carr	G3	S3	N
24955	*Carex aquatilis - Carex utriculata* Wet Meadow	Montane Wet Meadows	G4	S4	N
24585	*Salix monticola* / Mesic Graminoids Wet Shrubland	Montane Riparian Willow Carr	G3	S3	N
24585	*Salix monticola* / Mesic Graminoids Wet Shrubland	Montane Riparian Willow Carr	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Exotic species are not dominant within the wetland, but include frequent Kentucky bluegrass and patches of Canada thistle (*Cirsium arvense*).

Offsite

No Data

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
170844	Randolph, D., Smith, Kettler, Redders, Roy, and Aitken. 1994. San Juan National Forest Riparian Site Survey.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.
193558	USDI, Bureau of Reclamation. No date. Dams, Projects and Powerplants: San Juan-Chama Project, Colorado and New Mexico. <<http://www.usbr.gov/dataweb/html/sjuanchama.html#general>>. Accessed 18 Nov 2005.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

Original site design by Kettler, S.M. 1997-06-10.

LOCATORS

Nation United States **Latitude** 370821N

State Colorado **Longitude** 1064825W

Quad Code	Quad Name
37106-B7	Harris Lake

Level 4 Potential Conservation Area (PCA) Report

Name Buckles Lake **Site Code** S.USCOHP*9476

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 11/23/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Coal Creek Trailhead **Site Code** S.USCOHP*25691

IDENTIFIERS

Site ID 2241 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Coal Creek is a small, moderately steep montane creek located in the northwest corner of Archuleta County, flowing generally northwest from a prominent, unnamed ridge in the South San Juan Wilderness to its confluence with the San Juan River north of Pagosa Springs. The creek flows through the site with low to moderate sinuosity, through a cool, narrow canyon bordered by steep hillsides. The area is owned by the U.S. Forest Service, with patchy private land on three sides of the site, and the South San Juan Wilderness beginning at the east edge of the site at the headwaters of Coal Creek. A dense, tangled cover of thinleaf alder (*Alnus incana*) and Drummond's willow (*Salix drummondiana*) lines the narrow floodplain, with occasional mature narrowleaf cottonwood (*Populus angustifolia*) dotting the community. The creek bed is approximately ten to twelve feet wide and is made up of multiple drop pool-riffle complexes, with overhanging riparian shrubs also including a high percentage of redosier dogwood (*Cornus sericea*) and Rocky Mountain maple (*Acer glabrum*). The understory has mesic graminoids and forbs such as mixed in about equal percentages, with a high percentage of litter and duff covering the ground. Typical herbaceous species include bluejoint grass (*Calamagrostis canadensis*), scouringrush horsetail (*Equisetum hymale* var. *affine*), common cowparsnip (*Heracleum maximum*), and Rocky Mountain hemlock parsley (*Conioselinum scopulorum*). The creek bed shows evidence of flooding with sediment deposition, small woody debris, and drift lines caught in shrub branches and on the banks of the creek. High creek flows appear to undercut the creek banks, but roots of creekside plants maintain the bank integrity. Wilson's Warbler and other songbirds flit through the dense shrub layer along the creek, and small trout fingerlings occur in the creek upstream of the trail crossing. Deer and elk use the area as well. The surrounding forest is mature and comprised of spruce (*Picea* sp.), white fir (*Abies concolor*), and Douglas-fir (*Pseudotsuga menziesii*), with a few quaking aspen (*Populus tremuloides*). The thinleaf alder and Drummond's willow in the riparian zone are dense and vigorous, and show abundant signs of regeneration. However, as is typical throughout Archuleta County in 2005, some alder plants are exhibiting branch dieback or leaf blight. In addition, the surrounding forest has approximately 5% spruce and fir death, documented in the form of dead standing trees. Downed wood and trees also occur all over the hillsides and within the creek corridor. The area is actively grazed, and typical weeds associated with grazing are present, including common plantain (*Plantago major*), common dandelion (*Taraxacum officinale*) and Kentucky bluegrass (*Poa pratensis*). Steep hillsides adjacent to the creek show severe erosion in areas, possibly due to natural soil conditions or aggravated by cattle grazing.

Key Environmental Factors

The thinleaf alder-Drummond's willow community occurs within a cool, narrow canyon with steep, forested hillsides, and a channel with low to moderate sinuosity, all typical conditions for the community (Carsey et al 2003). The geology of the area is mapped as Animas formation in the upper half of the community, and Pictured Cliffs Sandstone and Lewis Shale in the lower half of the community (Tweto 1979). Soils in the local area typically are derived from interbedded sandstone and shale and are predominantly sandy loam or silt loams. The upper half-mile of the community occurs on Corta silt loam, a small portion of the middle section occurs on Castelleia loam, and the majority of the community at the lower end is on Pescar sandy loam. Pescar sandy loams in particular typically occur within the floodplains and terraces of drainages (USDA 1981). Soils sampled within the stream channel are alluvium with sandy deposits.

Climate Description

No Data

Land Use History

Review of a recent aerial photo indicates logging may have occurred in the past, upslope of the north banks of Coal Creek and within the site (USDA 2002).

Cultural Features

No Data

Minimum Elevation	7,950.00	**Feet**	2,423.16	**Meters**
Maximum Elevation	9,400.00	**Feet**	2,865.12	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/02/2005

Designer Freeman, K.M.

Boundary Justification

The boundaries incorporate an area that will allow natural hydrological processes such as seasonal flooding, sediment deposition, and new channel formation to maintain viable populations of the riparian shrubland and forest along Coal Creek. It should be noted that the hydrological processes necessary to the riparian communities are not fully contained by the site boundaries. Given that the riparian communities are dependent on natural hydrological processes associated with Coal Creek and its tributaries, upstream activities such as logging, residential or other development, water diversions or impoundments, and improper livestock grazing are detrimental to the hydrology of the riparian area. The boundary also identifies a buffer around existing trails, trailheads and forest service roads where surface runoff may contribute nutrients and sediment, and where impacts may promote weed invasion. Lastly, the boundary includes an approximate 1,000 foot buffer to control sedimentation, protect the aquatic and plant communities from direct disturbance such as trampling (Karr and Schlosser 1978), and to allow additional native riparian plants to become established over time. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 558.44 **Acres** 225.99 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

This site supports a good (B-ranked) occurrence of the globally vulnerable (G3/S3) thinleaf alder - Drummond's willow (*Alnus incana - Salix drummondiana*) montane riparian shrubland plant association. This plant community is an early- to mid-seral association that is typically confined to the immediate edges of steep, shady streams. Both species produce profuse amounts of seed, and readily colonize areas of bare sediment deposition including areas that have been recently scoured by floodwaters or seasonal runoff. Their inherent flexibility as seedlings allows them to persist through flood events. Drummond's willow may capitalize on the ability of thinleaf alder to fix atmospheric nitrogen and become more populous over time (Carsey et al. 2003).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24743	*Alnus incana - Salix drummondiana* Wet Shrubland	Montane Riparian Shrubland	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

Current land uses include cattle grazing, horse riding/packing, hunting, hiking, and wildlife habitat. Residential development is occurring downstream of the site.

Natural Hazard Comments

No Data

Exotics Comments

Upslope of the riparian zone near the Forest Service road (FR 666) and trailhead, there is a high percentage of pasture species such as smooth brome (*Bromus inermis*), Kentucky bluegrass, Timothy (*Phleum pratense*), and common dandelion. These continue down the slope, along the pack trail, which eventually crosses the creek, and then parallels the creek for the length of the site, creating a vector for weed distribution. A site survey in 1995 documented many exotic weed species along FR 666 and in adjacent areas, though it did not specify which species were present.

Offsite

The west end of the site, though contained on USFS land, abuts two private parcels, both of which show residential development (USDA 2002). The east end of the site abuts the South San Juan Wilderness boundary. Old mining prospects are indicated on USGS 7.5 minute quadrangle maps occurring immediately south of the boundary, and large areas of private property downstream of the site are subject to residential development as Pagosa Springs and Archuleta County populations grow.

Information Needs

Some species within the riparian zone and on the adjacent upland slopes seem to be experiencing some type of disease possibly resulting in death, including spruce, Douglas-fir, currants (*Ribes* spp.), alder, and aspen. These plants show leaf wilt, leaf discoloration or "burns", and dead branches, and a notable percentage of the tree species are entirely dead, though still standing. Research could address why aspen, narrowleaf cottonwood, spruce, Douglas-fir, thinleaf alder, currants, and other forest species in the site are suffering from leaf wilt, branch dieback, or entire plant death.

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 371858N

State Colorado **Longitude** 1065310W

Quad Code	Quad Name
37106-C8	Jackson Mountain
37106-C7	Blackhead Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/02/2005

Version Author Freeman, K.M.

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Level 4 Potential Conservation Area (PCA) Report

Name East Side of Chalk Mountains **Site Code** S.USCOHP*25771

IDENTIFIERS

Site ID 2263 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The Chalk Mountains are a small, north-south mountain range in the southeast corner of Archuleta County, bound on the north by Flattop Mountain (11,436') and on the south by Navajo Peak (11,323'). The Navajo River drains the east side of the Chalk Mountains, and the west side drains to the Rio Blanco and the Little Navajo River. All are tributaries to the San Juan River. The Chalk Mountains display an array of colored cliff faces as they rise dramatically from more gently sloping foothills. The toe and mid slopes east of the Chalk Mountains contain highly erosive surface geology resulting in hillslopes that are slumpy with hummocky soils. Many steep montane streams flow eastward from the mountains, and depressional wetlands have formed in the breaks of the slope and are fed by groundwater and/or surface water (streams) or sheet flow. Uplands are dominated by pine (*Pinus ponderosa*) or spruce-fir forests (*Picea pungens - Abies concolor, Abies lasiocarpa*), aspen groves (*Populus tremuloides*), and grasslands dominated by Thurber's fescue (*Festuca thurberi*) and pasture grasses. The depressional wetlands across the toe and mid slopes of the Chalk mountains support many scattered populations of retrorse sedge (*Carex retrorsa*), usually occurring with beaked sedge (*Carex utriculata*), American mannagrass (*Glyceria grandis*), bluejoint reedgrass (*Calamagrostis canadensis*) on the mudflats and within shallow water. Emergent vegetation includes common spikerush (*Eleocharis palustris*) and narrowleaf bur-reed (*Sparganium emersum*). There is typically little aquatic vegetation present and open water in the center of the pond. At the foot of some dramatic colored cliffs, a thinleaf alder (*Alnus incana*) / mesic graminoid community surrounds a large pond called Dolomite Lake, and follows the outlet drainage eastward down the hillside to larger Grayhackle Lake, where it surrounds the latter lake as a fringe. The plant association is characterized by a dense canopy cover of alder and a dense canopy cover of mesic graminoids, dominated by beaked sedge, American mannagrass, common spikerush, and bluejoint reedgrass.

Key Environmental Factors

Field ecologists in 2005 found that in Archuleta County, retrorse sedge often occupies clayey soils on muddy shorelines, and sometimes within shallow standing water, of depressional wetlands roughly between 8,000 and 9,500 feet elevation. It is also often found on slightly higher ground along perennially wet areas, especially preferring banks along small channels, small to mid-size depressional wetlands, open mudflats at pond edges, and surface-drying mud. Retrorse sedge is nearly always found with beaked sedge, but seems to occupy slightly higher ground or the mudflat niche that beaked sedge doesn't colonize as aggressively. The surface geology is comprised of Quaternary aged landslide deposits that are locally comprised of talus, rock glacier, and thick colluvial deposits (Tweto 1979), which often form hummocky soils and have poorly developed drainage patterns (USDA 1981). Dominant soil types include Castelleia loams, which are moderately deep and well drained, but often limited by an underlying layer of impervious shale or sandstone. Large pockets of Hunchback clay loams, which are deep, poorly drained and occurring on fans and toe slopes, appear to be directly related to locations of ponds mapped on the USGS 7.5 minute topographic quadrangle. The third dominant soil type in the area is Corta silt loam, a deep and well drained soil with low permeability, again limited by an underlying layer of impervious shale or sandstone (USDA 1981). Soil samples taken at the various retrorse sedge occurrences sometimes have a surface layer of muck, but then nearly all samples generally display a deep layer of silty-clay soils saturated to the surface, with mottling indicating fluctuating water levels. Specific soil samples taken within the alder/mesic graminoid community display a shallow surface horizon of loamy sand with mottling and a high percentage of roots. The next horizon was deeper with a loamy sand texture with a very dark color. Water collected at 30 cm depth in the soil pit.

Climate Description

No Data

Level 4 Potential Conservation Area (PCA) Report

Name East Side of Chalk Mountains **Site Code** S.USCOHP*25771

Land Use History

The site is located in an area of Archuleta County that was part of the original Tierra Amarilla Mexican Land Grant. Fifty-thousand acres of this land grant at the northern extent of the Navajo River are now divided into 3 private ranches: Banded Peak Ranch, Catspaw Ranch, and Navajo Headwaters Ranch.

Cultural Features

No Data

Minimum Elevation	8,080.00	**Feet**	2,462.78	**Meters**
Maximum Elevation	9,520.00	**Feet**	2,901.70	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 01/02/2006

Designer Freeman, K.M.

Boundary Justification

The boundary was drawn to encompass all known retrorse sedge occurrences as well as the alder/mesic graminoid occurrence, along with additional areas that offer similar geology, soils, drainages, and groundwater discharges suitable for supporting additional populations or allowing populations to expand. The boundaries were additionally determined by the edge of loam/silt-loam/clay loam soil types (USDA 1981) which support the populations, and landslide deposit surficial geology (Tweto 1979), which is essential in creating the hummocky soils intercepted by groundwater that support the small ponds and the retrorse sedge populations. Natural fluvial processes such as seasonal flooding, sediment deposition, and beaver activity will help maintain viable population of the alder/mesic graminoid component along the montane drainages (Sanderson and Kettler 1996, Carsey et al. 2003).

Primary Area 1,965.39 **Acres** 795.37 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site supports a good occurrence (B-ranked) of the globally vulnerable (G3/S3) thinleaf alder (*Alnus incana*) / mesic graminoids montane riparian shrubland. This is the only documented occurrence of this association in Archuleta County as of 2005. Often this association is found with a high percentage of non-native grasses in the graminoid understory (Carsey et al. 2003), but this occurrence is relatively undisturbed and supports mostly native graminoid species with the exception of the ubiquitous Kentucky bluegrass (*Poa pratensis*). The site also supports two good (B-ranked) populations of the globally secure (G5) but state critically imperiled (S1) retrorse sedge (*Carex retrorsa*). Retrorse sedge has a broad distribution throughout the north half of North America, but, as of 2005, is known only in Colorado from several locations in Archuleta County. This site contains a large concentration of subpopulations.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24976	*Alnus incana* / Mesic Graminoids Wet Shrubland	Montane Riparian Shrubland	G3	S2	Y
20504	*Carex retrorsa*	retrorse sedge	G5	S1	N
20504	*Carex retrorsa*	retrorse sedge	G5	S1	N

LAND MANAGMENT ISSUES

Land Use Comments

The area is primarily for wildlife use. The site crosses three private ranches that grazed cattle historically; however there have been no cattle on the property for approximately 10 years. Small areas of forestry delimited by the owners occur within the site. A very large (minimum 4,000 head) elk herd migrates through this area each year and often over-winters on the ranches, which accounts for any heavy grazing or browsing that might be observed.

Level 4 Potential Conservation Area (PCA) Report

Name East Side of Chalk Mountains **Site Code** S.USCOHP*25771

Natural Hazard Comments

No Data

Exotics Comments

Canada thistle and musk thistle (*Cirsium arvense* and *Carduus nutans*) occur on the uplands surrounding many of the small ponds and riparian drainages. Musk thistle is considered a noxious weed in the county (State of Colorado, no date). Pasture grasses such as smooth brome, Kentucky bluegrass, timothy, and redtop (*Bromus inermis*, *Poa pratensis, Phleum pratense,* and *Agrostis gigantea*) are common on the surrounding uplands as well. Weeds occurring within several of the pond areas include devil's beggar-tick (*Bidens frondosa*), Canada thistle, common dandelion (*Taraxacum officinale*), and Mexican dock (*Rumex triangulivalvis*).

Offsite

No Data

Information Needs

The current owners are very conservation minded, and the ranch managers are very interested in learning as much about the natural elements on the property as possible. Excellent opportunities exist here for future surveys and/or inventories by CNHP staff, and maintaining the established, positive environment of information exchange with the ranch owners/managers would be encouraged in order to ensure future access the ranches and their resources.

REFERENCES

Reference ID	Full Citation
193596	Allison, Leslie. 2005. Ranch Manager, Banded Peak Ranch. Personal communication to Karin Freeman of the Colorado Natural Heritage Program.
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
193597	Relyea, R.A. 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications 15:618-627.
158563	Sanderson, J. and S. Kettler. 1996. A preliminary wetland vegetation classification for a portion of Colorado's West Slope. Unpublished final report submitted to the Colorado Department of Natural Resources and the U.S. Environmental Protection Agency. Colorado Natural Heritage Program, Fort Collins.
193555	State of Colorado, Department of Agriculture. No date. State Conservation Board Noxious Weed Program: Archuleta County. <<http://www.ag.state.co.us/CSD/Weeds/mapping/counties/Archuleta.html>> Accessed 7 Nov 2005.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 370713N

State Colorado **Longitude** 1064225W

Quad Code	Quad Name
37106-A6	Chama Peak

Level 4 Potential Conservation Area (PCA) Report

Name East Side of Chalk Mountains **Site Code** S.USCOHP*25771

37106-B6 Elephant Head Rock

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 01/02/2006

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Fourmile Creek at Quien Sabe **Site Code** S.USCOHP*25751

IDENTIFIERS

Site ID 2258 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

Mineral (CO)

SITE DESCRIPTION

Site Description

At the north-central edge of Archuleta County, Fourmile Creek drops between Quien Sabe Mountain and Cade Mountain through a narrow V-shaped valley at a moderate gradient with little sinuosity. The floodplain is narrow due to steep hillsides on either side, but the creek is meandering and migrating laterally when it can. The creek overbanks and deposits fine sandy-silty sediment on the floodplain and in secondary channels, but the floodplain consists mostly of boulders and cobble. High flows create drift lines, and carry large woody debris and other litter, depositing it in the creek bed and on the floodplain. The creek has a drop pool-short riffle structure along the length of the community, though the grade becomes gentler at the downstream end of the occurrence. The creek bed is lined by a consistent thinleaf alder-Drummond's willow (*Alnus incana - Salix drummondiana*) shrub component, with scattered mountain willow (*Salix monticola*) and narrowleaf cottonwood (*Populus angustifolia*). The riparian shrubs and trees grow close to the creek bed, and dense native mesic forbs and graminoids make up the herbaceous understory, dominated by cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*), Fendler's cowbane (*Oxypolis fendleri*), and fowl bluegrass (*Poa palustris*). The alder has some branch dieback as noted elsewhere across the county in 2005; otherwise the stands of alder and Drummond's willow are vigorous and dense. No emergent vegetation was noted on the creek edges or within the riparian zone, likely due to lack of soil development. Narrowleaf cottonwoods increase at the downstream end of the site, as does red-osier dogwood (*Cornus sericea*), and the riparian community shifts toward a narrowleaf cottonwood - blue spruce (*Picea pungens*)/alder community, but the alder-Drummond's willow component is still present. The hillsides are forested with a dense and mature subalpine fir - Engelmann spruce - blue spruce-quaking aspen *(Abies lasiocarpa - Picea engelmannii - Picea pungens - Populus tremuloides*) forest complex, with an understory of mesic herbaceous plant material, especially on the west hillside where a leaky irrigation ditch supplies groundwater to the seepy hillside. Wildlife use is common; caddisfly larvae were found under rocks in the creek, and fingerling fish were seen in the creek. Deer tracks were seen in the sediment next to the creek, an Abert squirrel (*Sciurus aberti*) was seen, and Northern Flickers (*Colaptes auratus*), American Crows (*Corvus brachyrhychos*), chickadees (*Poecile* spp.), and Red-breasted Nuthatches (*Sitta canadensis*) were heard. Cattle grazing occurs in the area and causes erosion in seepy hillside locations. Cattle trails were noted above the creek and down to the creek in a few places, but the riparian area exhibits few direct impacts other than infrequent cattle visitation. Irrigation diversions occur upstream, within, and downstream of the community.

Key Environmental Factors

The geology of the upper third of the site is mapped as Landslide Deposits, and the lower two-thirds is mapped as Pictured Cliffs Sandstone and Lewis Shale (Tweto 1979). Soil within the upper two-thirds of the site is mapped as Pagosa Loam, formed in glacial till overlying shale. The lower third is mapped as Muggins Loam, derived from glacial till deposited as moraines (USDA 1981). Soils in the creek bed are alluvial, with large, granitic rounded cobbles (3"-18" diameter, on average) and boulders. Sandy-silty deposition occurs on banks and on cobble point bars.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Level 4 Potential Conservation Area (PCA) Report

Name Fourmile Creek at Quien Sabe **Site Code** S.USCOHP*25751

Minimum Elevation	7,980.00	**Feet**	2,432.30	**Meters**
Maximum Elevation	8,720.00	**Feet**	2,657.86	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/29/2005

Designer Freeman, K.M.

Boundary Justification

The boundaries incorporate an area that will allow natural hydrological processes such as seasonal flooding, sediment deposition, and new channel formation to maintain a viable population of the riparian shrubland along Fourmile Creek. It should be noted that the hydrological processes necessary to the riparian community are not fully contained by the site boundaries. Given that the riparian community is dependent on natural hydrological processes associated with Fourmile Creek and its tributaries, upstream activities such as logging, residential or other development, water diversions or impoundments, and improper livestock grazing are detrimental to the hydrology of the riparian area. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 206.31 **Acres** 83.49 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

This site supports a good (B-ranked) occurrence of the globally vulnerable (G3/S3) thinleaf alder - Drummond's willow (*Alnus incana - Salix drummondiana*) montane riparian shrubland plant association. This plant community is an early- to mid-seral association that is typically confined to the immediate edges of steep, shady streams. Both species produce profuse amounts of seed, and readily colonize areas of bare sediment deposition including areas that have been recently scoured by floodwaters or seasonal runoff. Their inherent flexibility as seedlings allows them to persist through flood events. Drummond's willow may capitalize on the ability of thinleaf alder to fix atmospheric nitrogen and become more populous over time (Carsey et al. 2003).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24743	*Alnus incana - Salix drummondiana* Wet Shrubland	Montane Riparian Shrubland	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

Current land uses include cattle grazing, irrigation diversions, and possibly hunting. The hillsides are too steep for much hiking and definitely prohibitive for OHV use.

Natural Hazard Comments

Much of the terrain within the site is quite steep.

Exotics Comments

The herbaceous understory within the riparian community is mostly native, with dandelions (*Taraxacum officinale*), timothy (*Phleum pratense*) and Kentucky bluegrass (*Poa pratensis*).

Offsite

The site is wholly within USFS lands, but a large private parcel occurs upstream on a tributary to Fourmile Creek, and downstream (after the creek leaves forest land) it travels through many private, agricultural parcels. Dutton Ditch diverts some of the Fourmile Creek flow at the upstream end of the site. The ditch runs parallel to and uphill of the occurrence by 0.25-0.3 mile and is being put into a pipe in 2005, which will alter some of the hydrology in the area since the piping is to offset water loss from the leaky ditch. Temporary sediment impacts during and after construction and long-term hydrologic impacts will be likely, since the leaking ditch supplemented the hydrology of the area from uphill. Approximately 1/2 to 2/3 of the flow of Fourmile Creek is diverted into Fourmile Ditch at the lower end of the site, and other similar diversions occur downstream. Forest Road 645 occurs uphill of Fourmile Creek, by about 0.25-0.3 mile.

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
193575	Sibley, David A. 2000. National Audubon Society The Sibley Guide to Birds, First Edition. New York: Chanticleer Press, Inc.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 372304N

State Colorado **Longitude** 1070235W

Quad Code	Quad Name
37107-C1	Pagosa Springs
37107-D1	Pagosa Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/29/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Fourmile Creek of San Juan River **Site Code** S.USCOHP*8450

IDENTIFIERS

Site ID 268 **Site Class** PCA

Site Alias Beaver Lake at Fourmile Creek

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Mineral (CO)

SITE DESCRIPTION

Site Description

Among rocks piled during trail construction. Eastern aspect midslope in partial shade. Much of Fourmile Creek within this site is a narrow canyon below a large snowmelt basin. The site includes several waterfalls and many sheer rock faces along the canyon. Bedrock is igneous rock and conglomerate. The streambed is very rocky and consists of exposed bedrock in many places. The steep canyon slopes support mesic forb stands comprised of bluebells - senecio (*Mertensia ciliata - Senecio triangularis*) and scattered fumewort (*Corydalis casenea*). Below the falls, the canyon opens to support willow stands. The upper elevations are a large basin with several large snowmelt-fed wet meadows in relatively flat valleys along with two large lakes in glacial tarns. Two small trails traverse the basin and are regularly used by hikers and horseback riders. The meadows support spikerush (*Eleocharis*) beds and diverse tufted hairgrass (*Deschampsia*) stands. This is a wide valley with a sinuous stream which drains the nearby mountains. Talus slopes dominate the west side of the valley while spruce - fir forest dominate the east side. The lower elevation is a white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), aspen (*Populus tremuloides*) and snowberry (*Symphoricarpos rotundifolius*). The ground cover is lush with Oregon-grape (*Mahonia repens*) and meadowrue (*Thalictrum*). Volcanic tuff is the primary parent material. The pictureleaf wintergreen is found within this forest.

Key Environmental Factors

No Data

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	8,690.00	**Feet**	2,649.00	**Meters**
Maximum Elevation	11,580.00	**Feet**	3,530.00	**Meters**

SITE DESIGN

Site Map P - Partial **Mapped Date** 04/11/1997

Designer Fayette, K.K.

Boundary Justification

The boundary includes the occurrence and a small buffer of suitable habitat to allow for additional individuals to become established over time. The buffer should also protect the occurrence from trampling or other surface disturbances. The boundary includes the headwater basin and the riparian zone of Fourmile Creek with a small buffer zone to help protect the wetland occurrences from trampling or other surface disturbance. The lower montane slopes are included for complete protection of pictureleaf wintergreen.

Primary Area 874.52 **Acres** 353.91 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

This site supports excellent examples of common wetland plant communities, *Eleocharis quinqueflora* (G4/S3S4) and *Cardamine cordifolia - Mertensia ciliata* (G4/S4).

Level 4 Potential Conservation Area (PCA) Report

Name Fourmile Creek of San Juan River **Site Code** S.USCOHP*8450

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
23155	*Eleocharis quinqueflora* Fen	Alpine Wetlands	G4	S4	Y
24679	*Cardamine cordifolia - Mertensia ciliata - Senecio triangularis* Wet Meadow	Alpine Wetlands	G4	S4	Y

LAND MANAGMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

No Data

Offsite

No Data

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
-	No Data

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 372646N

Longitude 1070220W

Quad Code	Quad Name
37107-D1	Pagosa Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 04/11/1997

Version Author Fayette, K.K.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Harris Lake **Site Code** S.USCOHP*25712

IDENTIFIERS

Site ID 2250 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Harris Lake is within the San Juan National Forest in the west-central part of Archuleta County, on the west slope of the Chalk Mountains and just west of the boundary of the South San Juan Wilderness. The site encompasses a small basin containing Harris Lake and adjacent slopes of the Chalk Mountains, which due to their landslide geology often have groundwater discharge and support many small ponds, lakes, drainages, wetlands and several fens. These water bodies subsequently support an extraordinarily rich and diverse mosaic of wetland and riparian habitats. It is important to note that both Harris Lake and Buckles Lake south of the site are manipulated (dammed), with headgates that provide control of water for irrigation diversions. Both lakes were enhanced many years ago and are well established and support extensive native wetland plant associations. Blanco Tunnel, a major US Bureau of Reclamation subterranean water diversion in the area built in the late 1960's as part of the San Juan-Chama Project to divert water from the San Juan River Basin across the Continental Divide and into the Rio Grande River Basin (USDI, no date), is mapped within 200 feet of the site, but no surficial impacts to the area were noted. The geomorphology of the Chalk Mountains area includes landslide deposits and generally slumpy, stepped topography. The western slopes of the Chalk Mountains typically have steep slopes, a dense, mature spruce-fir-aspen (*Picea* spp. - *Abies* spp. - *Populus tremuloides*) forest, and large rockslides and outcrops. Many small drainages flow from the mountains westward, eventually joining the Rio Blanco; these drainages frequently support thinleaf alder (*Alnus incana*) / mesic forb shrublands along with willow (*Salix* sp.) and mesic graminoid shrublands. Small ponds and wetlands across the site typically support beaked sedge (*Carex utriculata*) and water sedge (*Carex aquatilis*) dominated communities, frequently intermixed with other sedge species, swordleaf rush (*Juncus ensifolius*), northern green orchid (*Platanthera hyperborea* var. *hyperborea*), and Kentucky bluegrass (*Poa pratensis*). Often these wetlands are peat accumulating (peat less than 40 cm deep), and at least two of these wetlands are considered fens (where peat accumulation is greater than 40 cm in depth). One of the two fens consists of a floating mat of peat, which supports rare and infrequent wetland species including marsh cinquefoil (*Comarum palustre*), mud sedge (*Carex limosa*), silvery sedge (*Carex canescens*), inland sedge (*Carex interior*), lesser panicled sedge (*Carex diandra*), fewflower spikerush (*Eleocharis quinqueflora*), buckbean (*Menyanthes trifoliata*), and tall cottongrass (*Eriophorum angustifolium*). The Buckles Lake/Harris Lake trail is a very popular trail used by hikers/backpackers, horseback riders, fishermen and hunters, and therefore acts as a vector for impacts such as erosion, weed seed dispersal, and litter. ATV access is allowed from the trailhead to the headgates at Buckles Lake for irrigation maintenance, but other motorized vehicle use is prohibited. Exotic and invasive species such as Canada thistle (*Cirsium arvense*), common dandelion (*Taraxacum officinale*), and Kentucky bluegrass (*Poa pratensis*) are common and widespread, especially in upland areas and adjacent to trails and Harris and Buckles Lakes. However, many of the smaller riparian drainages and wetland and fen areas that are some distance from the trails are nearly weed-free. Because of the rugged (steep, rocky) terrain that occurs off-trail, neither cattle nor humans induce much impact on many of these difficult-to-reach areas, including the floating mat fen.

Key Environmental Factors

A large portion of the geology on the west slopes of the Chalk Mountains, including the area within the site, is mapped as Landslide Deposits (Tweto 1979), which includes areas of thick colluvial deposits. This geology seems to predispose the area to having a stepped or hummocky microtopography where the groundwater table often is intercepted, forming many small pocket lakes and ponds. Soils are mostly Castelleia loams - moderately deep and well-drained, but often limited by an underlying layer of impervious shale or sandstone. Pockets of Histic Cryaquepts occur frequently within the Castelleia matrix (USDA 1981), which appear to be directly related to locations of ponds, wetlands and fens.

Level 4 Potential Conservation Area (PCA) Report

Name Harris Lake **Site Code** S.USCOHP*25712

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	9,000.00	**Feet**	2,743.20	**Meters**
Maximum Elevation	9,720.00	**Feet**	2,962.66	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 11/18/2005

Designer Freeman, K.M. and M.A. March

Boundary Justification

The boundary incorporates an area that includes the element occurrences, associated wetlands and fens, and the immediate watersheds supporting the element occurrences. Additional area is included that will buffer hydrologic processes, such as stream flows into Harris Lake, which are thought to secondarily contribute to the groundwater availability that supports the element occurrences. The boundary also provides a buffer from the Blanco Tunnel assuming maintenance work may someday be necessary along its length. It should be noted that all hydrologic processes necessary for wetland viability are not contained within the site boundaries.

Primary Area 469.63 **Acres** 190.05 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B2: Very High Biodiversity Significance

Biodiversity Significance Comments

This site is drawn for a good (B-ranked) occurrence of the globally imperiled (G2/S1S2) and state critically imperiled mud sedge (*Carex limosa*) montane wetland community. This element occurs within a nearly pristine fen above 9,000 feet in elevation. Also occurring within the site is a fair (C-ranked) occurrence of the globally and state vulnerable (G3/S3) thinleaf alder (*Alnus incana*) / mesic forb riparian shrubland community.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24645	*Alnus incana* / Mesic Forbs Wet Shrubland	Thinleaf Alder/Mesic Forb Riparian Shrubland	G3	S3	N
24366	*Carex limosa* Fen	Montane Wetland	G2	S1S2	Y

LAND MANAGMENT ISSUES

Land Use Comments

The current dominant land uses within the site are grazing and recreation. Harris Lake is a very popular day-hike destination as well as an overnight (backpacking or horsepacking) camping destination. The area is well used during hunting season, and both Buckles and Harris Lakes are popular fishing sites.

Natural Hazard Comments

No Data

Exotics Comments

Common exotic species are found throughout the site, most notably Canada thistle (*Cirsium arvense*). Other common invasive or exotic species include dandelion (*Taraxacum officinale*), Kentucky bluegrass (*Poa pratensis*), common mullein (*Verbascum thapsus*), and common plantain (*Plantago major*). Weeds are more common along trails and readily accessible edges of Harris Lake, where the focus of recreational activities occurs, and in meadows and wetland areas that are easily accessible to cattle.

Offsite

A large, single privately owned parcel occurs downslope of the site, within 1,000 feet of the boundary. From aerial photo interpretation, it appears that the parcel is not subdivided, and contains a large house and several barns and outbuildings, and grazing may occur on the property (USDA 2002).

Information Needs

Establishment of baseline monitoring will enable accurate monitoring of the ongoing grazing impacts to the fens and riparian areas. Additional ground surveys in the area may also uncover additional fen locations.

REFERENCES

Reference ID	Full Citation
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.
193553	USDA, NRCS. 2005. The PLANTS Database, Version 3.5 (http://plants.usda.gov). Data compiled from various sources by Mark W. Skinner. National Plant Data Center <http://npdc.usda.gov/>, Baton Rouge, LA 70874-4490 USA. Accessed 2005.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.
193558	USDI, Bureau of Reclamation. No date. Dams, Projects and Powerplants: San Juan-Chama Project, Colorado and New Mexico. <<http://www.usbr.gov/dataweb/html/sjuanchama.html#general>>. Accessed 18 Nov 2005.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 370926N

Longitude 1064811W

Quad Code	Quad Name
37106-B7	Harris Lake

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 11/18/2005

Version Author Freeman, K.M. and M.A. March

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Level 4 Potential Conservation Area (PCA) Report

Name Middle Fourmile Creek **Site Code** S.USCOHP*25752

IDENTIFIERS

Site ID 2259 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The middle section of Fourmile Creek is located in north-central Archuleta County southwest of Jackson Mountain and due north of downtown Pagosa Springs, and flows generally southeast through a narrow canyon with gently sloping, 200 foot high hillsides and a broad floodplain. The hillsides support dense coniferous forests of blue spruce, Engelmann spruce, Douglas-fir, and ponderosa pine (*Picea pungens, Picea engelmannii, Pseudotsuga menziesii* and *Pinus ponderosa*). Fourmile Creek has a moderate gradient just upstream of the site boundary, but flattens as the valley broadens. The creek is broad and somewhat shallow with small banks, and the channel has very good access to its floodplain. The creek is sinuous within the floodplain, and is exhibiting signs of fluvial and flooding processes including overbanking, sediment deposition, secondary channels, and debris transport. The creek bed is cobble, and over slightly higher gradients sandy deposits begin to support dense riparian shrubs such as bluestem willow, strapleaf willow and sandbar willow (*Salix irrorata, Salix ligulifolia* and *Salix exigua*), thinleaf alder (*Alnus incana*), and a dense herbaceous layer including cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*) and white checker-mallow (*Sidalcea candida*). The creek is undercutting the sandy banks in some areas, and the roots of the willow species and streamside grasses such as Wheeler bluegrass, Kentucky bluegrass, and redtop (*Poa nervosa, P. pratensis*, and *Agrostis gigantea*) are barely holding the banks intact. Narrowleaf cottonwood (*Populus angustifolia*) mature trees and regenerating poles and saplings dominate the tree layer especially on the first terrace, and mid-aged and young blue spruce trees are also colonizing the terrace. Several exotic species inhabit the herbaceous layer on these broad terraces, including Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), and oxeye daisy (*Leucanthemum vulgare*) as well as non-native pasture grasses. Deer, elk and black bear are known to utilize the riparian zone. Unidentified fish were seen in the creek, and various birds were heard or seen including White-breasted Nuthatch (*Sitta carolinensis*), Red-tailed Hawk (*Buteo jamaicensis*), American Crow (*Corvus brachyrhynchos*), American Robin (*Turdus migratorius*), and possibly an Olive-sided Flycatcher (*Contopus cooperi*) whose song was only heard once, and was not repeated for verification. Fourmile Creek has several major irrigation diversions above and below the site boundary. No recent logging was noted in the area, but a part-time residence with outbuildings occurs within the forest at the uppermost edge of the site, and environmental education tours are led through the community, crossing the creek in several places. A faint ranch road also crosses the community and the creek, and is still used infrequently for accessing parts of the ranch.

Key Environmental Factors

The geology is mapped as Mesaverde Group, Undivided, consisting of sandstone and shale (Tweto 1979). Soils are mapped as Nunn loams, deep, well-drained soils derived from shale and sandstone, and found on floodplains and alluvial fans (USDA 1981). Soils on site are alluvial, consisting of rounded cobble with sandy deposits.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	7,420.00	**Feet**	2,261.62	**Meters**
Maximum Elevation	7,480.00	**Feet**	2,279.90	**Meters**

Level 4 Potential Conservation Area (PCA) Report

Name Middle Fourmile Creek **Site Code** S.USCOHP*25752

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/30/2005

Designer Freeman, K.M.

Boundary Justification

The boundary was drawn to incorporate the element occurrence, the immediate watershed supporting the occurrence, and an area that will allow natural hydrological processes such as seasonal flooding and sediment deposition to maintain the riparian woodland along Fourmile Creek. Buffers to the east and west include two irrigation ditches and the maintenance trails that occur alongside those ditches, where surface runoff from maintenance activities may contribute excess nutrients and sediment (Karr and Schlosser 1978), and may promote weed invasion. It should be noted that the hydrological processes necessary to the riparian community are not fully contained by the site boundaries. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 65.58 **Acres** 26.54 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site supports a fair (C-ranked) occurrence of the globally imperiled (G2/S2) narrowleaf cottonwood / bluestem willow (*Populus angustifolia / Salix irrorata*) foothills riparian woodland. This community is an early-seral type, occurring on point bars and islands within the bankfull level of meandering streams. The presence of bluestem willow and sandbar willow (*Salix exigua*) are indicators of frequent flood events and regular sediment deposition (Carsey et al. 2003). As of 2005, this is one of only two documented occurrences of this community type in Archuleta County.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24827	*Populus angustifolia / Salix irrorata* Riparian Woodland	Foothills Riparian Woodland	G2	S2	Y

LAND MANAGMENT ISSUES

Land Use Comments

A residence with outbuildings occurs at the very upper edge of the site, though the house is not inhabited year round. Irrigation diversions occur above and below the site, and environmental education trails and an old ranch road crisscross the community and the creek. Grazing also occurs in the area, and residential and agricultural activities occur adjacent to the site to the west. Wildlife usage is expected to be high.

Natural Hazard Comments

No Data

Exotics Comments

Exotic species occur frequently in the understory, including the weedy forbs Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), oxeye daisy (*Leucanthemum vulgare*), common dandelion (*Taraxacum officinale*), and white clover (*Trifolium repens*), and pasture grasses such as Kentucky bluegrass (*Poa pratensis*), redtop (*Agrostis gigantea*), foxtail barley (*Hordeum jubatum*), and timothy (*Phleum pratense*).

Offsite

Within 700 feet of the creek channel but 150 feet in elevation above the creek, atop the west slope of the creek valley, cultivated hay pastures, residential and agricultural buildings, and roads occur on Fourmile Ranch. Upstream, Forest Service property surrounds the ranch, and downstream the land is divided into large, privately owned parcels. Forest Road 646 crosses the creek 0.80 of a mile upstream of the site. This road crossing washed out during high spring flows in 2005, and subsequently contributed large amounts of sediment to the stream. One of the main tributaries to Fourmile Creek is Snowball Creek, which is actually a diversion from Turkey Creek 4.5 miles northeast of the site. This, along with many irrigation diversions above and below the site represent that the flows in Fourmile Creek are highly manipulated.

Level 4 Potential Conservation Area (PCA) Report

Name Middle Fourmile Creek **Site Code** S.USCOHP*25752

Information Needs

The regular environmental education programs provide an excellent opportunity to do basic documentation on species composition, weed lists, and the ongoing health and vigor of thinleaf alder, which is showing evidence of branch dieback here, as it is across the county in 2005.

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
193575	Sibley, David A. 2000. National Audubon Society The Sibley Guide to Birds, First Edition. New York: Chanticleer Press, Inc.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

Latitude 371945N

State Colorado

Longitude 1070011W

Quad Code	Quad Name
37107-C1	Pagosa Springs

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/30/2005

Version Author Freeman, K.M.

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Level 4 Potential Conservation Area (PCA) Report

Name Navajo Peak Trail **Site Code** S.USCOHP*23167

IDENTIFIERS

Site ID 915 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

In the southeast part of Archuleta County, the Navajo Peak Trail site occurs approximately one mile due west of Navajo Peak, along the Navajo Peak Trail in the Price Lakes area. The topography generally slopes to the west or southwest, and drains towards the Little Navajo River, a tributary to the Navajo River and eventually the San Juan River. Dense stands of mature white fir (*Abies concolor*) and Engelmann spruce (*Picea engelmannii*) with an understory of roundleaf snowberry (*Symphoricarpos rotundifolius*) dominate these slopes, with large stands of mature quaking aspen (*Populus tremuloides*) occurring within the forests. Open meadows, small streams, wetlands and small beaver-influenced ponds occur on the slumpy landforms within the forest. The wetland site is an old beaver-influenced depression with an ill-defined channel, within an opening in the surrounding spruce-fir-aspen forest. The wetland appears to be fed by an ephemeral drainage to the east which is identified by a small stand of mature thinleaf alder (*Alnus incana*), and has no apparent outlet. Most of the pond consists of emergent vegetation including common spikerush (*Eleocharis palustris*) and narrowleaf bur-reed (*Sparganium angustifolium*). A moderate-sized population of retrorse sedge (*Carex retrorsa*) is scattered on the north, east, and west edges of the pond within common spikerush-dominated stands, in clumps within stands of Northwest Territory sedge (*Carex utriculata*), or in small, self-dominating stands at the drying edges of the depressional wetland. Other common wetland plants in the area are field horsetail (*Equisetum arvense*), panicled bulrush (*Scirpus microcarpus*), seep monkeyflower (*Mimulus guttatus*), and American speedwell (*Veronica americana*). Exotic species at the site include Canada thistle (*Cirsium arvense*), nodding plumeless thistle (*Carduus nutans* ssp. *macrolepis*), common plantain (*Plantago major*), mountain tarweed (*Madia glomerata*), red clover (*Trifolium pratense*), white clover (*Trifolium repens*), nodding beggartick (*Bidens cernua*), and common dandelion (*Taraxacum officinale*). Non-native pasture grasses such as smooth brome (*Bromus inermis*), orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), and timothy (*Phleum pratense*) are common along roads and trails. Northern leopard frogs (*Rana pipiens*), a species formerly tracked by CNHP but now watchlisted, have been found in abundance in small ponds near the site.

Key Environmental Factors

The northeast corner of the pond appears to have a small incoming drainage (seasonal) which supports a small, healthy stand of thinleaf alder. No outlet is apparent. There is possibly some very old beaver activity in the pond as evidenced by large woody debris (piled), at the low end of pond, and at least one very old, beaver-gnawed stump near the pond on the uplands. At the time of the visit, the pond had no standing water, but soils were moist throughout. Soils were sampled in a drying sub-depression within the wetland dominated by common spikerush and needle spikerush (*Eleocharis acicularis*) with scattered clumps of knotsheath sedge. No detritus was noted on the surface, and soils were not saturated to the surface at the time of the visit. The uppermost horizon was very rooty and impossible to texture. Next, a moist, thin silty clay loam horizon overlaid a thicker, rust-mottled, silty clay layer which indicated that the wetland has had periods of saturation and drying. Soils in this area are mapped as Castelleia loams, with small inclusions of poorly drained Animas loam and Hunchback clay loam in depressions and swales (USDA 1981), both of which occur commonly in the landslide deposit (colluvial deposition) geology of the area (Tweto 1979).

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Level 4 Potential Conservation Area (PCA) Report

Name Navajo Peak Trail **Site Code** S.USCOHP*23167

Minimum Elevation	9,500.00	**Feet**	2,895.60	**Meters**
Maximum Elevation	9,800.00	**Feet**	2,987.04	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 11/16/2005

Designer Freeman, K.M.

Boundary Justification

The boundary was drawn to include the occurrence of knotsheath sedge with a buffer of approximately 1,000 feet, and the immediate watershed. There are hundreds of other small lakes, streams and wetlands in the area with potential habitat for retrorse sedge that are not included within this boundary. Further survey could result in enlargement of this site.

Primary Area 136.31 **Acres** 55.16 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

This site contains a good (B-ranked) occurrence of retrorse sedge (*Carex retrorsa*), a plant that is very rare (S1) in Colorado, but globally secure (G5). Retrorse sedge has a broad distribution throughout the north half of North America, but, as of 2005, is known only in Colorado from several locations in Archuleta County.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
20504	*Carex retrorsa*	retrorse sedge	G5	S1	Y

LAND MANAGMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Canada thistle (*Cirsium arvense*) is quite abundant, especially in upland areas near the wetland and on the fringes of the wetland itself. Other exotics include nodding plumeless thistle (*Carduus nutans* ssp. *macrolepis*), common plantain (*Plantago major*), mountain tarweed (*Madia glomerata*), red clover (*Trifolium pratense*), white clover (*Trifolium repens*), nodding beggartick (*Bidens cernua*), and dandelion (*Taraxacum officinale*). Non-native pasture grasses such as smooth brome (*Bromus inermis*), orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), and timothy (*Phleum pratense*) are common along roads and trails.

Offsite

No Data

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
166839	Lyon, P. 2001. Colorado Natural Heritage Program Field Surveys.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

Original site design by Lyon, M.J. 2002-02-15.

LOCATORS

Nation United States

State Colorado

Latitude 370533N

Longitude 1064453W

Quad Code	Quad Name
37106-A7	Chromo
37106-A6	Chama Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 11/16/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Navajo River at Banded Peak **Site Code** S.USCOHP*25772

IDENTIFIERS

Site ID 2264 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The Navajo River is a sinuous river in extreme southeast Archuleta County, originating at the Continental Divide and flowing within a broad, U-shaped valley between two high mountain ranges. The Chalk Mountains and Navajo Peak rise immediately to the west of the river, and to the east, the slopes rise dramatically to the Continental Divide, Banded Peak, and Chama Peak, all above 12,000' elevation. Dramatic, exposed rock cliffs of varying colors occur high on the slopes on both sides of the valley, and the mountain slopes are blanketed with spruce - fir (*Picea* spp. - *Abies* spp., *Pseudotsuga menziesii*) and aspen (*Populus tremuloides*) forests, with ponderosa pine (*Pinus ponderosa*), Gambel oak (*Quercus gambelii*) and infrequent Mexican white pine (*Pinus strobiformis*) occurring at lower elevations. The Navajo River and its tributaries carry a high bedload of cobble, gravel and sand, depositing it wherever the stream gradient flattens. On the valley floor, for a nearly six-river-mile stretch of the Navajo River, mature, vigorous and healthy narrowleaf cottonwood (*Populus angustifolia*) and blue spruce (*Picea pungens*) with a thinleaf alder (*Alnus incana*) understory occur on the floodplain and first terrace. Cottonwood, alder, Pacific willow and sandbar willow (*Salix lucida* ssp. *lasiandra* and *S. exigua*) are regenerating on the floodplain, but the first terrace supports the majority of the cottonwood, as well as the blue spruce and a few ponderosa pine. The understory on the floodplain and terrace contains mostly native shrubs, mesic forbs, and graminoids with some weedy forbs and pasture grasses. On the terraces above the riparian community, a mix of blue spruce, ponderosa pine and aspen are interspersed with large, grassy meadows. At the upstream end of the site, the East Fork of the Navajo River descends southwest from the Continental Divide below Fets Peak (12,127') and Gramps Peak (12,792') and eventually joins the main stem of the Navajo River. Several mapped and unmapped waterfalls occur along its run. Just above where the river enters the broad floor of the Navajo River valley, a small but fairly pristine white fir (*Abies concolor*) - blue spruce - narrowleaf cottonwood / Rocky Mountain maple (*Acer glabrum*) community occurs within a narrow canyon with steep rock walls. Mature and regenerating cottonwood, blue spruce, Douglas-fir (*Pseudotsuga menziesii*), and white fir dominate the canopy and shade the understory in the narrow, deep canyon. The understory shrub layer at the riverbank consists of thinleaf alder and red-osier dogwood (*Cornus sericea*), with sporadic willows (*Salix* spp.), and Rocky Mountain maple is scattered throughout the community. The herbaceous understory is quite sparse in this shady canyon, but common species are false lily-of-the-valley (*Maianthemum* spp.), few-flower meadow-rue (*Thalictrum sparsiflorum*), fringed brome (*Bromus ciliatus*) and bluejoint reedgrass (*Calamagrostis canadensis*). Downstream on the Navajo River, below the midpoint of the site, Headache Creek descends to the west from the Continental Divide, passing through alpine meadows, mixed Engelmann spruce - subalpine fir forests and aspen stands, and near its confluence with the Navajo River it passes through Douglas-fir and ponderosa pine forests with a Gambel oak understory. This creek supports a 90% genetically pure, viable, and reproducing population of Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*). Restoration activities are currently taking place on Headache Creek to create barriers to non-native trout species that could potentially interbreed with the cutthroat trout population.

Key Environmental Factors

No Data

Climate Description

No Data

Land Use History

Headache Creek joins with the Navajo River at the site of Gramps Oil Field. This oil field has produced over 5 million barrels of oil since 1935 (USDA 2004), but was decommissioned and closed in recent years; the closure included Phase I, II and III environmental assessments, well plugging, removal of equipment, and decompaction and restoration of roads and facility sites (Trident Environmental, no date). Additionally, the site is located in an area of Archuleta County that was part of the original Tierra Amarilla Mexican Land Grant. Fifty-thousand acres of this land grant at the northern extent of the Navajo River are now divided into 3 private ranches: Banded Peak Ranch, Catspaw Ranch, and Navajo Headwaters Ranch.

Cultural Features

No Data

Minimum Elevation	7,800.00	**Feet**	2,377.44	**Meters**
Maximum Elevation	11,200.00	**Feet**	3,413.76	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 01/02/2006

Designer Freeman, K.M.

Boundary Justification

The boundary incorporates an area that will allow natural hydrological processes such as seasonal flooding, sediment deposition, and new channel formation to maintain viable populations of the riparian woodlands along the East Fork of the Navajo River and the main stem of the Navajo River. Additionally, since the cutthroat trout population depends exclusively on the local hydrology for their life needs, the extent of the watershed was included from the headwaters of Headache Creek to its confluence with the Navajo River. Thus, the floodplain and immediate watershed, which are necessary to support natural hydrological processes, are included to ensure the long-term maintenance of the riparian ecosystems and the fish population. Activities within the boundary have the potential to impact the local hydrology and dependent ecology. The boundary also includes an approximate 500 foot buffer on the tributaries, and a 1,000 foot buffer on the main stem of the Navajo River, which includes nearby ranch roads, old development sites, hay meadows, and primitive campgrounds where surface runoff may contribute excess nutrients, sediment (Karr and Schlosser 1978), and weed invasion. These upland buffers are also provided to limit direct disturbance and local hydrologic alteration. It should be noted that the hydrological processes necessary to the riparian communities are not fully contained by the site boundary. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 2,337.62 **Acres** 946.00 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site supports several unique riparian communities as well as a rare fish subspecies. A fair (C-ranked) occurrence of the globally imperiled (G2/S2) white fir - (Blue spruce) - narrowleaf cottonwood / Rocky Mountain maple (*Abies concolor* - (*Picea pungens*) - *Populus angustifolia / Acer glabrum*) montane riparian forest is located within the site. This plant association is a mid- to late-seral community occurring on active floodplains of montane valleys, often within narrow shady canyons (Carsey et al. 2003). Large occurrences of two other montane riparian forests occur in a mosaic: a good (B-ranked) occurrence of narrowleaf cottonwood / thinleaf alder (*Populus angustifolia / Alnus incana*), a globally vulnerable (G3/S3) community and a good (B-ranked) occurrence of narrowleaf cottonwood - blue spruce / thinleaf alder (*Populus angustifolia - Picea pungens / Alnus incana*), another globally vulnerable (G3/S3) community. The site also supports a good (B-ranked) occurrence of Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*), a globally vulnerable (G4T3/S3) subspecies. This population is considered 90% genetically pure, showing minimal hybridization with other introduced (non-native) trout species. Currently, projects are being implemented by the private property owners in conjunction with the Colorado Division of Wildlife to install barriers to prevent further hybridization (Allison 2005).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
21796	*Oncorhynchus clarkii pleuriticus*	Colorado River Cutthroat Trout	G4T3	S3	N

24810	*Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum* Forest	Montane Riparian Forests	G2	S2	Y
24541	*Populus angustifolia / Alnus incana* Riparian Woodland	Montane Riparian Forest	G3	S3	Y
24823	*Populus angustifolia - Picea pungens / Alnus incana* Riparian Woodland	Montane Riparian Forests	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

The area is primarily for wildlife use. The site crosses two private ranches that grazed cattle historically; however there have been no cattle on the property for approximately 10 years. Small areas of forestry delimited by the owner(s) occur within the site. A very large (minimum 4,000 head) elk herd migrates through this area each year and often over-winters on the ranches, which accounts for any heavy grazing or browsing that might be observed. Ranch roads with several small bridge crossings, and several irrigation diversions occur within the site. These diversions serve to irrigate adjacent meadows, supplying feed and hay for the ranch and forage for migrating elk and deer. On the East Fork, a large shed exists with cars parked within and various equipment and tools nearby. Another large shed, other outbuildings, and several old holding ponds occur at the site of the old Gramps oil field, which has been closed and decommissioned. A river gauge is installed on the Navajo River just upstream of its confluence with Headache Creek. At the downstream end of the site, a small portion of USFS land and BLM land occur along the Navajo River. A primitive campground is located on the USFS land.

Natural Hazard Comments

No Data

Exotics Comments

Few if any weeds occur in the understory along the riparian community on the East Fork of the Navajo River. However, weedy species increase as the tributary enters the broad valley meadows, which were once grazed, and joins with the main stem of the Navajo River. The understory on the floodplain and terrace of the Navajo River often contains Canada thistle (*Cirsium arvense*), common dandelion (*Taraxacum officinale*), and hay grasses such as timothy, smooth brome, and Kentucky bluegrass (*Phleum pratense, Bromus inermis* and *Poa pratensis*), but also supports native shrubs, mesic forbs, and graminoids. Headache Creek was not botanically surveyed, and no weed information is available at this time; however, the Colorado Division of Wildlife, in association with the property owners and ranch manager of the Banded Peak Ranch, are actively working on projects to prevent invasion of exotic trout species into the Headache Creek drainage which threaten the existing population of Colorado River cutthroat trout.

Offsite

No Data

Information Needs

The current owners are very conservation minded, and the ranch managers are very interested in learning as much about the natural elements on the property as possible. Excellent opportunities exist here for future surveys and/or inventories by CNHP staff, and maintaining the established, positive environment of information exchange with the ranch owners/managers would be encouraged in order to ensure future access the ranches and their resources.

REFERENCES

Reference ID	Full Citation
193596	Allison, Leslie. 2005. Ranch Manager, Banded Peak Ranch. Personal communication to Karin Freeman of the Colorado Natural Heritage Program.
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
193622	Trident Environmental. No date. Summaries of Typical Trident Environmental Projects: Price Gramps Oil Field - Southern CO. The Decommissioning and Closure of an Oil Field. http://www.trident-environmental.com. Accessed 2006 January 03.
193621	USDA, U.S. Forest Service. 2004. Rio Grande National Forest: History and Culture of the San Luis Valley Area. http://www.fs.fed.us/r2/riogrande/about/history/index.shtml. Accessed 2006 January 3.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 370536N

Longitude 1064124W

Quad Code	Quad Name
37106-A6	Chama Peak
37106-B6	Elephant Head Rock

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 01/02/2006

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Opal Lake **Site Code** S.USCOHP*23163

IDENTIFIERS

Site ID 600 **Site Class** PCA

Site Alias White Creek at Opal Lake

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Opal Lake site is located in the east central part of Archuleta County, in a montane basin below Flat Top Mountain in the wonderfully erosive Chalk Mountain range. These mountains are forested in aspen (*Populus tremuloides*), blue spruce (*Picea pungens*) and fir (*Abies* spp. and *Pseudotsuga menziesii*), surrounding Opal Lake and White Creek. Opal Lake is approximately three acres, with a wide fringe of graminoids on the north and east edge supporting an occurrence of retrorse sedge (*Carex retrorsa*), and a dense riparian shrubland located above the hydrophytic fringe. Slopes on the other three sides of the lake drop sharply from the surrounding forests into the lake, supporting only a sporadic, thin fringe of graminoids. The lake is opaque whitish-gray in good weather, and turbid (muddy) during the summer monsoons. At least two small spring-fed creeks on the south edge feed the lake, both supplying white-tinged water to the lake. Two beaver live at the lake, and a new lodge sits at the southeast corner. A small dam controls the lake outflow at the northwest corner, where White Creek drains the lake, and near this outlet there is a dense, and healthy thinleaf alder - Drummond's willow (*Alnus incana - Salix drummondiana*) montane riparian shrubland. Additional shrub species including park willow (*Salix monticola*) and diamondleaf willow (*Salix planifolia*) combine to provide a 58% shrub canopy cover within this riparian area. The herbaceous understory is dominated by beaked sedge (*Carex utriculata*), with other native mesic graminoids and forbs such as largeleaf avens (*Geum macrophyllum*), northern green orchid (*Platanthera hyperborea* var. *hyperborea*), and common cowparsnip (*Heracleum maximum*). Below this riparian shrubland, White Creek flows down a valley with moderate to slightly steep slopes that are densely forested with conifers and aspen (*Populus tremuloides*). The creek appears to periodically flood and many overflow channels are present. Riparian shrubs including alder, Drummond's willow, and red-osier dogwood (*Cornus sericea*) as well as hydrophytic graminoids are found in the flood plain terrace and overflow channels. A rare blue spruce / thinleaf alder montane riparian forest occurs here with aspen and subalpine fir (*Abies lasiocarpa*) also present in the overstory. The herbaceous understory includes Richardson's geranium (*Geranium richardsonii*), Fendler's cowbane (*Oxypolis fendleri*), and cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*). A trail follows and crosses White Creek only at its upper end near the lake, but the lake is a popular destination for hikers and trails criss-cross the area and encircle the lake. A popular campsite at the west edge of the lake sits just off the trail and within 350 feet of the lakeshore.

Key Environmental Factors

Soils around Opal Lake are described as Typic Ustorthents on the north shore, derived from andesite and quartz latite and found on fans and toe slopes, and Castelleia loam on the south shore, with similar parentage. Along White Creek, from Opal Lake to below the Forest Road, the soils shift from Skyway loams just downstream of the lake to mostly Castelleia loams the remainder of the length of the site. Both soil types are deep and well drained, and derived again from andesite and quartz latite parentage (USDA 1981). Specifically, soils at Opal Lake vary along the lake's graminoid fringe as to their geomorphic position. At the top of the north forest slope, a shallow, clayey A horizon (10 cm) lies over sand and gravels. At the edge of a rivulet within the graminoids, a shallow, mottled sandy loam (10 cm) lies over gravels. At the lake's edge within the graminoids and near some willow and alder shrubs, the soil is better developed. The top 10 cm is rooty, organic matter in mottled gray clay; the next 15 cm contains mottled sandy loam in mosaic with sand/clay. These textures are not mixed, but lie next to each other. The entire horizon is 40% mottled. Below this, the next 10 cm contains clay with some gravel and sand. The soils at this location are saturated to the surface and collect water at 20 cm deep. It should be noted that field ecologists in 2005 found that retrorse sedge (*Carex retrorsa*) appears to occupy clayey soils on muddy shorelines or creek banks, and sometimes within shallow standing water roughly between 8,000 and 9,500 feet elevation. It is nearly always associated with beaked sedge (*Carex utriculata*). Along White Creek, soils are typically alluvial, and the streambed consists of rounded and angular cobble, averaging 1"- 8" in diameter. Sediment deposition within the floodplain is silty clay loam, and on the first terrace, soils show a shallow clayey mineral horizon (10 cm) over sand and gravel.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	8,080.00	**Feet**	2,462.78	**Meters**
Maximum Elevation	9,300.00	**Feet**	2,834.64	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/16/2005

Designer Freeman, K.M.

Boundary Justification

The boundaries were drawn to include the wetlands around Opal Lake and to incorporate an area that will allow natural hydrological processes such as seasonal flooding, sediment deposition, and new channel formation to maintain viable populations of the plant communities along White Creek. It should be noted that the hydrological processes necessary to the elements are not fully contained by the site boundaries. This boundary indicates the minimum area that should be considered for any conservation management plan. The boundary also includes a buffer of approximately 1,000 feet. Eliminating disturbance within this 1,000 foot buffer would aid in reducing impacts from sedimentation (Karr and Schlosser 1978), and assist in maintaining the integrity of the occurrences and its associated avian, macroinvertebrate and periphyton communities (Noel et al. 1986, Spackman and Hughes 1995).

Primary Area 262.94 **Acres** 106.41 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The Opal Lake site supports a good (B-ranked) example of the globally vulnerable (G3/S3) thinleaf alder - Drummond willow (*Alnus incana / Salix drummondiana*) montane riparian shrubland. As of 2005, this plant association has only been documented from Colorado and is limited in distribution, but widespread in Colorado. It is highly threatened by improper livestock grazing and stream impoundments. This association is generally found along steep-gradient streams with stable, shaded stream banks. The site also includes a fair (C-ranked) example of blue spruce / thinleaf alder (*Picea pungens / Alnus incana*) montane riparian forest, a community that is also globally vulnerable (G3/S3). This woodland occurs in deep, shaded canyons and narrow valleys along relatively straight stream reaches. It generally forms small patches, but can be continuous for several river miles. As of 2005, fewer than 100 stands exist in Colorado, and very few of these are in pristine condition. This association is threatened by development, road building and maintenance, heavy recreational use, improper livestock grazing, and stream flow alterations. An unranked occurrence of retrorse sedge (*Carex retrorsa*), a plant that is extremely rare (S1) in Colorado, although not threatened globally (G5) was documented at the site in 2001 but was not located in 2005. Site conditions have not changed dramatically so it is expected that the population still exists. Retrorse sedge has a broad distribution throughout the north half of North America, but, as of 2005, is known only in Colorado from several locations in Archuleta County.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
20504	*Carex retrorsa*	retrorse sedge	G5	S1	N

24743	*Alnus incana - Salix drummondiana* Wet Shrubland	Montane Riparian Shrubland	G3	S3	Y
24518	*Picea pungens / Alnus incana* Riparian Woodland	Montane Riparian Forests	G3	S3	N

LAND MANAGMENT ISSUES

Land Use Comments

Grazing and recreational use (such as hiking, hunting, horseback riding, fishing, and dispersed camping) have the greatest impacts on the site.

Natural Hazard Comments

No Data

Exotics Comments

Prominent exotic plant species observed at Opal Lake and the upper extent of White Creek were Canada thistle (*Cirsium arvense*) and timothy (*Phleum pratense*). In the lower extent of White Creek, only common dandelion (*Taraxacum officinale*) was noted as a prominent exotic species, but weeds may easily spread if introduced where the creek crosses FR 660.

Offsite

Hydrological processes originating outside of the planning boundary, including water quality, quantity, timing and flow are critical for maintaining the quality of the riparian and wetland communities.

Information Needs

The occurrence of retrorse sedge (*Carex retrorsa*) documented in 2001 was not relocated during the 2005 survey. Beaked sedge (*Carex utriculata*) was abundant at location described, but no retrorse sedge heads were identified; however it is possible that the seed heads were too immature or had dropped by the time of visit. No hydrologic or other alterations have occurred at the site since 2001, and soil and hydrology conditions are very similar to those occurring at other locations of retrorse sedge in Archuleta County. The associated species at the site also match what occurs at other sites; therefore, it is not unreasonable to assume the population still exists at this location. A small drainage coming into Opal Lake on the south shore supports a small sedge stand just upstream of the lake, and possibly has a small retrorse sedge population mixed with beaked sedge (specimens were not definitely identified, but photos were taken). Additional field work is necessary to verify the occurrence.

REFERENCES

Reference ID	Full Citation
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
166839	Lyon, P. 2001. Colorado Natural Heritage Program Field Surveys.
165959	Noel, D.S., C.W. Martin and C.A. Federer. 1986. Effects of Forest Clearcutting in New England on Stream Macroinvertebrates and Periphyton. Environmental Management 10: 661-670.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
159511	Spackman, S. C. and J. W. Hughes. 1995. Assessment of Minimum Stream Corridor Width for Biological Conservation: Species Richness and Distribution Along Mid-Order Streams in Vermont, USA. Biological Conservation 71:325-332.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

Original site design by Lyon, M.J. 2002-02-15.

LOCATORS

Nation	United States	**Latitude**	371200N
State	Colorado	**Longitude**	1064605W

Quad Code	Quad Name
37106-B7	Harris Lake
37106-B6	Elephant Head Rock

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/16/2005

Version Author Freeman, K.M.

DISCLAIMER

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Level 4 Potential Conservation Area (PCA) Report

Name Porcupine Creek Meadow **Site Code** S.USCOHP*25731

IDENTIFIERS

Site ID 2254 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Porcupine Creek Meadow site is located in the San Juan National Forest in the east central portion of Archuleta County. Squaretop Mountain rises to the east and the Rio Blanco flows downhill of the site. In a broad, very gently sloping meadow in a shallow, west-facing step in the slope below Squaretop Mountain, a Bebb's willow (*Salix bebbiana*) shrubland co-dominates with a mountain willow (*Salix monticola*) / mesic forb shrubland. The shrubland is in the northern portion of the meadow where an intermittent, unnamed stream flows in an entrenched channel. The meadow and willow shrubland is surrounded by quaking aspen (*Populus tremuloides*), spruce (*Picea* spp.), and subalpine fir (*Abies lasiocarpa*) forests, with a few signs of past logging but not in recent years. Within the shrubland, both willow species are mostly mature plants, with some regenerating plants that are being heavily browsed. The riparian understory is heavily grazed mesic graminoids and forbs, most of which are unidentifiable at their grazed height except where they grow within or between the willow stems. The meadow is also heavily grazed. At the time of the visit the graminoid stubble probably averaged 3 inches or less. It is very difficult to tell how weedy the community is, since it has been so heavily grazed. Many songbirds use the uplands and the willow shrublands for forage and shelter. The local area around the meadow and willow shrubland is used for grazing and for recreation, including OHV use and hunting.

Key Environmental Factors

No Data

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	8,480.00	**Feet**	2,584.70	**Meters**
Maximum Elevation	8,860.00	**Feet**	2,700.53	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/22/2005

Designer Freeman, K.M.

Boundary Justification

The boundary encompasses the element occurrence and the immediate watershed for the drainage that supports the occurrence. The boundary also includes an approximate 500 foot buffer, and includes nearby roads, trails, and grazing allotments where surface runoff may contribute excess nutrients, sediment (Karr and Schlosser 1978), and weed invasion. Given that the riparian shrubland is dependent on natural hydrological processes associated with the unnamed drainage where it occurs, upstream activities such as logging, roads, water diversions and impoundments, and improper livestock grazing are detrimental to the hydrology of the riparian area. It should be noted that the hydrological processes necessary to the riparian forest are not fully contained by the site boundaries. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area	93.38	**Acres**	37.79	**Hectares**

SITE SIGNIFICANCE

Level 4 Potential Conservation Area (PCA) Report

Name Porcupine Creek Meadow **Site Code** S.USCOHP*25731

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The site supports a fair (C-ranked) occurrence of the globally vulnerable (G3?) and state imperiled (S2) Bebb's willow (*Salix bebbiana*) montane willow carr. In Colorado, Bebb's willow stands are infrequent, forming tall thickets with an open to closed canopy. Bebb's willow stands often occur as a component of larger montane mixed-willow carrs or riparian mosaics with other species such as mountain willow (*Salix monticola*) or thinleaf alder (*Alnus incana*)(Carsey et al. 2003). The site also supports a fair (C-ranked) occurrence of a mountain willow (*Salix monticola*) / mesic forb montane riparian willow carr, a plant community considered globally apparently secure (G4) and vulnerable in the state (S3).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
20994	*Salix bebbiana* Wet Shrubland	Montane Willow Carrs	G3?	S2	Y
24809	*Salix monticola* / Mesic Forbs Wet Shrubland	Montane Riparian Willow Carr	G4	S4	N

LAND MANAGMENT ISSUES

Land Use Comments

Intensive grazing is occurring within the meadow where the willow carr occurs, and OHV use and hunting is common in the area. OHV trails criss-cross the hillside around the site.

Natural Hazard Comments

No Data

Exotics Comments

It is very difficult to tell how weedy the community is, since it has been so heavily grazed and all that remains is stubble. Most forbs and graminoids are unidentifiable. A very large grasshopper population was heavily predating the Colorado false hellebore (*Veratrum tenuipetalum*) and what was left of other forbs in the adjacent meadow after intensive cattle grazing. The mesic forbs within the willow shrubland were also being eaten by grasshoppers, but not to the extent of the upland forbs.

Offsite

An OHV trail descends the hillside just to the south of the meadow and enters a large private parcel below the National Forest boundary (USDA 2002).

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.

ADDITIONAL TOPICS

Additional Topics

No Data

Level 4 Potential Conservation Area (PCA) Report

Name Porcupine Creek Meadow **Site Code** S.USCOHP*25731

LOCATORS

Nation United States **Latitude** 371503N

State Colorado **Longitude** 1065118W

Quad Code	Quad Name
37106-C7	Blackhead Peak
37106-B7	Harris Lake

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/22/2005

Version Author Freeman, K.M.

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Level 4 Potential Conservation Area (PCA) Report

Name Quartz Creek at East Fork San Juan River **Site Code** S.USCOHP*9485

IDENTIFIERS

Site ID 176 **Site Class** PCA

Site Alias East Fork Quartz Creek
Site Alias Quartz Creek Trail

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

Mineral (CO)

SITE DESCRIPTION

Site Description

In the extreme northeast corner of Archuleta County, the Continental Divide rises to elevations averaging 12,500 feet along ridgelines, and up to a high point in this county corner of 13,300 feet, at Summit Peak. Draining to the northwest just below Summit Peak in the South San Juan Wilderness are several intermittent streams and rivulets that converge at the base of a large, semi-circular subalpine and alpine basin to form the East Fork of Quartz Creek. Flowing northwest, the East Fork joins Quartz Creek one mile downstream, crosses the Wilderness boundary into the San Juan National Forest, and joins the East Fork of the San Juan River approximately 7 miles downstream. The East Fork of the San Juan River then turns ninety degrees to Quartz Creek and drains to the southwest through a broad, U-shaped, glaciated valley with a wide floodplain. The watersheds of East Fork of Quartz Creek, Quartz Creek, and the East Fork of the San Juan River support a variety of unique riparian and wetland communities, one rare breeding bird population, and at least one rare plant species along their lengths. At the upper end of the site, in the snowmelt basin just below Summit Peak, steep alpine talus and meadows fed by snowmelt support lush stands of subalpine mesic forbs, dominated by a heartleaf bittercress - tall fringed bluebells (*Cardamine cordifolia - Mertensia ciliata*) community. The meadows are productive and pristine with little degradation. Quartz Creek Trail, used by horse riders and hikers, crosses above this riparian area, which has led to some erosion of the hillside above the meadows. Cattle also graze in the area. As the tributary streams and Quartz Creek Trail continue downslope and enter treeline in the subalpine and montane zones, dense forests begin on the steep hillsides and are comprised of mature Engelmann spruce, Douglas-fir, and subalpine fir (*Picea engelmannii, Pseudotsuga menziesii,* and *Abies lasiocarpa*) forests with pockets of mature quaking aspen (*Populus tremuloides*). Within this forest, the trail crosses a very steep, open-tree-canopy rockfall chute or avalanche path where a perennial rivulet drops from a large rock face down to the East Fork of Quartz Creek. The drainage is heavily vegetated and is dominated by a planeleaf willow (*Salix planifolia*) / mesic forb community. Additional shrubs in the community include short-fruit willow, Wolf's currant and gooseberry currant (*Salix brachycarpa, Ribes wolfii* and *R. montigenum*). The dense herbaceous understory is dominated by arrowleaf ragwort and tall fringed bluebells, as well as fewflower meadow-rue, Reeves' bladderfern (*Thalictrum sparsiflorum, Cystopteris reevesiana*) and mosses. Continuing downstream, Quartz Creek Trail crosses the East Fork of Quartz Creek, and just downstream of the crossing a small area of rock cliffs occurs near a waterfall carrying the creek down the moderately steep ravine. Steller's cliff brake (*Cryptogramma stelleri*) was found growing in horizontal crevices in the rock, with mosses and mat saxifrage (*Cilaria austromontana*), kept moist by spray from the falls, or in one place by a seep in an alcove. The surrounding forest is Engelmann spruce and subalpine fir with an understory of whortleberry (*Vaccinium* spp.). Immediately downstream of this rock face, the dominant riparian community of narrowleaf cottonwood - blue spruce / thinleaf alder (*Populus angustifolia - Picea pungens / Alnus incana*) begins along the East Fork of Quartz Creek, and continues past the confluence with the main stem of Quartz Creek, a montane, sinuous, dynamic creek carrying a high load of cobble, sand and silt. The broad floodplain has numerous wide cobble and sand point bars, which along with the creek banks, are populated by high numbers of regenerating cottonwood, alder, and Drummond's willow (*Salix drummondiana*). Blue spruce encroaches into the riparian zone from the surrounding forests. The understory is comprised of a sparse canopy of mesic shrubs such as white-stem gooseberry (*Ribes inerme*) and shrubby cinquefoil (*Dasiphora floribunda*), except at the banks of the creek where the alder and willow cover is vigorous. The herbaceous understory is comprised mostly of native mesic forbs and graminoids such as mountain parsley, common cowparsnip, and bluejoint reedgrass (*Pseudocymopterus montanus, Heracleum maximum,* and *Calamagrostis canadensis*), with a low cover of exotic herbaceous species. At the lower end, the creek gradient steepens and enters a narrow canyon with steep, shale slopes before opening up into a one-half-mile wide valley where Quartz Creek joins the East Fork of the San Juan River. The valley narrows again some five miles downstream at the west end of the site. Through this broad valley the river is low gradient, shallow, and braided, with a cobble bottom. The riparian vegetation is composed of a mosaic of three vegetation types, including a continuation of the narrowleaf cottonwood-blue spruce/thinleaf alder community from Quartz Creek in the upper portion of the valley, a thinleaf alder - mixed willow shrublands (*Alnus incana* - mixed *Salix* species) and wet meadows of beaked sedge (*Carex utriculata*) in the lower half of the valley. Beavers (*Castor canadensis*) are found on the secondary channels and help to maintain the wetlands. Grassy-forb meadows, often weedy, dominate the terraces within the valley floor and the toe slopes of the valley hillsides. North-facing hillsides support old growth Douglas-fir forest with a moist forb dominated understory. Small natural ponds and wetlands within the forest provide excellent habitat for mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and possibly frogs and other amphibians. The south-facing slopes are dominated by aspen (*Populus tremuloides*), ponderosa pine (*Pinus ponderosa*), or Gambel oak (*Quercus gambelii*). Cattle grazing has been the dominant use of this site, although grazing is being eliminated by the current land manager within the valley. There are no ditches, dams, man-made ponds, or irrigated hay meadows at this site, an unusual event given the elevation and geomorphology of the river. North of the river at the west end, Waterfall Creek drops down a steep cliff face, creating Silver Falls, a popular hiking destination. These steep cliff faces along the waterfall provide good nesting habitat for a small population of Black Swifts. Through the majority of the site, a popular Forest Road parallels the river and Quartz Creek to the Quartz Creek Trailhead. Both the trail and the road are almost always 50 to 500 feet from the river or the creek. The road crosses the river a mile downstream of the site boundary, and both the road and the trail cross Quartz Creek.

Key Environmental Factors

Starting at the upper (east) end of the site, the geology of the upper snowmelt basin is mapped as Ash-Flow Tuff of Main Volcanic Sequence (Tertiary-Oligocene; Age in San Juan Mountains, 26-30 million years old) transitioning to Pre-Ash-Flow Andesitic Lavas, Breccias, Tuffs, and Conglomerates (Tertiary-Oligocene; General Age 30-35 million years old) along the East Fork of Quartz Creek as it flows through subalpine and upper montane ecosystems and steep and narrow canyons. As the East Fork of Quartz Creek joins the main stem, the valley broadens into Quartz Meadow, the gradient flattens, and the soil type shifts to Pictured Cliffs Sandstone and Lewis Shale (Late Cretaceous). One mile above the confluence of Quartz Creek with the East Fork of the San Juan River, the surface geology transitions briefly to Animas Formation (Late Cretaceous; Arkosic sandstone, shale, and conglomerate) in a steep, narrow canyon. Then near the confluence, the valley of the East Fork of the San Juan River broadens and flattens, and the surface geology becomes recently deposited (Pleistocene-aged) Gravels and Alluviums (Pinedale and Bull Lake Age). Outside the boundary the surrounding mountains and contributing watersheds are dominated by Pre-Ash-Flow Andesitic Lavas, Breccias, Tuffs, and Conglomerates (Tweto 1979). Regarding soil types, again starting at the upper end of the site, the soils in the snowmelt basin are mapped as Igneous outcrop-Cryorthents complex, with barren exposures of andesite and quartz latite bedrock (USDA 1981). Soil sampling within the heartleaf bittercress-tall fringed bluebells community determined that soils are shallow silt loam with roots; mostly, the substrate is rocky with angular and rounded cobble, gravel and sand deposits. Lower in the site at the planeleaf willow occurrence, soils are mapped as Igneous outcrop; with steep, barren exposures of andesite and quartz latite bedrock, and areas of granite and metamorphic rock (USDA 1981). Samples taken here showed that the soils are rocky with boulders, angular cobble/talus, and gravel deposits. Areas closer to the forest edge with better soil development have a thin, loamy upper horizon. Along Quartz Creek within the broad valley of Quartz Meadow, the soils are mapped as Pescar sandy loam, derived from alluvium of various sources, and Igneous outcrop-Cryorthents complex, barren exposures of andesite and quartz latite bedrock. Pockets of Grenadier Loam and Adel Loam occur within the larger matrix. Soil samples taken along the riparian community on Quartz Creek are alluvial and consist of large and small cobble with large sand deposits on point bars and creek banks. After exiting Quartz Meadow, the creek drops through a steep, narrow valley lined by shale Badlands, consisting of barren, exposed shale, then enters the upper end of the broad, flat East Fork of the San Juan River valley. As the creek gradient drops and it joins with the East Fork, they both drop their bedloads of sand, gravel and cobble, classified as Riverwash. As the East Fork of the San Juan River travels through this lowest 1/3 of the site, the main, braided riverbed remains Riverwash, with soils slightly higher in the floodplain mapped as Pescar sandy loam, with pockets of Hunchback clay loams and Histic Cryaquepts in marshy areas. The surrounding contributing watershed is made up of a patchwork of Adel loam, Grenadier loam, and Sambrito loam, all derived from a mixed source of alluvium and colluvium or from andesite and quartz latite. The steep hill toe slopes along the valley bottom are Typic Ustorthents, again mainly derived from andesite and quartz latite, with areas of bedrock outcrops (Igneous Outcrop-Cryorthents complex) such as near Silver Falls (USDA 1981).

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	8,020.00	**Feet**	2,444.50	**Meters**
Maximum Elevation	11,640.00	**Feet**	3,547.87	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 01/27/2006

Designer Freeman, K.M.

Boundary Justification

Surface water and ground water were two primary ecological processes considered when designing the site boundary. Both are critical to the alpine wetland in its upper extremity, as well as the rare plant occurrence, the rare bird occurrence, and five riparian or wetland communities occurring in the lower part of the site. The boundary begins by capturing the snowmelt basin and its drainage that is so important to maintaining the viability of the alpine wetland. The boundary then incorporates the immediate watershed of the large narrowleaf cottonwood riparian community on Quartz Creek and East Fork San Juan River, the immediate watershed for the alder-willow community and the beaked sedge community on the East Fork San Juan River, the avalanche path supporting the planeleaf willow community, the cliffs where groundwater seepage and waterfall spray supports the slender rock-brake, and at a separate location, the waterfall and cliffs that provide nesting habitat for the Black Swift. Although the continuation of the current hydrology is essential to the long-term survival of the rock-brake and the persistence of the Black Swift breeding population, the larger watershed for each of those sites was not included in the boundary. Overall, the boundary generally reflects a 500 foot buffer that will aid in preventing direct disturbance of the riparian and wetland communities and rare species, and encompasses trails, roads, and dispersed campsites where surface runoff may contribute nutrients and sediment, and where impacts may promote weed invasion. It should be noted that not all the hydrologic processes necessary to all the element occurrences are contained within the boundary. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area	2,323.10	**Acres**	940.13	**Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

This site supports seven elements tracked by CNHP. Driving the biodiversity rank, a good (B-ranked), 8.5-mile-long example of the globally vulnerable (G3/S3) narrowleaf cottonwood - blue spruce / thinleaf alder (*Populus angustifolia - Picea pungens / Alnus incana*) montane riparian forest occurs along Quartz Creek and the East Fork of the San Juan River. This mid-seral community is reliant on continued fluvial activity and bank overflow to perpetuate the cottonwood component, and is typically dense and diverse in the shrub and herbaceous layer (Carsey et al. 2003). The site also contains an excellent (A-ranked) occurrence of a plant community that is apparently secure (G4/S4) on a global scale. As of 2005, this is the best-known occurrence of the heartleaf bittercress-tall fringed bluebells (*Cardamine cordifolia - Mertensia ciliata*) alpine wetland type in Archuleta County. Near a popular waterfall north of the river, a good (B-ranked) nesting population of the globally apparently secure (G4) but state-vulnerable breeding population (S3B) of Black Swift (*Cypseloides niger*) occurs. This site also contains a good (B-ranked) occurrence of planeleaf willow (*Salix planifolia*) / mesic forbs shrubland, a globally apparently secure (G4/S4) community occurring in montane and subalpine swales with persistent saturation from snowmelt (Carsey et al. 2003). This is the only documented occurrence of this community in the county as of 2005, but because it is a common community type, there are likely other undocumented examples. Near the midpoint of the site, a good (B-ranked) occurrence of slender rock-brake exists. This fern is rare in Colorado (S2), although globally secure (G5). This species of fern has a broad distribution throughout the north half of North America, but, as of 2005, is known from only 19 locations in Colorado. Lastly, a good (B-ranked) occurrence of the globally secure (G5/S4) beaked sedge (*Carex utriculata*) herbaceous vegetation community occurs along the East Fork of the San Juan River in saturated floodplain soils.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
18795	*Carex utriculata* Wet Meadow	Beaked Sedge Montane Wet Meadows	G5	S5	N
24679	*Cardamine cordifolia - Mertensia ciliata - Senecio triangularis* Wet Meadow	Alpine Wetlands	G4	S4	N
22152	*Cryptogramma stelleri*	Slender rock-brake	G5	S2	N
40641	*Salix planifolia* / Mesic Forbs Wet Shrubland	Planeleaf Willow/Mesic Forbs	G4	S2	N
23518	*Cypseloides niger*	Black Swift	G4	S3B	N
24823	*Populus angustifolia - Picea pungens / Alnus incana* Riparian Woodland	Montane Riparian Forests	G3	S3	Y
24912	*Alnus incana - Salix (monticola, lucida, ligulifolia)* Wet Shrubland	Thinleaf Alder-Mixed Willow Species	G3	S3	N

LAND MANAGMENT ISSUES

Land Use Comments

The Forest Service and Wilderness areas are closed to motorized vehicles except on designated Forest Roads. Hiking, horse riding, hunting, fishing, camping and wildlife use are the dominant land uses in moderate seasons. Grazing occurs on the Forest Service portion of the site. The private land at the west end currently is not being grazed, but there is moderate recreational use in the area in summer. Portions of the East Fork of the San Juan River on the private inholding have undergone river restoration techniques beginning in 1986. This river restoration was done on the mile of river just below its confluence with Quartz Creek. The goal was to minimize channel braiding, minimize bank erosion, and to increase riparian vegetation along the channel (Rosgen 1996). It is not known whether subsequent restoration projects have been done since the initial project.

Natural Hazard Comments

No Data

Exotics Comments

In the upper reaches weedy species are uncommon; however, grazing and horse packing in the area threaten to introduce exotic species into the subalpine meadows. Weeds are again uncommon in the mid-reaches, but red clover (*Trifolium pratense*) occurs along Quartz Creek Trail. Kentucky bluegrass (*Poa pratensis*) and common dandelion (*Taraxacum officinale*) are the most common weeds in the herbaceous understory of the riparian zone along Quartz Creek. Other weeds have not yet invaded the community in large numbers, but the possibility exists since adjacent meadows are heavily grazed. Much of the riparian system along the East Fork of the San Juan River is in need of weed management. The private property owner is aware and concerned about the weeds.

Offsite

No Data

Information Needs

Lynx (*Lynx canadensis*) have been historically documented as recently as 1994. New surveys for this species as well as wolverine (*Gulo gulo*) and Peregrine Falcon (*Falco peregrinus*), both occurring in this area of the San Juan Mountains, would benefit by possibly providing additional motivation for protection of the area from potential development in the downstream reaches. Some river restoration has occurred on the upper portion of the East Fork of the San Juan River on private lands, and more may be planned for additional reaches. We recommend researching the historical geomorphology in order to understand if the current braided stream is natural.

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
166839	Lyon, P. 2001. Colorado Natural Heritage Program Field Surveys.
170844	Randolph, D., Smith, Kettler, Redders, Roy, and Aitken. 1994. San Juan National Forest Riparian Site Survey.
191383	Rosgen, D. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

Original site design by Kettler, S.M. 1997-06-10. Modified by Lyon, M.J. 2002-02-15. Portions of the East Fork of the San Juan River on the private inholding have undergone river restoration techniques beginning in 1986. This river restoration was done on the mile of river just below its confluence with Quartz Creek. The goal was to minimize channel braiding, minimize bank erosion, and to increase riparian vegetation along the channel (Rosgen 1996). It is not known whether subsequent restoration projects have been done since the initial project.

LOCATORS

Nation United States **Latitude** 372302N

State Colorado **Longitude** 1064504W

Quad Code	Quad Name
37106-C6	Summit Peak
37106-D6	Elwood Pass
37106-D7	Wolf Creek Pass
37106-C7	Blackhead Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 01/27/2006

Version Author Freeman, K.M.

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Level 4 Potential Conservation Area (PCA) Report

Name Rio Blanco at Deadman Canyon **Site Code** S.USCOHP*9480

IDENTIFIERS

Site ID 848 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The Rio Blanco at Deadman Canyon is located in central Archuleta County, twelve miles south of Pagosa Springs and two miles southeast of Serviceberry Mountain. The Rio Blanco is a mid-elevation river flowing in a one half mile wide valley with a broad floodplain and well-defined riparian zone. It is moderately sinuous within its floodplain, depositing cobble on bars within the river and sediment on higher ground, where dense stands of thinleaf alder (*Alnus incana*) and sandbar willow (*Salix exigua*) dominate the riverbanks and are regenerating well. The alder displays some branch dieback as seen in other parts in the county, but is not as widespread as in other county locations. At the upper (east) end of the site, Pacific willow (*Salix lucida* ssp. *lasiandra*) and strapleaf willow (*Salix ligulifolia*) both occur within thinleaf alder / mixed willow community, but in low percentages. On the terraces, the alder decreases and sandbar willow is dominant, with strapleaf willow, Woods' rose (*Rosa woodsii*), redosier dogwood (*Cornus sericea*) and sapling narrowleaf cottonwood (*Populus angustifolia*). The understory is fairly weedy in the higher areas with exotic forb and graminoid species, but a narrow fringe of native hydrophytic plants such as common spikerush (*Eleocharis palustris*) occurs in flat, depositional areas along the river's edge. Blanco River Campground, a popular and heavily used USFS campground, occurs at the downstream end of the documented thinleaf alder / mixed willow community, and human-induced impacts immediately surrounding the campground boundaries can be heavy. The middle stretch of the river, below Blanco River Campground, has relatively low impacts except by cattle grazing. No roads directly access the river here, and dense Douglas-fir (*Pseudotsuga menziesii*) and blue spruce (*Picea pungens*) forests between the road and the river restrict views and limit accessibility. Within this stretch, riparian vegetation is vigorous and regenerating and dominated by a mix of willow species and scattered blue spruce and narrowleaf cottonwood individuals in the floodplain. At the lower end of the site, the banks of the river are occupied by dense stands of alder, mixed willow species and patches of silver buffaloberry (*Shepherdia argentea*), with a somewhat sparse herbaceous understory of mesic forbs and graminoids such as starry false lily of the valley (*Maianthemum stellatum*), cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*), and creeping bentgrass (*Agrostis stolonifera*). Here another thinleaf alder / mixed willow community co-dominates with a Silver Buffaloberry shrubland community. There is a scattered, mature narrowleaf cottonwood component, especially near the downstream end of the occurrence. The forest on the surrounding hillsides consists of Douglas-fir and blue spruce on north-facing slopes, with a ponderosa pine (*Pinus ponderosa*) forest with a hay grass understory on warmer, higher, dryer aspects. The area sees moderately heavy recreational use, particularly fishing and camping. The hydrology of the river has been altered upstream by a large, regional irrigation diversion, and Highway 84 crosses the river several hundred yards downstream of the site.

Key Environmental Factors

The wide valley floor and old side channels allows the river to spread in the event of a flood. The riverbanks are generally low and well vegetated, though some portions of the steeper banks on the north side of the river are eroding, apparently from natural causes, not necessarily from grazing impacts. The soils and streambed substrate are porous and probably provide significant groundwater recharge. The habitat diversity is limited to narrow fringes of emergent habitat and the more dominant scrub-shrub woody riparian vegetation. The canopy cover is dense in the shrub layer, but the tree canopy is open or nonexistent, providing little shade to the river. This, along with a fairly broad and shallow river with few deep pools, detracts from quality fish habitat.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	7,100.00	**Feet**	2,164.08	**Meters**
Maximum Elevation	7,300.00	**Feet**	2,225.04	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/15/2005

Designer Freeman, K.M.

Boundary Justification

The boundary incorporates an area that will allow natural hydrological processes such as seasonal flooding, channel migration, and sediment deposition to continue, maintaining a viable population of the riparian shrubland along the Rio Blanco. However, it is unclear if the linear gravel mounds present alongside the river channel in its lower reach prevent natural flooding of the terrace. The adjacent steep slopes that would most likely impact the riparian shrubland if altered are also included. The boundary also provides a small buffer from nearby roads where surface runoff may contribute excess nutrients, pollutants, and sediment. Eliminating disturbance within this buffer would also aid in reducing impacts from sedimentation (Karr and Schlosser 1978), and assist in maintaining the integrity of the occurrence and its associated avian, macroinvertebrate and periphyton communities (Noel et al. 1986, Spackman and Hughes 1995).

Primary Area 393.77 **Acres** 159.35 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

This site supports a fair (C-ranked) occurrence of thinleaf alder - mixed willow (*Alnus incana - Salix* (*monticola, lucida, ligulifolia*)) shrubland, a plant community that is globally vulnerable (G3/S3). This community type is often associated with beaver ponds and grazing disturbances, and may indicate a shift in physical setting, such as from a steep narrow valley to a broader, gentler valley (Carsey et al. 2003). The site also supports a fair (C-ranked) occurrence of silver buffaloberry (*Shepherdia argentea*) foothills riparian shrubland, a globally vulnerable (G3G4) plant community that is extremely rare (S1) in Colorado. This mesic community typically occurs in mosaic with other riparian plant communities such as willows or cottonwoods, and often occurs along broad river floodplains that, in Colorado, are typically impacted by improper grazing practices and altered hydrology. As of 2005, this community type is known from only 11 locations in the state, and the majority of these are located in southwestern Colorado.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
17439	*Shepherdia argentea* Wet Shrubland	Foothills Riparian Shrubland	G3G4	S2	Y
24912	*Alnus incana - Salix (monticola, lucida, ligulifolia)* Wet Shrubland	Thinleaf Alder-Mixed Willow Species	G3	S3	Y
24912	*Alnus incana - Salix (monticola, lucida, ligulifolia)* Wet Shrubland	Thinleaf Alder-Mixed Willow Species	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

The site occurs on USFS land, and is surrounded by USFS land. Forest Road 656 parallels the river for 2.5 miles on the south side, but is not immediately adjacent to the river. This road dead-ends at the popular Blanco Campground upstream. Downstream of the campground, near the highway, dispersed camping occurs on the broad floodplain as evidenced by short access roads, fire rings and litter. Grazing also occurs within the site, contributing to streambank erosion and the spread of weeds.

Natural Hazard Comments

No Data

Exotics Comments

The herbaceous understory of the riparian zone contains some invasive species including Canada thistle (*Cirsium arvense*), American licorice (*Glycyrrhiza lepidota*), and smooth brome (*Bromus inermis*). However, the uplands adjacent to the riparian zone are dominated by weeds in the herbaceous layer, with patches of bare soil.

Offsite

A busy road, Highway 84 between Pagosa Springs and Chama, New Mexico, is located immediately downstream of the communities, and the river runs under a large bridge at the highway and enters private land. Upstream of the site on the Blanco River, there are large ranches, stock ponds, small diversions and a large irrigation diversion at the Blanco Dam, though no reservoir exists at this location. A large, lightning-caused fire burned in the watershed on the north side of the river on the Winter Hills in 2005. Impacts to the community are not noticeable at this time, but increased sediment loading to the river for several years would not be unexpected.

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
165959	Noel, D.S., C.W. Martin and C.A. Federer. 1986. Effects of Forest Clearcutting in New England on Stream Macroinvertebrates and Periphyton. Environmental Management 10: 661-670.
170844	Randolph, D., Smith, Kettler, Redders, Roy, and Aitken. 1994. San Juan National Forest Riparian Site Survey.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
159511	Spackman, S. C. and J. W. Hughes. 1995. Assessment of Minimum Stream Corridor Width for Biological Conservation: Species Richness and Distribution Along Mid-Order Streams in Vermont, USA. Biological Conservation 71:325-332.

ADDITIONAL TOPICS

Additional Topics

Original site design by Kettler, S.M. 1997-06-10.

LOCATORS

Nation United States **Latitude** 370844N

State Colorado **Longitude** 1065252W

Quad Code	Quad Name
37106-B8	Serviceberry Mountain
37106-B7	Harris Lake

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/15/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Sand Creek **Site Code** S.USCOHP*8443

IDENTIFIERS

Site ID 1693 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The Sand Creek site encompasses a montane riparian area along Sand Creek, a tributary of the East Fork of the San Juan River, in the northeast corner of Archuleta County. Sand Creek flows northwest through a moderately narrow canyon with steep slopes and over 400 feet in relief from rim to canyon bottom. The creek flows in a dynamic and active montane floodplain which carries a large cobble and gravel bedload. Narrowleaf cottonwood (*Populus angustifolia*) and sandbar willow (*Salix exigua*) are regenerating/pioneering on the cobble bars within the floodplain, and the secondary floodplain is lined by dense stands of mature thinleaf alder (*Alnus incana*), with pockets of mature cottonwoods and blue spruce (*Picea pungens*) providing an overstory. Various willows, including park willow, Drummond's willow and dewystem willow (*Salix monticola, S. drummondiana* and *S. irrorata*) also occur within the floodplain along the creek, and along with the alder provide a dense streamside canopy cover. The narrowleaf cottonwood / mixed willow community occurs in mosaic with a narrowleaf cottonwood - blue spruce / thinleaf alder community along the length of the occurrence. The herbaceous understory within the riparian zone is generally sparse, consisting of weedy species such as common dandelion (*Taraxacum officinale*), clover (*Trifolium* spp.) and various hay grasses, in addition to native mesic forbs and graminoids including bluejoint grass (*Calamagrostis canadensis*), field horsetail (*Equisetum arvense*) and Rocky Mountain willow herb (*Epilobium saximontanum*). This herbaceous layer is especially sparse close to the creek banks where the cobble is exposed with little soil development. Higher cobble terraces with better soil development occurring above the floodplain exhibit both upland and riparian herbaceous and woody species, with more dense herbaceous cover. The floodplain is broader at the lower end of the site near the confluence of Sand Creek/East Fork of San Juan River, and narrows as the elevation increases and the valley narrows. The lower end of the site is also near a major forest service road, and the area receives high recreational use including camping and horseback riding, but the riparian plant communities on Sand Creek at this location continue to be very productive and diverse. A trail follows the creek for a short distance from its confluence with the San Juan River at the forest service road before climbing onto the hill northeast of the creek. After two miles, the trail drops back down to the streamside and follows along the riparian area of Sand Creek. The recreational activity at the trailhead and along the trail could introduce new populations of non-native plants and increase erosion through reduction of vegetation cover and destabilization of the slope above the creek.

Key Environmental Factors

The creek morphology is intact, and fluvial processes are dynamic and active. There is evidence of lateral movement by the creek in the form of secondary/abandoned channels. The creek carries a high cobble and gravel bedload, depositing it near the confluence with the East Fork of the San Juan River where the topography flattens and the valley widens. Sandy sediment deposition is also apparent within the floodplain and on the first terrace, and supports sparse native vegetation as well as weedy species in the herbaceous understory. The creekbanks are well vegetated by woody species, but the herbaceous cover is sparse due to the cobbly substrate. This type of dynamic channel with high amounts of sediment deposition and movement is a key feature for both the narrowleaf cottonwood community types found within the site.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Level 4 Potential Conservation Area (PCA) Report

Name Sand Creek **Site Code** S.USCOHP*8443

Minimum Elevation	8,000.00	**Feet**	2,438.00	**Meters**
Maximum Elevation	8,840.00	**Feet**	2,694.00	**Meters**

SITE DESIGN

Site Map P - Partial **Mapped Date** 06/10/1997

Designer Kettler, S.M. and K.K. Fayette

Boundary Justification

The boundaries incorporate an area that will allow natural hydrological processes such as seasonal flooding, sediment deposition, and new channel formation to maintain viable populations of the riparian shrubland and forest along Sand Creek. It should be noted that the hydrological processes necessary to the riparian communities are not fully contained by the site boundaries. Given that the riparian communities are dependent on natural hydrological processes associated with Sand Creek and its tributaries, upstream activities such as water diversions, impoundments, improper livestock grazing, and development are detrimental to the hydrology of the riparian area. This boundary indicates the minimum area that should be considered for any conservation management plan. The boundary also includes an approximate 1,000 foot buffer to control sedimentation, protect the aquatic and plant communities from direct disturbance such as trampling (Karr and Schlosser 1978), and to allow additional individuals to become established over time.

Primary Area 892.67 **Acres** 361.25 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

This site contains a good (B-ranked) occurrence of the globally vulnerable (G3/S3) narrowleaf cottonwood / mixed willow (*Populus angustifolia / Salix* (*monticola, drummondiana, lucida*) woodland. This woodland association is known from Colorado, Utah and Nevada, and is found on active floodplains of dynamic stream and river systems where flooding is frequent and alluvial material is regularly being deposited. Barren moist sandbars provide an excellent environment for the germination of both cottonwood and willow seed, and with its dynamic nature, it is not uncommon to see a patchwork of stands of different age classes. The herbaceous understory is typically sparse. A good (B-ranked) occurrence of the globally vulnerable (G3/S3) narrowleaf cottonwood - blue spruce / thinleaf alder (*Populus angustifolia - Picea pungens / Alnus incana*) montane riparian forest also occurs within this site. This plant association is a common riparian woodland in Colorado. Stands have a mixed deciduous-evergreen tree canopy with narrowleaf cottonwood and blue spruce as co-dominants. Frequently, other conifer trees are present, but not as abundant as blue spruce. The shrub understory is typically dense and diverse, but thinleaf alder is always present.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24823	*Populus angustifolia - Picea pungens / Alnus incana* Riparian Woodland	Montane Riparian Forests	G3	S3	Y
24808	*Populus angustifolia / Salix (monticola, drummondiana, lucida)* Riparian Woodland	Narrowleaf Cottonwood/Mixed Willows Montane Riparian Forest	G3	S2	Y

LAND MANAGMENT ISSUES

Land Use Comments

The extreme downstream end of the site is impacted by heavy use at a popular Forest Road, trailhead, and campsite occurring adjacent to the downstream extent. Upstream, the creek is within the South San Juan Wilderness, and the only anthropogenic impacts are from the Quartz Ridge Trail (TR 570), which often runs uphill from the creek and as far away as 0.5 mile from the creek. The hydrology of Sand Creek is intact, and no logging occurs within the watershed due to Wilderness designation.

Natural Hazard Comments

No Data

Exotics Comments

The riparian understory has a sparse cover due to the cobbly substrate, but has a high percentage of weedy species such as common dandelion (*Taraxacum officinale*), clover (*Trifolium* spp.), and hay grasses such as orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*), and redtop (*Agrostis gigantea*).

Offsite

Hydrological processes originating outside of the planning boundary, including water quality, quantity, timing and flow must be managed to maintain site viability.

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
170844	Randolph, D., Smith, Kettler, Redders, Roy, and Aitken. 1994. San Juan National Forest Riparian Site Survey.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 372151N

Longitude 1064934W

Quad Code	Quad Name
37106-C7	Blackhead Peak
37106-D7	Wolf Creek Pass

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/15/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Sparks Creek **Site Code** S.USCOHP*25694

IDENTIFIERS

Site ID 2244 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

In the northeast corner of Archuleta County, Sparks Creek is a small, perennial creek with a moderate grade flowing westward off the flanks of Squaretop Mountain in a small, narrow and shallow draw. It eventually joins the Rito Blanco about one mile below the site. The creek sinuosity is good, and the creek has a narrow floodplain and is not incised. A narrow and mature blue spruce / thinleaf alder (*Picea pungens / Alnus incana*) riparian woodland dominates the immediate floodplain and this overstory provides even shade to most of the creek. Both mature and sapling alder and blue spruce occur throughout the community and are vigorous and healthy. The thinleaf alder (*Alnus incana*) are not displaying the extent of branch dieback seen in other parts of the county, although some dieback is occurring downstream of the occurrence. The understory is fairly open and comprised of mesic forbs such as common cow parsnip (*Heracleum maximum*) and cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*), graminoids such as fowl mannagrass (*Glyceria striata*) and bluejoint grass (*Calamagrostis canadensis*), and riparian shrubs such as twinberry honeysuckle (*Lonicera involucrata* var. *involucrata*) mixed with open areas of litter, fallen logs, and duff. Hydrophytic vegetation, including small stands of retrorse sedge (*Carex retrorsa*) and smallwing sedge (*Carex microptera*), occurs in flat, seepy areas, usually within the floodplain or near the creek. The surrounding forest and adjacent uplands have mature corkbark fir (*Abies lasiocarpa* var. *arizonica*), blue spruce (*Picea pungens*), Rocky Mountain maple (*Acer glabrum*), and quaking aspen (*Populus tremuloides*) growing on short, steep hillsides with a forb and graminoid understory. Few weeds were found in the understory, although the presence of hay grasses such as orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), and timothy (*Phleum pratense*) increases downstream. Weeds seem to be localized along forest roads and OHV trails, although oxeye daisy (*Leucanthemum vulgare*) and common dandelion (*Taraxacum officinale*) were seen in a few places near the creek as well. The site is within the San Juan National Forest, and the surrounding forest is mature with a few signs of long-past logging. The hydrologic regime is mostly intact except for twin culverts at the Forest Road 024 crossing, and culverts at two downstream OHV trail crossings. In the middle of the site an old jeep trail, which is signed prohibiting vehicular travel, crosses the bed of Sparks Creek without culverts just upstream from FR 024. There is no evidence of recent vehicular travel on this jeep trail. Trampling and soil disturbance by cattle occurs mostly above the culverts at any road or OHV crossings, otherwise grazing impacts to the creek are not frequent. However, a salt lick placed near the midpoint of the site concentrates the cattle on the allotment, and the creek in that location is heavily impacted by the cattle as evidenced by severely eroding banks, broken branches, pushed-over trees and shrubs, and denuded soils, especially within 200 feet of the salt lick and along the creek banks.

Key Environmental Factors

Field ecologists in 2005 found that retrorse sedge appears to occupy clayey soils on muddy shorelines or creek banks, and sometimes within shallow standing water roughly between 8,000 and 9,500 feet elevation. In this site, the soils in which the retrorse sedge was growing were determined to be silty clay loams, with a higher component of sandy soils within the creek bed.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation 8,400.00 **Feet** 2,560.32 **Meters**

Level 4 Potential Conservation Area (PCA) Report

Name Sparks Creek **Site Code** S.USCOHP*25694

Maximum Elevation 9,800.00 **Feet** 2,987.04 **Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 11/17/2005

Designer Freeman, K.M. and M.A. March

Boundary Justification

The boundary was drawn to include the known extent of the element occurrences and an additional area large enough to include the natural hydrologic flows, including surface and groundwater flows, which support the habitat for the element occurrences. The boundary represents the immediate watershed for the riparian system in which the elements occur, with a minimum 500-foot buffer. The boundary indicated is the minimum area that should be considered for any conservation management plan.

Primary Area 559.85 **Acres** 226.56 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The site is drawn for a fair (C-ranked) occurrence of the globally vulnerable (G3) and state vulnerable (S3) blue spruce / thinleaf alder (*Picea pungens / Alnus incana*) montane riparian forest plant community, which typically occurs in shady canyons and narrow valleys subject to infrequent flood events. A fair (C-ranked) occurrence of the globally secure (G5) but statewide critically imperiled (S1) retrorse sedge (*Carex retrorsa*) also occurs within the site.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24518	*Picea pungens / Alnus incana* Riparian Woodland	Montane Riparian Forests	G3	S3	Y
20504	*Carex retrorsa*	retrorse sedge	G5	S1	N

LAND MANAGMENT ISSUES

Land Use Comments

An old jeep track follows Sparks Creek above where the creek crosses FR 024. Signs on the track at its junction with FR 024 state that vehicular travel is prohibited, but no gates or other physical barriers prevent unauthorized use. Several active four-wheel drive or OHV trails criss-cross the slope below FR 024, and cross the creek in several places. These are most likely used most frequently during hunting season. Logging has occurred in the past on this part of the San Juan National Forest, and the tree stumps do not appear to be recent (at least 10 years old).

Natural Hazard Comments

No Data

Exotics Comments

Exotic or invasive plant species, notably oxeye daisy and common dandelion, are infrequent within this site and appear to be localized mostly near the Forest Road and OHV trails, as well as the area near the existing salt lick where cattle tend to congregate.

Offsite

A large privately owned parcel occurs 1,000 feet down slope of the site. Ocular reconnaissance from USFS lands and aerial photos (USDA 2002) indicate that it currently has a road that crosses Sparks Creek below the site, but otherwise the parcel appears undeveloped and utilized only for grazing. Sparks Creek's blue spruce / thinleaf alder riparian community is in much better shape than the same community on the adjacent Porcupine Creek drainage (to the south). Porcupine Creek is much more utilized by cattle and is more impacted, and the alder on that riparian system is exhibiting significant branch dieback.

Information Needs

A survey to determine the full extent of the population of retrorse sedge and the blue spruce/thinleaf alder community would be beneficial for management of the area.

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 371538N

Longitude 1065017W

Quad Code	Quad Name
37106-C7	Blackhead Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 11/17/2005

Version Author Freeman, K.M. and M.A. March

DISCLAIMER

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Level 4 Potential Conservation Area (PCA) Report

Name Spring Creek Lakes **Site Code** S.USCOHP*25715

IDENTIFIERS

Site ID 2253 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

In the southeast portion of Archuleta County one mile southwest of the prominent geologic landmark called V Rock, a short chain of small lakes occur on Spring Creek, a small perennial tributary to the Little Navajo River, and support a thinleaf alder - mixed willow riparian shrubland, and a smallwing sedge montane wetland. Immediately north of Spring Creek, a moderately sized, mature and regenerating Bebb willow (*Salix bebbiana*) - dominated shrubland occurs on a small, unnamed, intermittent tributary to Spring Creek. The site is within USFS land, and the northeast edge occurs within the South San Juan Wilderness. The entire site is on a moderately steep, south-facing hillside with a rough microtopography caused by its landslide origins. The slumpy, hummocky landform generally has some groundwater discharge and varied topography which holds pockets of moisture in a manner that can mimic human-created water retention berms, and can mislead an observer to believe there has been more berming across the hillside than has really occurred. These depressional areas as well as the creek drainages support mesic herbaceous and shrub vegetation. Along Spring Creek, a dense, vigorous alder - mixed willow community and a smallwing sedge community are associated with the stream channel, five small ponds, and other small depressional wetlands and stream backwaters. Pacific willow (*Salix lasiandra*), park willow (*Salix monticola*) and Bebb willow along with thinleaf alder all occur within the riparian zone, with beaked sedge (*Carex utriculata*) dominating the pond margins as well as the creek banks in the wettest, most saturated parts. On slightly higher ground, smallwing sedge and ebony sedge (*Carex ebenea*) dominate in broad stands, transitioning into vigorous and diverse native mesic forbs and the surrounding alder-mixed willow community. Canada thistle (*Cirsium arvense*), Kentucky bluegrass (*Poa pratensis*) and common dandelion (*Taraxacum officinale*) are common within and between the wetland complexes, but native mesic graminoids and forbs such as largeleaf avens (*Geum macrophyllum*) and bluebells (*Mertensia* sp.) dominate the herbaceous layer. The hillside on which Spring Creek flows is generally open with little overstory canopy cover away from the riparian corridor, except for a few tall, narrow quaking aspens (*Populus tremuloides*), which occur singly over the hillside among many old, fallen trees. It is unclear whether this is due to recent logging (no stumps observed) or a natural phenomenon. Above the second lowest pond on the creek, a mature spruce - fir (*Picea* spp. - *Abies* spp.) forest begins, and continues as a mature forest uphill from this point. North of Spring Creek, a small, unnamed, intermittent tributary to Spring Creek supports a Bebb willow shrubland. The willow stands are vigorous, and alternately open-canopy and dense along the ill-defined rivulets of the stream. The herbaceous understory is a mixture of upland and weedy species, such as Rocky Mountain iris (*Iris missouriensis*), Colorado false hellebore (*Veratrum tenuipetalum*), Arizona mule-ears (*Wyethia arizonica*), and a large component of roundleaf snowberry (*Symphoricarpos rotundifolius*). On the adjacent upland hillsides is a mix of mature quaking aspen stands, mature Gambel oak (*Quercus gambelii*) stands, and open-cover roundleaf snowberry and Woods' rose (*Rosa woodsii*) stands in a matrix with native and non-native grasses and other native forbs. The site is within a current grazing allotment and sees heavy cattle use and subsequent weeds and erosion. Within the Bebb willow shrubland, cattle may be contributing to the ill-defined nature of the stream flow through hoof compaction and water spreading. Some browse was noted on the riparian shrubs, but not at severe levels. An OHV/hiking trail travels up the hillside and passes the Bebb willow shrubland on its southeastern edge, and crosses the Spring Creek drainage at the midpoint of the alder - mixed willow community.

Key Environmental Factors

A large portion of the geology on the west slopes of the Chalk Mountains, including the area within the site, is mapped as Landslide Deposits (Tweto 1979), which includes areas of thick colluvial deposits. This geology seems to predispose the area to having a stepped or hummocky microtopography where the groundwater table often is intercepted, forming many small pocket lakes and ponds. Soils in the lower 1/2 of the site are mapped as Hunchback clay loam, formed in alluvium and colluvium of mixed parent materials, and Animas loam, formed in landslide material derived from quartz latite, andesite, and other volcanic rock, and occurring in swales and lower parts of hummocky areas. Soils in the upper 1/2 of the occurrence are mapped as Castelleia loams, formed from similar parent material as the Animas loam, and found also in hummocky landslide areas (USDA 1981). A soil pit taken within a *Carex* spp.-dominated pond margin shows soils saturated to the surface, with little to no organic matter in the top layer. Only one horizon was noted in the 36 cm-deep pit, of silty clay with 10-25% mottling, and roots found throughout.

Climate Description

No Data

Land Use History

Grazing and recreation are likely the only past land uses in the area, though some logging may have been done historically.

Cultural Features

No Data

Minimum Elevation	8,740.00	**Feet**	2,663.95	**Meters**
Maximum Elevation	9,540.00	**Feet**	2,907.79	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/13/2005

Designer Freeman, K.M.

Boundary Justification

The boundary incorporates an area that will allow natural hydrological processes to continue, such as seasonal flooding, sediment deposition, and groundwater discharge, maintaining a viable population of the wetland and riparian communities. The boundary also provides a small buffer from nearby trails where surface runoff may contribute excess nutrients and sediment. It should be noted that the hydrological processes necessary to the elements are not fully contained by the site boundaries. Given that the elements are dependent on natural hydrological processes associated with runoff from the Chalk Mountains, activities such as water diversions, impoundments, and improper livestock grazing within riparian areas and along the wetland are detrimental to the hydrology within the site. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 179.62 **Acres** 72.69 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site boundary is drawn for a good (B-ranked) occurrence of the globally vulnerable (G3/S3) thinleaf alder - mixed willow (*Alnus incana - Salix* (*monticola, lucida, ligulifolia*)) shrubland plant association. This community type is often associated with beaver ponds and grazing disturbances, and may indicate a shift in physical setting, such as from a steep narrow valley to a broader, gentler valley (Carsey et al. 2003). Also found within the site is a good (B-ranked) occurrence of the globally apparently secure (G4/S2?) smallwing sedge (*Carex microptera*) montane wetland, which commonly occurs in small patch size along streams and small ponds or marshes (Carsey et al. 2003). A fair (C-ranked) occurrence of the globally vulnerable (G3?/S2) Bebb willow (*Salix bebbiana*) montane willow carr follows a braided drainage just west of the other two occurrences.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24912	*Alnus incana - Salix (monticola, lucida, ligulifolia)* Wet Shrubland	Thinleaf Alder-Mixed Willow Species	G3	S3	Y
20994	*Salix bebbiana* Wet Shrubland	Montane Willow Carrs	G3?	S2	N
22744	*Carex microptera* Wet Meadow	Montane Wetland	G4	S1	N

LAND MANAGMENT ISSUES

Land Use Comments

Current land uses include heavy grazing, recreational access (hiking and horseback riding), and hunting.

Natural Hazard Comments

No Data

Exotics Comments

Canada thistle (*Cirsium arvense*), Kentucky bluegrass (*Poa pratensis*) and common dandelion (*Taraxacum officinale*) are common in the riparian and wet meadow zones of the wetland complex along Spring Creek, and in the uplands immediately adjacent. In the Bebb willow shrubland the herbaceous understory also exhibits the same species.

Offsite

Many downed trees occur in the area, especially aspen, but do not appear to be caused by logging activities. The Blanco Tunnel, a major US Bureau of Reclamation subterranean water diversion in the area, is mapped just outside the western boundary of the site but no surficial impacts to the area were noted. It was built in the late 1960's as part of the San Juan-Chama Project, to divert water from the San Juan River Basin across the Continental Divide and into the Rio Grande River Basin (USDI no date). V-Rock is a prominent landmark rising directly above the site. Also on the slope above and to the north of the site is an area of bare, light-colored exposed rock, which from a distance appears to be mined. However, evaluation of an aerial photo (USDA 2002) does not disclose any roads, trails, logging, or other disturbances in the area that may be present with a mining operation. It appears to be a natural outcrop.

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 370641N

State Colorado **Longitude** 1064825W

Quad Code	Quad Name
37106-A7	Chromo

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/13/2005

Level 4 Potential Conservation Area (PCA) Report

Name Spring Creek Lakes **Site Code** S.USCOHP*25715

Version Author Freeman, K.M.

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Level 4 Potential Conservation Area (PCA) Report

Name Tributary to Little Navajo River **Site Code** S.USCOHP*25732

IDENTIFIERS

Site ID 2255 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The Tributary to Little Navajo River site is in the southeastern portion of Archuleta County within the South San Juan Wilderness, lying approximately 2 miles northwest of Navajo Peak. The unnamed tributary drains generally west, turning southwest as it nears its confluence with the Little Navajo River. Navajo Trail, a popular hiking trail, crosses the stream in the lower 1/3 of the site. The headwaters of the stream originate a mile east of the trail on the steep, west-facing slopes of the Chalk Mountains, amidst upland upper montane and subalpine forests dominated by dense to patchy stands of spruce, fir and quaking aspen (*Picea* spp., *Abies* spp., *Pseudotsuga menziesii* and *Populus tremuloides*), and interspersed with open shrublands and meadows. The stream cuts through a cool, steep, narrow V-shaped ravine that eventually widens and flattens below the trail crossing, at the lower extent of a quaking aspen / thinleaf alder (*Populus tremuloides / Alnus incana*) montane riparian plant community. The ravine has a very narrow floodplain and the streambed contains small gravels and sand, with few if any larger rocks or larger woody material. The stream channel is sinuous within its limited floodplain, but the stream course is overall fairly straight. The riparian vegetation is generally vigorous and dense, even lush. The channel and immediate floodplain are dominated by a dense, tall cover of mature thinleaf alder with the adjacent terraces occupied by mature to decadent aspen forests, with little regeneration. The herbaceous layer of mesic forbs and graminoids is diverse and includes cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*), thimbleberry (*Rubacer parviflorus* ssp. *parviflorus*), Fendler's cowbane (*Oxypolis fendleri*), and Porter's licorice root (*Ligusticum porteri*). Adjacent uplands contain open shrublands dominated by roundleaf snowberry (*Symphoricarpos rotundifolius*), and grasslands with a high percentage of needlegrass (*Hesperostipa* sp.). Downstream of where Navajo Trail crosses the creek, a very small, open-water emergent wetland occurs, supporting bluejoint grass (*Calamagrostis canadensis*), beaked sedge (*Carex utriculata*), and a fringe of Canada thistle (*Cirsium arvense*) and cutleaf coneflower. Navajo Trail is popular with hikers and horseback riders, especially during hunting season. The general area is well grazed, with ample evidence of cattle. Near the trail crossing, the channel is shallow-banked and spread out slightly, possibly caused by grazing impacts. Many cattle trails exist within the aspen component of the community, and several cross the creek up and downstream of the hiking trail.

Key Environmental Factors

Mixed landslide materials from quartz latite and igneous rock overlying shale and sandstone comprise the parent material for the soils in the area (USDA 1981). The geology of the lower two-thirds of the site is mapped as Landslide Deposits, including talus, rock-glacier and colluvial depositions. The upper third (the headwaters in the Chalk Mountains) is mapped as Pre-Ash Flow Andesitic Lavas, Breccias, Tuffs and Conglomerates (General Age 30-35 million years old) (Tweto 1979). Soils in this area are mapped as Castelleia loams, with small inclusions of poorly drained Animas loam and Hunchback clay loam in depressions and swales (USDA 1981). Soil samples taken on the streambank had a 10 cm thick layer of detritus over 10 cm of loam, then over 35 cm of silt loam; all horizons are a dark 10YR2/2 Munsell color.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	9,290.00	**Feet**	2,831.59	**Meters**
Maximum Elevation	10,480.00	**Feet**	3,194.30	**Meters**

Level 4 Potential Conservation Area (PCA) Report

Name Tributary to Little Navajo River **Site Code** S.USCOHP*25732

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/19/2005

Designer Freeman, K.M.

Boundary Justification

The boundary encompasses the element occurrence and a 250 foot buffer to contain the immediate watershed and buffer the hydrologic processes (stream flow) necessary to the viability of the element. The boundary also provides a small buffer from nearby trails and grazing allotments where surface runoff may contribute excess nutrients, sediment and weed invasion. It should be noted that the hydrologic processes necessary to the element are not fully contained by the site boundary.

Primary Area 61.99 **Acres** 25.09 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site contains a good (B-ranked) occurrence of the globally vulnerable (G3/S3) quaking aspen / thinleaf alder (*Populus tremuloides / Alnus incana*) montane riparian forest. This community typically occurs on steep and narrow ravines where aspen intermix with riparian vegetation (Carsey et al. 2003). As of 2005, this is the only documented occurrence of this community type in Archuleta County.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24911	*Populus tremuloides / Alnus incana* Riparian Forest	Montane Riparian Forests	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

Dominant land uses in this area include recreation (hiking, horseback riding, wilderness camping), hunting, grazing, and wildlife use.

Natural Hazard Comments

No Data

Exotics Comments

Common dandelion (*Taraxacum officinale*) is found within the riparian area, and adjacent uplands harbor common weeds such as Canada thistle (*Cirsium arvense*), common dandelion, and hay grasses including Kentucky bluegrass (*Poa pratensis*). Canada thistle is especially common at the downstream edge of the site along the fringes of a small emergent wetland, just below the trail crossing.

Offsite

No Data

Information Needs

Some alder along the creek have branches of leaves that appear to be suffering from a disease that turns the leaves rusty before they die. This may be the same as what is causing the branch dieback seen on the alder all along the creek. Alder branch dieback is common across the county, and research into the branch dieback would benefit this species across the county. Monitor grazing impacts on the riparian system, progression of the alder dieback, and lack of regeneration within the aspen portion of the community.

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193553	USDA, NRCS. 2005. The PLANTS Database, Version 3.5 (http://plants.usda.gov). Data compiled from various sources by Mark W. Skinner. National Plant Data Center <http://npdc.usda.gov/>, Baton Rouge, LA 70874-4490 USA. Accessed 2005.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 370601N

Longitude 1064453W

Quad Code	Quad Name
37106-A7	Chromo
37106-A6	Chama Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/19/2005

Version Author Freeman, K.M.

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Level 4 Potential Conservation Area (PCA) Report

Name Tributary to Rito Blanco **Site Code** S.USCOHP*25695

IDENTIFIERS

Site ID 2245 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

In the northeast corner of Archuleta County, the Rito Blanco drains southwest from the Continental Divide to the San Juan River. Near the headwaters for Rito Blanco, on the northwest flank of Squaretop Mountain and between the Mariposa Creek and Sparks Creek drainages, a small, open, and northwest-facing wet meadow with a slight slope occurs within a mature and dense spruce, fir and quaking aspen (*Abies* spp. - *Picea* spp. - *Populus tremuloides*) forest. Two unnamed intermittent creeks converge at the top of the meadow and flow northwest to the Rito Blanco, passing through the meadow where several historic, nearly hidden 2 to 3-foot berms in disrepair step down the meadow. These berms, though broken, still retain some ponded water and allow soils to remain saturated, supporting sedges (*Carex* spp.) and other native and non-native mesic graminoids and mesic forbs. The vegetative structure in the clearing is mostly herbaceous, dominated by beaked sedge (*Carex utriculata*), retrorse sedge (*Carex retrorsa*), smallwing sedge (*Carex microptera*), mannagrass (*Glyceria* sp.), Colorado false hellebore (*Veratrum tenuipetalum*), bluebells (*Mertensia* sp.), Columbian monkshood (*Aconitum columbianum*), common cowparsnip (*Heracleum maximum*), checkerbloom (*Sidalcea* sp.), and cutleaf coneflower (*Rudbeckia laciniata* var. *ampla*). Sporadic, mature thinleaf alder (*Alnus incana*) stands create an open canopy overstory, mixed with a few scattered young spruce and fir saplings and mature trees. However, the alder in the meadow are experiencing significant branch dieback or decadence and are not in vigorous condition. Weeds and hay grasses are also common, and old stumps/snags, downed wood, and fallen logs are found frequently within the meadow. The retrorse sedge population is well distributed in the wet meadow complex and continues down the drainage, but it is unknown whether there are other populations on the same drainage upstream or further downstream. Subpopulations of retrorse sedge are split up based on hydrologic circumstances, but are connected within the overall soil/hydrology/topographical location.

Key Environmental Factors

In general terms, in Archuleta County, retrorse sedge (*Carex retrorsa*) occurs in slightly higher ground along perennially wet areas, especially preferring banks along small channels, small to mid-size depressional wetlands, open mudflats at pond edges, and surface-drying mud. Retrorse sedge is nearly always found with beaked sedge (*Carex utriculata*), but seems to occupy slightly higher ground or the mudflat niche that beaked sedge doesn't colonize as aggressively. Clusters of retrorse sedge are spread around the basin in small subpopulations depending on the hydrology. The hydrology on site is altered by the historic construction of berms stepping down the hill which creates a wetland mosaic of small, flowing channels, shallow ponded areas, and moist-to-saturated soils with no surface standing water. These berms are in disrepair and well-vegetated by native shrubs and herbaceous plants as well as colonized by weeds such as various species of thistle (*Cirsium* sp. and *Carduus* sp.). However, it is likely this population would not exist without the flow detention and subsequent soil saturation provided by the berms. The stands are vigorous but impacted by hoof disturbances due to heavy grazing in the area; fortunately, the cattle seem to prefer browsing on beaked sedge and other plants rather than the retrorse sedge. However, the cattle impacts are otherwise threatening the population by contributing to soil erosion, soil compaction, and disruption of the stream channels.

Climate Description

No Data

Land Use History

Logging has historically occurred within two miles of the site, but it is unknown whether the forest immediately surrounding the population has been logged. Livestock grazing is a historic and current use on this portion of the San Juan National Forest, and is the probable reason that detention berms were once constructed within the meadow, presumably to create watering areas for the cattle on the allotment. Recreational uses such as hunting and hiking are also historic as well as current land uses.

Cultural Features

No Data

Minimum Elevation	8,900.00	**Feet**	2,712.72	**Meters**
Maximum Elevation	9,680.00	**Feet**	2,950.46	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 11/04/2005

Designer Freeman, K.M.

Boundary Justification

The boundary was drawn to include the known extent of the occurrence of retrorse sedge (*Carex retrorsa*) and an additional area large enough to include the natural hydrologic flows, including surface and groundwater flows, which support the habitat for the species. The boundary represents the immediate watershed for the basin in which the species occurs, with a minimum 1,000 foot buffer except where the watershed boundary is closer to the occurrence than 1,000 feet. The intent of this buffer is to minimize sedimentation, protect the species population and associated wetland and riparian plant communities from direct disturbance such as trampling, and to allow additional individuals to become established over time. Given that this species is dependent on perennially wet or moist soils associated with the drainages within this small basin (Johnston 2001), upstream activities such as water diversions, impoundments, and improper livestock grazing are detrimental to the hydrology of the wetland area. The boundary indicated is the minimum area that should be considered for any conservation management plan.

Primary Area 220.41 **Acres** 89.20 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site is drawn for a good (B-ranked) occurrence of the globally secure (G5) but statewide critically imperiled (S1) retrorse sedge (*Carex retrorsa*). As of 2005, this site contains the largest known population of retrorse sedge at one site in Archuleta County.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
20504	*Carex retrorsa*	retrorse sedge	G5	S1	Y

LAND MANAGMENT ISSUES

Land Use Comments

The site is on USFS land that is open to OHV use; however, the main OHV road from FR 024 is essentially impassible for vehicles due to hillside erosion and large-diameter downed trees. OHV access is possible from the north, from the Mariposa Creek drainage. The closest forest road (FR 024) is 1/2 mile away. The area is used for hunting as evidenced by shell casings along the OHV trail and within the meadow, and past logging in the area is possible since it has occurred elsewhere along FR 024. Intensive cattle grazing on this allotment is the major threat to the rare plant population. It is estimated that these land uses may reduce the viability of the population if the area remains under the current level of management.

Natural Hazard Comments

No Data

Exotics Comments

Canada thistle (*Cirsium arvense*), a Colorado-prioritized and Archuleta County-listed noxious weed species (State of Colorado, no date), occurs frequently in dense patches on the top of the old berms within the wetland complex, and could easily expand its presence to other areas of the wetland. Eradication or control of this species would benefit the retrorse sedge (*Carex retrorsa*) population by reducing competition for resources and providing better opportunities for expanding colonization. Oxeye daisy (*Leucanthemum vulgare*), also a

Colorado-prioritized noxious weed species, and various haygrasses (*Poa pratensis, Phleum pratense, Bromus inermis*) are also present. Control of these species would benefit the population by again reducing competition for resources, but would be very difficult due to their widespread distribution and high percentage of canopy cover across the site.

Offsite

No Data

Information Needs

Since retrorse sedge (*Carex retrorsa*) is considered an S1 (critically imperiled) species in Colorado, further research is needed on the distribution and habitat needs for retrorse sedge in the state in order to develop specific and appropriate management plans for sites on private and U.S. Forest Service lands that support retrorse sedge populations.

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
193556	Johnston, B.C. 2001. Field guide to sedge species of the Rocky Mountain Region. Publication R2-RR-01-03. United States Department of Agriculture Forest Service, Denver, CO.
193472	Sovell, J., P. Lyon, and L. Grunau. 2003. Final Report: Upper San Juan Biological Assessment. Colorado Natural Heritage Program, Fort Collins, CO.
193555	State of Colorado, Department of Agriculture. No date. State Conservation Board Noxious Weed Program: Archuleta County. <<http://www.ag.state.co.us/CSD/Weeds/mapping/counties/Archuleta.html>> Accessed 7 Nov 2005.
193553	USDA, NRCS. 2005. The PLANTS Database, Version 3.5 (http://plants.usda.gov). Data compiled from various sources by Mark W. Skinner. National Plant Data Center <http://npdc.usda.gov/>, Baton Rouge, LA 70874-4490 USA. Accessed 2005.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 371609N

State Colorado **Longitude** 1065013W

Quad Code	Quad Name
37106-C7	Blackhead Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 11/04/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Turkey Creek at Snowball Creek **Site Code** S.USCOHP*25696

IDENTIFIERS

Site ID 2246 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Turkey Creek is located in the north central portion of Archuleta County north of Jackson Mountain. It flows generally southward from its headwaters in Hinsdale County to its confluence with the San Juan River, north of Pagosa Springs. Turkey Creek flows through a moderately narrow montane valley with steep side slopes dominated by montane spruce-fir forests comprised of blue spruce (*Picea pungens*), corkbark fir (*Abies lasiocarpa* var. *arizonica*) and white fir (*Abies concolor*). Within this very productive valley, Turkey Creek, groundwater discharges, and seeps from an ill-defined ditch diversion (Snowball Ditch) support a lush diversity of riparian vegetation and mossy areas with tall mesic forbs. On a step of a northeast-facing side slope above Turkey Creek, retrorse sedge (*Carex retrorsa*) occupies the moist fringes of a depressional wetland. The wetland is groundwater and surface water fed, and overflow drains down slope into Turkey Creek. The pond displays a diverse vegetation structure; riparian shrub communities dominated by thinleaf alder (*Alnus incana*), red-osier dogwood (*Cornus sericea*), Rocky Mountain maple (*Acer glabrum*), park willow (*Salix monticola*) and tall mesic forbs occupy the south (north-facing) and west shorelines, which are steep and rocky. The more gently sloping shorelines of the wetland are dominated by retrorse sedge and meadow sedge (*Carex praticola*), with more saturated areas dominated by northern water plantain (*Alisma triviale*) and beaked sedge (*Carex utriculata*). Most of the pond is open, deeper water, while emergent vegetation including common spikerush (*Eleocharis palustris*) and narrowleaf bur-reed (*Sparganium angustifolium*) occur in shallow standing water near the shoreline. Soil on the shoreline is silty clay loam. Impacts due to recreation include dispersed campsites, fishing trails, and associated soil compaction and erosion, and some weed invasion by pasture grasses. Most impacts occur near the streambanks, and there are few direct impacts upslope at the wetland, which supports the element occurrence.

Key Environmental Factors

Field ecologists in 2005 found that retrorse sedge (*Carex retrorsa*) occupies clayey soils on muddy shorelines, and sometimes within shallow standing water, of depressional wetlands roughly between 8,000 and 9,500 feet elevation. Soils at the wetland shoreline display a single horizon (42 cm+) of silty clay loam with wood pieces and few roots. Water collected at 20 cm depth in the soil pit and soil was saturated to the surface.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	7,840.00	**Feet**	2,389.63	**Meters**
Maximum Elevation	8,280.00	**Feet**	2,523.74	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 10/05/2005

Designer March, M.A.

Boundary Justification

The boundary is drawn to encompass the ecological processes necessary for the viability of the element occurrence; specifically the immediate watershed and the groundwater and surface water flows that support the element occurrence. The boundary also identifies a buffer around the trails and dispersed campsites where surface runoff may contribute nutrients and sediment, and where impacts may promote weed invasion.

Level 4 Potential Conservation Area (PCA) Report

Name Turkey Creek at Snowball Creek **Site Code** S.USCOHP*25696

It should be noted that not all the hydrologic processes necessary to the element occurrences are contained within the boundary.

Primary Area 356.46 **Acres** 144.26 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The site supports a good (B-ranked) example of the demonstrably globally secure (G5) and state critically imperiled (S1) retrorse sedge (*Carex retrorsa*). Retrorse sedge has a broad distribution throughout the north half of North America, but, as of 2005, is known only in Colorado from several locations in Archuleta County.

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
20504	*Carex retrorsa*	retrorse sedge	G5	S1	Y

LAND MANAGMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Weed invasion appears to be localized near trails. Referring to such resources as the Nature Conservancy's web site on invasive species (http://tncweeds.ucdavis.edu/index.htm) or http://www.invasivespecies.gov/ may provide some assistance with control and eradication of non-native species.

Offsite

No Data

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 372302N

State Colorado **Longitude** 1065754W

Quad Code	Quad Name
37106-C8	Jackson Mountain
37106-D8	Saddle Mountain

Watershed Code	**Watershed Name**
14080101	Upper San Juan

VERSION

Version Date 10/05/2005

Version Author March, M.A.

DISCLAIMER

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Level 4 Potential Conservation Area (PCA) Report

Name Upper Coyote Creek **Site Code** S.USCOHP*25697

IDENTIFIERS

Site ID 2247 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

Coyote Creek site is located in the southeast portion of Archuleta County, in the San Juan National Forest, draining west-southwest from below V-Rock until it joins with Spence Creek and turns south, joining the Navajo River many miles downstream. Coyote Creek flows through a narrow, montane channel with a moderate gradient, little sinuosity, and many pools caused by downed wood, rocks and gradient changes. The rough land surface is caused in part by the surface geology in the area, which is dominated by landslide deposits (Tweto 1979) visible in the slumping hillsides. The creek passes through a culvert where it crosses FR 663. Grazing is heavy in the area, and impacts noted include cow trails, hoof shearing and bank erosion in areas where cattle water or cross the creek. Tall thinleaf alder (*Alnus incana*) dominates the stream channel, with a lush diversity of mesic forbs in the understory. Examples of the native composition within the herbaceous component include beaked sedge (*Carex utriculata*), tall mannagrass (*Glyceria elata*), smallwing sedge (*Carex microptera*), largeleaf avens (*Geum macrophyllum*), Fendler's cowbane (*Oxypolis fendleri*), common cowparsnip (*Heracleum maximum*), Fendler's waterleaf (*Hydrophyllum fendleri*) and several others. Weedy species include common dandelion (*Taraxacum officinale*) within the riparian area and pasture grasses such as Kentucky bluegrass (*Poa pratensis*) on adjacent uplands. Surrounding uplands consist of spruce - fir (*Picea* spp. - *Abies* spp.) forests on north-facing slopes and quaking aspen / snowberry (*Populus tremuloides / Symphoricarpos rotundifolius*) forests on the south-facing slopes. In open meadows there are stands of Colorado false hellebore (*Veratrum tenuipetalum*).

Key Environmental Factors

Soils in the riparian area are alluvial with angular cobble and silty clay, silty loam, and sandy deposits. Soils are mapped as Hunchback clay loams, which occur on fans and toe slopes and are derived from fine textured alluvium and colluvium from mixed rock sources (USDA 1981).

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	8,560.00	**Feet**	2,609.09	**Meters**
Maximum Elevation	9,800.00	**Feet**	2,987.04	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 10/05/2005

Designer March, M.A.

Boundary Justification

The boundary is drawn to encompass the element occurrence and areas that are identified as a buffer that reflect the ecological processes supporting the wetland, including the immediate watershed, surface runoff, and groundwater discharge. The boundary also identifies an area that can provide a buffer from nearby trails, roads and open range where surface runoff may contribute excess nutrients, sediment and weed invasion. It should be noted that the hydrologic processes necessary to the element are not fully contained by the site boundaries.

Primary Area 183.03 **Acres** 74.07 **Hectares**

Level 4 Potential Conservation Area (PCA) Report

Name Upper Coyote Creek **Site Code** S.USCOHP*25697

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The site supports the globally vulnerable (G3/S3) thinleaf alder (*Alnus incana*) / mesic forbs riparian shrubland plant association in fair (C-ranked) condition. This plant association is characterized by a tall riparian shrub component with fewer shorter shrubs and a lush diversity of mesic forbs and wetland graminoids (Carsey et al. 2003). Upper Coyote Creek site displays a classic example of the association. Alder is typically considered an early-seral species where it is one of the first to establish on fluvial or glacial deposits (Carsey et al. 2003).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24645	*Alnus incana* / Mesic Forbs Wet Shrubland	Thinleaf Alder/Mesic Forb Riparian Shrubland	G3	S3	Y

LAND MANAGMENT ISSUES

Land Use Comments

Grazing is currently the dominant land use in the site. Recreation occurs in the general vicinity and includes hiking, camping, OHV use, hunting, and horse use. Other impacts include erosion and sediment loading from the road crossing and the culvert.

Natural Hazard Comments

California nettle (*Urtica dioica* ssp. *gracilis*), a stinging nettle, is common along the stream. Uplands surrounding the site have patches of bare soil with anthills and hornet nests.

Exotics Comments

Currently the community is vigorous with a few weeds noted in the herbaceous understory, including Kentucky bluegrass (*Poa pratensis*) and common dandelion (*Taraxacum officinale*). Canada thistle (*Cirsium arvense*) was noted on adjacent hill slopes in past surveys (Randolph et al. 1994).

Offsite

A private 160-acre parcel, entirely surrounded by USFS lands, is located just north of the west edge of the site. A dirt road leading to the private parcel crosses Coyote Creek and the site at its lower end, and several buildings are clustered in the corner of the parcel closest to the boundary (USDA 2002).

Information Needs

No Data

REFERENCES

Level 4 Potential Conservation Area (PCA) Report

Name Upper Coyote Creek **Site Code** S.USCOHP*25697

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
193582	Leonard, S., G. Kinch, V. Elsbernd, M. Borman, S. Swanson. 1997. Riparian Area Management: Grazing Management for Riparian-Wetland Areas. Technical Reference 1737-14. U.S. Department of Interior, Bureau of Land Management, National Applied Resource Sciences Center, Denver, CO.
170844	Randolph, D., Smith, Kettler, Redders, Roy, and Aitken. 1994. San Juan National Forest Riparian Site Survey.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193554	USDA, NRCS. 2002. Orthophoto Mosaic for Archuleta County, CO. USDA-NRCS, National Cartography and Geospatial Center, Geospatial Data Branch, Fort Worth, TX.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.
193558	USDI, Bureau of Reclamation. No date. Dams, Projects and Powerplants: San Juan-Chama Project, Colorado and New Mexico. <<http://www.usbr.gov/dataweb/html/sjuanchama.html#general>>. Accessed 18 Nov 2005.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 370701N

Longitude 1064847W

Quad Code	Quad Name
37106-A7	Chromo

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 10/05/2005

Version Author March, M.A.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Upper Rito Blanco **Site Code** S.USCOHP*25733

IDENTIFIERS

Site ID 2256 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Archuleta (CO)

SITE DESCRIPTION

Site Description

The Rito Blanco, a montane river in northeast Archuleta County, originates below Blackhead Peak (12,500'), Nipple Mountain (12,060') and Sand Mountain (12,410') on the west side of the Continental Divide, and flows down a steep, V-shaped valley before joining with the Rio Blanco 20 miles downstream. The river flows as a riffle-pool complex, but the steep tributaries consist of more step-pool complexes. The riverbed typically consists of large, rounded cobbles and gravel, but pockets of shale bedrock along its length contribute additional angular bedload material. Steep, narrow topography along the river and its tributaries limits human and cattle access to the river so the riparian forest is fairly pristine. Mature subalpine fir - Engelmann spruce (*Abies lasiocarpa - Picea engelmannii*) forests occurs on the valley slopes with stands of quaking aspen (*Populus tremuloides*) on higher slopes, and narrowleaf cottonwood (*Populus angustifolia*) occurring along the floodplain, increasing in frequency as the river drops in elevation. Riparian areas in the floodplain and adjacent to the river and its tributaries typically are lush and dense with riparian shrubs and a high diversity of mesic forbs. Mature and large thinleaf alder (*Alnus incana*) and Drummond's willow (*Salix drummondiana*) co-dominate the shrub layer along the river. The understory is comprised of dense mesic forbs such as bluebells (*Mertensia franciscana* and *M. ciliata*), arrowleaf ragwort (*Senecio triangularis*), Sierra corydalis (*Corydalis caseana* ssp. *brandegeei*), brook saxifrage (*Saxifraga odontoloma*), Carolina tassel-rue (*Trautvetteria caroliniensis*), bluejoint grass (*Calamagrostis canadensis*) and very few weeds. Riverbanks are well vegetated in the lower reaches of Rito Blanco, and more sparsely vegetated in the steeper parts of the drainage higher in the watershed. Forest Road 665 generally follows the occurrence, but is typically far uphill from the occurrence due to the steep topography. It crosses several of the tributaries to the Rito Blanco with culverts and several stretches of riparian forest that reach up the tributaries, but the riparian community occurs with vigor both above and below these crossings. Forest Road 735 crosses the Rito Blanco at one point within the occurrence, with a flat concrete road crossing/flow-over, but the community is still vigorous to the edges of the concrete. Songbirds and insects including many types of moths and flies are very common in the riparian community and game trails occur throughout the riparian forest. A good population of Sierra corydalis (*Corydalis caseana* ssp. *brandegeei*), a CNHP watchlisted species, occurs in the upper reaches of the Rito Blanco, especially at the easternmost reach of the site, on a side tributary above and below the Forest Road at about 10,000 feet.

Key Environmental Factors

The majority of the occurrence is mapped on the geologic formation Pre-Ash-Flow Andesitic Lavas, Breccias, Tuffs and Conglomerates (General Age 30-35 million years old). The lowest 0.4 mile on the main stem of the Rito Blanco below Mariposa Creek is mapped as Eocene Prevolcanic Sedimentary Rocks, including mudstones, sandstones and conglomerates (Tweto 1979). Soils within the community are mapped (from the upstream extent downward) as Grenadier loams and Castelleia loam. Small pockets of Igneous outcrop-Cryorthents complex and Muggins cobbly loam occur on several tributaries (USDA 1981). Soils within the riparian zone are alluvial with a thin layer of forest duff on the terraces. Shaley-gravel deposits occur along the length of the community.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Level 4 Potential Conservation Area (PCA) Report

Name Upper Rito Blanco **Site Code** S.USCOHP*25733

Minimum Elevation	8,520.00	**Feet**	2,596.90	**Meters**
Maximum Elevation	10,120.00	**Feet**	3,084.58	**Meters**

SITE DESIGN

Site Map Y - Yes **Mapped Date** 12/21/2005

Designer Freeman, K.M.

Boundary Justification

The boundary encompasses the element occurrence and the immediate watershed for the drainages that support the occurrence. The adjacent steep slopes that would most likely impact the riparian forest if altered are also included. Given that the riparian forest is dependent on natural hydrological processes associated with Rito Blanco and its tributaries, upstream activities such as logging, water diversions, impoundments, and improper livestock grazing are detrimental to the hydrology of the riparian area. The boundary also includes an approximate 500 foot buffer, which includes nearby roads, trails, and grazing allotments where surface runoff may contribute excess nutrients, sediment (Karr and Schlosser 1978), and weed invasion. It should be noted that the hydrological processes necessary to the riparian forest are not fully contained by the site boundaries. This boundary indicates the minimum area that should be considered for any conservation management plan.

Primary Area 864.54 **Acres** 349.87 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The site supports a large example of a good (B-ranked) occurrence of the globally secure (G5/S5) subalpine fir / thinleaf alder (*Abies lasiocarpa / Alnus incana*) montane riparian forest plant association. This plant community may be a late-seral association, representing a slow succession from a deciduous-dominated to coniferous-dominated riparian zone along drainages with infrequent disturbances such as flooding. The dominant understory shrub, thinleaf alder, typically co-dominates with Drummond's willow (*Salix drummondiana*), with the willow becoming more dominant at higher elevations and alder more dominant at lower elevations (Carsey et al. 2003).

Other Values Rank No Data

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24684	*Abies lasiocarpa - Picea engelmannii / Alnus incana* Swamp Forest	Montane Riparian Forests	G5	S5	Y

LAND MANAGMENT ISSUES

Land Use Comments

Forest Road 665 (Nipple Mountain Road) parallels Rito Blanco, crossing tributaries to Rito Blanco and portions of the element occurrence along its length, but often remaining uphill of the occurrence by 60 to 80 vertical feet. Forest Road 735 crosses Rito Blanco via a concrete road crossing/flow-over, to access Mariposa Creek, and also crosses the element occurrence on Mariposa Creek via culverts. The road is closed by locked gate before it reaches the Mariposa Creek crossing. Recreation in the area is dominated by hiking and hunting, though horse use is probable also. The area is closed to OHV use, but open to snowmobile use in the winter. Grazing, though not witnessed during the site visit, is probable and expected. The steep terrain limits extensive recreational use and probably limits utilization by cattle in some areas.

Natural Hazard Comments

No Data

Exotics Comments

This is a large, vigorous, and fairly pristine community protected from many impacts by steep topography. Few or no weeds occur in the understory of the riparian community.

Offsite

No Data

Level 4 Potential Conservation Area (PCA) Report

Name Upper Rito Blanco **Site Code** S.USCOHP*25733

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
160903	Carsey, K., D. Cooper, K. Decker, D. Culver, and G. Kittel. 2003. Statewide wetlands classification and characterization: Wetland plant associations of Colorado. Prepared for Colorado Department of Natural Resources, Denver, CO by Colorado Natural Heritage Program, Fort Collins, CO.
193633	Freeman, K.M., March, M.A. and D.R. Culver. 2006. Final Report: Survey of Critical Wetlands and Riparian Areas in Archuleta County. Colorado Natural Heritage Program, Fort Collins, CO.
172808	J. R. Karr and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.
192747	Tweto, O. 1979. Geologic Map of Colorado, 1:500,000. United States Geological Survey, Department of Interior, and Geologic Survey of Colorado, Denver, CO.
193553	USDA, NRCS. 2005. The PLANTS Database, Version 3.5 (http://plants.usda.gov). Data compiled from various sources by Mark W. Skinner. National Plant Data Center <http://npdc.usda.gov/>, Baton Rouge, LA 70874-4490 USA. Accessed 2005.
193423	USDA, SCS. 1981. Soil Survey of Piedra Area, Colorado; Parts of Archuleta, Hinsdale, La Plata, Mineral, and Rio Grande Counties. In cooperation with the United States Forest Service and the Colorado Agricultural Experiment Station.
172684	Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope, Third Edition. University Press of Colorado, Niwot, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States

State Colorado

Latitude 371715N

Longitude 1064926W

Quad Code	Quad Name
37106-C7	Blackhead Peak

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 12/21/2005

Version Author Freeman, K.M.

DISCLAIMER

Level 4 Potential Conservation Area (PCA) Report

Name Wolf Creek **Site Code** S.USCOHP*9502

IDENTIFIERS

Site ID 642 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

County

Mineral (CO)

SITE DESCRIPTION

Site Description

Floodplain in a broad opening and narrow upper canyon near Campground. The Wolf Creek site includes Wolf Creek and the upper slopes that support the rare plants of the site. The riparian area near Wolf Creek Campground is comprised of a Douglas-fir/narrowleaf cottonwood-white fir (*Pseudotsuga menziesii*/*Populus angustifolia-Abies concolor*) community. The community overstory is very diverse with numerous species of trees and shrubs. Age class is diverse with very large individuals of narrowleaf cottonwood and white fir. Upland communities are also diverse. Lower slopes are composed of blue spruce/white fir (*Picea pungens*/*Abies concolor*) with Douglas-fir. Southwestern white pine (*Pinus strobiformis*) is subdominant. Upslope is subalpine fir/Engelmann spruce (*Abies lasiocarpa*/*Picea engelmannii*). The valley receives high precipitation creating a very lush and productive landscape. Grazing occurs in the valley below but does not appear to affect this community.

Key Environmental Factors

No Data

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

Minimum Elevation	7,800.00	**Feet**	2,377.00	**Meters**
Maximum Elevation	9,000.00	**Feet**	2,743.00	**Meters**

SITE DESIGN

Site Map P - Partial **Mapped Date** 06/10/1997

Designer Kettler, S.M.

Boundary Justification

The boundary encompasses the occurrence and an approximate 1000 ft. buffer. This boundary should protect the occurrence from direct disturbance and is thought to protect the avian, macroinvertebrate and periphyton communities and limit impacts from sedimentation (See Noel et al. 1986, Spackman and Hughes 1995, Karr and Schlosser 1978). The boundary encompasses the occurrences and an approximate 1000 foot buffer. This site was not visited by CNHP in 1998.

Primary Area 260.62 **Acres** 105.47 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The Wolf Creek site contains a good (B-ranked) occurrence of the globally vulnerable riparian plant community comprised of narrowleaf cottonwood - Douglas-fir (*Populus angustifolia - Pseudotsuga menziesii*) and a fair (C-ranked) occurrence of the globally imperiled (G2/S2) *Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum* forest.

Other Values Rank No Data

Level 4 Potential Conservation Area (PCA) Report

Name Wolf Creek **Site Code** S.USCOHP*9502

Other Values Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24810	*Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum* Forest	Montane Riparian Forests	G2	S2	Y
18905	*Oenothera kleinii*	Wolf Creek evening primrose	GUGHQ	SX	N
24692	*Populus angustifolia - Pseudotsuga menziesii* Riparian Woodland	Montane Riparian Forest	G3	S2	Y

LAND MANAGMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

No Data

Offsite

Hydrological processes originating outside of the planning boundary, including water quality, quantity, timing and flow must be managed to maintain site viability.

Information Needs

No Data

REFERENCES

Reference ID	Full Citation
-	No Data

ADDITIONAL TOPICS

Additional Topics

No Data

LOCATORS

Nation United States **Latitude** 372650N

State Colorado **Longitude** 1065313W

Quad Code	Quad Name
37106-D8	Saddle Mountain

Watershed Code	Watershed Name
14080101	Upper San Juan

VERSION

Version Date 06/10/1997

Version Author Kettler, S.M.

DISCLAIMER

APPENDIX E: 2D AQUATIC HABITAT ASSESSMENT

2-Dimensional Aquatic Habitat Evaluation

1 Introduction

Aquatic habitat quality and availability within a stream network is by temporally variable hydrological and hydraulic conditions within channels. Various aquatic species/life-stages exhibit preferences for certain habitat types, as described by several hydraulic characteristics (e.g., water depth and velocity in riffles). Where optimal conditions exist, aquatic biota can utilize local habitat for feeding, reproducing, etc. Localized changes in streamflow (in timing, magnitude, and frequency) impact channel hydraulics. Suboptimal hydraulic conditions not only preclude use of local habitat but may present a significant barrier to passage that limits utilization of some upstream or downstream portion(s) of the stream network.

Several methodologies exist for assessing local hydraulic conditions against the preferred conditions for various aquatic species. These methodologies include R2Cross, PHABSIM, RHABSIM, the wetted-perimeter method, the Tennant method, and others. Colorado Water Conservation Board and Colorado Parks and Wildlife rely extensively on the R2Cross methodology[1] to describe minimum flow needs for assemblages of fish as support for development of Instream Flow (ISF) water rights on rivers across Colorado. ISF water rights are established on some tributaries in the planning area. The R2Cross methodology uses quickly obtainable hydraulic geometry data and assumes that streamflows sufficient to maintain aquatic habitat in critical riffle segments will also maintain habitat quality in other channel segments such as runs and pools. More nuanced characterizations of the relationship between habitat quality and streamflow can be developed through application of more complex, 2-dimensionaly hydraulic habitat modeling methods.

2 Methods

Two dimensional models of channel hydraulics and fish habitat quality were developed on the mainstem San Juan River in downtown Pagosa Springs and below the San Juan's confluence with Fourmile Creek. Each reach included pools, runs and riffles in proportions typical to the geomorphological characteristics of the larger segments they were situated in. These reaches were selected due to their location and the transition point between the warm water and cold-water fisher, ease of access, and popularity among anglers. Modelling evaluated adult trout habitat suitability; juvenile trout are not accounted for and their habitat needs vary greatly from those of adults. Typically, the best suitability for juveniles of many species is found in shallower waters and river margins, side channels, and backwaters.

Ground and water surface elevation surveys on each reach were completed using GPS-grade survey equipment. Additional survey points were collected along road surfaces and other recognizable hard surfaces using survey grade GPS equipment. These points were used to adjust the vertical datum of the local survey so that it could be spliced into LiDAR coverages for Archuleta County. Detailed bathymetric survey data was collected throughout each reach using CHIRP sonar devices and RTK survey antennas mounted to a floating platform. Bathymetric data were collected using multiple longitudinal passes, zig-zag patterns, and cross-sections, providing a high density of survey points. Surveyed depths were interpolated onto a ~1-meter curvilinear grid for both sites. These interpolated surfaces provided a digital representation of bathymetric and floodplain geometry for each reach.

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[1] D. Espegren, "Development of Instream Flow Recommendations in Colorado Using R2Cross.," Colorado Water Conservation Board., Jan. 1996.

Comprehensive flow characterization required simulations with both one- and two-dimensional modeling tools and high-resolution topographic data for each representative reach to predict flow depth, flow velocity and flow extent. The topographic surfaces were used to create two-dimensional hydraulic models using the FASTMECH[2] numerical code. FASTMECH is a quasi-steady two-dimensional river flow and morpho-dynamics modeling platform useful for long river reaches where high grid resolution is required for estimating water surface elevations and velocities. The solver was developed with quasi-steady approximation, but unsteady variables are ignored in the motion equations. Spatially detailed calculations are performed to gain an estimate of depth and velocity variations within the flow system.

The FASTMECH models for each reach were calibrated 1-dimensional HEC-RAS[3] models, developed separately from local channel cross-section data. HEC-RAS, is designed to perform steady gradually varied flow water surface profile computations. The computations are based on the one-dimensional energy equation. Energy losses are evaluated by friction with the Manning's equation and contraction/expansion (a coefficient multiplied by the change in velocity head).

Drag coefficients and lateral eddy viscosity values were refined in FASTMECH until the model produced an accurate representation of surveyed water surface elevations when simulating the discharge of the river on the day of the survey. The model was deemed sufficiently calibrated when the mean error on discharge was less than 3%. All FASTMECH simulations used a constant energy slope solution and 1000 iterations.

The calibrated models were used to characterize water depth and vertically averaged water velocity at each point in the curvilinear solution grid across a range of discharges. Modeled discharges were selected by processing data available from the USGS stream gauge on the San Juan River at Pagosa Springs (USGS 09342500). Exceedance percentile flows, ranging from the 99th to 1st percentile, were calculated based on historic discharge measurements over a 35-year time period.

Two-dimensional hydraulic modeling simulations provided the necessary velocity and depth parameters for hydraulically-controlled habitat quality characterization. Reach-scale habitat suitability is generally defined as a function of velocity, depth, substrate type, and the characteristics of streambank vegetation. Published Habitat Suitability Indices (HSIs) that indicate relative habitat quality along gradients of velocity, depth, etc. are available for many fish species. However, only a few of the published HSIs include characterizations for habitat preference relative to each of the channel characteristics listed above. As a matter of practice, habitat suitability is regularly modeled as a bivariate response to water velocity and depth—characteristics that are easily measured and modeled and tend to capture meso-scale variability in channel unit types (e.g., pools, riffles, glides, etc.). Pools typically have lower velocities and higher depths while riffles have higher velocities and lower depths.

Bluehead Suckers, as well as Speckled Dace and Rainbow Trout are resident riffle obligates. Other resident native and sportfish species utilize other habitats in the river. Pools provide holding habitat and feeding areas for a variety of fishes. They may also act as refuges for many fish species in high and low flow periods due to lower velocities and deeper waters. Pools and their transitions between habitats provide cobbled substrate for spawning by multiple fish species. Riffles provide some spawning habitat as well, and are important for macroinvertebrate production. Riffles and runs can also provide cover for fish from predators that reside both within and outside of the river.

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[2] https://wwwbrr.cr.usgs.gov/gstl/project-FaSTMECH.html

[3] https://www.hec.usace.army.mil/software/hec-ras/

This effort processed hydraulic modeling output with published HSIs for Bluehead and Flannelmouth Suckers[4] and for Brown Trout[5]. Available information characterizing habitat preferences for the two native species is not differentiated between life-stages. Composite HSI curves for velocity and depth are, therefore, taken to represent aggregate preferences for all life-stages. In an effort to maintain some consistency in approach, only water depth and velocity HSI curves for adult Brown Trout and adult Rainbow Trout were utilized to characterize habitat preferences for those cold-water species.

3 Results

Comparison of hydraulic modeling outputs across a range of flows to CSI values for each species yielded weighted usable habitat area (WUA)[6] curves. These curves reflect changes in suitable habitat in a modeled reach as a function of flow. Habitat modeling results indicate that WUA for native species generally increases with flows. At both San Juan River sites, habitat conditions were found to be more suitable for warm-water fish than cold-water fish at flows above 200 cfs.

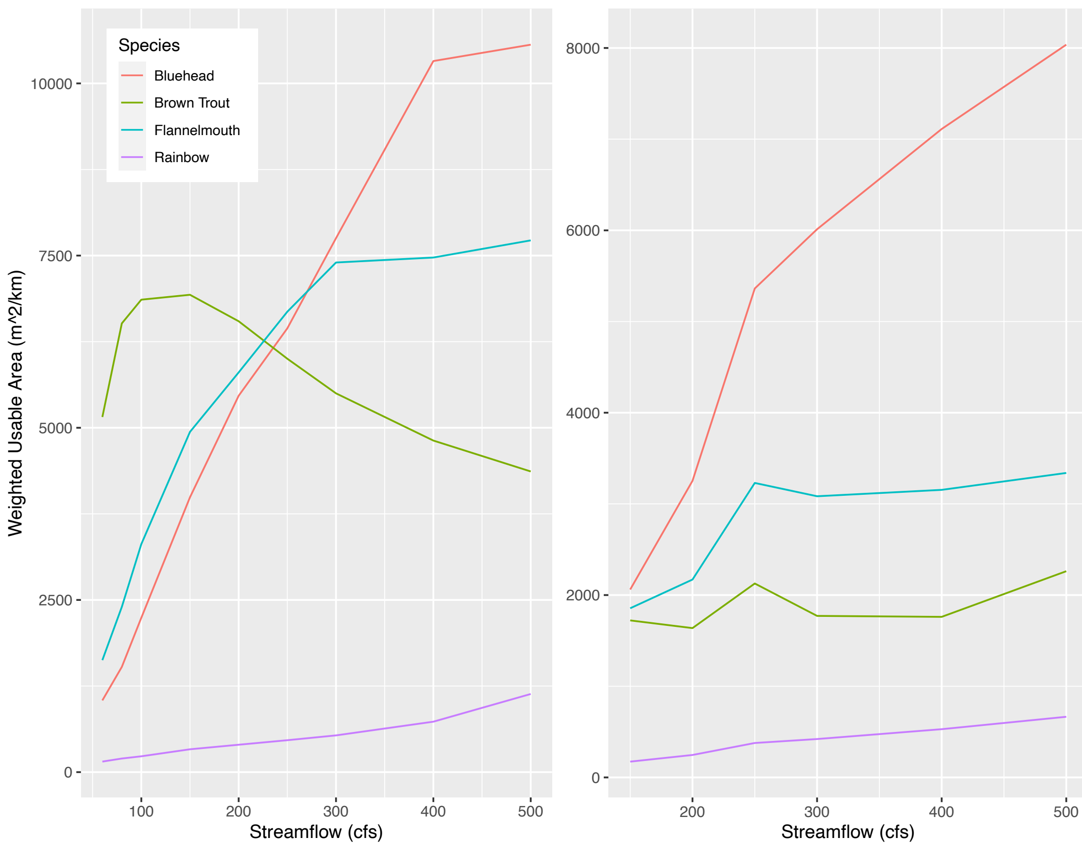

Figure 1. WUA curves generated for adult life-stages of four species in the San Juan near Fourmile Creek (left) and the San Juan at Pagosa Springs (right)

[4] Anderson, R. M., & Stewart, G. B. (2003). Riverine fish flow investigations. Colorado Division of Wildlife, Fish Research Section.

[5] Raleigh, R. F., Zuckerman, L. D., & Nelson, P. C. (1986). Habitat suitability index models and instream flow suitability curves: Brown Trout (Vol. 82, No. 10-71). National Ecology Center, Division of Wildlife and Contaminant Research, Research and Development, Fish and Wildlife Service, US Department of the Interior.

[6] The concept of Weighted Usable Area is presented by numerous resource management agencies and researchers but is described succinctly here: https://www.ars.usda.gov/ARSUserFiles/60600510/Topashaw/aquatic_habitat_suitability.pdf

Relative comparisons of WUA curves between the species at each site indicate habitat conditions potentially more favorable to bluehead suckers than either flannelmouth suckers as flows increase beyond 300 cfs. WUA values for the non-native sport species indicate conditions may be more favorable to brown trout than rainbow trout at all flows. Both cold-water species seem less sensitive to changes in flow than the warm-water species. It is important to be aware that this assessment did not consider water quality characteristics, angling pressure, inter-species competition, or other factors that may partially dictate species success on a given reach. This assessment instead took a narrow view at the potential limiting effect of streamflow on habitat quality and species success on the selected reaches.

The relationship between streamflow and habitat suitability metrics (described by WUA values) is most useful for river management decision-making when considered within the context of historical hydrology and potential future hydrology changes. Comparing WUAs for each species under the baseline hydrology scenario to the range of hydrologic regimes described by other planning scenarios allows stakeholders to predict potential aquatic habitat impacts associated with each of those scenarios. For example, on the San Juan River near Fourmile Creek median August minimum flows are expected to decrease by 63% when shifting from Baseline conditions to conditions proposed under Scenario E. This change in flows corresponds to a greater than 25% decrease in habitat suitability for adult brown trout and a greater than 35% decrease in habitat suitability for adult rainbow trout.

Polynomial approximations of the computed WUA curves are provided below. These equations may be used by stakeholders during subsequent WEP planning phases in order to evaluate the impact of changing streamflows at a particular time of year on a given species or life stage. Additionally, this information can be processed using hydrological scenario modeling output to inform local communities about the potential for climate change, water development, and/or population growth to impact habitat availability for three locally-important species at different locations and at different times of year. Future analyses may be expanded to include assessments of additional life-stages for each species of interest or models may be developed for other locations in the watershed. Take note that the outputs produced by these polynomial equations will become less reliable as streamflows approach zero.

Table 1. Approximated WUA curves for each species across a range of streamflows in the reach that flows through downtown Pagosa Springs. The term Q = streamflow measured in cubic feet per second.

Species	WUA Equation
Bluehead Suckers	$WUA = 0.0001Q^3 - 0.159Q^2 + 80.581Q - 6991$
Flannelmouth Suckers	$WUA = 0.0001Q^3 - 0.1266Q^2 + 49.158Q - 3140.4$
Brown Trout	$WUA = 0.0001Q^3 - 0.0928Q^2 + 27.247Q - 681.69$
Rainbow Trout	$WUA = 1.3702Q - 9.0621$

Table 2. Approximated WUA curves for each species across a range of streamflows in the reach of the San Juan River below the confluence with Fourmile Creek above Pagosa Springs. The term Q = streamflow measured in cubic feet per second.

Species	WUA Equation
Bluehead Suckers	$WUA = -9E\text{-}05Q^3 + 0.0379Q^2 + 24.998Q - 558.55$
Flannelmouth Suckers	$WUA = 0.0001Q^3 - 0.1376Q^2 + 61.146Q - 1589.6$
Brown Trout	$WUA = 0.0002Q^3 - 0.1904Q^2 + 45.008Q + 3660.8$
Rainbow Trout	$WUA = 2.0115Q + 7.9031$

APPENDIX F: RECREATIONAL USER FLOW PREFERENCE SURVEY

Report for San Juan Recreational Use Survey: Whitewater Boating

1. Please rate the streamflows in the columns below according to the category that best captures them for supporting rafting on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	66.7%	50.0%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	33.3%	50.0%	75.0%	66.7%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	50.0%	50.0%	100.0%	100.0%	75.0%	75.0%	80.0%	50.0%	25.0%	20.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	25.0%	20.0%	50.0%	75.0%	80.0%

2. Please rate the streamflows in the columns below according to the category that best captures them for supporting kayaking on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	33.3%	40.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	66.7%	60.0%	100.0%	100.0%	66.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	60.0%	50.0%	50.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	40.0%	50.0%	50.0%

3. Please rate the streamflows in the columns below according to the category that best captures them for supporting tubing on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Low but acceptable for use Column Check %	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	100.0%	100.0%	100.0%	80.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

4. Please rate the streamflows in the columns below according to the category that best captures them for supporting SUP on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	50.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	50.0%	66.7%	100.0%	100.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	50.0%	50.0%	50.0%	25.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	50.0%	75.0%

5. For each of the activities considered in the previous questions, what times of year would users prefer to engage in the activity if flows were not the primary limiting factor? For example, angling may be constrained to periods when insects are hatching, tubing may be constrained to periods when water and air temperatures are high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rafting Column Check %	0.0%	0.0%	0.0%	37.5%	37.5%	25.0%	25.0%	25.0%	37.5%	33.3%	0.0%	0.0%
Kayaking Column Check %	0.0%	0.0%	100.0%	37.5%	37.5%	25.0%	25.0%	25.0%	37.5%	50.0%	0.0%	0.0%
Tubing Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	0.0%
SUP Column Check %	0.0%	0.0%	0.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	16.7%	0.0%	0.0%

7. Please rate the streamflows in the columns below according to the category that best captures them for supporting rafting on the San Juan River through Mesa Canyon:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	100.0%	33.3%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	75.0%	75.0%	66.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	33.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%

8. Please rate the streamflows in the columns below according to the category that best captures them for supporting kayaking on the San Juan River through Mesa Canyon:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	66.7%	40.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	33.3%	60.0%	100.0%	100.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	100.0%	100.0%	100.0%	100.0%	100.0%	75.0%	50.0%	20.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	50.0%	80.0%

9. Please rate the streamflows in the columns below according to the category that best captures them for supporting SUP on the San Juan River through Mesa Canyon:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	50.0%	50.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	100.0%	100.0%

10. For each of the activities considered in the previous questions, what times of year would users prefer to engage in the activity if flows were not the primary limiting factor? For example, angling may be constrained to periods when insects are hatching, tubing may be constrained to periods when water and air temperatures are high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rafting Column Check %	0.0%	0.0%	0.0%	37.5%	33.3%	33.3%	33.3%	33.3%	37.5%	16.7%	0.0%	0.0%
Kayaking Column Check %	0.0%	0.0%	66.7%	37.5%	33.3%	33.3%	33.3%	33.3%	37.5%	50.0%	0.0%	0.0%
SUP Column Check %	0.0%	0.0%	33.3%	25.0%	33.3%	33.3%	33.3%	33.3%	25.0%	33.3%	0.0%	0.0%

12. San Juan River: East Fork Confluence to River Center Please rate the streamflows in the columns below according to the category that best captures them for supporting rafting on the San Juan River from the East Fork Confluence to the River Center:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	66.7%	66.7%	100.0%	50.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%	50.0%	100.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%

13. Please rate the streamflows in the columns below according to the category that best captures them for supporting kayaking on the San Juan River from the East Fork Confluence to the River Center:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	50.0%	50.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	50.0%	50.0%	66.7%	100.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	100.0%	100.0%	100.0%	66.7%	66.7%	100.0%	100.0%	50.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%	50.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%

14. Please rate the streamflows in the columns below according to the category that best captures them for supporting SUP on the San Juan River from the East Fork Confluence to the River Center:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%

15. For each of the activities considered in the previous questions, what times of year would users prefer to engage in the activity if flows were not the primary limiting factor? For example, angling may be constrained to periods when insects are hatching, tubing may be constrained to periods when water and air temperatures are high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rafting Column Check %	0.0%	0.0%	0.0%	40.0%	42.9%	37.5%	37.5%	37.5%	40.0%	33.3%	0.0%	0.0%
Kayaking Column Check %	0.0%	0.0%	100.0%	40.0%	42.9%	37.5%	37.5%	37.5%	40.0%	66.7%	0.0%	0.0%
SUP Column Check %	0.0%	0.0%	0.0%	20.0%	14.3%	25.0%	25.0%	25.0%	20.0%	0.0%	0.0%	0.0%

22. Please rate the streamflows in the columns below according to the category that best captures them for supporting rafting on the East Fork San Juan from the First Bridge to the East Fork Campground:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	100.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	100.0%	100.0%	100.0%	100.0%	50.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	100.0%	100.0%

23. Please rate the streamflows in the columns below according to the category that best captures them for supporting kayaking on the East Fork San Juan from the First Bridge to the East Fork Campground:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	50.0%	50.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	50.0%	50.0%	50.0%	50.0%	100.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	50.0%	50.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%

25. For each of the activities considered in the previous questions, what times of year would users prefer to engage in the activity if flows were not the primary limiting factor? For example, angling may be constrained to periods when insects are hatching, tubing may be constrained to periods when water and air temperatures are high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rafting Column Check %	0.0%	0.0%	0.0%	33.3%	50.0%	50.0%	50.0%	50.0%	50.0%	33.3%	0.0%	0.0%
Kayaking Column Check %	0.0%	0.0%	100.0%	66.7%	50.0%	50.0%	50.0%	50.0%	50.0%	66.7%	0.0%	0.0%

Report for San Juan Recreational Use Survey: Angling

1. Please rate the streamflows in the columns below according to the category that best captures them for supporting float fishing on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	100.0%	100.0%	50.0%	50.0%	0.0%	20.0%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	50.0%	20.0%	50.0%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	40.0%	25.0%	75.0%	40.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	40.0%	50.0%	66.7%	20.0%	0.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	33.3%	80.0%	100.0%	100.0%	100.0%

2. Please rate the streamflows in the columns below according to the category that best captures them for supporting bank fishing on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	60.0%	100.0%	20.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	40.0%	0.0%	40.0%	66.7%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	40.0%	33.3%	60.0%	66.7%	66.7%	75.0%	100.0%	40.0%	50.0%	33.3%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	16.7%	25.0%	0.0%	20.0%	50.0%	33.3%	50.0%	100.0%	100.0%	66.7%	33.3%	50.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%	0.0%	0.0%	40.0%	0.0%	33.3%	0.0%	0.0%	0.0%	33.3%	66.7%	50.0%

3. Please rate the streamflows in the columns below according to the category that best captures them for supporting wade fishing on the San Juan River Town Stretch:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	80.0%	60.0%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	20.0%	40.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	33.3%	50.0%	100.0%	66.7%	80.0%	40.0%	66.7%	20.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	60.0%	0.0%	40.0%	50.0%	50.0%	50.0%	33.3%	0.0%	0.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	33.3%	40.0%	0.0%	50.0%	50.0%	66.7%	100.0%	100.0%	100.0%	100.0%

4. For each of the activities considered in the previous questions, what times of year would users prefer to engage in the activity if flows were not the primary limiting factor? For example, all angling may be constrained to periods when insects are hatching, when water and air temperatures are not too high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Float Fishing Column Check %	0.0%	0.0%	0.0%	30.0%	50.0%	35.7%	23.1%	16.7%	8.3%	9.1%	0.0%	0.0%
Wade Fishing Column Check %	66.7%	66.7%	42.9%	30.0%	25.0%	28.6%	38.5%	41.7%	58.3%	54.5%	62.5%	75.0%
Bank Fishing Column Check %	33.3%	33.3%	57.1%	40.0%	25.0%	35.7%	38.5%	41.7%	33.3%	36.4%	37.5%	25.0%

5. Please rate the streamflows in the columns below according to the category that best captures them for supporting float fishing on the San Juan River through Mesa Canyon:

	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	100.0%	100.0%	66.7%	50.0%	50.0%	0.0%	16.7%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	0.0%	0.0%	33.3%	50.0%	50.0%	66.7%	33.3%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	50.0%	33.3%	60.0%	66.7%	50.0%	0.0%	16.7%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	50.0%	100.0%	33.3%	20.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	0.0%	50.0%	80.0%	100.0%	100.0%

6. What times of year would users prefer to engage in this activity if flows were not the primary limiting factor? For example, angling may be constrained to periods when insects are hatching, when water and air temperatures are not too high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Float Fishing Column Check %	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%

7. Please rate the streamflows in the columns below according to the category that best captures them for supporting float fishing on the San Juan River from the East Fork Confluence to the River Center:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	100.0%	50.0%	100.0%	50.0%	66.7%	50.0%	66.7%	25.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	0.0%	50.0%	0.0%	0.0%	33.3%	0.0%	0.0%	50.0%	66.7%	50.0%	33.3%	50.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	0.0%	50.0%	0.0%	50.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	75.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	25.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%	66.7%	50.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	0.0%	0.0%	25.0%	33.3%	50.0%	100.0%	100.0%

8. Please rate the streamflows in the columns below according to the category that best captures them for supporting bank fishing on the public land portions of the San Juan River from the East Fork Confluence to the River Center:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	66.7%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	33.3%	85.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	100.0%	100.0%	66.7%	50.0%	75.0%	25.0%	33.3%	66.7%	33.3%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	33.3%	50.0%	0.0%	50.0%	33.3%	33.3%	33.3%	50.0%	100.0%	50.0%	33.3%	0.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	25.0%	33.3%	0.0%	33.3%	0.0%	0.0%	50.0%	66.7%	100.0%	100.0%	100.0%

9. Please rate the streamflows in the columns below according to the category that best captures them for supporting wade fishing on the public land portions of the San Juan River from the East Fork Confluence to the River Center:

	30	50	100	150	200	250	300	400	500	600	800	1000	1250	1500	2000	2500	3000	3500
Too low for use Column Check %	71.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low but acceptable for use Column Check %	28.6%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optimal conditions Column Check %	0.0%	0.0%	100.0%	100.0%	75.0%	66.7%	60.0%	66.7%	25.0%	50.0%	33.3%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High but acceptable for use Column Check %	0.0%	0.0%	0.0%	0.0%	25.0%	33.3%	20.0%	33.3%	25.0%	50.0%	0.0%	33.3%	50.0%	33.3%	0.0%	0.0%	0.0%	0.0%
Too high for use Column Check %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	50.0%	0.0%	66.7%	33.3%	50.0%	66.7%	100.0%	100.0%	100.0%	100.0%

10. For each of the activities considered in the previous questions, what times of year would users prefer to engage in the activity if flows were not the primary limiting factor? For example, angling may be constrained to periods when insects are hatching, tubing may be constrained to periods when water and air temperatures are high, etc:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Float Fishing Column Check %	0.0%	0.0%	14.3%	25.0%	38.5%	38.5%	30.8%	23.1%	18.2%	11.1%	0.0%	0.0%
Bank Fishing Column Check %	50.0%	50.0%	42.9%	41.7%	30.8%	30.8%	30.8%	38.5%	36.4%	44.4%	50.0%	50.0%
Wade Fishing Column Check %	50.0%	50.0%	42.9%	33.3%	30.8%	30.8%	38.5%	38.5%	45.5%	44.4%	50.0%	50.0%

11. For each of the activities listed below, what times of year would most users prefer to engage in the activity on the East Fork between San Creek and the First Bridge? For this question, please take into consideration your understanding of periods of the year when streamflows limit angling.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bank Fishing Column Check %	0.0%	0.0%	50.0%	50.0%	50.0%	50.0%	53.8%	50.0%	46.2%	50.0%	50.0%	0.0%
Wade Fishing Column Check %	0.0%	0.0%	50.0%	50.0%	50.0%	50.0%	46.2%	50.0%	53.8%	50.0%	50.0%	0.0%

12. For each of the activities listed below, what times of year would most users prefer to engage in the activity on the East Fork between the First Bridge and the USFS Campground? For this question, please take into consideration your understanding of periods of the year when streamflows limit angling.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bank Fishing Column Check %	0.0%	0.0%	50.0%	50.0%	50.0%	50.0%	53.8%	50.0%	46.2%	50.0%	50.0%	0.0%
Wade Fishing Column Check %	0.0%	0.0%	50.0%	50.0%	50.0%	50.0%	46.2%	50.0%	53.8%	50.0%	50.0%	0.0%

13. Copy of For each of the activities listed below, what times of year would most users prefer to engage in the activity on the West Fork in the vicinity of the USFS Campground? For this question, please take into consideration your understanding of periods of the year when streamflows limit angling.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bank Fishing Column Check %	0.0%	0.0%	50.0%	50.0%	50.0%	53.8%	50.0%	50.0%	45.5%	50.0%	50.0%	0.0%
Wade Fishing Column Check %	0.0%	0.0%	50.0%	50.0%	50.0%	46.2%	50.0%	50.0%	54.5%	50.0%	50.0%	0.0%