

FUTURE SCENARIO PLANNING WORKSHOP FOR DROUGHT AND RIVER DRYING IN THE MIDDLE RIO GRANDE

October 28-29, 2025, Albuquerque, NM

WORKSHOP REPORT JANUARY 2026



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On October 28-29, 2025, the University of New Mexico (UNM) Accelerating Resilience Innovations in Drylands (ARID) Institute held a Future Scenario Planning Workshop for Drought and River Drying in the Middle Rio Grande (MRG). Over the two days, approximately 85 participants convened to consider and explore the implications of the probable climate future on water resources, ecosystem function, indicator species, and human water uses in the region. This document summarizes the presentations, discussions, and strategies developed over the two-day workshop.

ACKNOWLEDGEMENTS

We would like to acknowledge the workshop planning team consisting of Debbie Lee from UNM ARID Institute, Janna Martinez a UNM Student, Stephanie Mladinich from South Central Climate Adaptation Science Center, Teresa Smith de Cherif from Valencia Soil and Water Conservation District, and Marcy DeMillion from Connecting Visions. Their hard work and dedication were essential to the successful planning and coordination of the workshop.

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We extend our appreciation to the federal and state agencies, non-profit organizations, academic partners, Tribal representatives, community groups, and local stakeholders who contributed their time and expertise during this two-day workshop. Their active participation fostered thoughtful dialogue and brought attention to critical issues affecting the MRG ecosystem.

Throughout the summit, their contributions enriched conversations on climate resilience, water management, habitat protection, and important considerations for future scenario planning. The diversity of perspectives ranging from scientific research and regulatory insights to on-the-ground experience strengthened our collective understanding of the challenges facing the Rio Grande ecosystem and supported the development of more informed and collaborative approaches moving forward.

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Pond at Whitfield Wildlife Conservation Area, Valencia Soil and Water Conservation District Staff

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DAY ONE

A. WELCOME AND INTRODUCTIONS

On the morning of day one, October 28, 2025, *Anne Kinsinger, Director of the ARID Institute*, opened the meeting and welcomed participants. She emphasized the importance of the workshop for the future planning of the Middle Rio Grande and for the state as a whole and remarked on the number and diversity of participants and their collective knowledge to support robust conversations leading to strong outcomes.

Patrick McCarthy, Water Policy Officer with the Thornburg Foundation, expressed his gratitude to the organizers and participants. He emphasized the critical importance of supporting community-driven initiatives that integrate science, management, and policy to address large-scale challenges like climate disruption. He framed the workshop as a vital opportunity to build resilient systems in the face of these challenges including, government disruptions, confronting a challenging future, building community, and integrating knowledge bases and authorities.

B. SCENARIO PLANNING OVERVIEW & ANTICIPATED WORKSHOP OUTCOMES

Debbie Lee, Senior Program Manager for the ARID Institute, provided an overview of the workshop. She acknowledged the members of the planning team from ARID, Valencia Soil and Water Conservation District (VSWCD), South Central Climate Adaptation Science Center, and Connecting Visions; and the additional organizations who provided funding for the workshop, VSWCD and Albuquerque Bernalillo County Water Utility Authority.

She noted the following workshop objectives:

- Create community and build partnerships;
- Develop a shared understanding of a probable climate future;
- Center water uses within a framework of ecosystem functions;
- Link human water use to ecosystem and species water needs;
- Identify appropriate adaptation strategies to implement and test for different water uses; and
- Contribute to fire- and drought-adapted restoration planning in the bosque.

She summarized the make-up of the registrants by affiliation and self-reported familiarity with the climate projections for the MRG. She then provided the framework for the workshop, noting the overall flow of the agenda and that the workshop combined ecosystem functions and services, water user priorities, and climate adaptation to facilitate planning for future water uses in the basin. For the purposes of the workshop, the MRG was defined as the region along the Rio Grande, south of Buckman Direction Division (Santa Fe) and north of the southern boundary of Elephant Butte Reservoir. The workshop also used four indicator species, identified by the Rio Grande Basin Study and used in the NGO Sectoral Committee

Environmental Flow Hypothesis Process for the MRG, as indicative of different water uses in the MRG: the southwestern willow flycatcher (*Empidonax traillii extimus*), the Rio Grande silvery minnow (*Hybognathus amarus*), the cottonwood (*Populus deltoides wislizeni*), and the sandhill crane (*Antigone canadensis*).

Debbie then provided the expected outcomes of the workshop, noting that impacts on the ecosystem and water uses and priority adaptation and mitigation strategies will be provided to different local and regional planning processes, including the Rio Grande Basin Study; information and data gaps will be incorporated into a resilience research plan being developed by ARID; and emphasized the hope that there will be continued conversations and actions.

Following the presentation, one participant noted that the boundary of the Middle Rio Grande as defined includes more than the Six Middle Rio Grande Pueblos, and emphasized that any solutions to water use in the basin must include all of the Pueblos and consider their water rights. This individual added that the Pueblos play an important role in both water and land connectivity, including wildlife corridors, and must be approached collectively instead of individually. There must also be an equity lens taken to planning, raising the question of how to compensate the Pueblos and Tribes for past groundwater depletions of shared aquifers, noting that the drying of the river directly affects the ecosystems which they depend upon. And lastly, the workshop participant argued that the group consider more than just the four indicator species and include macroinvertebrates and other flora and fauna in the whole ecosystem.

C. MIDDLE RIO GRANDE & WHITFIELD WILDLIFE CONSERVATION AREAS: A CASE SCENARIO OF DROUGHT AND RIVER DRYING FUTURES

Teresa Smith de Cherif, Board Chair of VSWCD, presented on the District's history, land, and operations, focusing on the Whitfield Conservation Area Complex. The VSWCD encompasses 5 counties and 2 Pueblos, and includes 279 acres of land in conservation. The Whitfield Conservation Area Complex includes three units of riparian conservation land adjacent to the San Juan Drain: Whitfield Wildlife Conservation Area (Whitfield; 97.54 ac), Stacy Unit (42.88 acres), and the Rio Abajo Unit (138.87 acres). Teresa told the story of Whitfield, which started as the Curran Dairy, with the land being sold in 1986 to the Whitfields, who in turn donated the 97 acres to VSWCD in 2003 to form the Whitfield Wildlife Conservation Area.

Teresa explained how VSWCD manages Whitfield, with a mix of cottonwoods and wetlands, providing the bosque mosaic that was historically seen in the MRG. She then described the April 2022 Big Hole Fire, which burned 75% of Whitfield and the Stacy Unit, including the iconic 100-year-old Owl Tree located at Whitfield.

She indicated this fire was a sign of the climate threats facing Whitfield and the rest of the MRG, and emphasized that the Southwestern United States is one of four megadrought regions in the world. As climate and hydrological dynamics change in the MRG, so do fire dynamics. This trend is being observed at Whitfield: in thirteen years of monthly groundwater monitoring, there is an observed one-foot decline in groundwater levels, with three wells running dry this past summer for the first time.

Teresa ended by summarizing the post-fire recovery work being done at Whitfield, and the emphasis on climate- and fire-adapted restoration. She asked the workshop participants to consider the following questions as they hold their discussions over the next two days:

- What are key considerations for revegetation design, in light of the long-term viability of plants in the context of a hotter and drier New Mexico?
- What are strategies to reduce the severity of wildfires?
- Where are there opportunities for collaborative restoration?

For more details, please see Teresa’s presentation slides in Appendix H.

D. DROUGHT AND RIVER DRYING FUTURES OVERVIEW

Paul Tashjian, Director of Freshwater Conservation with Audubon Southwest, presented on the work being done by the NGO Sectoral Committee of the Rio Grande Basin Study, focusing on the MRG environmental flow recommendations. He began by summarizing the U.S. Bureau of Reclamation (USBR) WaterSMART Basin Study Program, which are “collaborative studies, cost-shared with non-Federal partners, to evaluate likely future imbalances between water supply and demand, and help ensure sustainable water supplies by identifying and modelling strategies to address these projected imbalances.” The Rio Grande Basin Study was initiated by USBR and the Middle Rio Grande Conservancy District (MRGCD) and is funded through 2028. The NGO Sectoral Committee of the Basin Study has been focused on defending the environmental flow (e-flow) needs for six reaches of the Rio Grande in New Mexico, including the MRG. The committee convened a peer review workshop in August 2024 focused on adaptation strategies for improving e-flows. The report, “Environmental Flow Recommendations for Six Reaches of the Rio Grande in New Mexico,” was finalized in April 2025. Currently, the committee is modelling select strategies.

Paul explained that the committee identified indicator species for each reach that represent key parts of the native hydrograph. The MRG indicator species were used during this workshop, and he summarized the relationship of each species to the hydrograph, noting the flow needs for each of the species and pointing out that the spring pulse is critical for the total ecosystem and species. Much of the infrastructure in the Rio Grande was developed and evolved to meet farming needs, and he explained the important roles irrigation and agriculture play in keeping water in the river and creating habitat for species, pointing to MRGCD’s environmental water leasing program.

He then showed the calculated minimal river flows needed in each reach to meet Rio Grande Compact, agricultural, and environmental needs, informing the group that these were not met in the past three summers. The river has dried completely in several reaches, leading to habitat loss and stress on agriculture and communities. Drying is a paramount issue, and it negatively impacts both ecosystem health and ability to move water through the system (“dry rivers suck” by increasing groundwater consumption when flow returns).

He also explained that these minimal flows do not necessarily align with channel capacity, pointing out that even low spring pulse recommendations are above safe channel capacity below Abiquiu. He also

summarized the MRG low flow adaptation strategies that were included in the Environmental Flow Recommendations report.

For more details, please see Paul's presentation slides in Appendix H.

The following comments were made during the question and answer session:

- After three years of extreme drought, young trees and endangered species are stressed and failing, and the state has not been able to meet Rio Grande Compact delivery obligations.
- Improving conveyance, including meeting Rio Grande Compact deliveries, are critical components being evaluated in the modelling phase.
- The hydrologic extremes have been affecting riverside infrastructure such as levees and wetlands. The "feast or famine" hydrology is embedded into the Rio Grande Basin Study.
- The Rio Grande Basin Study modelling incorporates extended drought scenarios, as that affects both environmental and agricultural needs.
- Strategies have been developed for meeting Compact deliveries and addressing infrastructure issues in the lower San Acacia Reach. The next step is to crosswalk the strategies with ecosystem needs (e.g., to see if the strategy can be achieved in a way that connects floodplain, etc.).

One participant commented on the critical importance of stream storage to water operations in the MRG, adding that decreased storage capacity has also decreased operational flexibility and increased river drying.

Another workshop participant noted that agriculture also includes ranching, which should be included when considering water uses. This individual emphasized the importance of keeping farming alive in the MRG, and suggested the group consider strategies to ensure labor needs for farming can be met, given the importance of agriculture to the ecosystem.

E. MIDDLE RIO GRANDE WATER USE VERSUS WATER BUDGET

Enrique Prunes, Rio Grande Manager and Freshwater Lead Specialist with World Wildlife Fund, presented the results of an upcoming paper in *Discover Water*, "Overconsumption Gravely Threatens Water Security in the Binational Rio Grande-Bravo Basin." The authors developed detailed water consumption estimates for 14 sub-basins of the Rio Grande-Bravo Basin (RGB) looking at five consumptive water uses:

- Municipal and commercial,
- Thermoelectric power plants,
- Irrigated agriculture,
- Reservoir evaporation, and
- Riparian evapotranspiration.

Enrique summarized the water consumption by use in the full Rio Grande Basin, and for the New Mexico portion of the Rio Grande basin. He further broke it down to direct consumption, and then within that to irrigation consumption. In New Mexico, the authors considered reservoir depletion and groundwater depletion, calculating a 52% overconsumption of water in the RGB Basin-wide, and 85% overconsumption

in the Rio Grande in New Mexico. Most of the water consumed comes from depleting rivers, reservoirs, and aquifers.

He also noted that agriculture accounts for 47% of overall consumption in the Rio Grande in New Mexico, and 90% of direct consumption (once riparian evapotranspiration and reservoir evaporation is removed). Reminding the group of the importance of agriculture for ecosystem health, Enrique talked about the overall trend of declining farmland in the basin, with New Mexico having lost 28% of its farmland in the Rio Grande basin between 2000-2019. Concurrently, the basin has also experienced river and groundwater depletion. He ended with the message that the Rio Grande is at a tipping point, and advocated for the group to consider bold, collaborative solutions that include community empowerment, policy and management reforms, investment in Nature-Based Solutions, strengthening and expanding science and data monitoring, and championing catalytic, innovative ideas.

For more details, please see Enrique’s presentation slides in Appendix H.

The following point was made during the following question and answer session:

- The analysis showed that the entire RGB Basin is being depleted, and that certain sub-basins, like the Rio Grande in New Mexico, are facing the most severe losses.

F. RIO GRANDE BASIN STUDY: MODELLING OVERVIEW

Emma Metcalf, Resource Management Coordinator, and Lucas Barrett, Hydrologic Civil Engineer, both with the U.S. Bureau of Reclamation, summarized the modelling approach of the Rio Grande Basin Study for projections of water availability and use, stress on infrastructure, and adaptation strategies under deep uncertainty. They provided background into the Basin Study, which has the goals of (1) evaluating water supply and demand; and (2) identifying strategies to address imbalances in water supply and demand through projecting future supply and demand, analyzing existing operations and infrastructure, developing strategies to meeting current and future water demands, and undergoing a trade-off analysis of identified strategies. The Rio Grande Basin Study area starts from the Colorado state line down to Elephant Butte Dam and includes the San Juan-Chama Project tributary basins. Forty-two non-Federal signatories have signed onto the Memorandum of Agreement for the Basin Study.

The Study incorporates a climate model, a hydrologic model, and two operations models to project future conditions. Adaptations are implemented within the operations models, with both general projections being developed through running a large number of scenarios, and then using selected scenarios to get more information and accuracy on projected future conditions. Emma and Lucas explained that in order to support decision-making under deep uncertainty, the Basin Study is developing multiple future “storylines” within the potential futures in order to stress-test proposed policies, and identify new, more robust strategies that can meet multiple objectives over a wide range of potential futures.

They listed the proposed storylines:

1. Overall dry
2. Overall wet

3. Median
4. High spring rain, low snowpack/monsoon
5. Very high monsoon with low snowpack (high intensity, low frequency)
6. High monsoon with low snowpack (low intensity, high frequency)
7. High annual variability (a lot of back and forth wet/dry years)
8. Low annual variability (periods of many wet or dry years in a row)

Emma and Lucas noted that they will need different adaptation strategies to test through the storylines, and hope that the strategies developed by the workshop participants will be included. For more details, please see Emma and Lucas's presentation slides in Appendix H.

The following point was made during the following question and answer session:

- The historical data used in the modelling was from 1980-2022.

G. GROUNDWATER FUTURES: GROUNDWATER MANAGEMENT AND AQUIFER RESPONSE

Diane Agnew, Water Rights Program Manager with the Albuquerque Bernalillo County Water Utility Authority (ABCWUA), presented on how ABCWUA manages groundwater. She noted that their Groundwater Management Plan includes monitoring and stewardship of the aquifer beneath the Albuquerque metro area, and the ABCWUA has demonstrated a successful case of groundwater stabilization. The ABCWUA has a policy to establish and maintain a groundwater reserve in order to supply water during catastrophic drought or other emergencies. This reserve includes a working reserve (between 50-250 feet of drawdown) and a safety reserve (250-300 feet of drawdown) which can both be accessed without adversely impacting the aquifer. The ABCWUA targets 110 feet for average drawdown, well above the safety reserve, and balances depletions with recharge.

Diane briefly provided an overview of the ABCWUA's groundwater monitoring and mapping via a network of monitoring wells from USGS, Bernalillo County, Kirtland Air Force Base, and the City of Albuquerque. The data are used to model water-level elevation contours, showing where there are cones of depression and greater drawdown. She noted that based on the data, groundwater levels remain above the management target level of 110 feet of drawdown and that groundwater levels appear to be stabilizing. This has been achieved through a diversified water supply (which includes surface water from the San Juan-Chama Project, conservation, and reclaimed water) and adaptive management.

For more details, please see Diane's presentation slides in Appendix H.

H. CLIMATE CHANGE IN THE MIDDLE RIO GRANDE

Dagmar Llewellyn, a volunteer with ISET International and retired Hydrologist with the USBR, and Stephanie Mladinich, Climate Adaptation Specialist with the South Central Climate Adaptation Science Center, synthesized the climate impacts discussed throughout the day, connecting them to direct consequences for the MRG ecosystem, to prepare the workshop participants for considerations for the day's discussions and

breakout sessions. Dagmar noted the key trends, which include increasing temperatures, decreasing average flows, reduced system-wide water storage, more flow variability, intense storms, earlier and less snowmelt, larger wildfires, and declining groundwater. She added that these changes do not occur in isolation; they compound (e.g., wildfire leads to sedimentation, which reduces channel capacity and water quality). At the same time, the models project increases in water demand, including agricultural use, riparian evapotranspiration, and reservoir evaporation.

Dagmar also emphasized the high degree of uncertainty around future changes, including the speed of those changes. She noted that uncertainty regarding future human behavior is the largest source of uncertainty in temperature projections, meaning that much of the uncertainty in the models is irreducible.

The key takeaways from the projected climate impacts for the river and riparian corridor include:

- Likely lower flows, and increased loss of water to the aquifer, further decreasing flow;
- Significantly more sediment in the river channels from erosion and debris flows, likely leading to riverbed aggradation and a decrease in channel capacity;
- A decrease in channel width from lower average flows and vegetation encroachment, further decreasing channel capacity;
- Loss of the existing cottonwood gallery (the “class of 1941,” the year the Rio Grande last overbank flooded); and
- Increase in the intensity of extreme precipitation events, creating occasional high flows in a river with less ability to convey water, causing increasing challenges regarding Rio Grande Compact deliveries.

For more details, please see Dagmar and Stephanie’s presentation sides in Appendix H.

The following points were made during the question and answer session:

- The interaction between groundwater pumping and surface flow is critical. As surface water supply decreases, groundwater pumping increases, which in turn further depletes river flow. This interaction is modelled and managed for in the system.
- Flooding or encroachment will greatly affect the deposition and relocation of sediment.

In addition, one participant commented that water managers are increasingly challenged by greater uncertainty of flows, as that impacts their ability to move water for Compact compliance and other needs. Our future ability to model and predict future weather and water is challenged by climate change. Old methods and trends may no longer hold or be accurate at all. This is summarized by an increase in variability (of extreme weather and water stresses.)

I. FIELD TRIP AND DINNER AT WHITFIELD WILDLIFE CONSERVATION AREA

Following the close of the first day, workshop participants were given the option of travelling to the Whitfield Wildlife Conservation Area for a field tour and dinner. During the tour, Teresa Smith de Cherif went into more detail about the VSWCD’s vision and mission, service area, and history. She stated that today, Whitfield is home to salt-grass meadows, towering cottonwoods, and restored wetlands that provide

habitat for elk, wild turkeys, and over 200 species of migratory birds. It is also an important outdoor education and recreational site, having been called a “hidden nature park that adults and children will love exploring” by *Only in New Mexico*, and has been voted the area’s best nature park and outdoor recreation area in 2024 and 2025 by *Valencia County News-Bulletin*.

Teresa explained the impact of the 2022 Big Hole Fire on the site and recovery efforts. The group discussed VSWCD’s leveraging of partnerships to plan and implement projects at Whitfield and their other units. As a result of the fire, the salt grass meadows were naturally restored, and made VSWCD think more purposefully about bosque restoration with more fire-adapted trees and plant species, perhaps even by assisted migration. In 2016, VSWCD will commence restoration and envisions partnerships to be key in that process.

During the walking tour, Teresa posed two questions to participants that VSWCD is actively soliciting input on:

- In restoring Whitfield, what recommendations would you offer for the revegetation design, in light of the long-term viability of plants and trees in a hotter and drier New Mexico?
- Should restoration be climate-adapted, aim to increase biodiversity of native trees in the bosque, including re-introduced native species that once tried in the MRG, and perhaps through assisted migration from the Rio Abajo and Rio Bravo basins?

DAY TWO

A. HUMAN DIMENSIONS OF WATER USE IN THE MIDDLE RIO GRANDE: PAST, PRESENT AND FUTURE

Stephanie Russo Bacca, a Staff Attorney with the UNM Utton Transboundary Resources Center and a member of the MRGCD Board, provided an overview of the legal and institutional framework governing water use in the Middle Rio Grande. She discussed what was the legal definition of a “water right,” and provided the highlights of water law in New Mexico in the 20th and 21st centuries.

She explained that in New Mexico, water rights are summarized by “first in time, first in right,” with water rights being given priority based on age. In reality, very few priority calls have been issued; instead, the state prefers to share the scarcity. She emphasized that no one owns water in New Mexico—rather we have rights to use water. Stephanie then explained the Rio Grande Compact and how water is accounted for per the Compact. She noted that the Six Middle Rio Grande Pueblos are not part of the Compact.

Stephanie also summarized other important aspects of water management in New Mexico, including the role of acequias, the Middle Rio Grande Conservancy District (MRGCD), and Tribal water rights. She then covered the newest changes, such as the Strategic Water Reserve, and provided thoughts on how to manage water in the state given 21st century climate realities. She suggested some possible tools: changing agricultural practices, the Active Water Resource Management initiative, and shortage sharing agreements.

For more details, please see Stephanie’s presentation sides in Appendix H.

The following points were made during the question and answer session:

- Per the Rio Grande Compact, water is considered “delivered” to Texas once it is in Elephant Butte Reservoir, but due to groundwater pumping by Lower Rio Grande irrigators, Texas is constantly shorted their delivery.
- New Mexico currently owes 124,000 acre-ft to Texas, and if that goes over 200,000 acre-ft, New Mexico will be in an Article 7 violation of the Rio Grande Compact.
- There is enough reservoir storage in New Mexico to meet Compact obligations; it equals about 20% of Elephant Butte capacity. However, New Mexico chooses to use it and prevent evaporation in the reservoir.
- Article 6 of the Compact requires New Mexico stores water to pay down the state’s debt before storing for local use. This has limited water operations flexibility in recent dry years.
- Tribal members became U.S. citizens through the Pueblo Lands Act of 1924, and the Pueblos and Tribes have a codified right to 8,847 acre-ft of water, tying back to Prior and Paramount water rights. The 1930 Rio Grande Compact does not apply to Tribal nations and Pueblos, but as Tribal members were not allowed to vote as citizens until 1948, taxation and water rights were determined without representation.

B. CENTRAL NEW MEXICO CLIMATE ACTION PLAN’S TOP ADAPTATION STRATEGIES - RESILIENT FUTURES INITIATIVE

Alice Main, Climate Pollution Reduction Grant Manager with the City of Albuquerque Office of Sustainability, presented on the ongoing development of the Central New Mexico Climate Action Plan, focusing on mitigation (greenhouse gas reduction) and its benefits. Debbie introduced Alice’s presentation as an example of how to approach adaptation planning and developing adaptation strategies.

Alice reviewed the lessons from the development of the Central New Mexico Climate Action Plan, which was developed through a grant from the U.S. Environmental Protection Agency’s (U.S. EPA) Climate Pollution Reduction Grants Planning Program. The plan goals were to 1) cut climate pollution, and 2) benefit communities. Identified gaps and opportunities were then used to identify strategies for action. She explained that modeling “business-as-usual” helped identify greenhouse gas emissions without additional actions. Additional modeling and projections showed that Central New Mexico needed to reduce emissions by 10% every year from 2023 to 2030 in order to meet international best practices. The final Climate Action Plan was released in December 2025, and a monthly newsletter will provide updates on implementation.

Alice noted that during the public and stakeholder engagement, water conservation rose to the top as a priority, pointing to a cultural awareness of climate change and drought and a love of water and place. The community selected the following cross-cutting strategies:

- Priority 1: Increase climate education.
- Priority 2: Expand climate governance.
- Priority 3: Improve climate finance.
- Priority 4: Support the green workforce.

- Priority 5: Advance sustainable economies.

And within the “Water and Waste” category, the community selected the following priority strategies:

- Priority 1: Reduce water use.
- Priority 2: Reduce food/organic waste.
- Priority 3: Increase composting and application.
- Priority 4: Reduce nonfood waste.
- Priority 5: Increase material reuse and repurposing.

For more details, see Alice’s presentation slides in Appendix H.

The following points were made during the question and answer session:

- The strategies were developed to be detailed enough to respond to general public and technical expert priorities and opinions. Lotus is helping model the mitigation and key performance indicators across the region.
- The City is not changing their methodology due to changes at the U.S. EPA, but is planning on revising language based on feedback from the Community Task Force in order to be able to communicate to a broad audience. The Plan is focusing on communicating community benefits and lived experience without using potentially problematic terminology, while still upholding the intent of equitable outcomes.
- To ensure water quality is preserved, the plan is focused on monitoring atmospheric emissions. There are also strategies to address impermeable surfaces.
- The City publishes an indicator progress report on reducing stormwater pollution.

BREAKOUT SESSION 1 - CLIMATE IMPACTS TO ECOSYSTEM FUNCTION

Breakout Session 1 centered on understanding how climate change is altering the ecological processes that underpin healthy habitat and functioning ecosystems in the Middle Rio Grande. Participants identified hydrological, geomorphological, biogeochemical, and biological processes as the foundational drivers of ecosystem function.

Participants described several key indicators of functional habitat that are becoming increasingly vulnerable under changing climate conditions. These include the timing and magnitude of the spring flood pulse, monsoon-driven streamflow, the degree of floodplain connectivity, and the exchange between groundwater and surface water. Together, these indicators reflect the river's ability to sustain periodic inundation, recharge aquifers, and support native species. The group noted that these processes rely on predictable seasonal patterns being disrupted by climate change.

A number of metrics were identified as essential for tracking these changes, such as the behavior of the hydrograph, soil moisture, groundwater levels, and the frequency of overbanking events. Participants emphasized the importance of continued monitoring to capture shifts in river flow patterns, riparian condition, and species habitat needs.

Across discussions, uncertainties related to climate impacts stood out as a major obstacle to planning. Participants expressed concern about the increasing variability of the spring runoff and monsoon season, both of which are critical for river flow and ecological function. Reduced overbanking events, heightened irrigation pressures, and unregulated groundwater use were also noted as compounding stressors. Additional information gaps include the future role of upstream reservoirs, low flows and stormwater flows, sediment transport, channel drying, and impacts of water availability to vegetation recruitment and reproduction. These uncertainties make it difficult for land and water managers to anticipate the future conditions necessary for sustaining resilient ecosystems.

The implications of these changes for ecosystem function are significant. Participants described the risk of losing a sustained flowing river with diminished spring recharge and extended dry periods threatening riparian vegetation, wildlife, and aquatic species. A decline in floodplain connectivity could lead to the collapse or transformation of riparian ecosystems, reducing habitat availability for native fish and other species that rely on periodic flooding. These ecological shifts may also accelerate the spread of invasive species and increase wildfire risk, further altering the system.

Key Outcomes

- **Hydrological Processes:** Spring flood pulses are expected to diminish due to earlier snowmelt and decreased snowpack, altering streamflow, riparian recruitment, and habitat for species like the Rio Grande silvery minnow. Monsoon-season streamflow is projected to be more variable with shorter duration pulses and an extended dry season, complicating agricultural planning and river management

- Floodplain Connectivity: Reduced inundation periods and baseflow may threaten wetland and riparian ecosystems, potentially favoring drought-tolerant or upland species over native wetland flora and fauna
- Geomorphology: Intense rainfall and wildfires are increasing sediment yield and bank erosion, resulting in channel changes, reduced habitat diversity, and fewer large woody debris
- Biogeochemical Processes: Water quality concerns include higher temperatures, more frequent nutrient pulses, lower dissolved oxygen, increased turbidity, and risk of harmful algal blooms, impacting aquatic life and recreational water use

Main Knowledge Gaps and Uncertainties across Ecological Processes

- Role of upstream reservoirs
- Cottonwoods resprout but don't recruit and uncertainty around vegetative reproduction
- Changes in the upper watershed, conveyance issues (e.g., Rio Chama), changes in runoff supply due to wildfire and landscape transformation
- Impacts of albedo
- Sediment dynamics under changing flow regimes, sediment mobility
- Low flows, stormwater flows
- Channel drying events
- Unpredictable monsoon behavior (e.g., less predictable, more extreme, changes in timing)
- Aquatic biological community transformations
- The ability to store monsoonal rainwater
- Possibility of increasing floodplain connectivity with higher sediment loads and lower flows
- Biological benefits of return outfalls
- Improved understanding of channel capacity
- Wetland channel storage
- Changes in irrigation and impacts on unregulated water well use and groundwater
- Impacts of irrigation infrastructure on the geomorphology of the system
- Impacts of removal of invasive species and dead and down woody debris from wildfire

Recommendations and Ideas

- Improved management flexibility (e.g., water project redesign) and nature-based storage approaches are needed to buffer climate extremes and support ecosystem services
- Encourage connectivity (e.g., outfall management and beaver wetlands) and restoration techniques that maintain flows, vegetation age structure, and habitat patchiness.
- Monitor impacts to community livelihoods and recreation as streamflow timing and quality shift, affecting fishing, wildlife observation, and crop pollination
- Shifting policy to prioritize using less water for farming
- Proactive management interventions for fuels reduction to reduce fire risk through the removal of dead and dying trees, invasive vegetation removal, etc.

Climate Impacts on Ecosystem Services and Human Uses of Water

- Loss of a "living river"
- Loss of spring aquifer recharge

- Loss of biodiversity and entire ecosystems
- Less water for human uses overall
- Impacts to compact delivery
- Isleta and Santa Ana water projects will be impacted and may need to be reworked
- Reliance of river operations on active management
- Water storage in drought conditions
- Efficient water conveyance
- Regulatory issues
- Increase fire season and impacts on Bosque ecosystem
- Agricultural losses due to decreased pollinator populations and increased monsoonal variability
- Increased challenges in decision-making, particularly for MRGCD
- Increased risk of flooding
- Impacts for recreation: changing and decreasing fish populations for fishing, loss of shade for hiking, decreased avian populations for bird watching, etc.
- Impacts on drinking water and filtration/treatment needs (e.g., water quality)
- Decreased soil health

Overall, the session underscored the need to understand, monitor, and plan for the cascading ecological effects of climate change. The discussion highlighted both the complexity of climate-driven changes in the Middle Rio Grande and the critical importance of management approaches to sustaining ecosystem functions in the face of growing uncertainty.

Table 1. Anticipated changes to ecosystem functions in the MRG.

Ecological Processes	Indicator of functional habitat for one or more indicator species	Metrics for each indicator	Likely climate impacts to ecosystem functions
Hydrological Processes <i>Hydrologic regulation, floodplain dynamics, streamflow maintenance, groundwater recharge, baseflow support, habitat maintenance.</i>	Spring flood pulse	Flood pulse magnitude, timing and duration, receding limb; elevation of snowpack; rate of change in flow; regeneration of cottonwoods; and recruitment of Rio Grande Silvery Minnow.	Magnitude expected to decrease due to declining snowpack and earlier melt; pulse occurs 1–2 months earlier and is of shorter duration; recruitment of cottonwood and other riparian plants will be affected; maintenance of habitat for silvery minnow, other native vertebrates and fish and other endangered species; loss of overbank flooding affects soil processes; and build up of litter which changes arthropod communities and fuel structure.
	Monsoon season streamflow	Volume and timing of streamflow events from monsoon precipitation.	More variable and flashier flows and increase in magnitude of extreme events. Generally shorter-duration pulses shifting to later into the season.
	Floodplain connectivity	Discharge at inundation; spatial area of inundation; and duration, timing and depth of inundation.	Connectivity reduced; shortening of inundation period and lower lateral extent due to reduced baseflow and channel incision; and drying of floodplain and impacts on vegetation composition. Potential loss of native species; and drought-tolerant or upland species favored.
	Groundwater/surface water exchange	Depth to groundwater.	Deeper water tables in valley floors and reduced recharge; and diminished baseflow contribution.
Geomorphology <i>Channel formation and maintenance, sediment transport, nutrient retention, habitat provisioning, structural diversity, bank stabilization,</i>	Sediment transport	Stream power and sediment plugs.	Higher sediment yield after intense monsoonal rains and wildfire; debris flows; and increased erosive flash floods.
	Large woody debris transport and storage	Large woody debris count and size.	Increased loss from wildfire and bank erosion; and reduced recruitment as mature riparian trees die or decline.
	Plant community physical structure	Vegetation composition and density, number of layers (understory, mid-story, etc.).	Lower canopy cover; more open structure; transition to shrub dominance instead of forests; and simplified

<i>erosion control, soil formation.</i>			structure with lower biodiversity.
	River / Stream Bed form diversity	Percentage of riffles and pools and fish community diversity.	Homogenization (less diversity) of bedforms as decreased baseflows and episodic floods cause scour and infilling; riffle area declines; and simplified food web if some fish can't survive in modified habitats.
	Bed material characterization	Substrate particle size and composition.	Materials grow finer after wildfire and erosion pulses, followed by hardening when flows drop.
	Irrigation infrastructure impacts		
<i>Biogeochemical Water quality regulation, nutrient cycling, nutrient retention.</i>	Water quality, including stormwater	Temperature; dissolved oxygen; conductivity; pH and turbidity; macroinvertebrate community.	Rise in mean water temperature; lower dissolved oxygen; higher turbidity after fire or monsoon runoff; conductivity increase during drought years; changes in water quality, especially oxygen and temperature; and impact to fish and other aquatic life.
	Nutrients	Common nutrient types in water (Nitrate; ammonia; nitrite; total phosphorus; phosphate, etc.) and dissolved oxygen.	Higher nutrient pulses after post-fire runoff and reduced baseflow dilution; longer low-flow periods concentrate solutes; harmful algal blooms may increase, impacting oxygen levels and aquatic communities including fish.
<i>Biology Nutrient cycling, decomposition, carbon sequestration, pollination, habitat provisioning, primary production, genetic exchange.</i>	Aquatic microbial communities	Biomass; primary productivity.	Decreased pollinator abundance and community simplification (less diversity) due to heat and vegetation loss; reduced crop pollination by native pollinators; and loss of host plants for specialist native pollinators.
	Soil microbial and fungal communities	Diversity and abundance.	Reduced diversity and biomass; slower decomposition; and impacts of fires/vegetation treatments on soil communities. If vegetation changes as a result of soil community changes it can impact shading and therefore water quality and fishing. Nutrient cycling and

			water uptake capacity of trees and other plants.
	Macrophyte communities	Species composition; abundance; biomass and primary productivity.	Reduced cover due to lower water levels, and expansion of stress-tolerant plants.
	Benthic macroinvertebrate communities	Species composition; abundance; and trophic composition.	Sensitive species decline; replaced by drought tolerant species; water quality declines reflected in macroinvertebrate community changes impact fish, fishing, and potentially drinking water; and impacts on higher trophic levels that feed on macroinvertebrates.
	Terrestrial invertebrate communities	Species composition; trophic composition; and abundance.	Decreased pollinator abundance and community simplification (less diversity) due to heat and vegetation loss; reduced crop pollination by native pollinators; and loss of host plants for specialist native pollinators.
	Aquatic vertebrate communities	Species composition; trophic composition; and abundance.	Habitat contraction for cold-water fish; and amphibians breed 1–2 months earlier.
	Terrestrial vertebrate communities	Species composition; abundance; and trophic composition.	Species move up in elevation; riparian species decline; increased dominance of generalists (animals that do not depend on specific habitat; diet; etc., highly adaptive).
	Landscape connectivity	Habitat patch size and distance between habitat patches.	Reduced patch size and increased distance between patches; increased shrub encroachment and fire fragmentation; potential for loss of biodiversity; population fragmentation; and reduction in gene flow.
	Plant communities	Species composition and abundance; biomass and primary productivity; invasive species abundance; fire pressure and dynamics; and dead and down vs. natural decomposition.	Shift to drought-tolerant shrub and grass species; forest biomass reductions; earlier green-up; reduced carbon sequestration; drying channel allowed for cottonwood seedlings to enter soil; changes in wildlife community structure; and potential to favor non-native species/lose forest-dependent species.

BREAKOUT SESSION 2 - KEY IMPACTS, STRATEGIES, DATA GAPS, AND RESEARCH NEEDS FOR INDICATOR SPECIES

Breakout Session 2 built off of the conversations about ecosystem functions to extrapolate impacts to the four indicator species being used by the Rio Grande Basin Study to determine environmental flow needs in the MRG: (1) Rio Grande cottonwoods, (2) sandhill cranes, (3) Rio Grande silvery minnow, and (4) southwestern willow flycatcher. Breakout groups were assigned one of the four species, and also discussed potential adaptation strategies for mitigating impacts, and research needs. Reference sheets of each species' life history were provided to workshop participants to inform discussions (see Appendix F).

A. RIO GRANDE COTTONWOODS

Cottonwood trees (*Populus deltoides wislizenii*) are found throughout the riparian zone along the Rio Grande from southern Colorado down to Mexico. In the MRG, they are synonymous with the bosque ecosystem to many. Participants noted that cottonwoods are especially vulnerable to the projected future, noting that there will not be enough subsurface water available to maintain current populations, and the lack of spring flow pulses will hinder growth of existing trees and recruitment of new cottonwoods through decreased germination rates and decreased survival of seedlings/saplings. Cottonwoods will also face stress from lower water quality, aridification, and erosion/sedimentation. Increased fires in the bosque will alter the microbial soil structure, further hindering cottonwood survival. And invasive vegetation density is likely to increase, leading to non-native species increasingly outcompeting cottonwoods.

Potential management strategies developed by workshop participants to mitigate the above impacts include:

- Increase channel capacity restrictions to allow for larger spring pulses
- Adjust reservoir management to improve spring pulse metrics, particularly recession limb
- New regime and succession planning
- Continue to fund the Bosque Ecosystem Monitoring Program (BEMP)
- Increased coordination between MRGCD, U.S. Bureau of Reclamation, N.M. Interstate Stream Commission/N.M. Office of the State Engineer, and Texas
- Maintain soil microbial health after fires
- Remove exotics to reduce soil disturbances
- Assess where state funding is needed to support loss of federal funding
- Education and resource support for improving cottonwood health, bringing students into the field
- Change the Rio Grande Compact Elephant Butte supply index to include upstream reservoirs (Heron, El Vado) as extensions of Elephant Butte storage. This would allow for pulse flows throughout the year, not just November through January

Identified research needs for better understanding how to manage cottonwoods and mitigate negative impacts to the species include:

- Research where/when irrigation efficiency and conservation benefit river/groundwater connectivity

- Research how Rio Grande Compact delivery times could benefit cottonwood survival and recruitment
- Monitor cottonwood leaf beetles population and impact
- Create a model for the Rio Grande Basin Study that incorporates active and continuous monitoring
- Create cultural shifts through interpersonal community communication in neighborhoods near the bosque
- Germination studies to better understand the cottonwood germination process
- Research on mistletoe infection rates on bosque cottonwoods
- Research into the efficacy of assisted migration of cottonwoods (e.g., does moving cottonwoods from drier, warmer environments to the MRG increase viability?)

B. SANDHILL CRANES

The majority of the Rocky Mountain population of sandhill cranes (*Grus canadensis tabida*) overwinter in the MRG valley, with smaller numbers wintering in southwestern New Mexico, Arizona, and Mexico. During the winter months, the cranes will nest in farmlands, wetlands, and open fields and have high site fidelity, returning to the same winter locations year after year. Water availability and irrigation infrastructure is highly important for the maintenance of these habitats. Workshop participants noted that land use changes have reduced the availability of suitable roosting habitats and access to food. This will be further exacerbated by changes in access to water from irrigation and flooding, increasing disease vulnerability and mortality from lack of resources. Changes in agricultural land will also further reduce food supply and roosting habitat. Additionally, climatic changes leading to extreme weather events and shifting in seasonal temperatures and other conditions will disrupt migration patterns and their phenology.

Potential management strategies developed by workshop participants to mitigate the above impacts include:

- More flexible land management plans to adjust to changing annual conditions
- Management plans in response to specific environmental thresholds
- Coordinate plans/actions between government, private and NGO stakeholders
- Improve communication about potential futures, anticipated needs, and transparencies in organizations/agencies
- Incentive programs for farmers with fallowed fields
- Education about the cultural significance of the sandhill crane and their economic value to increase conservation investment

Identified research needs for better understanding how to manage for sandhill cranes and mitigate negative impacts to the species include:

- Construct plausible scenarios with water/resource access and phenology changes to allow for contingency planning
- Research on minimum viable flows and groundwater levels required for cranes' access to resources
- Research the role of disease on population dynamics
- Historic case studies

- Research into agricultural expansion
- Research/knowledge distribution on basic crane biology

C. RIO GRANDE SILVERY MINNOW

The Rio Grande silvery minnow (*Hybognathus amarus*; RGSM) had a historic range throughout the Rio Grande and Pecos rivers, but today is only found in the Rio Grande south of Cochiti Dam and north of Elephant Butte Reservoir, approximately seven percent of its historic range. The species relies on the spring pulse hydrograph for spawning, and uses overbanked floodplain for larval production. It has been used as an indicator species for the general health of the river. Workshop participants identified that reduced spring flows will impact spawning events and reduce suitable nursery habitat. Fish health and survival will also be impacted from increased water temperatures from reduced canopy cover (also impacting the suitability of nursery habitat), decreased dissolved oxygen in the water column from increased temperatures and lower flows, and increased turbidity and decreased water quality from erosion and sediment deposition. Flashier monsoons will lead to variable water supply during the summer, increasing stranding events.

Potential management strategies developed by workshop participants to mitigate the above impacts include:

- Augment minnow populations to drains that are wet year round
- Rescue fish from stranded pools during low flows
- External spawning and release into suitable habitats
- Ensure minimum flows through the Rio Grande
- Sediment management
- Maintain current overbank and side channel projects

Participants also raised the question of how to manage the high cost of refuge breeding programs.

Identified research needs for better understanding how to manage for RGSM and mitigate negative impacts to the species include:

- Sediment flow statics and how they impact RGSM
- Research on suitable habitats and places for release
- External spawning growth and development support
- Effectiveness of perennial drains as silvery minnow habitat

Participants also raised the following specific questions:

- How can we predict reductions in San Juan-Chama deliveries further in advance?
- How Compact and irrigation water be moved more effectively to also benefit RGSM?

D. SOUTHWESTERN WILLOW FLYCATCHER

The southwestern willow flycatcher (*Empidonax traillii extimus*) is a migratory songbird that breeds in the riparian zones in the southwestern United States in the summer, fledges in the late summer, and migrates to its overwinter habitat in Central America in September. The species requires wide floodplains, dense vegetation, diverse habitat, and proximity to water for its breeding, nesting, and feeding habitat. Workshop participants identified that the flycatcher will face declining suitable habitat with the loss of cottonwoods and other tree canopy. Decreased canopy will also reduce nesting success. Less water accessibility will impact vegetation diversity, decreasing terrestrial invertebrates the flycatcher relies on for food. Changes to the timing of insect emergence may decrease access to food resources during critical nesting times. And fewer high quality nest sites could lead to increased interspecies competition.

Potential management strategies developed by workshop participants to mitigate the above impacts include:

- Restore flows during key times in specific suitable habitats
- Flycatcher success is tied to dense coyote willows and water within 50 m
- Implement more conservation projects based on current knowledge
- Requires flexible planning, coordinated land management, and habitat diversification

Identified research needs for better understanding of how to manage for the flycatcher and mitigate negative impacts to the species include:

- Obtain more general biology and life history information and distribute it to the community
- Suitability of mixed used habitat for flycatcher success
- Evaluation of flycatcher habitat sites to identify markers of successful habitat

BREAKOUT SESSIONS 3 AND 4 – ADAPTATION STRATEGIES FOR TRIBAL, RECREATION, AGRICULTURE/FOOD, MUNICIPAL, ENVIRONMENTAL, AND ENERGY/TECHNOLOGY WATER USES

For the third and fourth breakout sessions, participants discussed Tribal, Recreation, Agricultural/Food, Municipal, Environmental, and Energy/Technology sectors. All breakout groups discussing those sectors identified water use categories that should be considered in future adaptation planning, adaptation strategies, and potential partners needed for strategy implementation. Some breakout groups also identified data gaps, barriers, impacts, expertise and resources needed to implement strategies, and ideas for implementation.

Themes between the groups discussing Tribal, Recreation, Agricultural/Food, Municipal, Environmental, and Energy/Technology Sectors included:

- *Sovereignty & Governance*: Tribal sovereignty and co-management must be central to water decisions.
- *Stronger Collaboration and Decision Making Across Jurisdictions*: Increased communication among tribes, state, federal, and non-profit organizations are needed for more effective management of the MRG and its ecosystem.

- *Flexibility in Legal Frameworks:* Current Compact and storage rules limit adaptation across sectors.
- *Infrastructure Investment:* Aging irrigation, stormwater, and storage systems need modernization.
- *Ecological Health:* Declines in bosque health, fire risk, and biodiversity are recurring concerns along with environmental flows.
- *Water Quality:* Essential for agriculture, recreation, tribal uses, and ecological resilience.
- *Public Education:* Needed around river function, environmental flows, responsible recreation, native ecosystems, and local food systems.
- *Climate Impacts:* Reduced snowpack, higher temperatures, and hydrologic variability affect all sectors.

A. TRIBAL

Breakout sessions identified categories of Tribal water use that participants believed should be considered in future adaptation planning efforts. There was overlap with other breakout group sessions, but participants were of the opinion that Tribal uses were unique and important enough that these should also be discussed specifically within the Tribal cultural contexts. These uses included agricultural uses, domestic household uses, municipal uses (e.g., soccer fields, casinos, golf courses), recreational uses, and environmental (including in-stream flows) uses. Additionally, participants noted the importance of non-consumptive cultural and traditional water use. Participants also identified Tribal use of water for energy and technology development, which are similar to the rest of the state.

The breakout group then brainstormed potential adaptation strategies. Three main categories of strategies came out of the discussion: the first around Tribal environmental water use; the second around voluntary leasing of water, and the third around agricultural practices and food security. Participants also identified the multi-purpose use of water, and noted there are opportunities to leverage one water use to benefit others (such as agricultural water use also provides environmental benefits for bosque restoration efforts).

All the strategies below would be centered around the integration of Indigenous knowledge and values, and assurance of Tribal sovereignty.

PRIORITY ADAPTATION STRATEGIES

The breakout groups then provided more details for several priority adaptation strategies, identifying barriers, resource needs, and potential partnerships.

1. TRIBAL ENVIRONMENTAL WATER USE: INCLUDE ENVIRONMENTAL WATER USE IN TRIBAL WATER CONSIDERATIONS

In order to achieve this strategy, participants suggested two actions:

1. Tribes should consider environmental water when negotiating the Tribal water rights settlement; and
2. Leverage partnerships with other water managers and existing water infrastructure (like outfalls) to use environmental water.

Potential options include leasing water, diversifying the timing of Prior and Paramount releases, carry-over storage, and continuing Reclamation programs for irrigation infrastructure. Water could even be leased outside of Tribal boundaries as long as it was within the same basin. Participants also discussed a potential future strategy of Colorado providing a portion of federal water for Tribes - this is currently not legally feasible, but may be in the future.

This strategy would increase opportunities for keeping the river wet when other sites may dry. Strategic partnerships between Tribes and other water managers would capitalize irrigation efficiencies, and facilitate collaboration to address diminished e-flows, a changed bosque, and increased fire risk. Projects for environmental water should be driven by Tribal interests and sovereignty should be respected and honored by all actors across the state.

In order to implement this strategy, participants identified uncertainty of locations for projects beneficial to environmental water that are possible, efficient, and impactful. Legal expertise in the Tribal Water Rights Settlement Act is also needed.

Participants identified several barriers to implementation, including the need for a new water rights settlement negotiated to support implementing environmental water use. Then there is the need for funding for project implementation, Tribal buy-in, and environmental compliance (permitting, etc.). As Tribal governance can change regularly, there is a need to act quickly on project implementation.

Potential partners on strategy implementation include all the Six Middle Rio Grande Pueblos, MRGCD, the U.S. Bureau of Reclamation, non-governmental organizations, and any other interested parties.

2. VOLUNTARY PRIOR AND PARAMOUNT WATER LEASING

A related strategy would be implementation of voluntary water leasing. This would require federal authorization, with Congress signing onto the water settlement. This strategy would move to more active co-management of the Rio Grande and the water in the river. Participants also suggested a legal designation of personhood for the Rio Grande.

The key information gap is how much water is needed for Tribal use. This informs how much water each Pueblo can lease. Like above, this strategy will also require a new Tribal water settlement and the establishment of a governance infrastructure to track and enforce leased water agreements.

Potential partners for this strategy are the Six Middle Rio Grande Pueblos, MRGCD, and state and federal agencies.

3. TRIBAL FOOD SOVEREIGNTY

Participants acknowledged the important role agriculture plays in providing ecosystem services to the MRG, as well as the need for Tribal food sovereignty. The group discussed how to provide economic opportunities for Tribal youth to keep farming and develop local marketable food products. In order to achieve this, participants suggested two actions:

1. Build people capacity through job and skills training, and identify community success stories and champions to create wide-spread buy-in and increase participation; and

2. Support the formation of food and agricultural co-ops to create buying power and access to markets.

In order to implement this strategy, participants identified the need for funding and access to processing facilities (e.g., mills, commercial kitchens, slaughterhouses, etc.). Expertise needs including marketing and branding, business, grant writing, and individuals or organizations who can provide technical assistance and jobs training.

Current barriers to implementation include market access, meeting the rules and regulations to be able to sell products (e.g., food inspection, licensing, certifications, insurance), and the quality and quantity of water needed for food production. Participants also noted that there may be cultural considerations regarding economic growth with some Tribal communities considering growth beyond personal consumptive needs “excessive”.

The participants identified potential partners for implementation. These included soil and water conservation districts and farmer’s markets.

B. RECREATION

Breakout group participants identified a wide spectrum of water-dependent and water-adjacent activities that contribute to health and community well-being, economic vitality, and cultural values. Recreation activities discussed included fishing, birding, golfing, and non-motorized boating including rafting, kayaking, stand-up paddle boarding, motorized boating on lakes and reservoirs where it’s permissible, scuba diving, swimming and water play, and a range of trail-based activities including biking, hiking, running, and equestrian use. Additional uses discussed included off highway use where permissible, foraging for mushrooms, hunting, golf courses, and activities tied to spiritual and mental health benefits such as meditation and nature-based restoration. These diverse recreational activities underscore the importance of maintaining a healthy ecosystem that supports both recreation and ecological functions.

ADAPTATION STRATEGIES

Participants identified the need for a comprehensive *River Recreation, Education, and Conservation (REC) Plan*, recognizing that successful planning and implementation will require broad collaboration among federal, state, and local governments along with the list of partners listed below. Strategies include expanding stewardship and ranger programs, improving site-specific bosque and river management, creating site specific entities for addressing recreation, and determining how to maintain riparian habitats under changing conditions.

Improving trail access and signage, developing more river access points (especially in rural areas), and addressing homeless encampments were also discussed. Educational efforts focused on trail use, ecosystem health, and future changes to the landscape were considered essential. Technical needs include clarifying flow requirements for boating (e.g., approximately 500 CFS during summer), and improving coordination with partners who are listed below. Stewardship and existing programs that could be

considered as a model include the CABQ Open Space Ranger Program and Isleta Reach Stewardship programs.

KNOWLEDGE AND INFORMATION GAPS

Participants discussed assessing the public's understanding of the Rio Grande and its ecosystem to evaluate public perceptions and knowledge. A more holistic understanding of the river-bosque ecosystem is needed, including how to design landscapes that are adaptable to drought and fire, and how to identify plant species capable of continued adaptation. Educating the public was also discussed related to what constitutes a healthy and functional ecosystem and changes due to drought, fire, and hydrologic shifts.

Improving the availability of environmental safety information for recreational users, and information about river conditions, safety, and ecosystem function was discussed, and the development of a comprehensive directory of river and bosque access points in the river corridor. Additional information is needed to quantify the effects of human activity on the river and bosque, and to determine the carrying capacity of recreational areas to avoid ecological degradation.

Gaps discussed include understanding how to effectively remove invasive species, reintroduce a variety of native plants (without relying solely on cottonwood planting), and distinguish between exotic and invasive species. Additional scientific and ecological gaps include the need for detailed lifecycle studies, improved soil composition data, updates to species or vegetation "cuts lists," and expanded native seed bank strategies such as broader testing and the "shotgun method." Recreation-specific knowledge gaps include educating the BOR about kayaker needs and determining the summer flow requirements necessary to support kayaking, with current estimates suggesting a need for approximately 500 CFS.

BARRIERS

Participants discussed a wide range of ecological, social, and operational barriers. These affect the health of the Rio Grande ecosystem and its ability to support safe and sustainable recreation. Participants noted the increase in fire risk, declining biodiversity, including losses in bird populations, and the degradation of iconic riparian landscapes such as cottonwood stands. Hydrologic challenges, including fluctuating water flows, lack of floodplain activation, reduced natural disturbance, and warming water temperatures, further limit ecosystem function.

Water-quality concerns are affected by human activities, sunscreen, algae, and bacteria – all posing risks to ecosystem health. Administrative and social barriers discussed included complex permitting processes, business-permitting hurdles for boating, and unresolved human dimensions issues such as encampments. Limited public education, insufficient technical expertise, and a need for specialized staff—such as botanists, biologists, hydrologists, environmental educators, and stewards were discussed as a need to help with better management and stewardship. Collectively, these factors contribute to reduced management of the ecosystem including habitat diversity, and challenges to implementing coordinated restoration and recreation strategies.

EXPERTISE NEEDED

Effective management, restoration, and long-term stewardship of the river and bosque will require a diverse range of professional expertise. Participants emphasized the need for a dedicated technical team supported by specialists such as botanists, biologists, and hydrologists to guide ecological planning, restoration design, and monitoring. They also mentioned environmental educators and community stewards as essential for public engagement, on-the-ground management, and fostering a shared understanding for ecosystem health and recreation needs. An interdisciplinary and collaborative approach would help to address complex ecological challenges, and enhance recreational safety and access.

RESOURCES NEEDED

Advancing effective restoration, recreation management, and long-term stewardship will require strengthening and aligning available resources. Participants highlighted the importance of building on existing efforts, such as the MRG Conservation Action Plan, while fostering an environment of openness, transparency, and consistent communication with surrounding neighborhoods. Together, these resources form the foundational support system needed to guide coordinated planning, implement large-scale ecological actions, and sustain community engagement across the river corridor.

PRIORITIES

The priorities include: 1) developing a river “REC Plan” including recreation, education, and conservation, 2) developing a stewardship/ranger program, and 3) creating site specific management entities to include recreation as well as natural resource management.

PARTNERS

Strong, collaborative partnerships are essential to advancing coordinated management, restoration, and recreation planning. Participants emphasized the importance of maintaining open, honest engagement with communities while strengthening relationships with key governmental and tribal partners. Partners that were identified included for planning and implementation included: Tribes, CABQ and other cities, counties, USBR, BLM, Army Corp, conservation districts, water authorities, state parks, state office of outdoor recreation, MRGCD, guides and outfitters, soil and water conservation districts, recreation managers, and organizations such as the Paddlers Coalition, Adobe Whitewater, and NM Aquatic Connectivity Team. Involvement of tribes, local, state, and federal government partners would provide critical cultural insight, governance alignment, and needed operational capacity. Aligning priorities and work on consistent communication were also discussed as a need for planning and the ability to provide sustainable recreational access while balancing ecosystem needs.

C. AGRICULTURE AND FOOD

Participants discussed the importance of agriculture for ecosystem health in the MRG, pointing to the role that irrigation infrastructure plays in groundwater recharge, supporting vegetative communities, and keeping the river wet. In turn, agricultural systems require healthy ecosystems, including forests. The group noted the importance of including all consumptive uses in planning to avoid siloing. Participants identified the following agricultural water use categories: ranching, forage crops, dairy, livestock, wildlife

management, food systems, irrigation, and consumable food production. Participants emphasized the important differences in water use between “big” agriculture and smaller farms which must be considered during planning. They also noted that irrigation water can be from different sources (rain, surface, municipal, and/or groundwater).

PRIORITY ADAPTATION STRATEGIES

Ultimately, workshop participants identified three priority strategies for development and implementation:

- Reduce agricultural evapotranspiration (ET).
- Increase food security for the MRG.
- Better align water storage, conveyance, and releases with agricultural and ecosystem needs.

AGRICULTURAL EVAPOTRANSPIRATION

ET is driven by crop water use and climatic factors. The group identified needing to increase the water budget through increased efficiency of water use as well as expanding the available water supply. The group noted that there were economic barriers, identifying that interventions will involve purchasing new technology, installing new infrastructure, adopting different management practices, and implementing pest management.

Potential strategies to reduce agricultural ET include improving soil health, reducing “ponding” (standing water in a closed depression) without compromising groundwater recharge, crop conversion, conjunctive water use, and expanding existing conservation programs.

FOOD SECURITY

Supporting initiatives to increase local and regional food security benefits local farms, ranches, and other food producers, which in turn keep agricultural land in production in the MRG. Participants discussed the importance of ensuring there was a local market for produce, which requires labor, infrastructure, and investment. Transporting products to market is costly, and high water quality standards are needed for crop production. Growing consumer demand for local agricultural products and increasing market access benefits the MRG ecosystem and provides an economic path for local producers to keep farming.

Specific strategies identified by the workshop participants to address these issues were:

- Investments to ensure high water quality standards.
- Control turbidity and sediment in irrigation water, as sediment levels can kill young crops.
- Support irrigation infrastructure.
- Support water markets to enable transfer of water rights.
- Marketing campaigns to educate the community on local food production and how to access local produce. This can include television and social media advertising.
- Invest in cultural education around the history of agriculture in the MRG, and support intergenerational learning.

Participants discussed other opportunities to make local agriculture more economically viable, self-sufficient, and sustainable. They noted the need for more data on production and the efficacy of different

interventions. One participant suggested researching how adaptable cows were to renewable technology adoption on the farm, such as solar panels and shade powering water pumps.

Specific barriers identified were availability and access to food processing facilities, such as mills and slaughterhouses, the need to develop land use planning documents, and a lack of professional training opportunities.

WATER STORAGE, CONVEYANCE, AND RELEASES

Workshop participants noted the current limitations in operational flexibility which constrains the agricultural community's ability to adapt to the projected future hydrological variability. They noted the need to be able to align water releases with the needs for agriculture, species, and recreation. One example is changing storage for Rio Grande Compact deliveries to allow for on-demand deliveries from flood control infrastructures that double as water storage (e.g., ponds, underground storage) and moving storage to northern reservoirs. This would also mitigate evaporative loss from Elephant Butte Reservoir.

Participants also identified the following potential strategies:

- Conservation easements and increasing payments and tax credits.
- Providing credit for actions that benefit the ecosystem, such as groundwater recharge, habitat creation, keeping viewsheds clear, and contributing clean air quality.
- Option to transfer water rights.
- Creating an environmental benefits index, including water supply in upstream reservoirs.

In order to implement these strategies, changing to the current legal framework for water operations is needed, as well as permitting for new flood control and storage infrastructure. There also must be political will and community support for keeping agricultural land in production. Currently, the MRG has been losing farmland and the resulting land development has impacted overall ecosystem health. Also, the uncertainty of future conditions makes it difficult to plan.

Partners for implementation include soil and water conservation districts, MRGCD, irrigators, educational institutions, NM Office of the State Engineer/Interstate Stream Commission, Rio Grande Agricultural Land Trust, and the U.S. Bureau of Reclamation.

D. MUNICIPAL

Breakout sessions identified categories of municipal water use that participants believed should be considered in future adaptation planning efforts. These included residential indoor, residential irrigation, institutional use (such as city buildings, parks), industrial (manufacturing), commercial businesses, landscaping, stormwater, community recreation, and sewage. Regarding industrial water use, participants noted that much industrial use is not consumptive and there have been reductions in consumptive use. They also acknowledged the need to balance water use with the need for jobs for the community, and that there tends to be community pushback when the industry is not aligned with community values.

PRIORITY ADAPTATION STRATEGIES

Participants brainstormed potential adaptation strategies for municipal water uses. These include increased efficiency in building and zoning codes, utilizing WaterSMART Grants, refusing new consumptive development through permits and zoning, and de-privitizing utilities to reduce the incentive for consumption. The priority strategies that the groups discussed were:

1. Shifting from non-functional turf to trees and xeriscapes;
2. Community action and cross-jurisdictional collaboration to reflect community values;
3. Rate changes and implementing education and outreach about tiered rates; and
4. Address stormwater.

SHIFTING FROM NON-FUNCTIONAL TURF TO TREES AND XERISCAPES

The elements of this strategy would require knowledge about the alternatives to turf that would be water efficient and adapted to the future climate of New Mexico, and incentives for adoption, and political collaboration and will. The breakout groups identified the need for an analysis on the heat island effect and water use of turf vs. trees and xeriscapes, and a list of drought tolerant trees and plants that can be planted. The key resource needed was funding for implementation.

The participants noted there were currently no strong incentives for xeriscaping. And political cross-jurisdiction collaboration and community was required for widespread adoption, which means buy-in and participation from state, county, and city agencies as well as neighborhood associations and community groups.

RAISE UTILITY RATES AND/OR CHANGE RATE STRUCTURES

Workshop participants acknowledged this strategy would be one of the hardest to implement, but agreed this was a priority as it has a high impact potential. Currently, in Albuquerque, there are three tiers to the rate structure. The group discussed the potential for raising rates and increasing the number of tiers. The main barrier for implementation was political will.

Participants identified the need to develop more efficient industrial water uses, and a better understanding of what tiers are economically motivating. There was also a need for cross-agency partnerships and cooperation.

TRANSFORM COMMUNITY VALUES INTO COMMUNITY ACTION

Water is already a community priority for Albuquerque. Participants discussed how to leverage that into community action and collaboration. The main crux of this strategy is the need for public education and communication around current policies and political actions. The group noted the need to reframe the conversation around water into a conversation about jobs and economic development, which required a need for a better understanding on what those economic and workforce development opportunities were.

Participants noted the key barriers were a lack of public awareness of water policy, and a lack of political will. They suggested that increased awareness through education, communication, and education will in turn impact decision-makers to act.

Potential partners for implementation include neighboring jurisdictions and economic interests, including the New Mexico Economic Development Department.

ADDRESS STORMWATER

This adaptation strategy encompasses several actions to address stormwater, which can have a negative impact on Rio Grande health, contributing to impaired water quality, erosion and sedimentation (due to the high flow of the stormwater runoff from cemented drains), and minimal contributions to groundwater recharge. Participants identified the following actions to both mitigate negative impacts of stormwater runoff and create benefits:

- Incorporate stormwater management into planning and zoning.
- Change conveyance to allow for more percolation and increase water quality.
- Create habitat for species and recreation spaces through rewilding retired agricultural fields, increasing ecosystem services that would slow down and treat stormwater
- Better distribute infiltration to groundwater.
- Use stormwater for landscaping instead of raw or treated water.
- Reduce per capita water use.
- Increase industrial and commercial water recapture.
- Provide assistance to smaller communities to implement strategies.

Key data and information gaps included the quantity of municipal stormwater reaching Elephant Butte Reservoir, the level of funding needed for stormwater infrastructure, and what an effective pricing structure would look like in order to encourage non-potable water use. Participants also suggested looking at what has worked in other states.

For implementation, both funding and workforce capacity is needed. Barriers to implementation are both regulatory and logistical. Currently, state law mandates that stormwater can only be held for a maximum of 96 hours. Implementation is also constrained by Rio Grande Compact delivery obligations and current zoning and planning laws. There is also a financial cost to upgrade stormwater infrastructure and to remove non-needed impervious surfaces.

Participants identified state and local agencies, environmental groups, and the Flood Control Authority as potential implementation partners.

E. ENVIRONMENT (INCLUDING ECOSYSTEM SERVICES)

Breakout groups discussing environmental water use, including for ecosystem services, identified the following categories of environmental water to be considered in future adaptation planning: environmental flows, including base flow and spring pulse runoff; species needs, including habitat needs and phenological needs; shallow depth-to-groundwater; environmental services, including those provided by wetlands (water filtration, recreating historic conditions) and upland forests (soil stabilization, snow and snowpack); cultural uses; riparian evapotranspiration and habitat; seed transport and propagation; instream flow for fish and other aquatic species; urban heat island reduction; public health via clean air and water quality;

stormwater runoff; ecosystem services provided by agricultural land; and flood irrigated agricultural (providing wetlands for migratory birds).

Participants then discussed potential adaptation strategies. These included keeping water rights in communities with incentives for conservation easements and other tools, modifying Rio Grande Compact deliveries to take into account environmental water use, adopting a resilient riparian mosaic, expanding engagement and public outreach on the importance of environmental water, and moving to a bio-regional framework promoted by the [Design School for Regenerating Earth](#).

PRIORITY ADAPTATION STRATEGIES

Participants identified the following two main areas to focus on for environmental water use:

- Maintain and ensure instream flow.
- Decrease variability in groundwater levels and contribute to recharge.

INSTREAM FLOW

The group noted the following future impacts on instream flow: reduced surface water, changes to peak flow, more groundwater pumping leading to more river losses, reduced floodplain connectivity, changes in the aquatic community, changes in water quality, and changes in riparian composition. The participants identified four priority strategies to address instream flow:

1. *Ban the sale of ravenna grass.* In addition to the ban, remove existing ravenna grass from public lands, and encourage the removal of ravenna grass from private lands through providing replacement native species. More information is needed on effective control methods for ravenna grass. And there needs to be funding for ravenna grass removal, and to provide replacement species for planting. The group also noted a need to educate the public on the negative impacts of ravenna grass and other invasive plant species, and on alternative species to plant. Related strategies include expanding native plant kits and adopting a policy of allowable domestic and commercial landscape plant palettes.

Participants noted the following barriers for implementation: individual property owners' rights to plant ravenna grass and other invasive species, retailer buy-in, the need for long-term maintenance, and the need for long-term program sustainability.

Partners for this strategy include the governmental agencies such as the City of Albuquerque, the NM Interstate Stream Commission, Bernalillo County, Albuquerque-Bernalillo County Water Utility Authority; non-profits such as the Xerces Society for Invertebrate Conservation, which maintains a native plant list; homeowners and neighborhood associations; and good samaritans interested in invasives species control.

2. *Maintain baseflows.* In order to maintain and contribute to instream baseflows, participants identified a number of potential strategies, ranging from restoration activities, changes in water operations and policy/law, and providing incentives for voluntary actions.

Potential strategies for restoration or utilizing natural features include:

- Wetland restoration, including for beaver habitat
- Upland water restoration
- Riparian restoration with plants that are more water efficient
- Floodplain reconnection
- Using ponds, expanding refugia during low flows and in-seam pool creation

Potential strategies for changing water operations and policy/law include:

- Change in irrigation season timing
- Establish legislation to establish instream flows as a beneficial use
- Conservation easements
- Establishing environmental rights for the Rio Grande (“personhood”) and bosque species

Potential strategies for incentivizing and encouraging voluntary actions include:

- Voluntary reduction in diversion and voluntary change in crops.
- Incentives for voluntary leases of instream flow to third parties, such as tax credits or compensation.
- Property tax breaks based on consumption.

For implementation for each of the above, participants identified the need for financial resources to fund instream flow leasing, outside the channel hydro-connected storage options, and outreach and education activities. There also needs to be policy incentives for adoption of voluntary actions.

In order to facilitate more effective implementation of these strategies, participants identified the need more information on the role of the leading arm of the hydrograph for instream flows—specifically, the amount of instream flow needed to achieve ecosystem functions and services. Working with water managers and water users, feasible options need to be developed for how to achieve that instream flow target during low flow year. Demographic studies in order to understand the viewpoints of perspectives of different water users (e.g., urban, agricultural), would also help inform implementation.

3. *Communication and outreach.* Participants suggested different outreach programs and activities in order to inform targeted communities and the general public on the general state of the Rio Grande presently and into the future, and discrete actions individuals can take to conserve water and/or contribute to overall riverine health. This in turn will create public support for regulatory and policy change.

Potential partners in developing and implementing communication and outreach efforts include trusted institutions and organizations, reporters, and legislators. Participants emphasized that messaging should focus on voluntary rather than prescriptive actions, and also give the audience hope. Different communication avenues identified were:

- Conversations with community members and the general public on how to address environmental water uses and keep water in the river.
- Outreach programs on implementable advantageous solutions to meet water needs

- Using the media to increase awareness of the issues facing the Rio Grande. Reporters telling the stories can encourage members of the public to vote and take other actions.
- Messaging targeting legislators to build political will.
- Leveraging existing organizations and institutions (e.g., MRGCD) to increase awareness for the bosque.
- Raise awareness with irrigators on existing MRGCD programs that incentivize dynamic fallowing and split irrigation seasons.

Current barriers to successful implementation include the Rio Grande being over allocated and current regulatory and legal requirements that limit water operational flexibility (e.g., Rio Grande Compact, the Doctrine of Prior Appropriation, current water adjudications, and time limitations on water operations).

4. *Fill and/or raise the grade of drains.* This would slow water recession and allow for longer inundation times. This strategy would also elevate levees and reduce flooding, increase channel capacity, and raise the water table. While engineering the drains, concurrent strategies can be implemented to restore bosque health along the project areas by addressing vegetation encroachment, removing invasive species, and managing the floodplain for sediment deposition.

Participants recommended pilot projects to test the effectiveness of this strategy. Implementation will require funding and engineering expertise and buy-in. Potential partners would include MRGCD, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and adjoining landowners. A potential barrier is ensuring this strategy does not conflict with MRGCD's statutory mission.

GROUNDWATER

The group identified future impacts on groundwater. Groundwater levels will have increasing variability, caused directly from variability in surface water, a dropping water table from channel incision and decreasing recharge, and water take-up by a changing riparian vegetative community. This variability in turn impacts species survival – species are not adapted to handle variability in groundwater to such extremes. Native cottonwoods, outcompeted by invasive species about to reach the lower groundwater faster, are dying off, increasing wildfire risk.

Participants identified the following potential adaptation strategies to address groundwater:

- Improving water storage to support aquifer recharge and aquifer storage and recovery.
- Maintain baseflows.
- Manage Rio Grande Compact deliveries to maintain baseflows.
- Manage the spring pulse to extend the descending limb of the hydrograph.

The group discussed the need for a better understanding of how wastewater returns impact groundwater, including agricultural runoff and municipal runoff.

F. ENERGY AND TECHNOLOGY

Note: This category of water use had the least engagement and workshop participants acknowledged there was insufficient expertise in the room to have a robust discussion on water uses for energy and technology. Participants recommended a more focused workshop specifically on this topic with targeted invitations to those working in the energy and technology sectors.

Workshop participants identified the following subcategories of water use under Energy and Technology that should be considered in future adaptation planning:

- Oil and Gas, which uses water for drilling and fracking and has a byproduct of produced water;
- Geothermal, including cooling for certain technology, and has the potential to damage the aquifer;
- Data centers, which use evaporative cooling;
- Biofuels, which need water for production; and
- Solar, which needs cooling for battery storage.

PRIORITY ADAPTATION STRATEGIES

The group focused on discussing and developing adaptation strategies around produced water from oil and gas development, and data centers. Common themes in both areas were the need for data transparency and the potential for technology innovation. In addition to the strategies detailed below, workshop participants developed the following strategies:

- Rain water harvesting on large buildings with data counters.
- Incorporating on-site built infrastructure, such as solar panels over parking lots and on large buildings. This would mitigate wildlife and ecosystem impacts of solar fields.

PRODUCED WATER FROM OIL AND GAS

The group discussed adaptation strategies for oil and gas use of water. They identified the impacts of oil and gas production, noting the potential for contaminating surface and groundwater, the need for water in production, and the produced water byproduct. Specific strategies to address these include increased data transparency on contamination and make-up of produced water, developing less water dependent technologies and techniques, and identifying short- and long-term goals for the industry. The group also discussed transitioning away from oil and gas.

Participants identified addressing produced water as a priority strategy. This would include three steps:

1. Increasing data transparency through implementing a legal framework for acquiring proprietary information on the constituent chemicals in produced water.
2. Technology development for treating produced water, opening up another source of water that could be used in place of raw or potable water.
3. Develop collaborations between agencies, research institutions, communities, and other water users.

The group also identified the potential for using produced water instead of raw/potable water for drilling and fracking.

Currently, little is known about the rates and instances of surface water and groundwater contamination. And the chemicals used in oil and gas production are currently considered proprietary. Barriers to implementation include industry resistance, competing agendas, and public trust/perception on the safety of treated produced water. There is also a need for a legal and regulatory process for the treatment and use of produced water, and incentives for technological development for treatment methods. One question raised was who would be responsible for paying for the treatment of produced water - industry or taxpayers?

DATA CENTERS

Participants also prioritized addressing data centers, pointing to the high water use from both evaporative cooling and power use for daily operations. The following strategies were identified to reduce water use by data centers:

- Recirculate, reuse, and recycle water to reduce water use.
- Use produced or brackish water instead of raw water.
- Adopt alternative energy sources (e.g., geothermal).
- Develop and use alternative cooling methods that require less water.
- Transparency on water and power usage, and greenhouse gas emissions from data centers.

Currently, there is no accurate public data on water use from data centers. And there is a lack of regulatory framework around water and energy use at data centers, as they are not subject to the Energy Transition Act. Workshop participants identified the need for an interdisciplinary approach with industry, and financial incentives for technological innovation.

Implementation partners would include research institutions, industry, state and local agencies, and policymakers.

NEXT STEPS

Debbie closed the meeting by summarizing anticipated next steps. She invited workshop participants to continue the conversations from the workshop, and take the lead in moving some of the strategies forward. The workshop summary report contains the adaptation strategies developed during the workshop, and the identified research questions/information gaps.

Future conversations will include specific engagement with Pueblo and Tribal partners, and with the Technology and Energy sectors. The World Wildlife Fund is already planning a follow-up workshop focused on agricultural water use sometime in 2026.

Specific outcomes of the workshop will be provided to different managers. The impacts to the ecosystem and species will be provided to land and water managers, and to the Middle Rio Grande Endangered Species Collaborative Program. The adaptation strategies will be provided to ongoing planning efforts such as the Rio Grande Basin Study, and to agencies undergoing their own adaptation planning, such as Valencia Soil and Water Conservation District. The research questions and information/data gaps will be incorporated into the New Mexico Resilience Research Strategy being developed by the ARID Institute, and will be made available to researchers and students. One of ARID's long-term goals is to link the research happening at UNM and other research institutions with management outcomes.

Additionally, workshop participants suggested the following:

- Webinars from others working on water from around the world in order to learn from other planning efforts.
- Spring 2026 river float trip
- Field trips separate from workshops
- Partner to provide capacity building

Anne Kinsinger closed the workshop, thanking participants for their engagement and the enriching conversations. She emphasized that one of the most important outcomes from the workshop was the community, and she hoped that the collaboration will continue and grow.

APPENDICES

- A. Agenda
- B. Participant list
- C. Spreadsheet for Breakout Session 1 - Climate Impacts to Ecosystem Functions
- D. Spreadsheet for Breakout Session 2 - Climate Impacts of Ecosystem Functions to indicator species including Cottonwood, Sand Hill Crane, Rio Grande Silvery Minnow, and Southwestern Fly Catcher

(Note that Breakouts 3 and 4 used flip charts for notetaking instead of spreadsheets, so consolidated notes are not available)

- E. Climate futures overview
- F. Indicator species reference
- G. Bibliography
- H. Workshop Presentations:

Debbie Lee, Senior Program Manager, University of New Mexico, ARID Institute
Presentation: Scenario Planning Overview & Anticipated Workshop Outcomes

Teresa Smith de Cherif, Board Chair, Valencia Soil & Water Conservation District
Presentation: Middle Rio Grande & Whitfield Wildlife Conservation Areas: A Case Scenario of Drought and Drying Futures

Paul Tashjian, Director of Freshwater Conservation, Audubon Southwest
Presentation: Drought and River Drying Futures Overview

Enrique Prunes, Rio Grande Manager and Freshwater Lead Specialist World Wildlife Fund
Presentation: MRG Water Use versus Water Budget

Emma Metcalf and Lucas Barrett, Resource Management Coordinator and Hydraulic Civil Engineer, U.S. Bureau of Reclamation
Presentation: Rio Grande Basin Study: Modelling Overview

Diane Agnew - Water Rights Program Manager,, Albuquerque Bernalillo County Water Utility Authority
Presentation: Groundwater Futures: Groundwater Management and Aquifer Response

Dagmar Llewelyn, volunteer with ISET International, and Stephanie Mladinich, Climate Adaptation Specialist, South Central Climate Adaptation Science Center
Presentation: Climate Change in the Middle Rio Grande

Stephanie Mladinich, Climate Adaptation Specialist, South Central Climate Adaptation Center
Presentation: Introduction to Breakout Session

Janna Martinez, Student University of New Mexico Student working for ARID Institute

Presentation: Introduction to Breakout Session 2- Indicator Species and Habitat: Implications of Changes in Ecosystem Function

Stephanie Russo Bacca, Staff Attorney with the UNM Utton Transboundary Resources Center and a member of the MRGCD Board

Presentation: Human Dimensions of Water Use in the Middle Rio Grande: Past, Present and Future

Alice Main, City of Albuquerque Office of Sustainability, Carbon Pollution Reduction Grant Manager
Presentation: Central New Mexico Climate Action Plan's Top Adaptation Strategies

Debbie Lee, Senior Program Manager UNM Arid Institute and Stephanie Mladinich, South Central Climate Adaptation Science Center

Presentation: Introduction to Breakout Sessions 3 & 4: Categories of Water Use

Debbie Lee, Senior Program Manager UNM Arid Institute

Presentation: Report outs and Open Discussion Strategies

APPENDIX A: Workshop Agenda

A. WORKSHOP AGENDA

Future Scenarios Planning for Drought and River Drying in the Middle Rio Grande

October 28-29, 2025

University of New Mexico Rotunda

801 University Blvd SE, Albuquerque, NM 87106

Workshop Objectives:

- Create community and build partnerships in the Middle Rio Grande
- Develop a shared understanding of a probable climate future
- Center water uses within a framework of ecosystem functions, and discuss the future impacts on the MRG's ecological, hydrological, and recreational resources
- Link human water use to ecosystem and species water needs
- Identify appropriate adaptation strategies to implement and test for different water uses
- Contribute to fire- and drought-adapted restoration planning in the bosque
- Pilot a multi-disciplinary ecosystem functions-based approach to climate adaptation planning

DAY 1: Drought and River Drying Futures, Ecosystem Functions, and Scenario Impacts

Time	Activity	Presenter
8:30 - 9:00 AM	Registration and Breakfast	
9:00 - 9:10 AM	Welcome	Patrick McCarthy, Thornburg Foundation
9:10 - 9:20 AM	Presentation: Scenario Planning Overview & Anticipated Workshop Outcomes	Debbie Lee, University of New Mexico, ARID Institute
9:20 - 9:35 AM	Presentation: Middle Rio Grande & Whitfield Wildlife Conservation Areas: A Case Scenario of Drought and Drying Futures	Teresa Smith de Cherif, Valencia Soil & Water Conservation District
9:35 - 9:50 AM	Presentation: Drought and River Drying Futures Overview	Paul Tashjian, Audubon Southwest
9:50 - 10:05 AM	Presentation: MRG Water Budget	Enrique Prunes, World Wildlife Fund
10:05 - 10:25 AM	Presentation: Hydrologic Futures	Emma Metcalf, John Branum, Lucas Barrett, U.S. Bureau of Reclamation
10:25 - 10:40 AM	Presentation: Groundwater Context	Diane Agnew, Albuquerque

APPENDIX A: Workshop Agenda

	Futures	Bernalillo County Water Utility Authority
10:40 - 11:00 AM	Presentation: Projected Climate Futures	Dagmar Llewelyn and Stephanie Mladinich
11:00 - 11:10 AM	Break/Move to Breakout Sessions	
11:10 - 11:15	Introduction to Breakout Session 1	Stephanie Mladinich, South Central Climate Adaptation Science Center
11:15 AM - 12:00 PM	Breakout Session 1: Ecosystem Functions <ul style="list-style-type: none"> ● What are likely climate impacts to ecosystem functions? ● What ecosystem functions are missing from the list? 	
12:00 - 1:00 PM	Lunch (provided)	
1:00 - 1:10 PM	Introduction to Breakout Session 2: Implications of Changes in Ecosystem Function <ul style="list-style-type: none"> ● Indicator Species assignments ● Habitat ● Link & Implications of Human Uses of Water 	Janna Martinez, UNM ARID
1:00 - 2:00 PM	Breakout Session 2: Species & Habitat Impacts Exercise <ul style="list-style-type: none"> ● Impacts of ecosystem functions to indicator species ● Impacts to habitat, life history, and water requirements 	
2:00 - 2:30 PM	Breakout Session Report Outs	
2:30 - 2:45 PM	Day One Wrap Up and Plan for Day Two	Debbie Lee, UNM ARID
2:45 PM	Day One Adjourn	

Optional Field Trip: Whitfield Wildlife Conservation Area

3:00 PM	Leave for Whitfield (optional field trip)	
3:00 - 3:45 PM	Travel to Whitfield	
3:45 - 5:00 PM	Walking Tours of Whitfield	
5:00 - 6:30 PM	Dinner	

APPENDIX A: Workshop Agenda

6:30 - 7:15 PM	Bus back to UNM	
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Day 2: Gaps & Strategy Building

8:30 - 9:00 AM	Breakfast	
9:00 - 9:20 AM	Welcome to Day 2 <ul style="list-style-type: none"> ● Summary from Day 1 ● Breakout Session Topics ● Anticipated outcomes from Day 2 	Debbie Lee
9:20 - 10:00 AM	Presentation: Human Dimensions of Water Use in the Middle Rio Grande: Past, Present and Future	Stephanie Russo Bacca, UNM Utton Transboundary Resources Center
10:00 - 10:15 AM	Presentation: Central New Mexico Climate Action Plan's Top Adaptation Strategies	Alice Main, City of Albuquerque Office of Sustainability
10:15-10:30	Q & A	
10:30 - 10:40	Introduction to Adaptation Strategy Activity <ul style="list-style-type: none"> ● Breakout session topics (pick 2, opportunities for input for others) ● Adaptation Strategy selection, development, prioritization ● What is needed for action (working groups, research, collaboration, workshops, training) 	Debbie Lee, UNM ARID & Stephanie Mladinich, South Central Climate Adaptation Science Center
10:40 AM - 12:00 PM	Breakout Session 3: Topic 1 <i>Participants select 1st topic to participate in discussion about</i> <ul style="list-style-type: none"> ● Identify strategies for mitigation and adaptation <ul style="list-style-type: none"> ○ Potential partnerships ○ Information and data needs ○ Barriers for implementation ○ Ongoing actions already underway ○ Resources and expertise needed to implement strategies 	

APPENDIX A: Workshop Agenda

	<ul style="list-style-type: none"> Identify top 3 priority strategies 	
12:00 - 1:00 PM	Lunch & Networking	
1:00 - 2:15 PM	<p>Breakout Session 4: Topic 2 <i>Participants select 2nd topic to participate in discussion about</i></p> <ul style="list-style-type: none"> Same as above 	
2:15 - 3:00 PM	<p>Open Discussion: Prioritized Adaptation and Mitigation Strategies</p> <ul style="list-style-type: none"> Actionability Planning Opportunities for future collaboration, working groups, etc. Present back the top adaptation strategies from each water use 	
3:00 - 3:15 PM	Workshop Summary, Next Steps	
3:15 - 3:30	Closing Remarks	Anne Kinsinger, UNM ARID Institute
3:30	Adjourn	

APPENDIX B: Participant List

B: PARTICIPANT LIST

NAME	TITLE	AFFILIATION
Ansbert Aduko	Student	University of New Mexico
Diane Agnew	Water Rights Program Manager	Albuquerque Bernalillo County Water Utility Authority
Jade Allen	Geomorphologist	N.M. Interstate Stream Commission
Missy Bacigalupa	Coordination Manager	Bosque Ecosystem Monitoring Program (BEMP)
Yining Bai	Hydrologist	N.M. Interstate Stream Commission
Lucas Barrett	Civil Engineer	U.S. Bureau of Reclamation
Amelia Barrow	Water Resources Specialist	Middle Rio Grande Conservancy District
Chelsey Begay	NM Tribal Liaison	South Central Climate Adaptation Science Center
Becky Bixby	Research Professor, Biology; Director Water Resources	University of New Mexico
John Branum	Civil Engineer	U.S. Bureau of Reclamation
Dustin Chavez-Davis	Bosque Project Coordinator	City of Albuquerque Open Space Division
Martha Cooper	Freshwater Program Dir.	The Nature Conservancy
Colleen Cunningham	Environmental Coordinator	N.M. Interstate Stream Commission
Tucker Davidson	Senior Water Associate	Audubon Southwest
Jennifer Davis	Biologist	Fish and Wildlife Service NMESFO
Marcy DeMillion	Owner	Connecting Visions
Jancoba Dorley	Civil Engineer	U.S. Bureau of Reclamation
Katelyn Driscoll	Research Ecologist	U.S. Forest Service
Amy Erickson	Conservation Specialist	Rio Grande Agricultural Land Trust
Rachel Finkelstein	Climate Policy Bureau Chief	N.M. Energy, Minerals and Natural Resources Dept
Megan Friggens	Research Ecologist	U.S. Forest Service, Rocky Mountain Research Station
Abdul Ganiu Tanko	Research Assistant	Community and Regional Planning - UNM
Lynette Giesen	Middle Rio Grande Program Coordinator	U.S. Bureau of Reclamation
David Gutzler	Professor Emeritus	University of New Mexico Earth & Planetary Sciences; Private Consultant
Grace Haggerty	Sr. Hydrologist	N.M. Interstate Stream Commission
Mike Hamman	Consultant	Corrales Farmers Cooperative

APPENDIX B: Participant List

NAME	TITLE	AFFILIATION
Elaine Hebard	Una Sabia	Sabias de Agua
Michael Hinke	CEO	EO-Insight
Pam Homer	Strategic Water Reserve Lead	N.M. Interstate Stream Commission
Alison Hutson	Supervisory Biologist	N.M. Interstate Stream Commission
Casey Ish	Director of Lands & Conservation	Middle Rio Grande Conservancy District
Mark Kelly	Water Resource Manager	Albuquerque Bernalillo County Water Utility Authority
Anne Kinsinger	Director, ARID Institute	University of New Mexico, ARID Institute
Debbie Lee	Senior Program Manager	University of New Mexico, ARID Institute
Matt Leister	Science Manager	Bosque Ecosystem Monitoring Program (BEMP)
Dagmar Llewellyn	Volunteer	Institute for Social and Environmental Transition (ISET)
Jared Lucian	Research Assistant	U.S. Forest Service, Rocky Mountain Research Station
Alice Main	CPRG Manager	City of Albuquerque Office of Sustainability
Aidan Manning	Rivers and Waters Program Associate	NM Wild
Anne Marken	Water Operations Manager	Middle Rio Grande Conservancy District
Monique Marquez	Program Coordinator	U.S. Bureau of Reclamation
Quantina Martine	Water Resource Specialist	Rio Grande Agricultural Land Trust
Janna Martinez	ARID Student Assistant	University of New Mexico
Anne Maurer	Indian Water Resources Technical Lead	N.M. Interstate Stream Commission
Patrick McCarthy	Senior Water Policy Officer	Thornburg Foundation
Chad McKenna	Ecologist/GIS Analyst	GeoSystems Analysis
Colleen McRoberts	Superintendent	City of Albuquerque Open Space Division
Emma Metcalf	Resource Management Coordinator	U.S. Bureau of Reclamation
Stephanie Mladinich	Climate Adaptation Specialist	South Central Climate Adaptation Science Center
Melinda Morgan	Regents' Professor	University of New Mexico, Geography and Environmental Studies
Adrian Oglesby	Director	University of New Mexico, Utton Center
Laura Paskus	writer/producer	writer/producer

APPENDIX B: Participant List

NAME	TITLE	AFFILIATION
Eugene Pickett	Founder/Chairman Black Farmers and Ranchers New Mexico Global	NM Food and Agricultural Policy Council Governance Committee; Valencia County Soil & Water Conservation District
Evan Pilling	Grants Coordinator	N.M. Outdoor Recreation Department
Robert Pine	Hydrogeologist Specialist	N.M. Bureau of Geology and Mineral Resources
Enrique Prunes	Manager Rio Grande Program	World Wildlife Fund
Monique Queen	Resource Specialist	Bernalillo County Open Space
Welsey Reinig	Community Volunteer Ambassador	AmeriCorps/Conservation Legacy
Cecilia Rosacker	Executive Director	Rio Grande Agricultural Land Trust & MRGCD Irrigator
Ari Rosner-Salazar	Director of Community Outreach & Partnerships	United Way of North Central New Mexico
Stephanie Russo Baca	Board of Directors, At-Large	Middle Rio Grande Conservancy District
Blane Sanchez	NA	
Anlo Schmitt-Olivier	Research Translation Officer	University of New Mexico
Nathan Schroeder	Restoration Division Manager	Pueblo of Santa Ana
Charles Schuab		
Kathryn Schulte	Rancher	Circle A Ranch
Virginia Seamster	Assistant Chief for Technical Guidance	N.M. Department of Game and Fish
Francesca Shirley	Senior Water Resources Scientist	Albuquerque-Bernalillo County Water Utility Authority
Anusha Shrestha	Water Resources Graduate Student	University of New Mexico
Maurianna Silk	Environmental Program Manager	Pueblo of Jemez
Mari Simbana	Open Space Manager	Bernalillo County Open Space
Jeremy Simon	ORISE Climate Research Fellow	Rocky Mountain Research Station/ORISE
Sarah Smith	Rio Grande Program Manager	Theodore Roosevelt Conservation Partnership
Teresa Smith de Cherif	Board Chair	Valencia Soil and Water Conservation District
Jo Strange	Bosque Management Coordinator	Middle Rio Grande Conservancy District
Rin Tara	Staff Attorney	University of New Mexico, Utton Transboundary Resources Center
Paul Tashjian	Director of Freshwater Conservation	Audubon Southwest

APPENDIX B: Participant List

NAME	TITLE	AFFILIATION
Tom Turner	Professor and Curator	University of New Mexico, Biology and Museum of Southwestern Biology
Christian von Huene	Water Resources Graduate Student	University of New Mexico
Rich Wagner	Ecologist/Director	BEMP/Isleta Reach Stewardship Association
Sarah Wentzel-Fisher	Land and Ag Policy Officer	Thornburg Foundation
Emily Wolf	Rio Grande Coordinator	American Rivers

C: BREAKOUT SESSION 1 NOTES: CLIMATE IMPACTS TO ECOSYSTEM FUNCTIONS

Ecological Processes	Indicator of functional habitat for one or more listed species	Metrics for each indicator	Likely climate impacts to ecosystem functions	What are the unknowns or information gaps in our understanding of ecological responses to anticipated changes?	Implications for ecosystem services & human uses of water
<p>Hydrological Processes</p> <p>Hydrologic regulation, floodplain dynamics, streamflow maintenance, groundwater recharge, baseflow support, habitat maintenance.</p>	<p>Spring flood pulse</p>	<p>Flood pulse magnitude, timing and duration, receding limb; elevation of snow pack; rate of change in flow; regeneration of cottonwoods; and recruitment of Rio Grande Silvery Minnow.</p>	<p>Magnitude expected to decrease due to declining snowpack and earlier melt; pulse occurs 1–2 months earlier and is of shorter duration; recruitment of cottonwood and other riparian plants will be affected; maintenance of habitat for silvery minnow, other native vertebrates and fish and other endangered species; loss of overbank flooding affects soil processes; and build up of litter which changes arthropod communities and fuel structure.</p>	<p>Primary unknown roles of reservoirs upstream. We don't know what flows are needed and the responses of those flows. stormwater-groundwater connection. Groundwater use and interaction with spring runoff.</p> <p>Do not know if cottonwoods resprout and recruit and vegetative reproduction. Changes in the upper watershed; albedo and its impacts. Conveyance issues in the upper watershed (e.g., Chama). Step change in runoff supply due to wildfire and landscape transformation. The sediment dynamics under changed flow regime. Sediment mobility is important, but lower flows may not mobilize sediments.</p>	<p>No living river. Loss of spring aquifer recharge impacting trees, fish, and insects. Timing of the flow with longer time period for low flows. Mistiming of Phenology. Lack of overbanking disrupt carbon cycled. Less water for human use and ecosystem function.</p> <p>Sediment transport; recruitment of cottonwoods; and groundwater recharge. Compact delivery.</p> <p>The channel must be operated by humans going forward because the river won't return the same amount.</p> <p>Ability to build a spring flood pulse.</p> <p>Isleta and Santa Ana Pueblo water projects need to be reworked and managed differently.</p>

APPENDIX C: Breakout 1 Consolidated Notes

				<p>Low flows and stormwater inflows.</p> <p>Channel drying is not accounted for when determining changes.</p> <p>When and how much runoff will occur after events.</p>	
	<p>Monsoon season streamflow</p>	<p>Volume and timing of streamflow events from monsoon precipitation.</p>	<p>More variable and flashier flows and increase in magnitude of extreme events. Generally shorter-duration pulses shifting to later into the season.</p>	<p>Monsoonal weather over the next 50-100 years including strength and timing under different climate condition. Difficult to predict with any degree of certainty. Don't know the shift in species composition. Less predictable patterns for monsoons--more extreme and changes in timing.</p> <p>Aquatic biological community transformations. Potential for longer and intense dry season. Replenishment is more variable, hotter, and longer - length and intensity of the dry season which is expected to increase. If it is possible to capture and store rain in the summer, and how to protect infrastructure. Watershed storage vs</p>	<p>Lengthening the dry season will be difficult for plants. The relationship between spring pulse and monsoon. If there's a disconnect, then there will be a lot of ground to make up for storage and drought conditions. Potential for increased fire season -- or earlier start -- will have a large impact on Bosque systems. Understory species dry out and become fire hazard. With increasingly unpredictable monsoons affects agricultural losses, and makes it difficult for MRGCD to make decisions due to unreliable predictions for when monsoons will arrive that increase the risk of flooding. Potential to impact fishing (flooding bad for fishing; not enough water bad for fish).</p>

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				nature-based storage, both upland and within the valley. Wetlands and beavers effects. Changes in monsoon timing.	
	Floodplain connectivity	Discharge at inundation; spatial area of inundation; and duration, timing and depth of inundation.	Connectivity reduced; shortening of inundation period and lower lateral extent due to reduced baseflow and channel incision; and drying of floodplain and impacts on vegetation composition. Potential loss of native species; and drought-tolerant or upland species favored.	Lots of current research. More overbanking at lower flows with high sediment flows, but poor connectivity in some reaches preventing fish and other organism movement into wetted floodplains. It's unknown if it's possible to increase connectivity given higher sediments and lower flows overall. Are groundwater wells for point source inundation of floodplains a benefit to organisms and ecosystem processes? MRGCD gravity return outfalls and the biological benefit? Need more outfalls and flexibility in their management. Natural processes like beavers hold more water on the landscape. Some outfalls are working very well - e.g., Los Chavez. What are age structures for	Loss of riparian ecosystem and if it will be replaced with upland species. Human use and consumption: conveyance and storage. Regulatory issues.

APPENDIX C: Breakout 1 Consolidated Notes

				<p>cottonwoods and their response to outfalls.</p> <p>We may consider a new a project rather than channelizing the river or changing the channelization of the river (possibly by understanding channel capacity or maybe changing the channel... width to 300 feet rather than 600 ft). A channel storage could be used as a way to develop wetlands rather than letting water simply evaporate or go to waste.</p>	
	Groundwater/surface water exchange	Depth to groundwater.	Deeper water tables in valley floors and reduced recharge; and diminished baseflow contribution.	<p>Irrigation uncertainty, unregulated water wells, and domestic well. How would a reduction in irrigation supply increase unregulated ground water in MRG?</p> <p>The shape of the hydrograph should be taken into account meaning the groundwater changes from monsoons and then dropping to normal levels. Also, changing the individual land and water rights. What could be an</p>	

APPENDIX C: Breakout 1 Consolidated Notes

				administrative model that prioritizes using the least amount of water through farming.	
Geomorphology Channel formation and maintenance, sediment transport, nutrient retention, habitat provisioning, structural diversity, bank stabilization, erosion control, soil formation.	Sediment transport	Stream power and sediment plugs.	Higher sediment yield after intense monsoonal rains and wildfire; debris flows; and increased erosive flash floods.		
	Large woody debris transport and storage	Large woody debris count and size.	Increased loss from wildfire and bank erosion; and reduced recruitment as mature riparian trees die or decline.		
	Plant community physical structure	Vegetation composition and density, number of layers (understory, mid-story, etc.).	Lower canopy cover; more open structure; transition to shrub dominance instead of forests; and simplified structure with lower biodiversity.		Potential changes in aquatic life, including fish community, if there is no overstory to shade the river and keep water temperatures cooler.
	River / Stream Bed form diversity	Percentage of riffles and pools and fish community diversity.	Homogenization (less diversity) of bedforms as decreased baseflows and episodic floods cause scour and infilling; riffle area declines; and simplified food web if some fish can't survive in modified habitats.		Impacts on fishing as fish communities change.
	Bed material characterization	Substrate particle size and composition.	Materials grow finer after wildfire and erosion pulses, followed by hardening when flows drop.		
	Irrigation infrastructure impacts			Does irrigation infrastructure impact the	

APPENDIX C: Breakout 1 Consolidated Notes

				geomorphology of the river system?	
Biogeochemical Water quality regulation, nutrient cycling, nutrient retention.	Water quality, including stormwater	Temperature; dissolved oxygen; conductivity; pH and turbidity; macroinvertebrate community.	Rise in mean water temperature; lower dissolved oxygen; higher turbidity after fire or monsoon runoff; conductivity increase during drought years; changes in water quality, especially oxygen and temperature; and impact to fish and other aquatic life.		Impacts on water-based recreation, including fishing (depending on contaminants in the water); and impacts on drinking water and filtration/treatment needs.
	Nutrients	Common nutrient types in water (Nitrate; ammonia; nitrite; total phosphorus; phosphate, etc.) and dissolved oxygen.	Higher nutrient pulses after post-fire runoff and reduced baseflow dilution; longer low-flow periods concentrate solutes; harmful algal blooms may increase, impacting oxygen levels and aquatic communities including fish.		Impacts on fishing if fish communities change.
Biology Nutrient cycling, decomposition, carbon sequestration, pollination, habitat provisioning, primary production, genetic exchange.	Aquatic microbial communities	Biomass; primary productivity.	Decreased pollinator abundance and community simplification (less diversity) due to heat and vegetation loss; reduced crop pollination by native pollinators; and loss of host plants for specialist native pollinators.		Water quality; impact of ash and sediment; and spatial temporal distribution of fire effects.
	Soil microbial and fungal communities	Diversity and abundance.	Reduced diversity and biomass; slower decomposition; and impacts of fires/vegetation treatments on soil communities. If vegetation changes as a result of soil community changes it can		Impacts of fires/vegetation treatments on soil communities (one PhD student studying this at UNM).

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			impact shading and therefore water quality and fishing. Nutrient cycling and water uptake capacity of trees and other plants.		
	Macrophyte communities	Species composition; abundance; biomass and primary productivity.	Reduced cover due to lower water levels, and expansion of stress-tolerant plants.		
	Benthic macroinvertebrate communities	Species composition; abundance; and trophic composition.	Sensitive species decline; replaced by drought tolerant species; water quality declines reflected in macroinvertebrate community changes impact fish, fishing, and potentially drinking water; and impacts on higher trophic levels that feed on macroinvertebrates.		Water quality declines reflected in macroinvertebrate community changes impact fish, fishing, and potentially drinking water.
	Terrestrial invertebrate communities	Species composition; trophic composition; and abundance.	Decreased pollinator abundance and community simplification (less diversity) due to heat and vegetation loss; reduced crop pollination by native pollinators; and loss of host plants for specialist native pollinators.		Reduced crop pollination by native pollinators.
	Aquatic vertebrate communities	Species composition; trophic composition; and abundance.	Habitat contraction for cold-water fish; and amphibians breed 1–2 months earlier.		Impacts on fishing, especially species available to anglers.
	Terrestrial vertebrate communities	Species composition; abundance; and trophic composition.	Species move up in elevation; riparian species decline; increased dominance of generalists (animals that do not depend on specific		Impacts on wildlife watching, especially if rare species decline (i.e., bird watchers).

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			habitat; diet; etc., highly adaptive).		
	Landscape connectivity	Habitat patch size and distance between habitat patches.	Reduced patch size and increased distance between patches; increased shrub encroachment and fire fragmentation; potential for loss of biodiversity; population fragmentation; and reduction in gene flow.	A channel storage could be used as a way to develop wetlands rather than letting water simply evaporate or go to waste.	Impacts on recreation, e.g., if there are large stretches without trees providing shade.
	Plant communities	Species composition and abundance; biomass and primary productivity; invasive species abundance; fire pressure and dynamics; and dead and down vs. natural decomposition.	Shift to drought-tolerant shrub and grass species; forest biomass reductions; earlier green-up; reduced carbon sequestration; drying channel allowed for cottonwood seedlings to enter soil; changes in wildlife community structure; and potential to favor non-native species/lose forest-dependent species.	Fire, dead and down woody debris, and invasive species removal importance.	Drying channel allowed for cottonwood seedlings to enter soil; and impacts on recreation e.g., loss of shade for hiking or wildlife watching or fishing along the river.

D: BREAKOUT SESSION 2 NOTES - INDICATOR SPECIES & HABITAT IMPACTS

Step 1: Please use the information in the species information sheet to select the 3-5 indicators from the Ecosystem Function worksheet that will be most impactful to your 1) species and 2) species habitat

Ecosystem Functions for Species					
Indicator	Metrics	Description of expected change to metric	Description of expected ecosystem functions and impacts to indicator species	Description of expected impact to habitat, life history, and water requirements	Notes / Ideas / Additional Thoughts for Discussion
<i>EXAMPLE: Spring flood pulse</i>	<i>Flood pulse magnitude, timing and duration.</i>	<i>Magnitude expected to decrease due to declining snowpack and earlier melt; pulse occurs 1–2 months earlier and is of shorter duration; and lack of receding limb.</i>	<i>Inability to distribute seeds to exposed sand/habitat; rapid loss of water access; and mistiming of seed release vs pulse.</i>	<i>Not enough water available</i>	
Floodplain connectivity	Interaction between river discharge and floodplain inundation supporting sediment/nutrient exchange and habitat.	Discharge at inundation; spatial area of inundation; and duration, timing and depth of inundation.	Connectivity reduced; shortening of inundation period and lower lateral extent due to reduced baseflow and channel incision; and duff buildup increases fire intensity and kills cottonwoods.	Lots of current research	Lose riparian ecosystem and it will be replaced with upland species. Human use and consumption: conveyance and storage. Regulatory issues.

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Sediment transport	Movement of suspended and bedload materials by flowing water.	Stream power.	Higher sediment yield after intense monsoonal rains and wildfire; debris flows, and increased erosive flash floods.		
Groundwater/surface-water exchange	The bidirectional interface controlling baseflow, recharge, and water quality in riparian zones.	Depth to groundwater source.	Deeper water tables in valley floors and reduced recharge and diminished baseflow contribution to cottonwood roots which can not reach capillary fringe or water table.	Irrigation uncertainty and unregulated water wells. A reduction in irrigation supply will increase unregulated ground water in MRG.	
Plant community physical structure	Vegetation density and vertical stratification affecting bank stability.	Vegetation composition and density.	Lower canopy cover; more open structure; transition to shrub (exotic) dominance instead of forests; and shift of stem density and water use to exotics from native species.		
Soil microbial and fungal communities	Soil organisms driving nutrient cycling.	Diversity and abundance.	Reduced diversity and biomass; slower decomposition; reduced nutrient cycling; plant/microbe		

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			interactions; and duff buildup increases fire intensity and kills cottonwoods.		
Water quality including salinity	Physical and chemical properties determining suitability for aquatic life.	Temperature; dissolved oxygen; conductivity; pH; and turbidity.	Rise in mean water temperature; lower dissolved oxygen; higher turbidity after fire or monsoon runoff; and conductivity increase during drought years.		
Healthy wetland habitat available for overwintering	Area of flooded wetland/ fields, abundance of macroinvertebrates, water quality in migratory sites, minimum winter flow, low pathogen presence, and cultivated land availability.	Lessened extent of suitable habitat; reduction in macroinverts; reduced water quality; lower winter flows; increased pathogen presence; and sediment deposition may decrease wetland flood zone.	Increased disease due to increased population density and reduced water quality; reduced population size due to reduced food; and lower overwinter survival rates.		
Resource timing/ location and availability for migration needs	Irrigation timing matches migration timing, migration lines up with plant and other organism phenology.	Changes in flowering and fruiting time of food species; irrigation later into fall; and loss of cropland due to urbanization.	Overwintering sites may move or be lost due to land use change; migration sites may eventually move, or be unable to move due to site fidelity; and timing of crops and other ecosystem changes		

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			may no longer sync with migration.		
Extreme weather disruptions to migration	Successful migration counts and incidence of extreme weather events.	Increasingly extreme and more frequent events.			
Floodplain connectivity	Discharge at inundation, spatial area of inundation, duration, timing, and depth of inundation.	Connectivity reduced; shortening of inundation period; and lower lateral extent due to reduced baseflow and channel incision.	Less recruitment; inability to mature; and decrease in population.	Drying and cascading effects (loss of canopy, warming water temps).	
Monsoon season streamflow	Volume and timing of streamflow events from monsoon precipitation.	More variable, flashier flows; and slight increase in magnitude of extreme events but generally shorter-duration pulses shifting later into the season.	Less consistent water supply throughout summer for habitat, spawning, stranding.	Increased erosion and inconsistency in water supply.	
Water quality	Temperature, dissolved oxygen, conductivity, pH, and turbidity.	Rise in mean water temperature; lower dissolved oxygen; higher turbidity after fire or monsoon runoff; and conductivity increase during drought years.	Species decline.	Decline in other species/community health overall.	
Bed material characterization	Substrate particle size and composition.	Materials grow finer after wildfire and erosion pulses, followed by hardening when flows drop.	Lack of access to substrate.	Decreated water quality	

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<p>Winter flooding for roosting; e.g., Bernardo and Bosque del Apache NWF. Agricultural infrastructure to move water onto fields, e.g., canals, etc. Irrigated Agriculture ends October 30, Pueblos end November 15. Crop choice would be important -- milo, chile, corn -- is better food for birds. Alfalfa is not as suitable. Late crop rotation might be good. Pueblos could be critical.</p>	<p>Corn under cultivation, water on the fields, acreage under inundation, distributed (distance between) inundated areas, and suitable acreage in the floodplain for crane roosting and sustainability.</p>	<p>Precipitation and melting regimes might make water more available, possibly making the growing season longer. Change in water availability affecting Sandhill Cranes through food shortage or increased predation. Possibly incentivizing Pueblos and farmers to grow food for wildlife, e.g., milo, red chile, etc. High voltage power lines (e.g., SunZia) on flyways and sandhill crane survivorship.</p>	<p>Lower water availability could negatively impact appearance and roosting. More water may be available in the winter compared to the spring and summer.</p>	<p>More suitable habitat and more distributed roosting areas with increased winter water availability. Could synergize with farmers to put last planting in for wild bird food.</p>	<p>More reliable winter precipitation/water delivery? Work with landowners to promote roosting sites. Eurasian Boar (feral pigs) impacts on roosting sites? Only have cranes for a portion of their life cycle, and it is mainly adults, so more natural resilience to variation in climate and water impacts.</p>
<p>Floodplain connectivity</p>	<p>Water table elevation, surface water elevation, an channel configuration.</p>	<p>Reduced flood plain connectivity due to reduced spring pulse; sediment issues; levees; greater loss to groundwater; and managing for compact deliveries.</p>	<p>Lowering of water table with less roots accessing water. Reduced propagation.</p>	<p>Habitat reduction for other riparian species.</p>	
<p>Irrigation infrastructure</p>	<p>Lined vs unlined conveyance channels, capacity of conveyance channels, return flows, and irrigation efficiencies,</p>	<p>Managing for compact deliveries (conveying water through lined canals vs through river channel); and lined canals reduces return flows and groundwater table.</p>	<p>Reduction in overall cottonwood survival and propagation and less germination.</p>	<p>Less species diversity; increase in invasive species; and aridification of floodplain.</p>	

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terrestrial invertebrates	Magnitude of bug infestation, type of invertebrates, and species diversity.	Increase in scale; spider mites; poplar tentmaker; and redhumped caterpillars.	Reduction in overall cottonwood survival.	Greater fire risk	
Plant communities	Area and percent of exotic riparian vegetation e.g. salt cedar and Russian olive.	Increase fire risk with non-natives and more understory.	Cottonwood die-off	Non-native competitors (tamarisk, Russian olive). Less streambanks stabilization and more sedimentation. Less species diversity.	
	Lack of water in the river				
	Groundwater levels crucial for cottonwood survival				
	Choking from invasive species				
Continuous river wetting	Flows about 125 cfs from state border to EB.	More years like 2025, with the longest (distance and time) dry stretch since 1977.	Fish death	Not enough water available.	
Braided side channels	Overbank and side channel areas within a braided river channel.	Incised and narrowed channel.	Inability of fry to develop	No calm areas for spawning and fry development.	
Species-appropriate levels of sedimentation	Water that is neither too silty nor too clear.	Sedimentation increases with increased severity precipitation.	Potential species death	Water quality too poor to support fish.	

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Monsoon	Magnitude, timing, and duration.	Magnitude highly unpredictable.	High intensity flows could overwhelm habitat; low monsoon flows could impact food source; and reduction of habitat. Timing of monsoon could also have effects on species due to climate conditions.	Could be positive or negative.	
Plant community physical structure	Structural and species diversity.	Loss of plant species diversity and increased invasive vegetation plant migration ie upland species moving to traditional riparian.	Changes in habitat could lead to fewer high quality nest sites leading to more competition.	Not enough suitable habitat.	
Terrestrial invertebrate communities	Diversity and abundant flying insects.	Changes in timings of insect emergence loss of habitat for insects.	Insect emergence changes could lead to lowered nest success if insect abundance due to less food source.	Lowered nest success leading to population decline.	
Step 2: Using the information above, summarize the major challenges you expect your species to face under future conditions based on changes to habitat (e.g. food availability, etc).					
Summary statements					
Spring flood pulses degradation (lower magnitude, earlier pulse, shorter duration, lack of receding limb) results in not enough subsurface water for cottonwoods at different life stages. Germination cannot occur with rapid ground water recession, while older trees cannot reach deeper water throughout the summer					
Salinity (and potentially other water quality issues) stress trees. This stress is increasing as upland fire and aridification increase erosion and sedimentation rates.					
Lowland fire alters soil microbial structures and understory vegetation, making it harder for the system to recover.					
Reduction in suitable habitat (ie wetlands and irrigated cropland) due to land use changes; shifts in irrigation timing; lack of flooding leading to higher mortality due to disease and lack of resources.					

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Changes in climate such as increased extreme weather events; shifts in seasonal conditions disrupting migration and causing decoupling of crane phenology from environment and phenology of other organisms.	
If floodplain connectivity is reduced, which would be an expected result from reduced flows, nursery habitat will be reduced. This cascading effect will lead to increased drying, reduced canopy cover, and increased water temperatures exacerbating condition degradation.	
With flashier monsoons; less consistent water supply throughout summer for habitat and spawning; and potential impact on minnow management that could lead to stranding. Habitat degradation including erosion, etc. could occur.	
Lower DO; increased turbidity; and water temperature will negatively impact species recruitment.	
Cranes are in relatively good shape compared with other indicator species.	
Challenge is growing harvestable crops that are suitable for birds (not alfalfa).	
Waterways to move water onto fields in winter to provide roosting habitat. Distributed roosting areas near food sources is important. Possibly important role for tribes because they can have a more steady water supply.	
Difficulty in land management and food production in the MRG to provide adequate food for birds. E.g., High salt levels; and no GMO or hybridized crops at Bosque del Apache which is inadequate for birds.	
Increase fuel load is a stressor upon young and old cottonwoods. Decrease in water tables kill established cottonwoods and prevent young cottonwood from emerging; and increasing number of tamarisk and other invasives. The lack of pulse is detrimental.	
If continuous river wetting is not possible, fish rescue and external spawning (in places like refugiums) will be required.	
If side channels are not maintained, the minnow fry will be unable to reach maturity.	
If sediment is not managed then water quality could degrade further and potentially reduce livable areas of the river for the RGSM.	
Less suitable habitat and less food abundance will lead to population decline. Water availability influences all the metrics described above including: low spring pulse influencing vegetation success and insect emergence; variable monsoon flows will have variable effects; vegetation diversity and structure; and terrestrial invertebrate success strongly influenced by water availability.	
Management and Research Needs	
Management Needs: What can be done to mitigate impacts of expected change to species and their habitat?	Research Needs: What information do we need to improve decision-making for species/habitat?
Improve channel capacity restrictions to allow larger spring pulses.	
Adjust reservoir management to improve spring pulse metrics, especially recession limb.	

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Research and assess where and when irrigation efficiency and conservation measures benefit river and ground water connectivity.		
Maintain post-fire soil microbial health with exotics removal; reducing soil disturbance; and education and resource support.		
Assess where state funding is needed due to loss of federal funding including for farmers.		
Flexibility of land management plans to allow for changes to plan as needed given changing annual and interannual conditions.	Incentive programs including economic research into best incentives; successful economic model for fallow fields; and environmental water rights.	
Planning of specific management actions in response to specific environmental thresholds/indicators.	Minimum viable flows and groundwater levels - solid research and outreach/education for research outcomes.	
Coordination of response actions between government, private, and NGO stakeholders. Contingency planning between managers with diversity of methods, constraints, and flexibility.	Role of disease in population dynamics (vectors, population density limits).	
Availability of a diverse, large area of land as redundancy for low yields, and lack of flooding etc (multiple tactics).	Planning recommendations for habitat mosaic - population densities, land area and cover, etc.	
Improved communication: capacity for "horizon scanning" toward trends and potential futures; communication of anticipated needs; and transparency of organizations/ agencies.	Knowledge of cultural significance of sandhill cranes,; economic value; and other human impacts to spread awareness and increase conservation investment.	
Monitoring for decline	Construct a series of plausible scenarios including restricted water use; declining population; and changing timing to allow for contingency planning.	
Environmental flows, floodplain restoration that anticipates more extreme monsoons; erosion control; habitat projects to lower banks; recruiting vegetation cover; and converting land use in riparian zone.	Historic case studies and success stories and challenges to factor into future management scenarios.	
Growing corn (and other food crops) instead of alfafa.	Agricultural extension and research.	
Water available for winter flooding of fields.	Basic crane biology and monitoring.	

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Distributed roosting areas	Disease epidemiology (e.g., bird flu, avian cholera).	
Bank cutting		
Education	Keep funding the Bosque Ecosystem Monitoring Program (BEMP).	
Embrace the mosaic approach		
Adaptive management with new regime and succession planning	Monitoring	
Restoring spring pulse	Research timing of compact delivery	
Increased channel capacity below Abiqui		
Change RG compact EB supply index to include upstream reservoirs (Heron and El Vado as extensions of EB storage). Allow for pulse flows throughout year, not just in November-January.	Modeling - Rio Grande Basin Study	
Increased coordination between MRGCD, BOR, Interstate Steam Commission, NM OSE, and TX.		
Update Management Plans	<p>Research on how to improve habitat not really needed, but rather implement projects based on knowledge</p> <p>Other research needs:</p> <ul style="list-style-type: none"> - Why some sites are more successful than others. - If mixed uses of suitable habitat with other uses is feasible. 	
Education among farmers for better crops to grow. Feedback from universities to communities. Alternative feed sources for cattle.	Monitoring of cottonwood leaf beetles.	
Culture is a big factor in encouraging younger farmers.	Germination studies: what are the conditions like soil type and depth.	
More water is key but not a reliable reality. Restore water at key times and in specific suitable habitat - SWFL success rate tied to dense, coyote willows and water w/in ~50 m.	One dataset on phrenology is nature's notebook: community science based.	
Promote culture shift though interpersonal community communication. How are we all going to benefit from this change?	Determine if moving cottonwoods from drier locations further north increase their viability.	

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Maintain existing overbank and side channel projects.	Research mistletoe infection rates along the bosque cottonwoods.	
Potentially add minnows to drains that are wet year-round.	How can we predict reductions in SJCP deliveries further in advance?	
Ensure minimum flows through the Rio Grande.	How can minnow high flows be used to effectively move compact water and irrigation water to serve multiple purposes?	
Sediment management		

E: ANTICIPATED CLIMATE FUTURES

Key Impacts of Climate Change on the Middle Rio Grande and Associated Watershed

Synthesized from Dunbar, N. W. et al. 2022. Climate Change in New Mexico Over the Next 50 Years: Impacts on Water Resources. Prepared by Dagmar Llewellyn and Stephanie Mladinich for the 2025 Middle Rio Grande Drought and River Drying Workshop, October 28-29, 2025

Climatic changes

- If we don't take action to stop the increase in greenhouse gases in the atmosphere, **we can expect an average temperature rise in the state of 5 to 7 degrees F** from pre-industrial levels over the next 50 years.
- **Greater variability in precipitation** – year to year, and within-year, including **hotter, more-severe droughts**, interspersed with **more intense storms**, and **larger floods**.
 - Differences in seasonality - spring precipitation may decline, trend toward somewhat stronger monsoonal activity (although difficult for Global Climate Models to capture)
- **Increasing temperatures coupled with no clear increasing trend in precipitation** leads to projections of increasingly arid conditions.

Surface water

- **Decreasing snowpack**, and **earlier and steadily diminishing snowmelt runoffs**.
- More **winter precipitation expected to fall as rain** instead of snow
- **Aridifying soils** in the lowlands lead to **more dust on snow, and more sublimation**, further decreasing the snowpack available to run off.
- **Increased rates of evaporative loss**, exacerbating loss of system-wide water storage
- **Lower streamflow** (by 25% over the next 50 years according to the Leap Ahead Analysis)
- **Degraded water quality** (higher concentration of nutrients, salinity, temperature, turbidity...)

Groundwater

- **Decreasing recharge**, and greater demands on the dwindling groundwater supply due to surface-water shortfall.
- **Increasing water use by plants**
- **Decreasing soil infiltration and soil-water content**

Watershed

- **Stress on natural vegetation**, including tree mortality in riparian and upland forests and changes in dominant vegetations, caused by increasing temperature, disturbance, and decreased water availability. This stress **increases the likelihood of bark-beetle infestation and more damaging wildfire**.
- **Increasing catastrophic forest fire frequency** resulting from heat and aridity.
- Widespread impacts from **post-wildfire debris flows**.
- **Irreversible damage to soils** through loss of vegetation; resulting soil erosion.

River Corridor Channel

- **Lower river flows much of the time, and increasing river drying**, will lead to narrowing of the channel through vegetation encroachment.

APPENDIX E: Climate Futures Overview

- **Increased soil erosion and post-wildfire debris flows** will lead to significant increases in sedimentation in the river. Leap-Ahead analysis suggests that the **25% decrease in flows** in the next 50 years could be paired with a doubling or more of the sediment entering the river.
- **River channels will aggrade** since the lower flows will not be capable of transporting that much a **steadily decreasing ability to transport water** to Elephant Butte for delivery under the Rio Grande Compact, and **more loss of water to localized flooding**.
- Much of the current Bosque has an overstory of “decadent” cottonwoods all germinated in large floods in 1941. **These cottonwoods will start to die away**. Current river channelization and designated channel capacities do not provide processes needed to germinate new cottonwoods along much of the river corridor. Over time, increased sedimentation and aggradation of the channel could create more overbank flows, which could increase germination, but we are unlikely to allow that level of decrease ability to convey water to Elephant Butte.

Additional Considerations

- **Ecological transformation:** Disturbance pushes system beyond its resilience threshold, resulting in a system with altered structure and function
- **Compound events:** Combination of multiple climate-related hazards occur simultaneously, or in close succession, and interact, increasing overall risk, such as flooding after a wildfire
- **Ecological feedbacks and Cascading impacts;** A single event can trigger a series of related, consequential impacts that lead to wide-spread change across multiple systems (can include both climatic and non-climatic drivers, including societal vulnerabilities). Consequences may be non-linear and difficult to predict.

F: INDICATOR SPECIES REFERENCE SUMMARIES

RIO GRANDE SILVERY MINNOW (*HYBOGNATHUS AMARUS*)

Overview

This fish species' historic range includes the Rio Grande and the Pecos rivers in New Mexico and Texas which flow to the Gulf of Mexico. The Rio Grande silvery minnow is about 4.6 inches in length and is the last of five pelagic spawning fish species that still exist in the Rio Grande River. This species currently occupies about 7% of its historic range and can only be found in the Rio Grande from the Cochiti Dam to the Elephant Butte reservoir. It can be used as an indicator species for determining the general health of the river's overall aquatic environment.

Habitat - *River / Floodplain*

The Silvery Minnow prefers large streams and rivers with slow to moderate flow over silty sandy substrates. Habitats with water depths less than 15.75 inches and low to moderate velocity are the most favorable for the Silvery Minnow. These habitats usually include eddies and pools with submerged vegetation and debris. Rio Grande silvery minnow are herbivores, and their diet is composed of algae and other plant materials, so vegetated habitats are necessary for this species.

Life cycle (breeding) and Behavior

This species is a pelagic spawner where they release semi-buoyant eggs that are fertilized in the water column and are then carried along the river's current. These eggs typically hatch within 24 to 48 hours after fertilization and this hatching time also depends on the temperature of the water. Warmer waters help the eggs develop quicker and transition the larvae from drifting to actively swimming. Reproduction cycles usually occur over a 12-hour period and the spawning season lasts between one and two months. The average life span of Silvery Minnows is about 18 months in the wild.

Climate Impacts and Threats

Threats include reduced availability of water, loss of shallow, low-velocity habitats for larval and juvenile fish, and significantly decreased flooding events needed for successful reproduction, leading to population declines. Additionally, channel bed degradation/incision from management and climate change have negatively impacted connectivity to floodplain habitat, and subsequent population viability.

Link & Implications for Human Use of Water

High flow pulses are required at the beginning of the breeding season for this fish because this opens up backwater areas and inundates key floodplain areas. These spots are crucial for egg spawning and larval development. Low-flow requirements throughout the year support minnow persistence. As more water is required to flood the Bosque ecosystem, less water is available for human uses in agriculture and industry.

RIO GRANDE COTTONWOOD (*POPULUS DELTOIDES WISLIZENII*)

Overview

The Rio Grande cottonwood is found along the Rio Grande from southern Colorado down to Mexico. This species primarily inhabits the San Juan basin in northwest New Mexico and southwest Colorado. It is a keystone species in the Rio Grande Bosque ecosystem and has inhabited the river valley for over 2 million years. Cottonwoods require close proximity to water in order to grow, and they can grow up to 30 meters (40-80 feet) tall with a trunk diameter of 2-5 feet. Cottonwoods also have some medicinal properties that can treat fevers, infections, help with indigestion, muscle aches, and joint pain. Prior to the impoundment of the river, germination was linked with periods of high spring flows from snowmelt and periodic storm runoff.

APPENDIX F: Indicator Species Reference Summaries

Habitat

Cottonwoods prefer wet soils along streams, rivers, or lakes in desert grasslands at elevations up to 6500 feet. This proximity to water is crucial because Cottonwoods require flooding to disperse and germinate their seeds. Historically, the Middle Rio Grande Bosque experienced frequent flooding, however there has not been a natural large flood since the 1940s when Jetty Jacks and dams were used to control water flow. Cottonwood has to compete against non-native and invasive Russian olive and salt cedar trees; this competition has increased due to decreased flooding events. Cottonwoods are a keystone species because they provide important shelter and food for wildlife and their roots help prevent erosion in desert environments.

Life cycle (germinating) and Behavior

Cottonwood trees are dioecious which means they are separate male and female trees. This sexual separation makes reproduction more difficult because both male and female trees need to interact in order for proper seed growth. Their leaves are triangular and their seeds are attached to tufts of cotton-like hairs which helps distribute the seeds through the wind/water. Flooding is necessary for seed transport and germination and with recent declines in flooding events the Rio Grande Bosque has less young Cottonwoods and more older near end of life trees. Cottonwoods and willows are fast-growing, deciduous trees, and require scoured sand bars for germination.

Climate Impacts and Threats

Cottonwoods are highly dependent on river flow and groundwater to persist, as well as flood events for their germination and establishment of trees. Significant water is required during summer months and rely on shallow roots to access saturated soil, and have low tolerance to soil salinity. Therefore, the reduction of water availability has serious negative implications for cottonwoods and riparian habitat. Non-native invasive plants, such as Russian olive and saltcedar, outcompete native cottonwoods and willows and accumulate woody debris, increasing wildfire risk. Cottonwoods can take up to 10 years to resprout after fire.

Link & Implications for Human Use of Water

The need for high flow pulses to create floodplains for seed dispersal and germination poses a concern for human water use because this would require frequent high level dam releases of water to create pulses of this magnitude. Frequent large releases from dams would decrease the water storage available for human consumption. Additionally, these trees require consistent groundwater levels during warm low-flow months in late summer so that their shallow tree roots can reach the water table.

SANDHILL CRANE (GRUS CANADENSIS TABIDA)

Overview

There are five populations of sandhill cranes across North America. Nearly the entire population of cranes spend 3-4 months annually staging for spring and fall migration in the San Luis Valley, Colorado. The primary wintering habitat is the Middle Rio Grande Valley in New Mexico where the majority of the Rocky Mountain Population winters, with smaller numbers wintering in southwestern New Mexico, Arizona, and Mexico.

The North American sandhill cranes are the most abundant crane species in the world and are divided into non-migratory and migratory subspecies. Both species are typically 1-1.2 m tall (3.2-3.9 ft), with a wingspan of 1.8-2.0 m wide (5.9 to 6.5 ft). Migratory sandhill cranes subspecies include the lesser and greater sandhill cranes.

There are specialized conservation programs in place to help aid both groups of these subspecies and ensure continued populations. Additionally, management programs help to monitor population numbers and habitat stability for this species.

Habitat - *open wetland habitat, agricultural fields, working lands*

APPENDIX F: Indicator Species Reference Summaries

Sandhill cranes nest in a wide variety of habitats that offer the resources required for growth. In the Middle Rio Grande Valley during migration periods and winter months, these habitats include farmlands and wetlands, river, shallow lakes and impoundments, sandbars, and open fields. Cranes depend on these habitats for roosting and food sources. They also return to the same wintering locations yearly (high site fidelity).

Life cycle (breeding) and Behavior

Sandhill cranes are perennially monogamous, and the breeding pair stay together from year to year and engage in courtship displays. Typically, breeding pairs raise one brood per year which usually consist of 2 eggs. Egg laying can occur anywhere between December and August in non-migratory populations, and between April and May in migratory populations.

Nests are built by both members of the breeding pair and are usually located in marshes with occasional nesting on dry land. Incubation usually lasts 30 days after which the parents brood the chicks for 3 weeks. The crane chicks become independent after 9 to 10 months. Young cranes form breeding pairs and begin breeding between the ages of 2 and 7 years old. This species can live 20 years or more in the wild.

Sandhill cranes are omnivores that eat ground litter like seeds, grains, berries, and animals like invertebrates, reptiles, amphibians and sometimes small mammals. This species feeds by probing for food with their bills. During migration periods and wintered areas, the cranes primarily eat cultivated grains like wheat, rice, and corn.

Climate Impacts and Threats

Threats to sandhill crane populations include reduced wetland and flooding habitat from reduced water supply, decreasing shallow bars in the Rio Grande during high flow releases for the Compact, loss and change of foraging habitat and food resources, range contraction, migration timing, and extreme weather events.

Link and Implications for Human Use of Water

Sandhill cranes roost and breed in open wetlands typically used for farming or found near the Bosque ecosystem. This makes water availability within the Rio Grande and consistent irrigation to agricultural fields extremely important. With recent reductions in farming/farmland in New Mexico, these cranes have less suitable habitat. To increase habitats for these cranes, more water would need to be diverted to agricultural fields and managed wetland habitat during the winter months. However, with the current strain on water use and availability in New Mexico, this would take a toll on surface and groundwater levels, impacting water availability for human uses elsewhere.

SOUTHWESTERN WILLOW FLYCATCHER (*EMPIDONAX TRAILLII EXTIMUS*)

Overview

The southwestern willow flycatcher is a small bird that is typically 6 inches in length from head to tail. These birds live in riparian forested habitats and feed on small flying insects. These birds have light-colored wingbars and lack the common pale eye-ring of many other Empidonax species. Their bodies are a brownish green color with a yellowish belly and their beaks are relatively large for their body size. This species is best identified by their vocalizations and their characteristic upward tail flick they do while perched.

Habitat - *Dense riparian vegetation, wide floodplains*

This species requires dense riparian vegetation with cottonwood and willow trees and microclimatic conditions available for nesting. Standing water, streams, cienegas, and pools, as well as saturated soils are important components for nesting habitats. These water sources also influence microclimates and vegetation density important for flying insects, their primary food source. Habitat that are not suitable for nesting are often used for migration and foraging locations. Frequent flooding in riparian habitat helps to

APPENDIX F: Indicator Species Reference Summaries

support successful nesting habitat because the influx of water reduces the growth of invading non-native species like tamarisk.

The flycatcher typically breeds in the southwestern U.S during the summer, fledges in late summer and then migrates to Central America for winter in September. Important habitat factors include wide floodplains, dense vegetation, diverse habitat, and proximity to water. In addition to riparian habitats, reservoir basins are also key locations for flycatcher breeding. These habitats include all the necessary aspects this species requires for breeding, nesting, and migrating and are therefore crucial habitats.

Life cycle (breeding) and Behavior

The southwestern willow flycatcher breeds in the summer along its range in the United States. They winter in Central America and migrate out by the end of September. Specific nest territories are set up during breeding times, and individuals commonly return to the same nest territory year after year. The flycatchers typically arrive at their breeding grounds between late April and early May and their nesting begins between May and June. Following this, the fledging season is from June to mid-August. This species usually lays three to four eggs per clutch, and each are laid in one day intervals. The females incubate the eggs for about twelve days until they hatch. Twelve to thirteen days after this, the young birds fledge. Typically, southwestern willow flycatchers raise only one brood per year, but some pairs can raise a second brood or renest after failure.

Climate Impacts and Threats

Threats include loss and degradation of dense riparian habitats, wildfire, parasitism, and overall loss of surface water. Lower than average precipitation has been documented to decrease seasonal productivity. Decreased water availability negatively impacts all essential habitat and food resources.

Link and Implications for Human Use of Water

This species experiences population decline when humans alter water abundance in their habitats. These alterations include river impoundment, groundwater pumping, water diversions and channelizations. As water is diverted away from the riparian ecosystems, there are less resources available to support these birds and their young leading to population declines. The heavy use of water in communities in the southwestern U.S leads to complications for remedying these challenges for flycatcher populations as it would require less diversion of water and therefore less water would be available for human use.

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https://animaldiversity.org/accounts/Grus_canadensis/#:~:text=Sandhill%20cranes%20raise%20one%20brood,material%20from%20the%20surrounding%20areas.

[https://www.nps.gov/articles/000/sandhill-crane.htm#:~:text=Sandhill%20cranes%20are%20large%20birds,\(5.9%20to%206.5%20ft\)](https://www.nps.gov/articles/000/sandhill-crane.htm#:~:text=Sandhill%20cranes%20are%20large%20birds,(5.9%20to%206.5%20ft))

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H: WORKSHOP PRESENTATIONS



Future Scenario Planning for Drought and River Drying in the Middle Rio Grande: Workshop Overview

Debbie Lee
Senior Program Manager
ARID Institute, UNM

October 28-29, 2025
UNM Rotunda

UNM Indigenous Peoples' Land and Territory Acknowledgement

Founded in 1889, the University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico – Pueblo, Navajo, and Apache – since time immemorial, have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain stewards of this land throughout the generations and also acknowledge our committed relationship to Indigenous peoples.

We gratefully recognize our history.

Developed by the Special Assistant for American Indian Affairs to the UNM President in consultation with the Native American Faculty Council.

Approved and adopted by President Garnett S. Stokes February 2020
Photo by Dr. Tim Schroeder

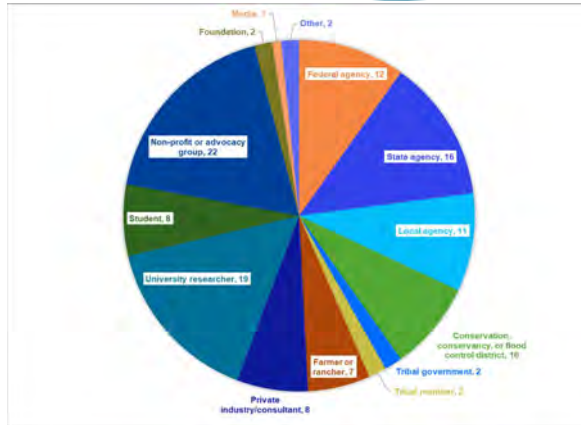
Acknowledgements

- Planning Team:
 - Debbie Lee & Janna Martinez, UNM ARID Institute
 - Teresa Smith de Cherif, Valencia Soil and Water Conservation District
 - Stephanie Mladinich, South Central Climate Adaptation Science Center
 - Marcy Demillion, Connecting Visions
- Funders:
 - Thornburg Foundation
 - Valencia Soil and Water Conservation District
 - Albuquerque Bernalillo County Water Utility Authority

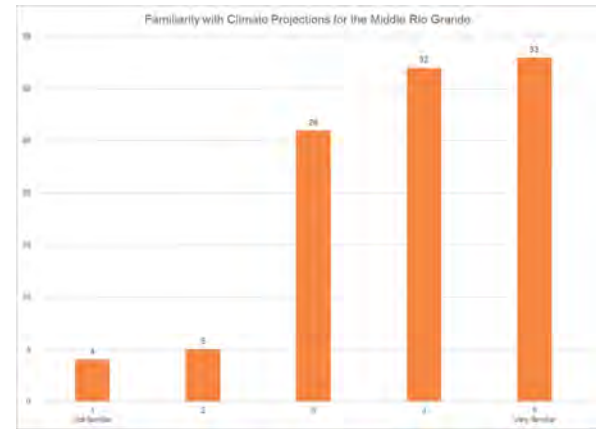
Workshop Objectives

- Create community and build partnerships
- Develop a shared understanding of a probable climate future
- Center water uses within a framework of ecosystem functions
- Link human water use to ecosystem and species water needs
- Identify appropriate adaptation strategies to implement and test for different water uses
- Contribute to fire- and drought-adapted restoration planning in the bosque

Participants



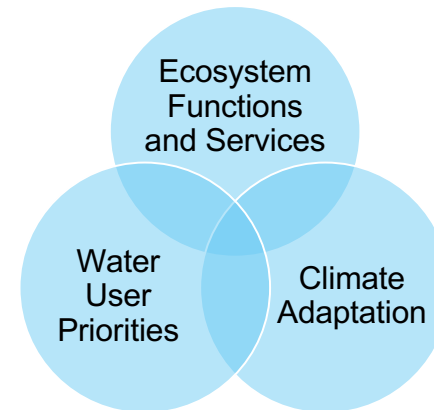
Participants



Workshop Overview

- Presentations to develop a shared understanding
- Overview of anticipated climate futures
- Impacts on key ecosystem functions for the Middle Rio Grande
- Impacts on indicator species and their habitats for environmental flows
 - Rio Grande silvery minnow
 - southwestern willow flycatcher
 - sandhill crane
 - cottonwood
- Implications for human water uses
- Mitigation and adaptation strategies
- Next steps

Workshop Framework





Middle Rio Grande

- Along the Rio Grande
- South of Buckman Direct Diversion (Santa Fe)
- North of southern boundary of Elephant Butte Reservoir

Source: New Mexico Interstate Stream Commission

Indicator Species



Southwestern willow flycatcher*^X



Cottonwood



Sandhill crane



Rio Grande silvery minnow*^X

* Federally listed as endangered under the Endangered Species Act
^X NM Species of Greatest Conservation Need

Reminders

- Posters on human water uses – place 2 stickers on the topics you want to discuss tomorrow
- Resource Packets available via the QR code
- During breakout sessions, please aim for a variety of participants with different backgrounds and expertises at each table
- Take notes in the online templates



Workshop Outcomes

- Impacts on ecosystem and water uses
 - Input into local and regional planning processes
 - Rio Grande Basin Study
- Priority adaptation and mitigation strategies for different water uses
- Information and data gaps, research questions
 - Input into a resilience research plan
- Next steps
 - Continued conversations and collaboration for action
 - Volunteers to lead next steps
 - VSWCD consider strategies for implementation



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ACCELERATING RESILIENCE
INNOVATIONS IN DRYLANDS
INSTITUTE



The Middle Rio Grande and Whitfield Wildlife Conservation Area

A Case Scenario of Drought and Drying Futures
 Teresa Smith de Cherif
 Board Chair, Valencia Soil and Water Conservation District



Valencia SWCD

- 1.59 million acres (size of Delaware)
- Includes 5 counties and 2 Pueblos
- Unique among 47 NM SWCDs in having substantial land in conservation (279 acres)

Whitfield Conservation Area Complex

- 3 units of riparian conservation land adjacent to the San Juan Drain (within the former course of the Middle Rio Grande)
- Whitfield Wildlife: 97.54 acres
- Stacy Unit: 42.88 acres
- Rio Abajo Unit: 138.87 acres (3 miles south of Whitfield)



1935 aerial photo of MRG, Whitfield, and Stacy Unit

- Historically, Whitfield & Stacy were flooded by the MRG before 1923
- These lands had bosque, wetlands, and grasslands
- Trees and grasses there were adapted to a flood regimen.

Picture courtesy of Audubon

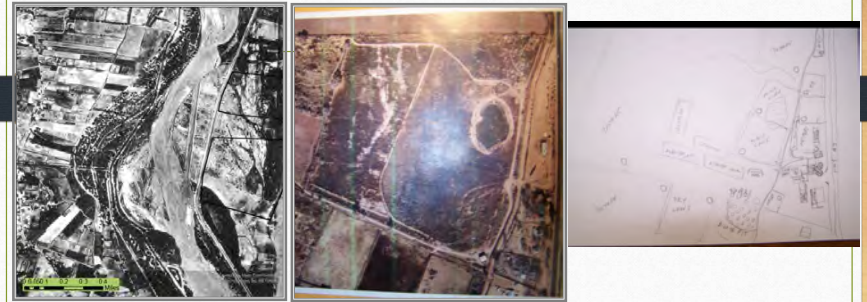


Curran Dairy



- The historic wetlands at Whitfield were converted to agriculture not long after the MRG was channelized by James J. and Cyndi Curran.
- They operated a dairy farm until January 24, 1986.
- Part of the reason that their dairy failed was that they couldn't grow enough alfalfa to feed their cattle.

Curran Dairy: pasture (l), alfalfa, lagoon (c), and cows

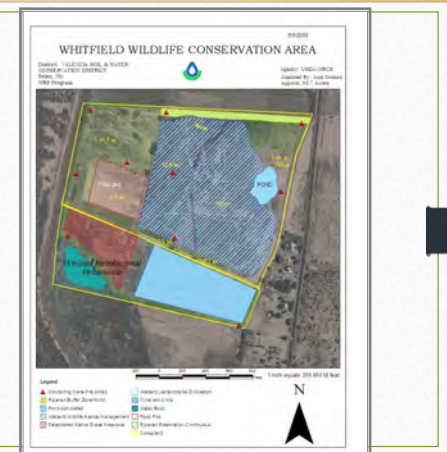


1986: a new subdivision?

- Curran family sells the property to Sue Trammell Whitfield and W.F. Whitfield.
- The Whitfield's dream of a new subdivision ended when they realized that being in a flood zone would require all homes to be elevated.
- The Whitfields donate 97 acres of conservation land to Valencia Soil and Water Conservation District on February 6, 2003.

Permanent Conservation Easement

- Natural Resource Conservation Service (NRCS): Wetland Reserve Program
- Monitoring Wells ▲
- Moist soil units/wetlands, crop field, bosque, grassland





Whitfield Wildlife Conservation Area

- Designed to mimic the historic ecosystem
- Hundreds of volunteers planted 8,000 trees & shrubs
- A cooperative conservation project

Whitfield in autumn



Ecosystem Mosaic

- NW bosque
- Central bosque
- Lower 1/3: young cottonwoods, some wetlands



Cottonwoods vs. Wetlands

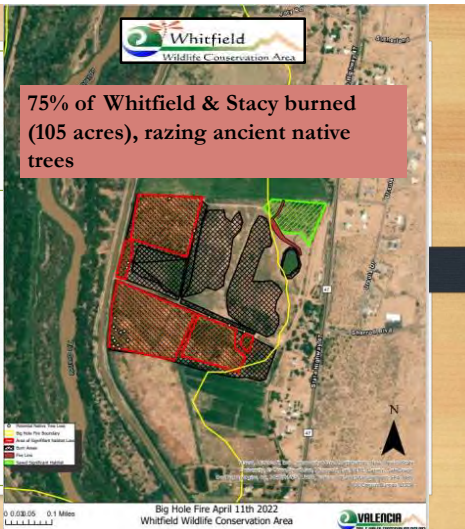
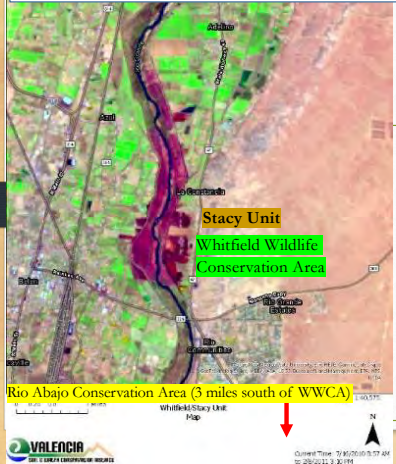


WHITFIELD'S Iconic OWL TREE



Whitfield Wildlife Conservation Area & Stacy Unit: Big Hole Fire of April 11, 2022

BIG HOLE FIRE --April 11th, 2022-- +800 Acres Valencia County's biggest bosque fire (and only fire ever included in a federal emergency declaration)(DR-4632) within Valencia County



100-year-old Teaching Tree
...but we didn't get the picture





Whitfield Destroyed!

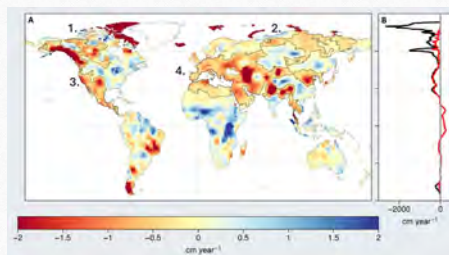
Current and future climate scenarios

“Climate change is driving profound changes within the Earth system, including to its water cycle. While **global temperatures continue to reach record heights**, with the year 2024 being the hottest year in the past 175 years, **the planet is experiencing increasing extremes of flooding and drought**, widespread glacial and ice sheet melt and sea level rise (↔), and **greater risk of wildfire** and biodiversity loss.”

“Areas experiencing drying increased by twice the size of California annually, creating ‘mega-drying’ regions across the Northern Hemisphere. While most of the world’s dry/wet areas continue to get drier/wetter, dry areas are now drying faster than wet areas are wetting.”

H.A. Chandanpurkar, J.S. Famiglietti, et al. “Unprecedented continental drying, shrinking freshwater availability, and increasing land contributions to sea level rise.” *Nature Advances*, 25 July 2025, Vol. 11, Issue 30, as accessed at <https://www.science.org/doi/10.1126/sciadv.adt0298>, September 30, 2025.

One of four mega drought regions: southwestern USA



More Fire?

1. The question is when, *not if*.
2. The next question is will there be sufficient groundwater or river water (terrestrial water storage) to respond to fires.

The climate & the hydrology of the MRG is changing; as are the fire dynamics.



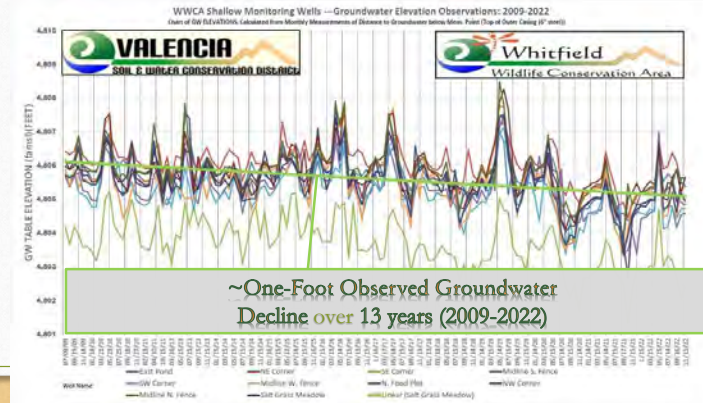
Photo: Teresa Smith de Cherif



Photo: Ivan Pierre Aguirre, NY Times

Cottonwoods are not fire adapted. The Rio Grande is drying. Is desertification the future?

Groundwater Monitoring @ Whitfield Wildlife Conservation Area: 13 Years of Monthly Tape Downs by Volunteers (2009-2022)



Recovery and Mitigation in post-fire year 1:

❖ Immediate Post-Fire Assessment:

- 105 acres burned April 11th, 2022
- 1,000 burned trees, including a dozen ancient trees (cottonwood/willows)

❖ Initial Post-Fire Actions in year 1:

- Irrigated burned areas/ceased travel on scar (grasslands recovered)
- Began to remove hazardous limbs and trees
- Worked with many partners [IRSA (Audubon), NRCS, MRGCD, EMNRD, NMDA/NMSU, local farmers, retired volunteers, community gardeners, staff, and Board members].



Restoring Whitfield Workshop A climate-adapted revegetation workshop: April 2023

Nearly 40 participants





Saltgrass Meadows

- We irrigated after the fire
- Saltgrass meadows recovered and flourished.

Before restoration begins

- **Three years for post-fire recovery and mitigation.**
- Our Conservation Program Assistant wrapped up most of the recovery and mitigation at the end of Fiscal Year 2025.
- We had to request additional **assistance from NM State Forestry** and from the local **Prison Labor Crew**.

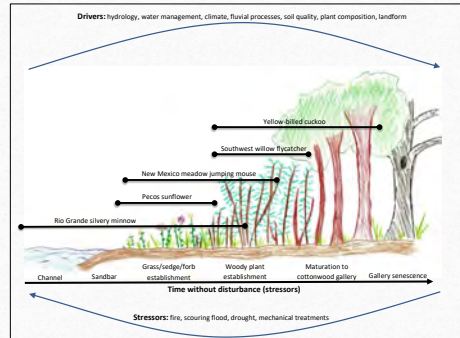
Key Questions for Restoration

- ❖ 1. What are key considerations for the **revegetation design**, in light of the long-term viability of plants in the context of **a hotter and drier New Mexico**?
- --Increase biodiversity of native trees in the MRG (beyond Cottonwoods and Desert Willows)
- --Implement a climate-adapted planting strategy: assisted migration, re-introduction of historic native species that could be more fire-adapted (role for Pueblo elders)

Key Questions for Restoration, cont'd

- ❖ **What are strategies to reduce the severity of wildfires?**
 - ❖ Strategic **bosque thinning**?
 - ❖ Using **fuel breaks** of various designs?
 - ❖ Dampen or flood the conservation areas (pump groundwater? Ditchwater?)

Opportunities for collaborative restoration



Resilient Restoration is the work of everyone.



Thank you.



USBOR WaterSMART Basin Study Program

Authorized through the SECURE Water Act of 2009

Collaborative studies, cost-shared with non-Federal partners, to evaluate likely future imbalances between water supply and demand, and help ensure sustainable water supplies by identifying and modeling strategies to address these projected imbalances.

Rio Grande Basin Study: USBOR and MRGCD study with multi-sectoral committees: Ag, municipal, tribal, NGO, local governance.
Funded through 2028



The NGO Sectoral Committee for the Basin Study is focusing on defining the environmental flow needs for 6 reaches of the Rio Grande in NM.

~15 national and local environmental NGOs with assistance from agency and academic experts.

How much water does the river need to stay alive?

What specific actions (“adaptation strategies”) can improve flows?

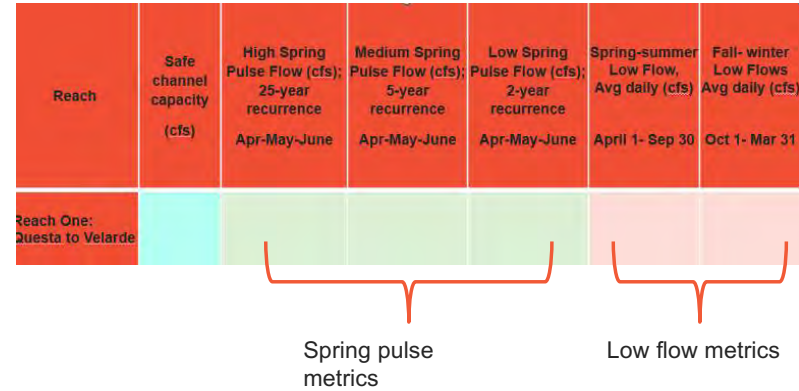
Modeled alongside other water needs to evaluate adaptation strategies.

Basin Study focus is on multi-beneficial opportunities.





Environmental Flow Structure: Rio Chama Flow Project!



Environmental Flow Hypotheses Process

Utilize all available resources: hydrologic information, geomorphic information, ecologic information, expert opinions and recreational observations.

Sectoral Committee 6 reach teams develop initial hypotheses (summer 2023- summer 2024). *Compiled citations and Identify uncertainties.*

Peer review workshop (August 2024). Included strong participation from NGO, water management agencies and university. *Focused on adaptation strategies for improving environmental flows.*

E-flow document: finalized April 2025
Many uses!

Basin Study Trade-off Tools Integration
Modeling of select strategies that lend themselves to modeling and hold promise for being impactful.

6 Reaches and Index Gages

Chama Headwaters: La Puente Gage

Chama Below El Vado: Below El Vado Gage

Chama Below Abiquiu: Below Abiquiu Gage

Rio Grande CO Stateline to Chama Confluence: Taos Junction Bridge Gage

Rio Grande Chama confluence to Cochiti Reservoir: Otowi Gage

Middle Rio Grande: Albuquerque Gage for spring pulse; Albuquerque, Bosque Farms and San Acacia Floodway Gages for low flows

8 gages in total; 6 primary (spring pulse and low flows) and 2 additional low flow gages for Middle Rio Grande



Indicator Species that represent key parts of the native hydrograph

Study Reach	Indicator Species
Questa to Velarde	Brown Trout, Cottonwood, Southwestern Willow Flycatcher, River Otter, American Dipper
Chama Headwaters	Cottonwood, Stonefly, Brown Trout
Chama below El Vado to Abiquiu	Cottonwood, Stonefly, Brown Trout
Chama – Abiquiu to confluence	SWFL, Brown Trout, Cottonwood
White Rock Canyon	Summer Tanager, Rio Grande Chub/ Rio Grande Sucker, River Otter, Coyote Willow
Middle Rio Grande	Rio Grande Silvery Minnow, Cottonwood, Southwestern Willow Flycatcher, Sandhill Crane

Reach	Safe channel capacity (cfs)	High Spring Pulse Flow (cfs); 25-year recurrence Apr-May-June	Medium Spring Pulse Flow (cfs); 5-year recurrence Apr-May-June	Low Spring Pulse Flow (cfs); 2-year recurrence Apr-May-June	Spring-summer Low Flow, Avg daily (cfs) April 1- Sep 30	Fall- winter Low Flows Avg daily (cfs) Oct 1- Mar 31
Reach One: Questa to Velarde	6,000	7,100 peak 10-day avg: 6000	4,700 peak 10-day avg: 4000	2,700 peak 10-day avg: 2300	260 avg 150 min	530 avg 450 min
Reach Two: Rio Chama Headwaters	7,000	4,100 peak 10-day avg: 3900	3,700 peak 10-day avg: 2900	2,200 peak 10-day avg: 1700	80 avg 50 min	70 avg 50 min
Reach Three: Rio Chama Below El Vado	6,000	5,800 peak 10-day avg: 3900	4,300 peak 10-day avg: 2000	2,000 peak 10-day avg: 1700	150 avg 70 min	150 avg 65 min
Reach Four: Rio Chama Below Abiquiu	1,800 (2025: 500)	3,400 peak 10-day avg: 3200	3,400 peak 10-day avg: 3200	1,800 peak 10-day avg: 1700	400 avg 300 min	250 avg 200 min
Reach Five: Rio Chama to Cochiti	9,000	8,200 peak 10-day avg: 7500	6,600 peak 10-day avg: 5800	3,700 peak 10-day avg: 3200	620 avg 450 min	610 avg 380 min
Reach Six: Middle Rio Grande	4,000	8500 peak 20-day avg: 7500	6000 peak 20-day avg: 5400	2,000 peak 20-day avg: 1700	270 avg 130 min	590avg 170 min

Reach	Safe channel capacity (cfs)	High Spring Pulse Flow (cfs) Risk of Flooding	Medium Spring Pulse Flow (cfs); 5-year recurrence Apr-May-June	Low Spring Pulse Flow (cfs); 2-year recurrence Apr-May-June	Spring-summer Low Flow, Avg daily (cfs) April 1- Sep 30	Fall- winter Low Flows Avg daily (cfs) Oct 1- Mar 31
Reach One: Questa to Velarde	6,000					
Reach Two: Rio Chama Headwaters	7,000					
Reach Three: Rio Chama Below El Vado	6,000					
Reach Four: Rio Chama Below Abiquiu	1,800 (2025: 500)					
Reach Five: Rio Chama to Cochiti	9,000					
Reach Six: Middle Rio Grande	4,000					

Middle Rio Grande: Indicator Species and Hydrograph

Cottonwood

Spring pulse disturbance events: especially 25 year recurrence large event

Rio Grande Silvery Minnow

*Spring pulse; medium and low, at least every 2 and 5 years
Low flows for survival*

Southwestern Willow Flycatcher

*Spring pulse for wet floodplain soils
Low flows*

Sandhill Crane

Fall and winter low flows for roost habitat- not too high

Middle Rio Grande RGSM Environmental Flow Needs

Table 28. Reach Six – Middle Rio Grande: Summary of streamflow prescriptions for Rio Grande Silvery Minnow.

One-Day Average Q around Peak	Average 20-Day Q Around Peak	Duration and (Timing)	Avg Rate of Recession	Reasoning and Source Information
High Spring Pulse Flow (associated with strong recruitment)				
6,577 ft ³ /s ¹ (186 m ³ /s ¹)	5,620 ft ³ /s ¹ (159 m ³ /s ¹)	20 days (May - June)	148 ft ³ /s ¹ per day (4.2 m ³ /s ¹ per day)	Based on May to mid-June flow that occurred in 1993, 1994 and 2005 that was considered by MRG experts to provide for robust minnow recruitment
Medium Spring Pulse Flow (associated with intermediate recruitment)				
4,426 ft ³ /s ¹ (125 m ³ /s ¹)	3,286 ft ³ /s ¹ (93 m ³ /s ¹)	20 days (May- June)	73 ft ³ /s ¹ per day (2.1 m ³ /s ¹ per day)	Based on correlation of MRG streamflow conditions with selected years group together that received a minnow grade of A by the Upper Rio Grande Report Card
Low Spring Pulse Flow (associated with weak recruitment)				
1,987 ft ³ /s ¹ (56 m ³ /s ¹)	1,498 ft ³ /s ¹ (42 m ³ /s ¹)	20 days (May- June)	54 ft ³ /s ¹ per day (1.5 m ³ /s ¹ per day)	Based on correlation of MRG streamflow conditions with selected years group together that received a minnow grade of B or C by the Upper Rio Grande Report Card
Average Q	Flow Variation	Duration	Minimum Q	Reasoning and Source Information
Spring-Summer Low Flow				
264 ft ³ /s ¹ (7.5 m ³ /s ¹)		183 days April 1 – Sept 30	131 ft ³ /s ¹ (3.7 m ³ /s ¹)	Based on correlation of MRG streamflow conditions with analysis of discharge of selected years identified by the Upper Rio Grande Report Card
Fall-Winter Low Flow				
320 ft ³ /s ¹ (9 m ³ /s ¹)		182 days Oct 1 – March 31	173 ft ³ /s ¹ (4.9 m ³ /s ¹)	Based on correlation of MRG streamflow conditions with analysis of discharge of selected years identified by the Upper Rio Grande Report Card

Middle Rio Grande Cottonwood Environmental Flow Needs

Table 30. Reach Six - Middle Rio Grande: Summary of E-flow prescription for Rio Grande Cottonwood.

One-Day Average Q around Peak	Average 10-Day Q Around Peak	Duration and (Timing)	Avg Rate of Recession	Reasoning and Source Information
High Spring Pulse Flow (associated with strong recruitment)				
8,455 ft ³ /s ¹ (239 m ³ /s ¹)	7,499 ft ³ /s ¹ (212 m ³ /s ¹)	10 days (May - June)	44 ft ³ /s ¹ per day (1.2 m ³ /s ¹ per day)	Based on riparian ecology and geomorphology expert assessment of magnitude required to establish multi-age, patchy cottonwood forests on significant portions of the MRG bottomland environment that in recent years was best realized by spring floods during years of 1984 and 1985.
Medium Spring Pulse Flow (associated with intermediate recruitment)				
5,985 ft ³ /s ¹ (169 m ³ /s ¹)	5,440 ft ³ /s ¹ (154 m ³ /s ¹)	10 days (May- June)	495 ft ³ /s ¹ per day (14 m ³ /s ¹ per day)	Based on streamflow characteristics that occurred during seven spring flow events in recent period that sparked intermediate cottonwood recruitment (1993-95, 1997, 2005, 2017, 2019, and 2023), which also overlap w years of strong recruitment for the RGSM.
Low Spring Pulse Flow (associated with weak recruitment)				
2,015 ft ³ /s ¹ (57 m ³ /s ¹)	1,655 ft ³ /s ¹ (47 m ³ /s ¹)	10 days (May- June)	140 ft ³ /s ¹ per day (4 m ³ /s ¹ per day)	Discharge that occurred during four spring flow events in recent period that sparked low recruitment of Rio Grande cottonwoods (1998, 1999, 2001, 2004, 2007-2010, 2015 and 2016), these spring flow events also overlap w years of low RGSM recruitment

Middle Rio Grande WIFL Environmental Flow Needs

Table 31. Reach Six – Middle Rio Grande: Summary of E-flow prescription for Southwestern Willow Flycatcher.

One-Day Average Q around Peak	Average 10-Day Q Around Peak	Duration and (Timing)	Avg Rate of Recession	Reasoning and Source Information
High Spring Pulse Flow (associated with strong propagation)				
8,455 ft ³ /s ¹ (239 m ³ /s ¹)	7,499 ft ³ /s ¹ (212 m ³ /s ¹)	10 days (May - June)	44 ft ³ /s ¹ per day (1.2 m ³ /s ¹ per day)	Identical to methodology used to quantify spring pulse flow prescriptions for the Rio Grande cottonwood. The underlying assumption being that flows supportive of a long-term viable, dynamic riparian forest are also supportive for the SWFL.
Medium Spring Pulse Flow (associated with intermediate propagation)				
5,985 ft ³ /s ¹ (169 m ³ /s ¹)	5,440 ft ³ /s ¹ (154 m ³ /s ¹)	10 days (May- June)	495 ft ³ /s ¹ per day (14 m ³ /s ¹ per day)	Identical to methodology used to quantify spring pulse flow prescriptions for the Rio Grande cottonwood. The underlying assumption being that flows supportive of a long-term viable, dynamic riparian forest are also supportive for the SWFL.
Low Spring Pulse Flow (associated with weak propagation)				
2,015 ft ³ /s ¹ (57 m ³ /s ¹)	1,655 ft ³ /s ¹ (47 m ³ /s ¹)	10 days (May- June)	140 ft ³ /s ¹ per day (4 m ³ /s ¹ per day)	Identical to methodology used to quantify spring pulse flow prescriptions for the Rio Grande cottonwood. The underlying assumption being that flows supportive of a long-term viable, dynamic riparian forest are also supportive for the SWFL.
Average Q	Flow Variation	Duration	Minimum Q	Reasoning and Source Information
Spring-Summer Low Flow				
265 ft ³ /s ¹ (7.5 m ³ /s ¹)		183 days April 1 – Sept 30	130 ft ³ /s ¹ (3.7 m ³ /s ¹)	Identical to the prescription for the RGSM.
Fall-Winter Low Flow				
320 ft ³ /s ¹ (9 m ³ /s ¹)		182 days Oct 1 – March 31	175 ft ³ /s ¹ (4.9 m ³ /s ¹)	Identical to the prescription for the RGSM.

Middle Rio Grande Sandhill Crane Environmental Flow Needs

Table 33. Reach Six - Middle Rio Grande: Summary of E-flow prescription for Sandhill Crane. Given the presence of sandhill cranes along the MRG only during the fall-winter period, the E-flow prescription for the crane is quantified only for that period.

Average Discharge for Entire Period	Percent of time discharge greater than 1000 cfs and 700 cfs	Duration and Timing	Minimum Q	Reasoning and Source Information
Fall-Winter Low Flow (Oct 1 – March 31)				
589 ft ³ /s ¹ (16.7 m ³ /s ¹)	6% and 22%	182 days Oct 1 – March 31	169 ft ³ /s ¹ (4.8 m ³ /s ¹)	Based on analysis of streamflow at Albuquerque gauge for years identified by experts when crane numbers and habitat during the fall-winter period were particularly healthy and well-distributed (i.e., robust) through much of the MRG reach (2003, 2009, 2013, 2014, 2016, 2018, and 2020)

Middle Rio Grande Synthesis Environmental Flow Needs

Safe channel capacity (cfs)	High Spring Pulse Flow (cfs); 25-year recurrence	Medium Spring Pulse Flow (cfs); 5-year recurrence	Low Spring Pulse Flow (cfs); 2-year recurrence	Spring-summer Low Flow, Avg daily (cfs)	Fall- winter Low Flows Avg daily (cfs)
4,000	8500 peak 20-day avg: 7500	6000 peak 20-day avg: 5400	2,000 peak 20-day avg: 1700	270 avg 130 min	590avg 170 min



A new ecosystem



Photo: Tucker Davidson

Future Scenario Planning Workshop for Drought and River Drying in the Middle Rio Grande
October 28-29, 2025 - Workshop Report

No irrigation water = drier river





Environmental Flow Recommendations for Six Reaches of the Mainstem of the Rio Grande and Rio Chama in New Mexico

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Middle Rio Grande Low Flow Adaptation Strategies

Priority flow issue	Potential implementation strategy/ opportunity	Adaptation Strategy for Modeling	Potential issues to review with modelers	Effort to model strategy vs expected system improvement (cost-benefit) 1-5 rating
Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Enroll additional acreage into MRGCD EWLP and deliver the saved water to targeted outfalls along the river to support endangered species.	Reduce irrigated acreage in MRGCD by 10%, 20%, 30% and deliver calculated water savings to the river.	Reductions in groundwater recharge to shallow aquifer and gw return to the river (variance in efficiency coefficient; need to identify gw gaining reaches).	Effort: Efficacy:
Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Lower San Acacia Reach Improvement Project- river realignment	Increase conveyance efficiency (reduce losses) in the Lower San Acacia reach in the model by efficiency % (range- will need to check with MikeSHE)	Increased ET/ gwap (already being accounted for in model).	Effort: Efficacy:
Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Reduce irrigation demand by infrastructure improvements: reduce losses by improving diversion structures, lining canals, improving field delivery conditions	Reduce irrigation losses by 5%, 10%, 15% and deliver calculated water savings to the river.	Loss of ditch side/ auxiliary riparian ecosystem.	Effort: Efficacy:
Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Alternative crops: less water intensive crops/ best practices that reduce irrigation demand.	Reduce irrigation losses by 5%, 10%, 15% and deliver calculated water savings to the river.	Impact to farmer's revenue and labor costs. (see "Alleviating water scarcity by optimizing crop mixers" by Richter et al.	Effort: Efficacy:

Middle Rio Grande Low Flow Adaptation Strategies

Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Reduce municipal water demand through conservation programs and incentives and improved delivery infrastructure	Reduce municipal water consumptive use by 5%, 10%, 15% and deliver calculated water savings to the river.	Need to distinguish between gw and gwy in model- how is this represented?	Effort: Efficacy:
Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Allow MRGCD EWLP multi-year storage in Abiquiu's existing environmental pool (30k af of storage space)	Reduce irrigated acreage in MRGCD by 10%, 20%, 30% and store calculated water savings in Abiquiu's existing environmental pool. Manage EWLP water from Abiquiu E-Pool with hold over capability.	NMOSE permitting hurdles. Could EWLP also use space in Heron/ El Vado? Potential $gwap$ reductions/ changes. Need for additional environmental water leasing/ wet water.	Effort: Efficacy:
Low Flows; Spring-Summer-Fall Middle Rio Grande: April - October	Allow MRGCD EWLP multi-year storage in aquifer storage recovery systems (ASR's).	Reduce irrigated acreage in MRGCD by 10%, 20%, 30% and store calculated water savings in ASR's. Manage EWLP water from MRG ASR's.	Analysis may be limited in current models.	Effort: Efficacy:





Assessing Consumptive Water Use

We developed detailed water consumption estimates for 14 sub-basins:

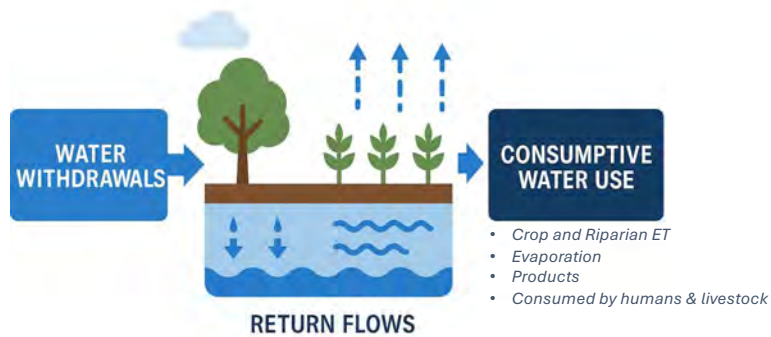
- Municipal & commercial
- Thermolectric power plants
- Irrigated agriculture
- Reservoir evaporation
- Riparian evapotranspiration

“Overconsumption Gravely Threatens Water Security in the Binational Rio Grande-Bravo Basin,” *Discover Water*, in publication.

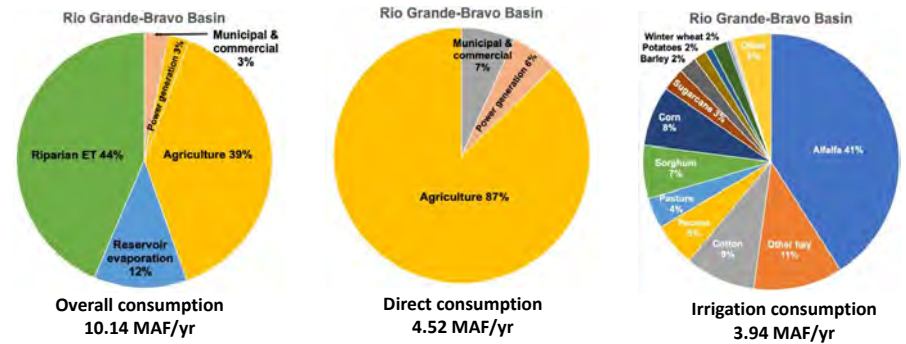
Brian D. Richter, Karem Abdelmohsen, Sameer Dhakal, James S. Famiglietti, Kat F. Fowler, Henry Green, Landon Marston, Mesfin M. Mekonnen, Enrique Prunes, Melissa M. Rohde, Benjamin L. Ruddell, Richard R. Rushforth, Samuel Sandoval, Natalie Shahbol, Eric C. Sjöstedt.



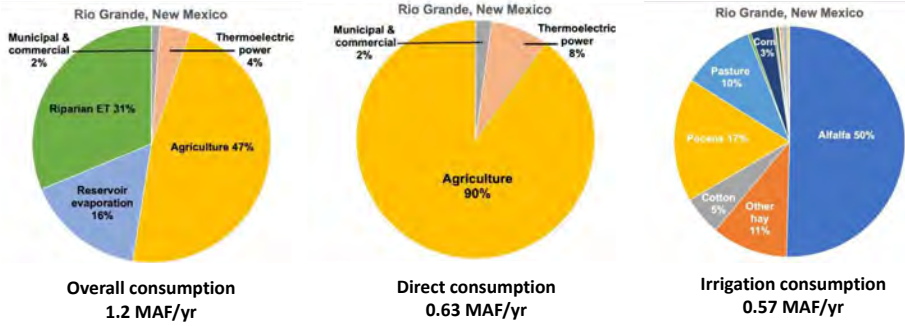
Assessing Consumptive Water Use



Water consumption in the RGB

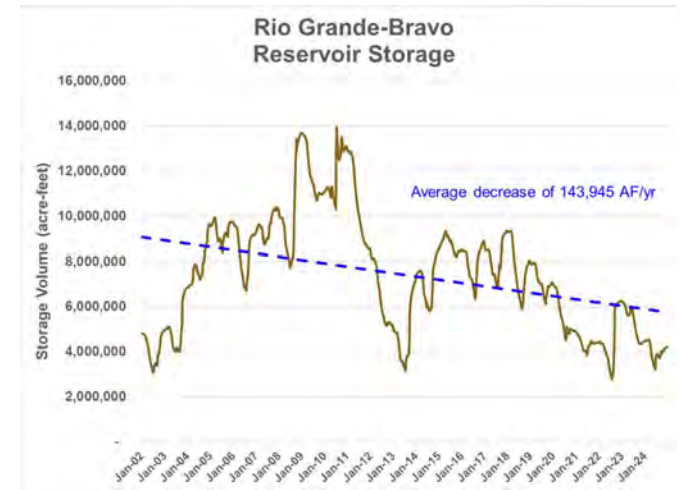


Water consumption in the Rio Grande of NM



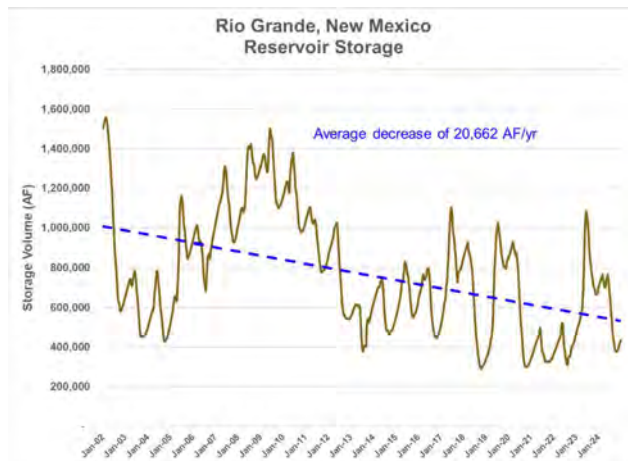
Reservoir depletion

Rio Grande-Bravo basin wide



Reservoir depletion

Rio Grande NM sub-basins

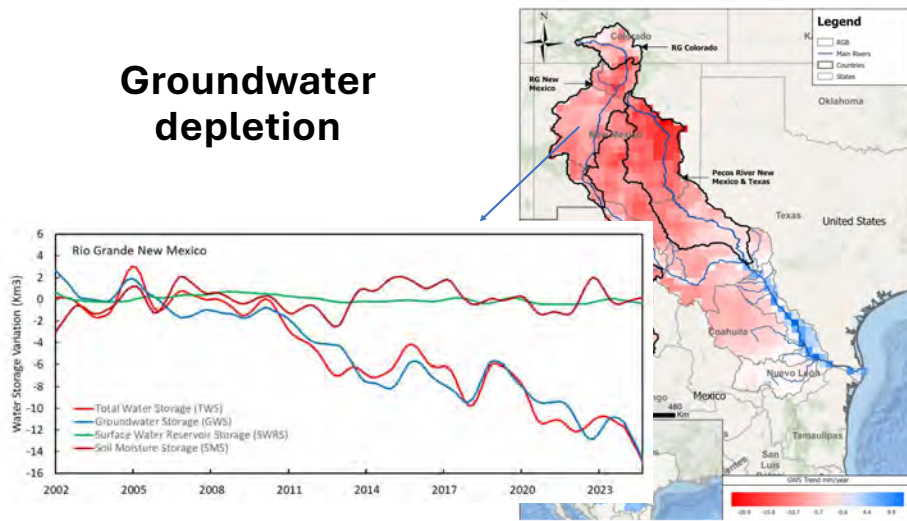


Elephant Butte Reservoir 3% of capacity



September 21, 2025

Groundwater depletion



Our water consumption is unsustainable

Rio Grande-Bravo basin wide

- Reservoir depletion = -143,945 AF/year
- Aquifer depletion = -2,189,000 AF/year
- River flow depletion = -18,147 AF/year
- Total depletion = -2,351,092 AF/year
- Direct consumption = 4,519,434 AF/year
- **Percent overconsumption = 52%**

➤ **Half of the water we consume is supplied by natural river flow and groundwater recharge. The other half comes from depleting rivers, reservoirs, and aquifers.**

Our water consumption is unsustainable

Rio Grande in New Mexico

- Reservoir depletion = -20,663 AF/year
- Aquifer depletion = -510,750 AF/year
- River flow depletion = -7,852 AF/year
- Total depletion = -539,264 AF/year
- Direct consumption = 632,411 AF/year
- **Percent overconsumption = 85%**

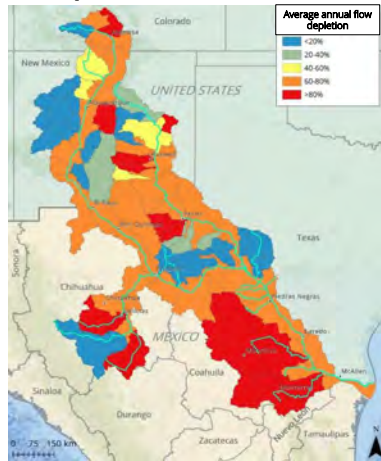
➤ **Most of the water we consume comes from depleting rivers, reservoirs, and aquifers.**

Loss of farmland in the RGB basin, 2000-2019

- Colorado sub-basin lost 18%
- New Mexico sub-basins lost 28%
- Pecos River sub-basin lost 49%



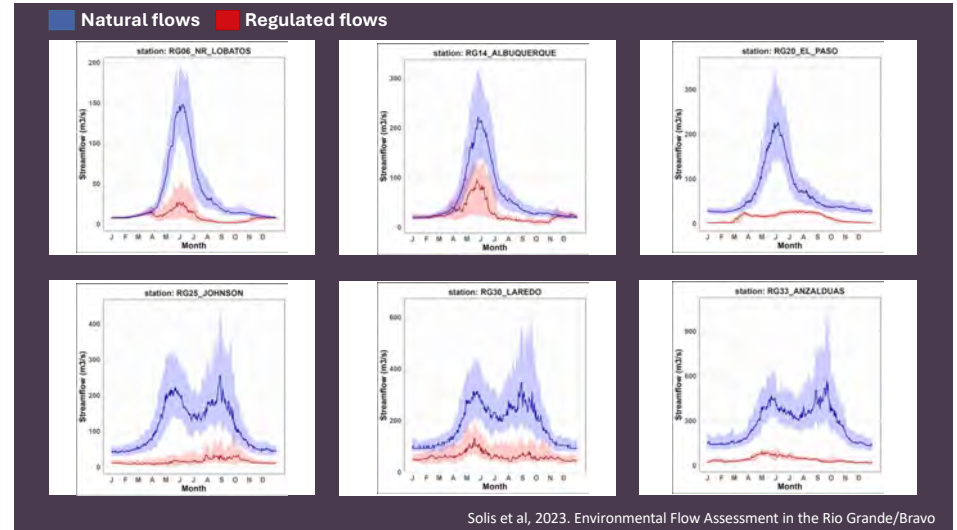
River Depletion



Richer, B.D., Prunes E., N. Liu, N., P. Caldwell, P., Wei, D., Davis, K.F., S. Sandoval-Soto, S., Herrera, O.R., Saez-Rodriguez, R., An, Y., Lemaire, G., Amaya, M., Shalaby, N. (2023). Opportunities for Restoring Environmental Flows in the Rio Grande–Rio Bravo Basin Spanning the US–Mexico Border.



Blythe, T., and Schmidt, J. (2017). Estimating the natural flow regime of rivers with long-standing development: the northern branch of the Rio Grande. *J. Water Resources Research*.



Solis et al., 2023. Environmental Flow Assessment in the Rio Grande/Bravo

Drying up the river



Will we save the river basin we need and love?

Securing a sustainable future for the Rio Grande will require bold, collaborative solutions. Together, we can:

Empower communities to co-create a vision for resilient agriculture that honors local values, supports livelihoods, and reduces water use.

Advance water policy and management reforms that optimize available resources and integrate environmental flows, driven by agency leadership and political will.

Accelerate investment in Nature-Based Solutions to restore ecosystems, recharge aquifers, and build climate resilience.

Strengthen foundational science and expand water data monitoring to inform decision making, leveraging emerging technologies.

Champion catalytic, innovative ideas that positively disrupt the status quo while preserving the cultural essence of the region.

© WWF-US / Diana Cervantes



The Rio Grande basin is at a tipping point, and everyone needs to be part of the solution.

Help us in shaping a water-secure future.

enrique.prunes@wwfus.org

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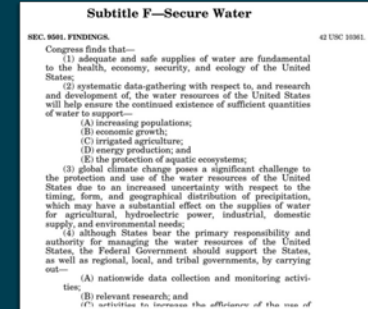


Rio Grande Basin Study: Modeling Overview

Future Scenarios Planning for Drought and River Drying in the Middle Rio Grande
October 28, 2025
Lucas Barrett and Emma Metcalf

Study Fundamentals

- Evaluate water supply and demand
 - Wholistic look at how our basin is doing and consideration of future conditions
- Identify strategies to address imbalances in water supply and demand
 - Community approach to working through these challenges
 - What works? What doesn't?



Basin Study Program Required Elements

- 1 State-of-the-art **projections** of future supply and demand by river basin
- 2 **Analysis** of how existing **water** and **power operations** and **infrastructure**
- 3 Development of **strategies** to meet current and future water demands
- 4 A **trade-off analysis** of strategies identified



Rio Grande Basin Study: Lobatos Gage to Elephant Butte

- RG Basin from CO state line to Elephant Butte dam
- Includes San Juan – Chama Project tributary basins
- Will consider lands outside of scope but they will not be specifically modeled



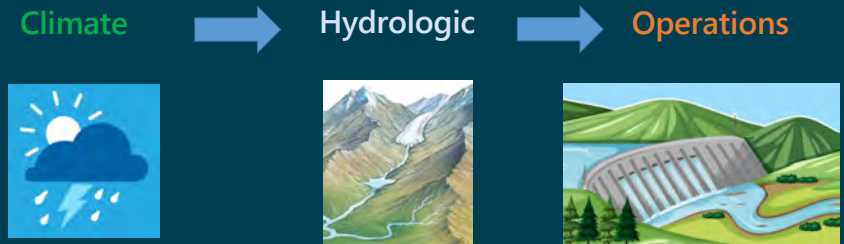
Map of Rio Grande Basin Study: Lobatos Gage to Elephant Butte Study Area. 2019. Bureau of Reclamation.

Memorandum of Agreement Signatories

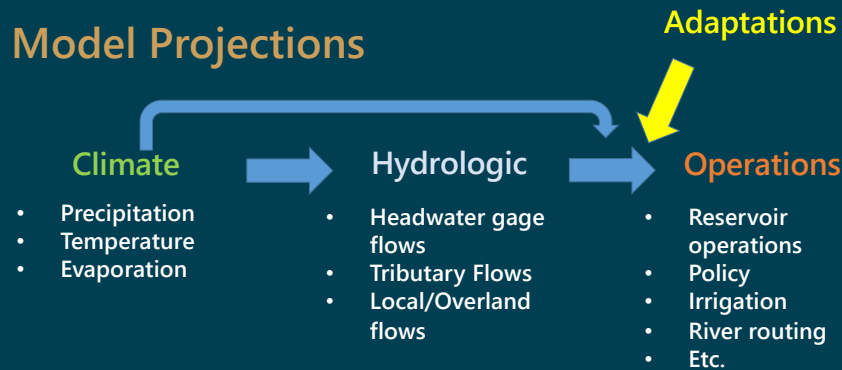
	Organization	Organization
1	American Rivers	22 Pueblo of Isleta
2	Amigos Bravos	23 Pueblo of Laguna
3	Audubon Southwest	24 Pueblo of San Felipe
4	Bernalillo County	25 Pueblo of Sandia
5	Bosque Ecosystem Monitoring Program	26 Pueblo of Santa Ana
6	Center for Social Sustainable Systems	27 Pueblo of Santo Domingo
7	City of Santa Fe	28 Pueblo of Taos
8	Cuidad SWCD	29 Rio Grande Restoration
9	Coronado SWCD	30 Sandoval County
10	Embudo Valley Regional Acequia Association	31 Save Our Bosque Task Force
11	Friends of the Bosque del Apache NWR	32 Sierra Club, Rio Grande Chapter
12	Las Acequias de Placitas	33 South Valley Regional Association of Acequias
13	Middle Rio Grande Conservancy District	34 The Nature Conservancy
14	Middle Rio Grande Water Advocates	35 The Wilderness Society
15	National Wildlife Federation	36 Theodore Roosevelt Conservation Partnership
16	New Mexico Environmental Law Center	37 Trout Unlimited
17	New Mexico Healthy Soils Working Group	38 Valencia SWCD
18	New Mexico Interstate Stream Commission	39 Water Culture Institute
19	New Mexico Water Dialogue	40 Western Resource Advocates
20	NM Wild	41 Wild Earth Guardians
21	Pueblo of Cochiti	42 World Wildlife Fund



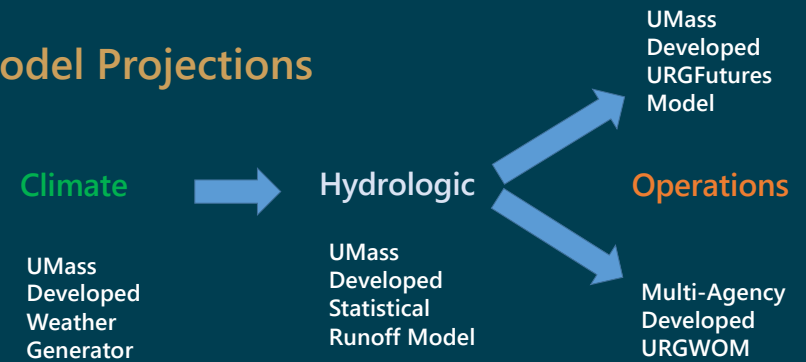
State-of-the-art projections of future supply and demand by river basin



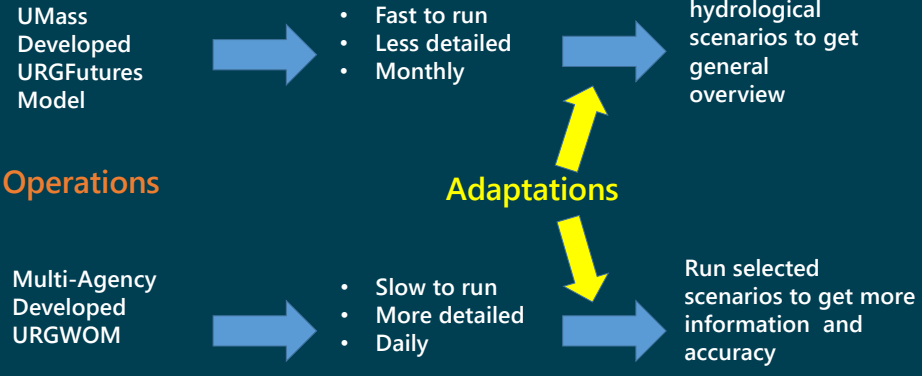
Model Projections



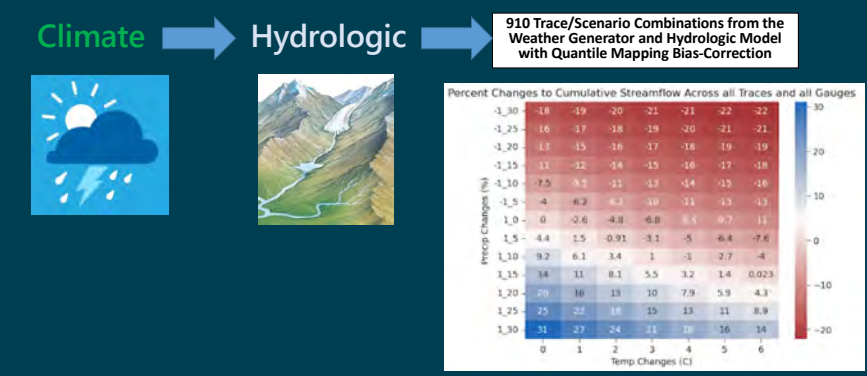
Model Projections



Model Projections

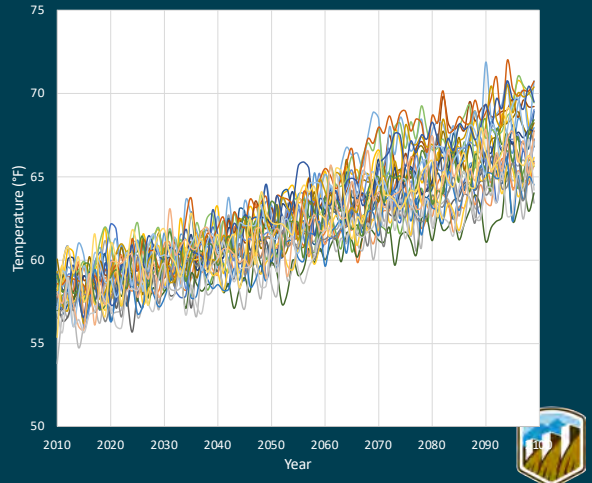


910 Total Traces

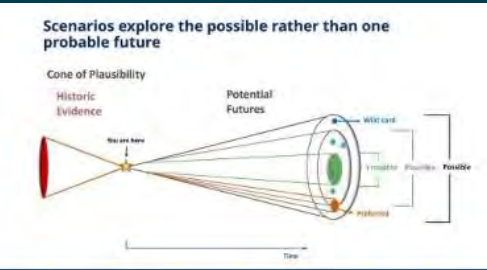


What's the problem?

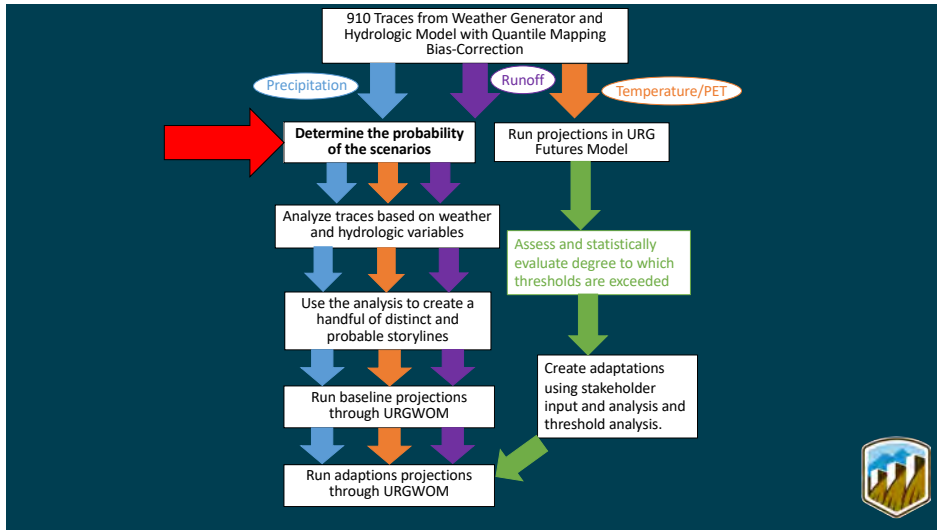
- So many possibilities, so little time
- How do you make sense of them all?



Decision Making Under Deep Uncertainty

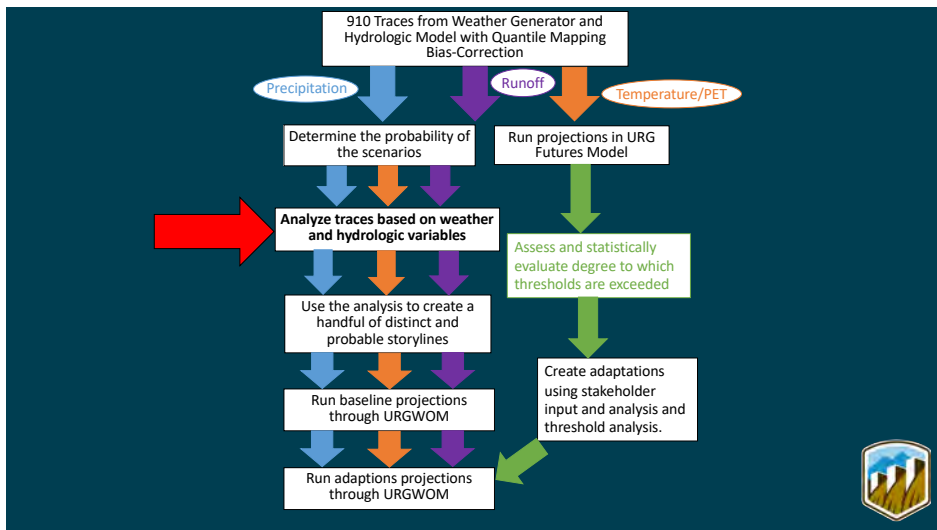


- We do not know exactly what the future holds
- Explore multiple pathways into the future, "storylines"
- Stress-test proposed policies to identify their strengths and weaknesses from multiple points of view
- Identify new, more robust strategies that meet multiple objectives over a wide range of futures

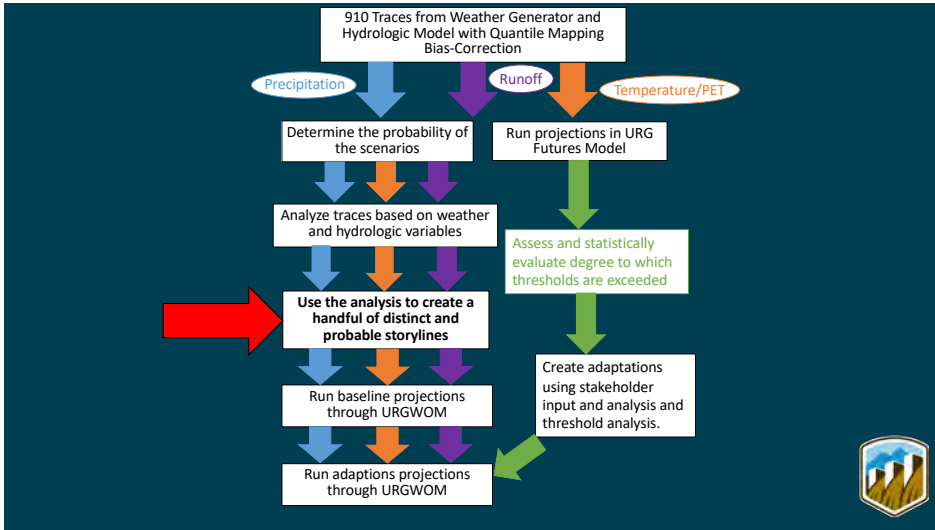


Determine the probability of scenarios

- There are 91 Scenarios per trace that range from 0°C to +6°C, and -30% to +30% precipitation change by 2099.
- Dr. David Gutzler's research showed the most likely range being +2°C to +5°C and precipitation from -15% to +10%.
- Also, looking at the GCMs UMass analyzed, a majority of them fall within that range.



Example of Pecos Basin Study



Proposed RG Basin Study Storylines

1. Overall Dry
2. Overall Wet
3. Median
4. High spring rain, low snowpack/monsoon
5. Very high monsoon with low snowpack (high intensity, low frequency)
6. High monsoon with low snowpack (low intensity, high frequency)
7. High Annual Variability (a lot of back and forth wet/dry years)
8. Low Annual Variability (periods of many wet or dry years in a row)

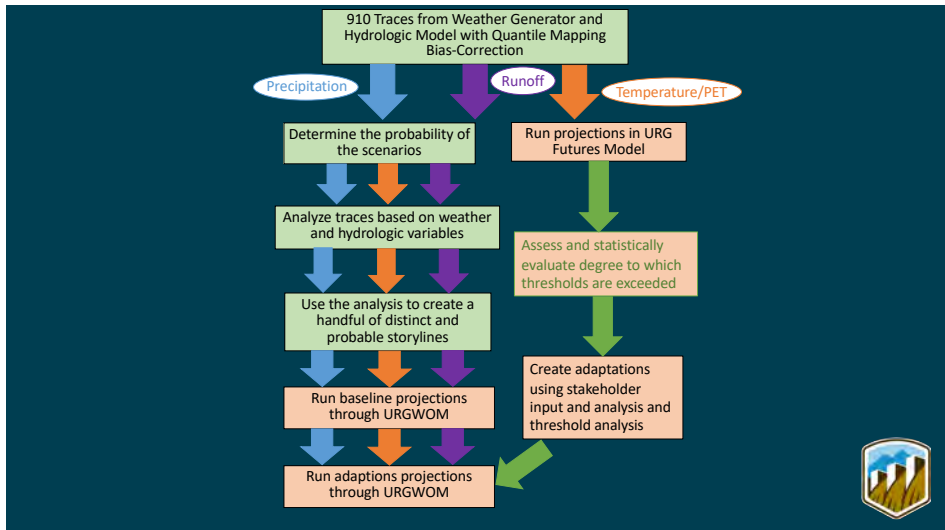
Select Trace for each Storyline based on Analysis

Example for Very Dry

Trace 5 shows a significant downward trend in runoff and monsoons over time compared to the other traces.

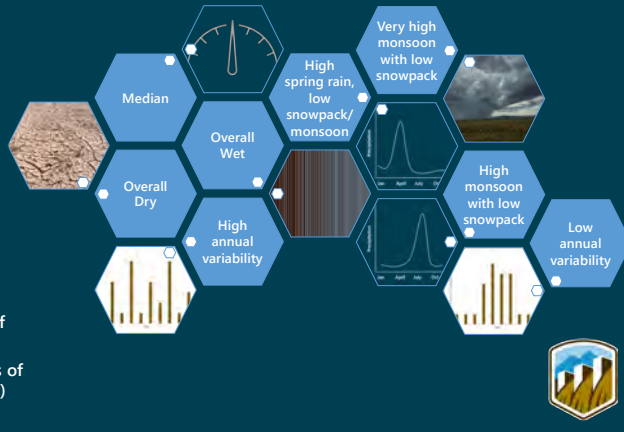
	Annual Snowmelt (March 1 - July 15) Statistics										
	trace 0	trace 1	trace 2	trace 3	trace 4	trace 5	trace 6	trace 7	trace 8	trace 9	Average
25-'49	19,287,684	17,323,821	19,988,379	20,360,621	18,289,351	20,521,017	1,624,030	18,889,770	20,225,694	19,198,491	19,570,945
50-'74	17,511,713	21,747,877	17,429,155	17,666,098	20,181,318	18,622,421	9,944,233	20,627,699	18,615,603	19,051,951	19,718,374
75-'99	20,572,982	18,616,512	21,871,638	19,830,325	19,255,881	18,202,514	20,673,512	19,209,636	18,846,914	19,919,127	19,699,925
Sum	57,372,378	57,688,211	59,289,373	57,856,444	57,326,951	58,242,365	58,526,901	57,688,210	58,169,572	57,689,244	
Slope	794	648	918	156	66	-1,841	630	86	-971	225	131
Min	246,422	208,398	275,793	360,388	275,081	265,551	296,551	280,220	188,288	278,622	265,618
10% Exceedance	455,301	474,664	415,764	449,188	412,228	471,514	426,081	491,110	450,288	528,400	458,321
25% Exceedance	585,403	597,841	572,083	596,848	626,211	619,878	598,978	588,861	564,616	611,463	596,219
50% Exceedance	770,176	782,899	755,318	773,877	765,687	791,298	1,770,415	769,680	768,640	734,461	767,247
75% Exceedance	890,249	906,531	904,658	953,569	945,311	923,699	951,632	945,434	949,541	950,491	942,939
90% Exceedance	1,095,210	1,095,620	1,112,470	1,085,848	1,064,481	1,083,781	1,110,057	1,130,138	1,100,043	1,079,569	1,095,718
Max	1,323,717	1,314,067	1,573,057	1,399,968	1,344,818	1,195,343	1,313,708	1,403,127	1,507,808	1,384,644	1,376,028

	Annual Monsoonal (July 1 - October 31) Statistics										
	trace 0	trace 1	trace 2	trace 3	trace 4	trace 5	trace 6	trace 7	trace 8	trace 9	Average
25-'49	613,503	556,801	607,648	615,911	648,216	612,796	545,098	623,546	620,031	660,987	620,464
50-'74	536,201	579,350	652,568	576,603	617,615	602,788	602,390	669,681	600,950	578,130	601,530
75-'99	864,988	626,701	588,189	615,723	577,915	516,942	289,181	601,831	505,074	583,526	596,982
Sum	1,814,692	1,762,852	1,848,406	1,807,244	1,842,746	1,732,526	1,434,609	1,896,098	1,816,061	1,813,047	1,818,976
Slope	37	37	-11	12	-6	-32	-47	-12	-29	-77	-18
Min	8,841	8,401	10,721	8,414	8,117	9,063	9,582	8,984	8,422	8,557	8,913
10% Exceedance	34,756	12,811	11,451	12,441	13,444	12,350	12,744	10,841	11,259	11,994	12,344
25% Exceedance	17,021	15,510	15,312	16,360	16,274	15,831	17,842	14,968	16,007	17,237	16,216
50% Exceedance	23,118	21,053	22,448	22,651	21,942	21,838	22,271	22,866	21,994	22,933	22,314
75% Exceedance	28,438	28,779	25,755	28,244	29,612	28,304	30,780	30,993	31,791	29,805	29,651
90% Exceedance	35,377	39,501	43,037	37,037	38,361	38,276	38,967	43,842	37,233	38,636	39,085
Max	73,907	56,089	63,137	65,061	52,819	53,578	54,807	80,896	72,948	61,097	63,437



Proposed RG Basin Study Storylines

1. Overall Dry
2. Overall Wet
3. Median
4. High spring rain, low snowpack/monsoon
5. Very high monsoon with low snowpack (high intensity, low frequency)
6. High monsoon with low snowpack (low intensity, high frequency)
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8. Low Annual Variability (periods of many wet or dry years in a row)



Groundwater Futures

Groundwater Management and Aquifer Response

Diane Agnew
Water Rights Program Manager
October 28, 2025



Water 2120 and Groundwater Management

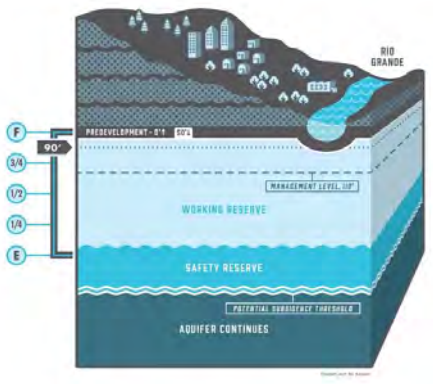
- Groundwater Management Plan is one of four implementation plans
- Collaboration with USGS for real-time and manual monitoring of aquifer levels
- Annual Open File reports with the New Mexico Bureau of Geology and Mineral Resources

Policy C: Establish and Maintain a Groundwater Reserve

The Authority shall establish a groundwater reserve that maintains sufficient water in aquifer storage to provide water supply during catastrophic drought or other unforeseen, largely unquantifiable events. The groundwater reserve shall be accessible without causing adverse impacts to the aquifer and shall be partitioned into a safety reserve and a working reserve.



Groundwater Management Levels

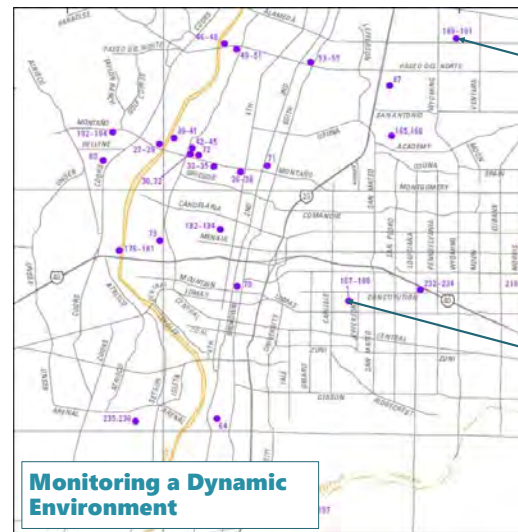


Target: 110 feet for average drawdown

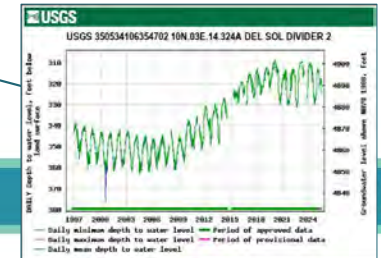
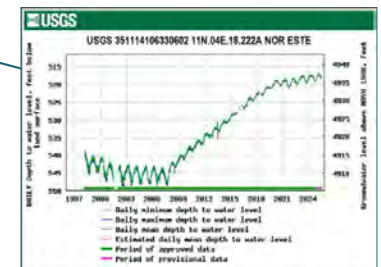
Working Reserve: between 50 and 250 feet of drawdown

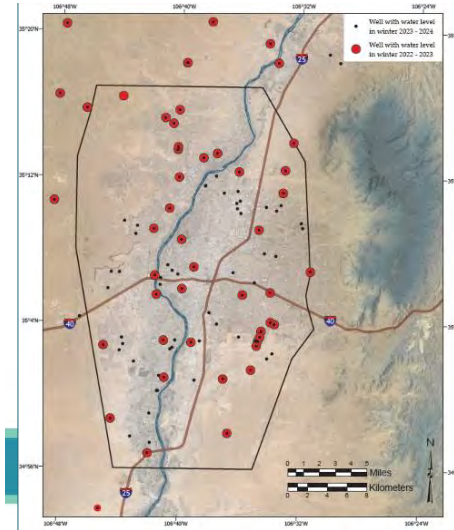
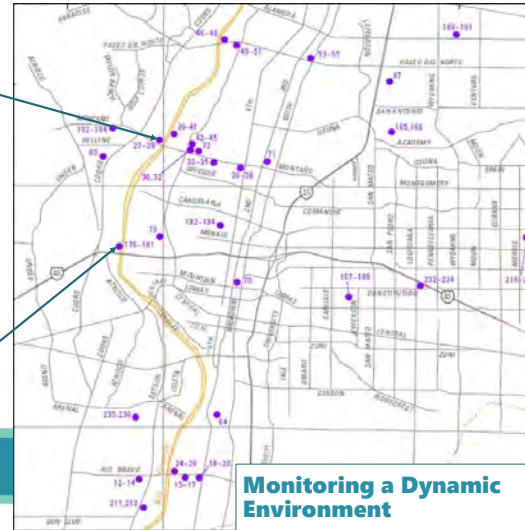
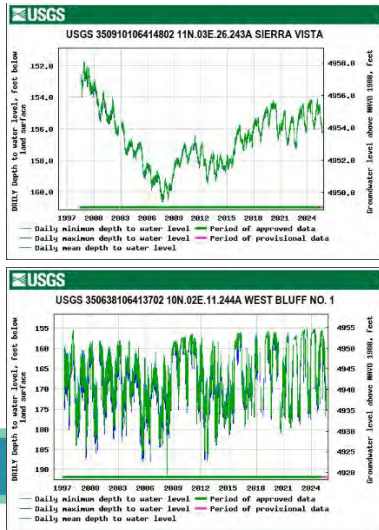
Safety Reserve: 250 – 300 feet of drawdown

"Fuel gage" approach tracks average drawdown relative to the top of the safety reserve.



Monitoring a Dynamic Environment





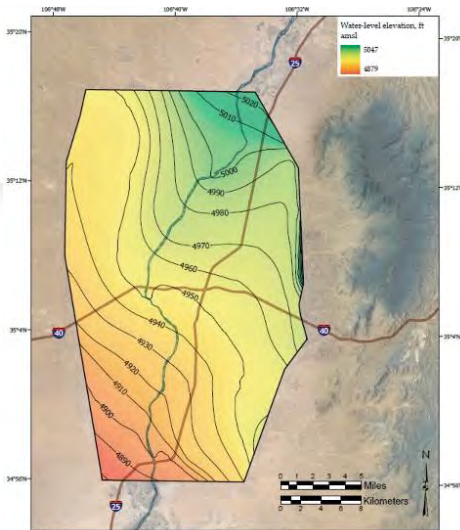
Groundwater Mapping

- Groundwater level monitoring across service area
- Data from:
 - USGS monitoring well network
 - Bernalillo County monitoring wells
 - KAFB Bulk Fuels Facility wells
 - City of Albuquerque monitoring wells
- Continuous and manual data collection



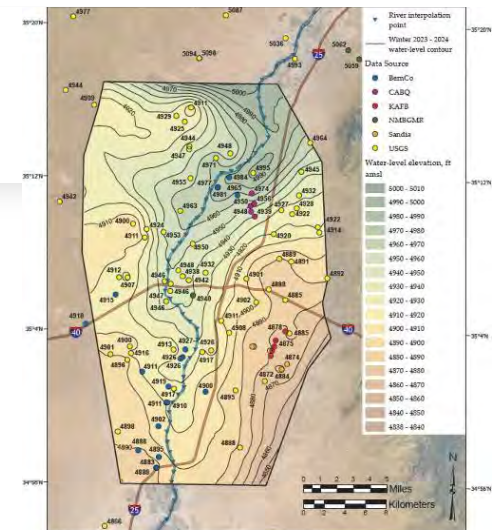
Pre-Development Water-level Elevation Contours

- Interpolated color shading
- Developed from Bexfield and Anderholm (2000)
- General gradient to the southwest across the study area



Water-level Elevation Contours 2023 - 2024

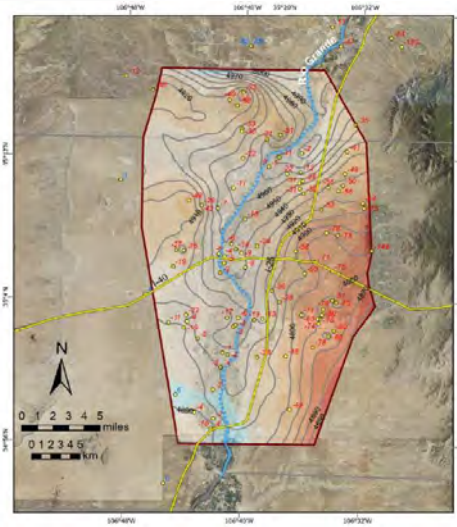
- Water-level measurements from winter period (2023-2024)
- Visible influence of groundwater pumping
- Map accuracy highly dependent on spatial distribution of data



Drawdown 2023 - 2024

- Increased number of data points, better understanding of changes in drawdown
- Generally, no change in drawdown in study area

Increase drawdown = red
Decrease drawdown = blue



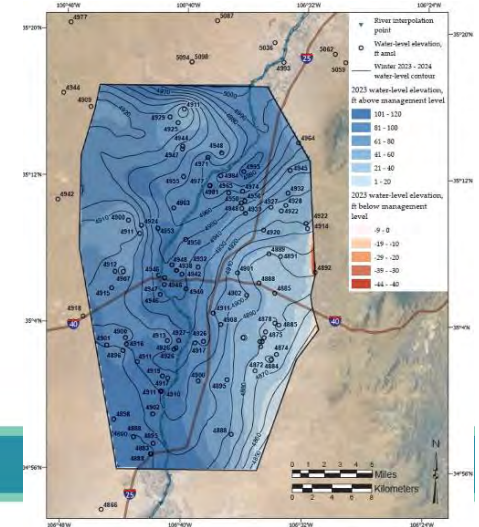
Groundwater Management Level

2023-2024 water levels relative to groundwater management level

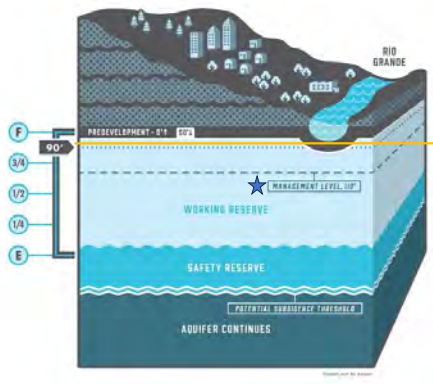
Above 100 ft = blue

Below 110 ft = red

Groundwater Management Level
Target: 110 feet of drawdown



Fuel Gage Status



- 2021 Level:**
88 feet of drawdown below predevelopment
- 2022 Level:**
78 feet of drawdown below predevelopment
- 2023 Level:**
80 feet of drawdown below predevelopment
- 2024 Level:**
78 feet of drawdown below predevelopment

Albuquerque Bernalillo County
Water Utility Authority

Summary

- An estimated 63,806 acre-feet of loss in groundwater storage over the year 2023
 - 139,200 acre-feet of water was added to groundwater storage in 2022
- Water levels in aquifer remain above groundwater management level of 110 feet below predevelopment
- Groundwater levels appear to be stabilizing
- Additional groundwater monitoring data points will increase certainty in estimations of changes in storage and aquifer levels

Albuquerque Bernalillo County
Water Utility Authority

Questions?



Climate Change in the Middle Rio Grande: Considerations for Breakout Sessions

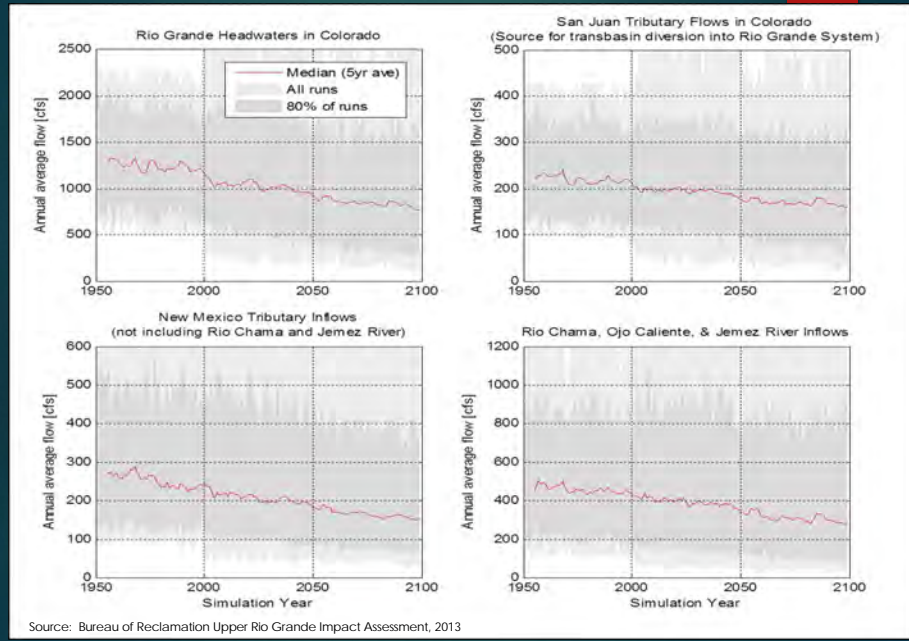
University of New Mexico
Drought and River Drying
Workshop
October 28-29, 2025

Dagmar Llewellyn, ISET
International

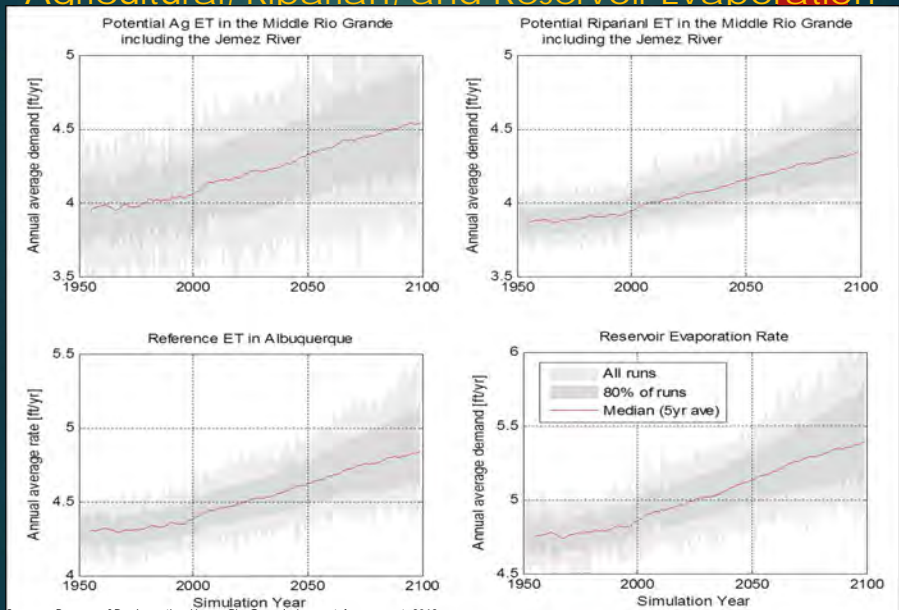
Stephanie Mladinich,
South Central Climate
Adaptation Science Center



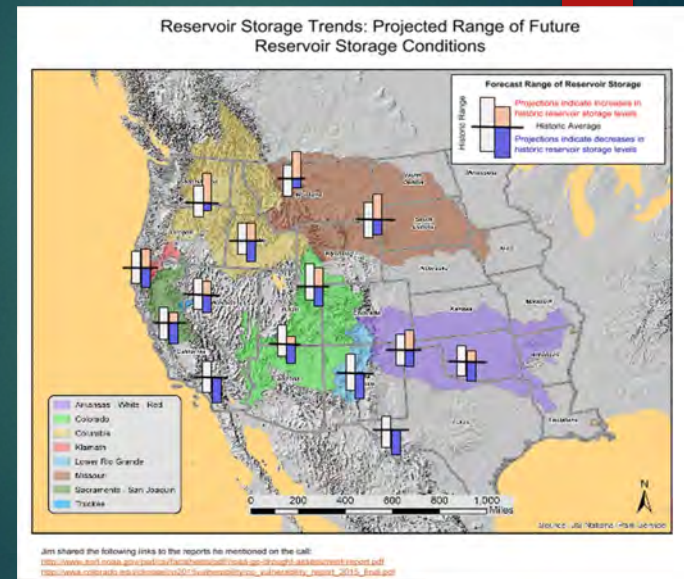
Models Project Reduced System Inflows



Models Project Increases in Demand: Agricultural, Riparian, and Reservoir Evaporation

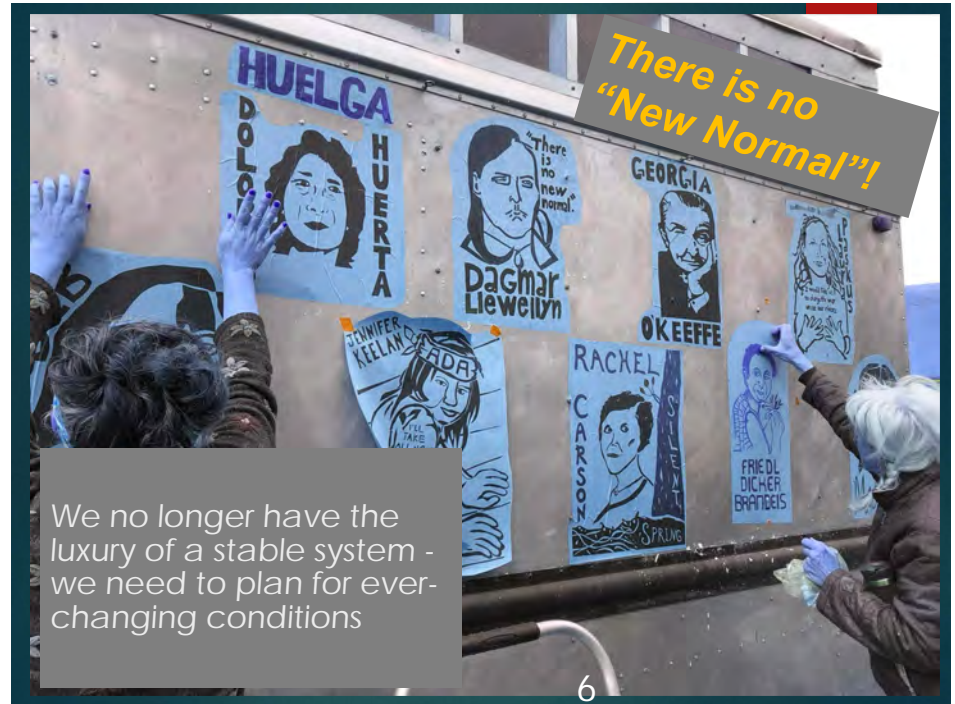


...Leading to reduced system-wide water storage.



From the Bureau of Reclamation's SECURE Report to Congress for 2016

Important considerations for the evaluation of impacts to ecosystem function, species and habitats....



We no longer have the luxury of a stable system - we need to plan for ever-changing conditions

6

There is a LOT of uncertainty about future changes, and how quickly they will develop.



Uncertainty in future human behavior provides the greatest source of uncertainty to temperature projections (which means that much of the uncertainty is irreducible).

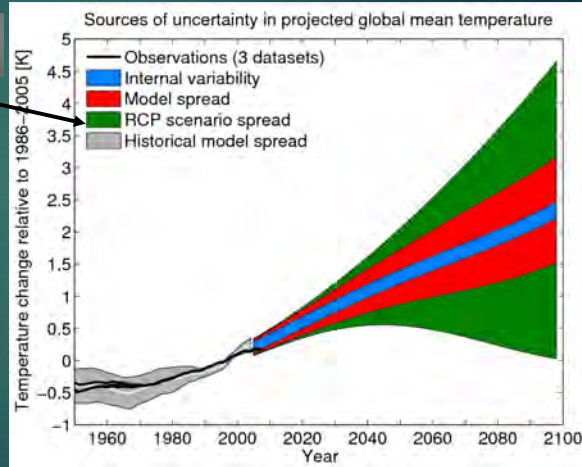
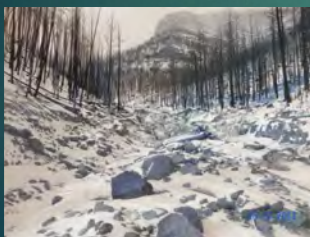
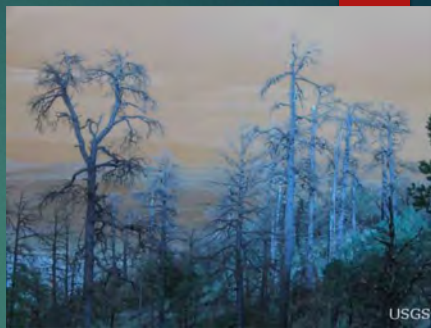


Image source: IPCC

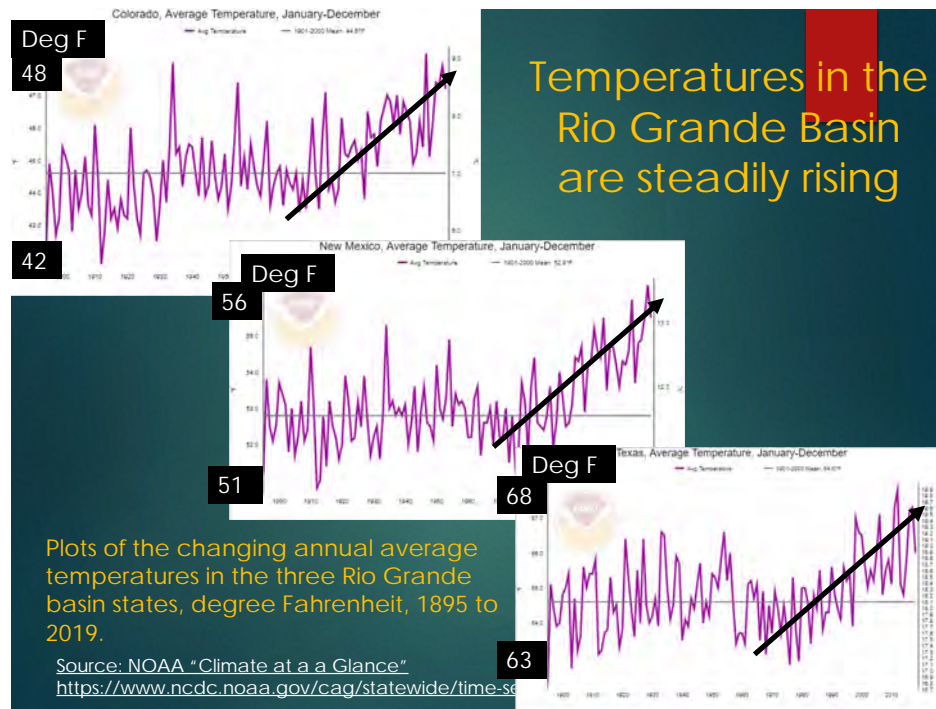
Impacts are not just to surface water availability...



Impacts Cascade into Other Systems



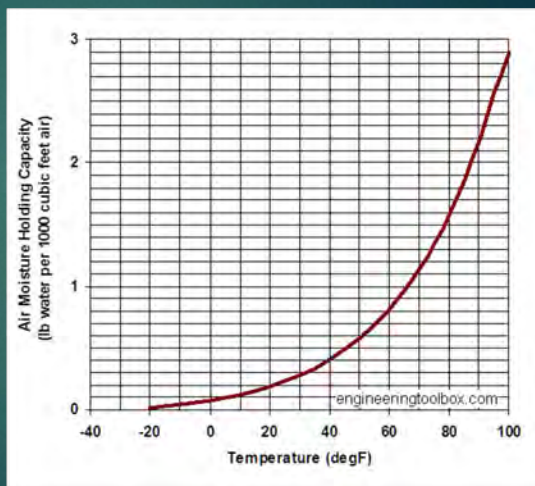
Las Conchas Fire (2011) and its aftermath



Temperatures in the Rio Grande Basin are steadily rising

Exponential relationship between air temperature and water-holding capacity

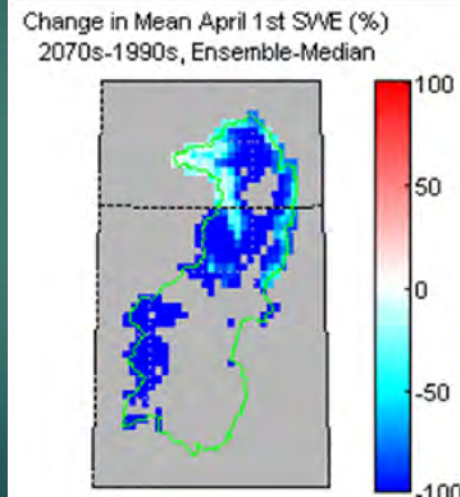
Small temperature changes can lead to significant loss of liquid water – from our water bodies, snow, vegetation, crops, and soils – into the atmosphere.



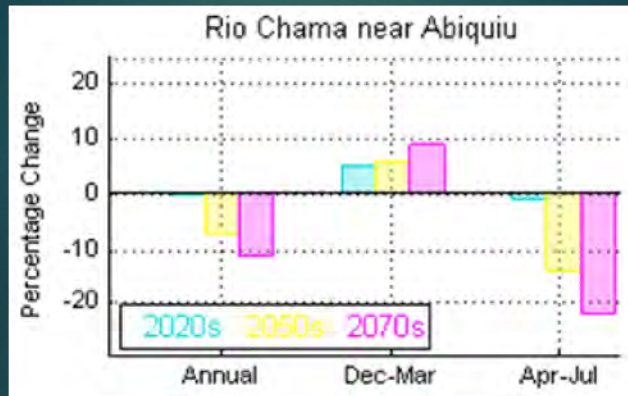
Implications of Increasing Temperature for Snowpack

Warmer temperatures mean more precipitation falls as rain rather than snow, and the snow we do get melts off faster

Upper Rio Grande Basin-Distributed Snow (2070s relative to the 1990s):

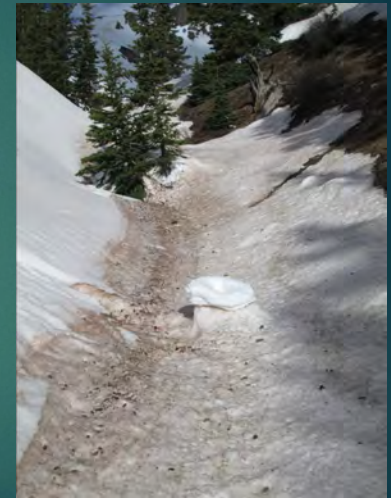


...Leading to changes in flow timing

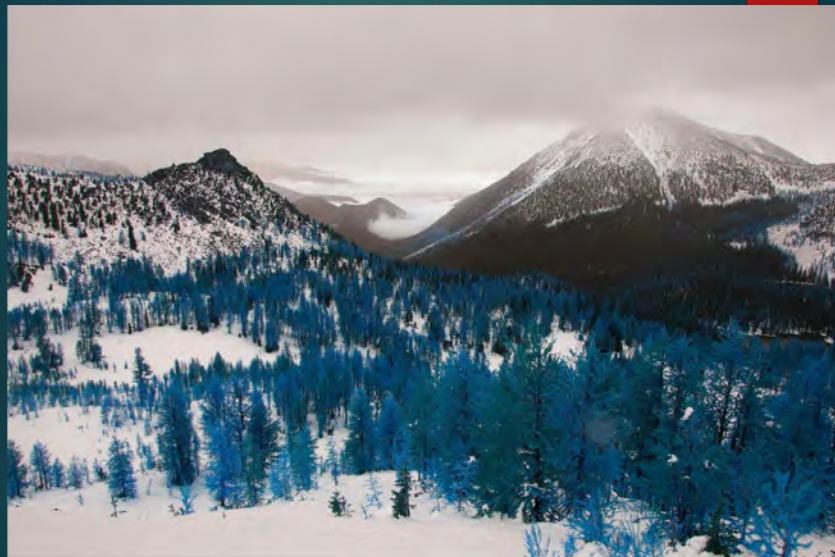


- Decreased annual runoff throughout basin
- Some regions have increased cool season runoff and reduced warm season runoff

Increasing aridity and wind, along with overgrazing, make our snow dirty, which makes it melt faster



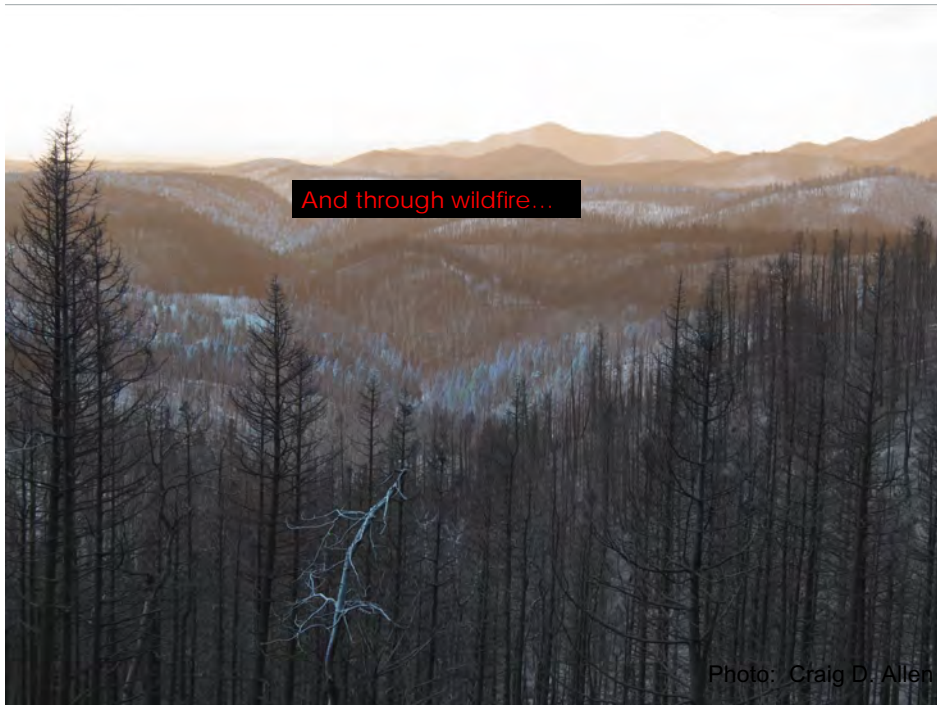
Upland Forest Impacts



Dying piñon pine, Jemez Mts. October 2002



Photo: Craig D Allen
Page 113 of 137



Conclusions from Park Williams's Work

- Temperature increases cause increased vapor-pressure deficit, and therefore increased drought stress on trees, regardless of species or location.
- Drought stress corresponds well with area killed by bark beetles, and area burned by wildfire.
- If climate models are correct, average drought stress by the 2050s will match that of the worst years during the largest mega-droughts in at least 1000 years.

Transformation!

Successful riparian establishments will require stronger, more effective remanagement of species that browse on riparian seedlings and bark.

Northern New Mexico Forest Lands are a mature pine dominated landscape. This forms a natural reservoir that captures snow during the winter and releases the moisture as runoff in the spring and summer.

Emergence (Renewal)

Consolidation (Maturity)

Growth

Creative Destruction

Disturbance

Regime 1

Regime 2

System State

Critical Threshold

New system with new adaptive cycle

Summer Monsoons...?

Some evidence suggests that the summer monsoons on the Rio Grande may intensify under warmer conditions.

More water (that doesn't ring the bell on the compact).

Intense rainstorms on burn scars and areas of lost vegetation causes debris flows and erosion



21

River Channels:



Lower Rio Chama after
mechanical removal of
sediment plug.



Another sediment pulse waiting to
be released to the Rio Chama?

Vegetation encroachment when river flows are lower (or non-existent)

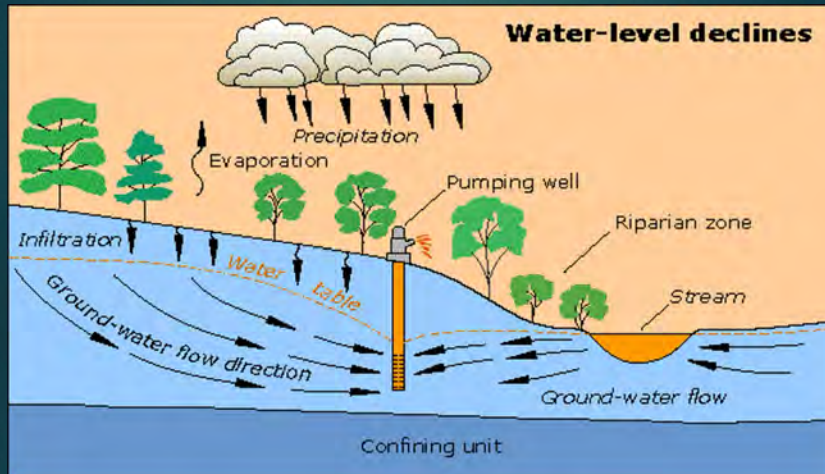
The "forgotten
reach" of the Rio
Grande in Texas.



Groundwater

- Cascade of primary impacts on groundwater*
 - Large increase in evaporation losses from shallow groundwater
 - Increases in water use by plants (transpiration)
 - Decrease in soil-water content
 - Decrease in water infiltration below the root zone
 - Reduced groundwater recharge
- Secondary impacts – increased groundwater pumping when surface-water supplies are low.

Depletion due to Pumping / Groundwater Interaction



Likely future Middle Rio Grande Conditions:

- Continuing likelihood of increasing temperatures, with wide-ranging system impacts.
- Decreasing average annual flows, primarily due to increasing temperatures.
- More flow variability (on top of the Rio Grande's already high flow variability) – deeper droughts, more intense storms and floods; less flow predictability.
- Changes in flow timing – Higher winter flows, earlier and shorter snowmelt runoff, more summer river drying.
- Increasing size and intensity of wildfire; loss of upland forests to wildfire and insect infestations. Increasing sediment supply to the river, including debris flows.
- Decreasing groundwater levels, as groundwater is used when surface-water is in short supply; increasing loss of river flow to the aquifer below; increasing water conveyance challenges.
- Potential for cascading impacts and system transformation.

Key Takeaways for the river and riparian corridor

- ▶ The future Middle Rio Grande will likely have lower flows most of the time, and lose more water to the aquifer below (which will further decrease flows).
- ▶ The river channels will be laden with significantly more sediment from erosion and debris flows due to vegetation stress and wildfires, in combination with less water in the river to move that sediment. These conditions will likely lead to riverbed aggradation, and a decrease in channel capacity.
- ▶ Lower average flows will lead to a decrease in channel width, through vegetation encroachment by both native and non-native species. This will further decrease channel capacity. The existing (class of 1941) cottonwood gallery will die away.
- ▶ Extreme precipitation events will increase in intensity, which will create occasional high flows in a river with less ability to convey them, leading to increasing challenges with Rio Grande Compact deliveries.

Anticipated Climate Futures

Key Impacts of Climate Change on the Middle Rio Grande and Associated Watershed
Synthesized from Dunbar, N. W. et al. 2022. *Climate Change in New Mexico: Over the Next 50 Years: Impacts on Water Resources*. Prepared by Dagmar Livewellyn and Stephanie Mladinich for the 2025 Middle Rio Grande Drought and River Drying Workshop, October 28-29, 2025

Climatic changes

- If we don't take action to stop the increase in greenhouse gases in the atmosphere, we can expect an average temperature rise in the state of 5 to 7 degrees F from pre-industrial levels over the next 50 years.
- Greater variability in precipitation – year to year, and within-year, including hotter, more-severe droughts, interspersed with more intense storms, and larger floods.

Surface water

- Decreasing snowpack, and earlier and steadily diminishing snowmelt runoffs.
- More winter precipitation expected to fall as rain instead of snow
- Aridifying soils in the lowlands lead to more dust on snow, and more sublimation, further decreasing the snowpack available to run off.
- Increased rates of evaporative loss, exacerbating loss of system-wide water storage
- Lower streamflow (by 25% over the next 50 years according to the Leap Ahead Analysis)
- Degraded water quality (salinity, temperature, turbidity...)

Groundwater

- Decreasing recharge, and greater demands on the dwindling groundwater supply due to surface-water shortfall.
- Increasing water use by plants
- Decreasing soil infiltration and soil-water content

Watershed

- Stress on natural vegetation, including riparian and upland forests, caused by increasing temperature and decreased water availability. This stress increases the likelihood of bark-beetle infestation and more damaging wildfire.
- Increasing catastrophic forest fire frequency resulting from heat and aridity.

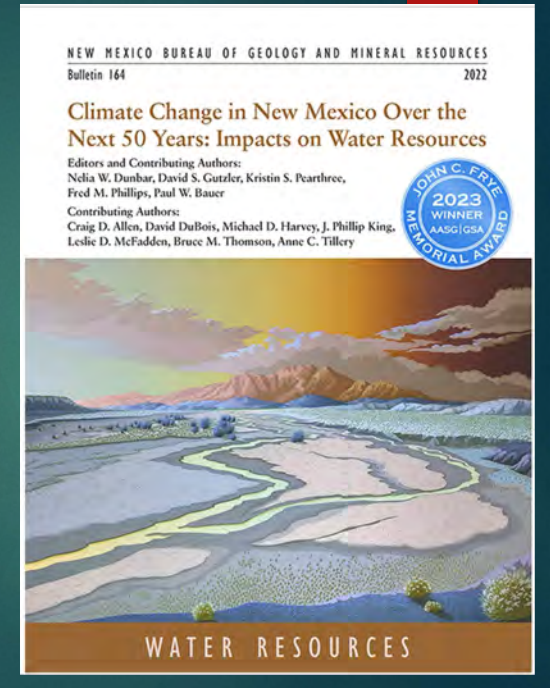
Name ↑
Participant Folder: Drought and River Drying Workshop



As you move through the day...

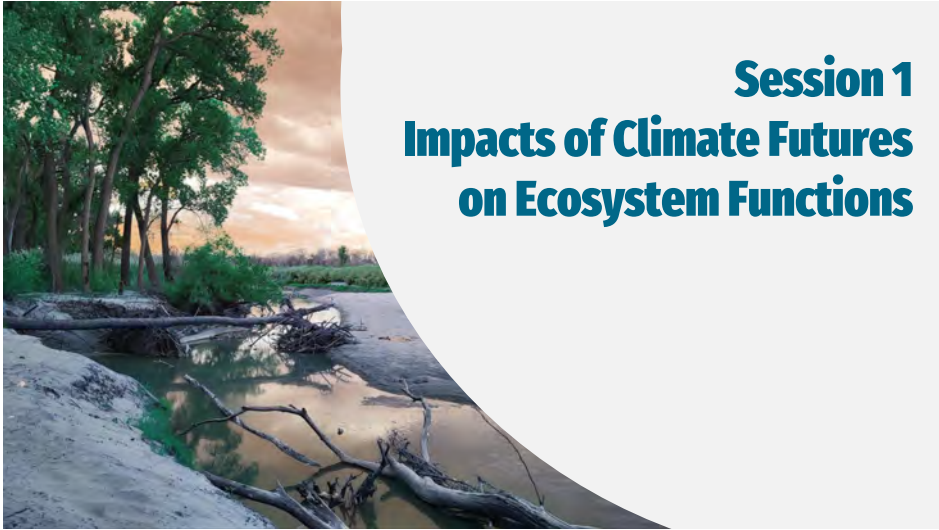
- Focus on general trends and storylines of change
- We can't predict the future, but we can plan for anticipated change
- Look out for gaps in our understanding and what we need to understand better
- Be creative

Great Reference: The New Mexico "Leap Ahead" Report



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Science Center
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Session 1

Impacts of Climate Futures on Ecosystem Functions

Ecosystem Function Overview

Why an ecosystem function-based approach?

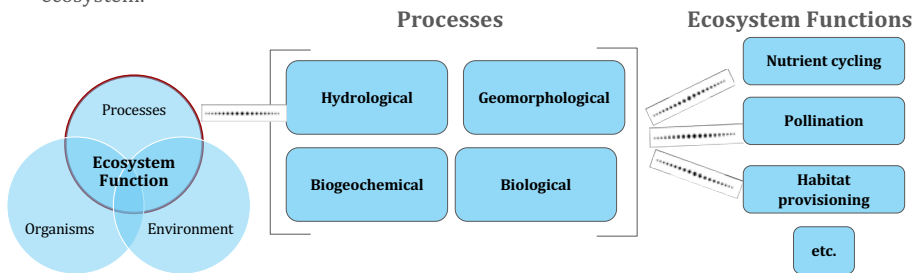
- Evaluation of ecosystem functions and processes that support viable populations of indicator species for the Middle Rio Grande and their habitats
- A foundation for understanding human dimensions of water use and management
- Guide adaptation strategies that maintain processes that support overall ecosystem health

How will anticipated changes in climate impact ecological processes and ecosystem functions in the Middle Rio Grande?

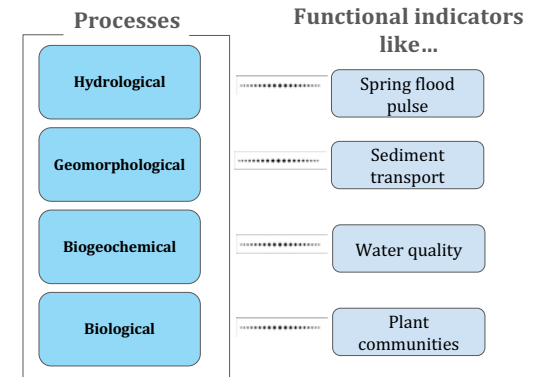
Ecosystem Function Overview

Supporting Processes: The collective physical, chemical, and biological mechanisms that sustain an ecosystem's structure, composition, and dynamics.

Ecosystem Function: The outcomes or results of those processes that support the ecosystem.



Ecosystem Function Overview



Session Overview

1. Review list of ecological processes that influence ecosystem function and add any that are missing (Columns A-D)

- Are there any ecological processes or indicators missing from the list?
- Are there any metrics missing from the list?
- If so, please add in
- Using [Anticipated Climate Futures Overview](#) and your group's knowledges and experiences, evaluate and elaborate on the anticipated changes to indicators.

~15-20 minutes

Session Overview

Folder: Breakout Session 1

Breakout Session 1: Climate Impacts to Ecosystem Functions				
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species <i>Is an important indicator missing from the list? If so, please add.</i>	Definition	Metrics for each indicator <i>Are there any metrics missing from the list? If so, please add.</i>	Discuss and document expected changes (in the absence of management) to the indicator metrics based on anticipated future changes. <i>Try to fill out the worksheet in the order presented, because the indicators will build on each other.</i>
Hydrological Hydrologic regulation, floodplain dynamics, hydrologic connectivity, streamflow maintenance, groundwater recharge, baseflow support	Spring flood pulse	The seasonal rise in discharge linked to snowmelt that shapes riparian and aquatic habitat	Flood pulse magnitude, timing and duration	Magnitude expected to decrease due to declining snowpack and earlier melt; pulse occurs 1-2 months earlier and is of shorter duration
	Monsoon season streamflow	Streamflow resulting from intense summer precipitation events that sustain ephemeral and intermittent reaches	Volume and timing of streamflow events from monsoon precipitation	More variable, flashier flows; slight increase in magnitude of extreme events but generally shorter-duration pulses shifting later into the season
	Floodplain connectivity	Interaction between river discharge and floodplain inundation supporting sediment/nutrient exchange and habitat	Discharge at inundation; spatial area of inundation; duration, timing and depth of inundation	Connectivity reduced, shortening of inundation period and lower lateral extent due to reduced baseflow and channel incision
	Groundwater/surface-water exchange	The bidirectional interface controlling baseflow, recharge, and water quality in riparian zones	Depth to groundwater	Deeper water tables in valley floors and reduced recharge (diminished baseflow contribution)

Breakout Session 1: Climate Impacts to Ecosystem Functions				
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species <i>Is an indicator missing from the list? If so, please add.</i>	Definition	Metrics for each indicator <i>Are there any metrics missing from the list? If so, please add.</i>	Discuss and document expected changes (in the absence of management) to the indicator metrics based on anticipated future changes. <i>Try to fill out the worksheet in the order presented, because the indicators will build on each other.</i>
Hydrological Hydrologic regulation, floodplain dynamics, hydrologic connectivity, streamflow maintenance, groundwater recharge, baseflow support	Spring flood pulse	The seasonal rise in discharge linked to snowmelt that shapes riparian and aquatic habitat	Flood pulse magnitude, timing and duration	Magnitude expected to decrease due to declining snowpack and earlier melt; pulse occurs 1-2 months earlier and is of shorter duration
	Monsoon season streamflow	Streamflow resulting from intense summer precipitation events that sustain ephemeral and intermittent reaches	Volume and timing of streamflow events from monsoon precipitation	More variable, flashier flows; slight increase in magnitude of extreme events but generally shorter-duration pulses shifting later into the season
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	Groundwater/surface-water exchange	The bidirectional interface controlling baseflow, recharge, and water quality in riparian zones	Depth to groundwater	Deeper water tables in valley floors and reduced recharge (diminished baseflow contribution)

C

Breakout Session 1: Climate Impacts to Ecosystem Functions		Definition	
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species	Indicator	Definition
Hydrological Hydrologic regulation, floodplain dynamics, hydrologic connectivity, streamflow maintenance, groundwater recharge, baseflow support	Spring flood pulse	Magnitude, timing and duration	The seasonal rise in discharge linked to snowmelt that shapes riparian and aquatic habitat
	Monsoon season streamflow	Timing of streamflow from monsoon precipitation	Streamflow resulting from intense summer precipitation events that sustain ephemeral and intermittent reaches
	Floodplain connectivity	Inundation; spatial area inundated; timing and duration	Interaction between river discharge and floodplain inundation supporting sediment/nutrient exchange and habitat
	Groundwater/surface-water exchange	Water table	The bidirectional interface controlling baseflow, recharge, and water quality in riparian zones

D

Breakout Session 1: Climate Impacts to Ecosystem Functions		Metrics for each indicator	
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species	Definition	Are there any metrics missing from this list? If so, please add
Hydrological Hydrologic regulation, floodplain dynamics, hydrologic connectivity, streamflow maintenance, groundwater recharge, baseflow support	Spring flood pulse	The seasonal rise in discharge linked to snowmelt that shapes riparian and aquatic habitat	Flood pulse magnitude, timing and duration
	Monsoon season streamflow	Streamflow resulting from intense summer precipitation events that sustain ephemeral and intermittent reaches	Volume and timing of streamflow events from monsoon precipitation
	Floodplain connectivity	Interaction between river discharge and floodplain inundation supporting sediment/nutrient exchange and habitat	Discharge at inundation; spatial area of inundation; duration, timing and depth of inundation
	Groundwater/surface-water exchange	The bidirectional interface controlling baseflow, recharge, and water quality in riparian zones	Depth to groundwater

E

Session Overview				Discuss and document expected changes (in the absence of management) to the indicator metrics based on anticipated future changes.
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species	Definition	Metrics for each indicator	Try to fill out the worksheet in the order presented, because the indicators will build on each other.
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Session Overview

2. Identify information gaps and discuss initial implications for ecosystem services and human uses of water

- Discuss and add if there are any unknowns or information gaps in our understanding of ecosystem functional responses to anticipated changes (Column F)
- Discuss and add thoughts for initial implications for human uses of water (Column G)
- Document any questions, additional thoughts, or points of discussion in the spreadsheet

~20 minutes

Breakout Session 1: Climate Impacts to Ecosystem Services & Human Uses of Water		F
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species <i>Is an important indicator missing from the list? If so, please add</i>	<p>What are the unknowns or information gaps in our understanding of ecological responses to anticipated changes?</p>
Hydrological Hydrologic regulation, floodplain dynamics, hydrologic connectivity, streamflow maintenance, groundwater recharge, baseflow support	Spring flood pulse	
	Monsoon season streamflow	
	Floodplain connectivity	
	Groundwater/surface-water exchange	

Breakout Session 1: Climate Impacts to Ecosystem Services & Human Uses of Water		G
Ecological Processes & Ecosystem Functions	Indicator of functional habitat for one or more indicator species <i>Is an important indicator missing from the list? If so, please add</i>	<p>Initial thoughts on implications for ecosystem services & human uses of water</p> <p><i>There will be more time to build on these on Day 2 for developing adaptation strategies</i></p>
Hydrological Hydrologic regulation, floodplain dynamics, hydrologic connectivity, streamflow maintenance, groundwater recharge, baseflow support	Spring flood pulse	
	Monsoon season streamflow	
	Floodplain connectivity	
	Groundwater/surface-water exchange	

Session Steps

45 minutes

1. Open Participant Folder
(Scan QR Code or access link in email)
1. Go to "Breakout Session 1"
 - Instructions for Breakout Session 1
 - Climate Impacts to Ecosystem Function
 - Anticipated Climate Futures Overview
1. You can work as one large group, or divide into smaller groups – you may need to divide up the worksheet
1. Complete session worksheet in shared spreadsheet (Separate sheet for each table)
1. Raise your hand if you have questions!



Session Overview

Determine implications of changes in ecosystem functions to indicator species and habitats

- Discuss and determine which ecosystem functions and metrics are most important for each species (~15 minutes)

Breakout Session 2 Indicator Species & Habitat Impacts					
Step 1: Please use the information in the species information sheet to select the 3-5 indicators from the Ecosystem Function worksheet that will be MOST IMPACTFUL to one (1) species and 2 (2) its habitat in the future. Copy and paste the selected rows below.					
Ecosystem Functions for Species					
Indicator	Metrics	Description of expected change to metric	Description of expected impact to species	Description of expected impact to habitat	Notes / Ideas / Additional Thoughts for Discussion
EXAMPLE: Spring flood pulse	Flood pulse magnitude, timing and duration	Magnitude expected to decrease due to declining snowpack and earlier melt, pulse occurs 1-2 months earlier and is of shorter duration	Ability to spawn	Not enough water available	

Session Overview

Discuss major challenges for each species

- How will the metrics you have outlined change, and what challenges will your species and their habitats experience? (~10 minutes)

Breakout Session 2 Indicator Species & Habitat Impacts					
Step 1: Please use the information in the species information sheet to select the 3-5 indicators from the Ecosystem Function worksheet that will be MOST IMPACTFUL to one (1) species and 2 (2) its habitat in the future. Copy and paste the selected rows below.					
Ecosystem Functions for Species					
Indicator	Metrics	Description of expected change to metric	Description of expected impact to species	Description of expected impact to habitat	Notes / Ideas / Additional Thoughts for Discussion
EXAMPLE: Spring flood pulse	Flood pulse magnitude, timing and duration	Magnitude expected to decrease due to declining snowpack and earlier melt, pulse occurs 1-2 months earlier and is of shorter duration	Ability to spawn	Not enough water available	

Session Overview

Summary statements of major challenges for each species

- Summarize the discussion and notes you took in the last step (~10 minutes)



Step 2: Using the information above, summarize the major challenges you expect your species to face under future conditions based on changes to habitat (e.g. food availability, etc).	
Summary statements	
EXAMPLE: If spring flood pulse continues to decline (and other factors selected), then there will not be proper timing to allow for spawning, or enough water available to allow the silvery minnow to persist.	

Session Overview

Discuss research and management recommendations for species habitats in the future

- How can people work to strengthen habitats for these species? What needs to be done to ensure prolonged species security? (~20 minutes)



Management and Research Needs	
Step 3: Fill out after Steps 1 and 2	
Management Needs: What can be done to mitigate impacts of expected change to species and their habitat?	Research Needs: What information do we need to improve decision-making for species/habitat?

Present to the room

- Take **5 minutes** with your group to summarize your discussions from session 2 into three main points.
- Have one member from each table present to the room your main points in **two minutes** or less.

Session Steps

75 minutes

1. Open Participant Folder
(Scan QR Code or access link in email)
1. Go to "**Breakout Session 2**"
 - Instructions for Breakout Session 2
 - Indicator species info document
 - Session 2 worksheet
1. Please work as a group with your whole table
– you may need to divide up the worksheet
1. Complete session worksheet in shared spreadsheet (Separate sheet for each table)
1. Raise your hand if you have questions!

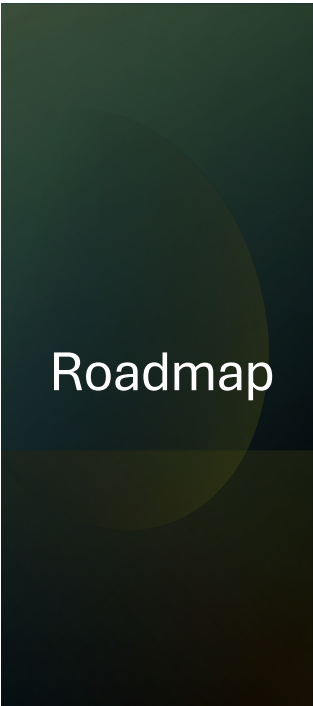




Human Dimensions of Water Use in the Middle Rio Grande: Past, Present, and Future

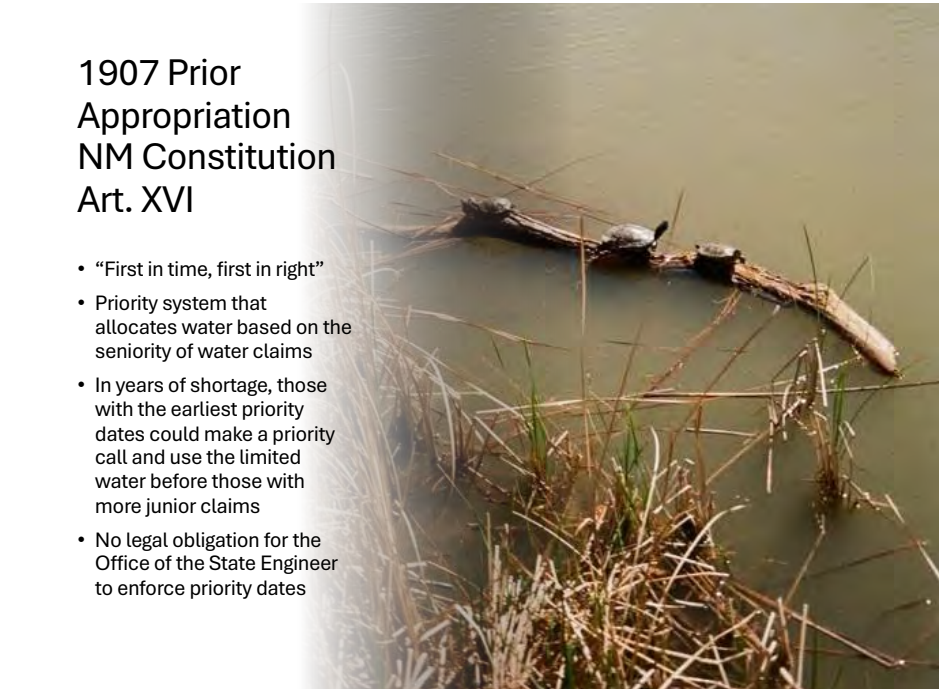
Stephanie Russo Baca & Rin Tara
Utton Transboundary Resources Center

Presentation for
Future Scenarios Planning Workshop for Drought and River Drying in the Middle Rio Grande
October 29, 2025



Roadmap

- Prior Appropriation – What is a Water Right?
- 20th Century Water Law in NM
 - Rio Grande Compact
 - Acequias
 - Pueblos and Neighboring Nations
 - Middle Rio Grande Conservancy District
- 21st Century Water Law in NM



1907 Prior Appropriation NM Constitution Art. XVI

- “First in time, first in right”
- Priority system that allocates water based on the seniority of water claims
- In years of shortage, those with the earliest priority dates could make a priority call and use the limited water before those with more junior claims
- No legal obligation for the Office of the State Engineer to enforce priority dates

New Mexico Constitution & Water Article XVI

<p>Section 1. [Existing water rights confirmed.]</p>	<ul style="list-style-type: none"> • All existing rights to the use of any waters in this state for any useful or beneficial purpose are hereby recognized and confirmed.
<p>Section 2. [Appropriation of water.] Water Belongs to the Public and is subject to appropriation by beneficial use & Priority of appropriation shall be given the better right</p>	<ul style="list-style-type: none"> • The unappropriated water of every natural stream, perennial or torrential, within the state of New Mexico, is hereby declared to belong to the public and to be subject to appropriation for beneficial use, in accordance with the laws of the state.
<p>Section 3. [Beneficial use of water.] Beneficial use shall be the basis, the measure and the limit of the right to the use of water.</p>	<ul style="list-style-type: none"> • Section 5. [Appeals in matters relating to water rights.] • In any appeal to the district court from the decision, act or refusal to act of any state executive officer or body in matters relating to water rights, the proceeding upon appeal shall be de novo as cases originally docketed in the district court unless otherwise provided by law.

Elements of a Water Right



- Priority date of the right
- Quantity
- Point of Diversion
- Place of use; If an irrigation right, the tract on which it is used.
- Purpose of use (the beneficial use)
- Source (Groundwater / Surface water)

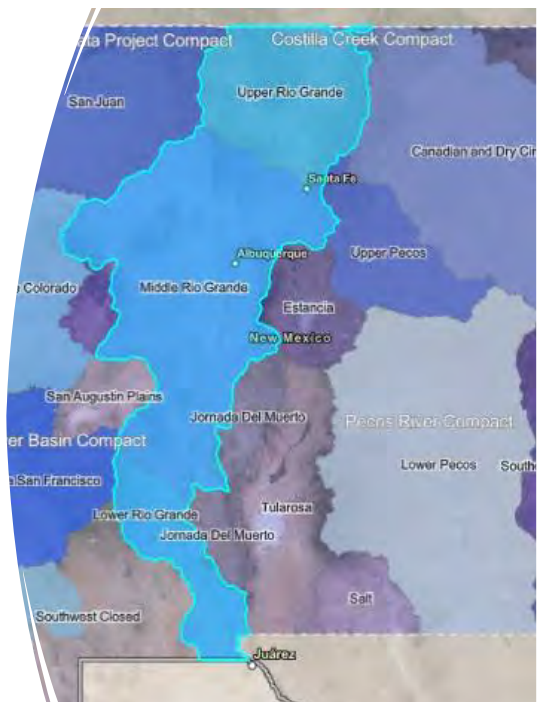


Recap 20th Century water rights

- Prior appropriation adopted in New Mexico in 1907
- Acequia Law codified Article 2, Chapter 73 NMSA
- Supreme Court in *Winters v. United States* acknowledged the seniority of tribes' water rights in 1908
- In 1928, Congress established prior and paramount water rights for Pueblo lands

Rio Grande Compact

- 1939 Compact between Colorado, New Mexico, and Texas to apportion waters of Rio Grande Basin
- Colorado must deliver a percentage of water runoff to NM state line
- NM must deliver a percentage of water to Texas at the TX state line
- Colorado was in violation of the Compact in the 60s and owed 1 MAF to NM and NM owed 0.5 MAF to TX
- *Texas v. New Mexico* found NM owed significant water to TX, this finding governs much of NM water management



Rio Grande Compact

200,000 AF
Article V

NM 43% / TX 57%
Split up to 405,000 AF
Ottowi Index Supply
ARTICLE IV

Debits & Credits
ARTICLE VI, VII, VIII

ARTICLE XVI Nothing in this Compact shall be construed as affecting the obligations of the United States of America to Mexico under existing treaties, or as impairing the rights of the Indian Tribes.

Elephant Butte Reservoir

Article VI of the Compact limits New Mexico's ability to store native water behind dams that were built after 1929, when New Mexico has a Rio Grande Compact Debt

- When New Mexico has a Rio Grande Compact debt, New Mexico must store a volume of water equal to the debt before storing water for middle valley use
- Water stored to satisfy Article VI of the Compact is then moved down to Elephant Butte after the irrigation season

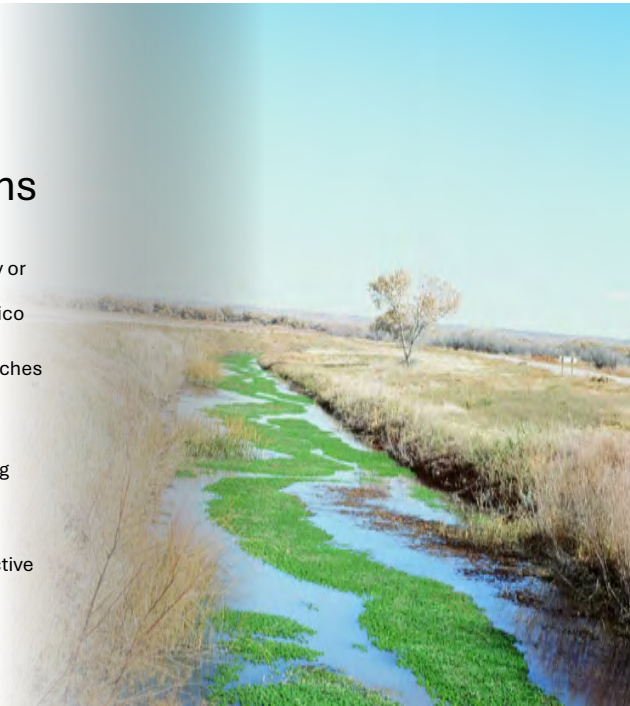
ARTICLE VII Neither CO nor NM shall increase the amount of water in storage in reservoirs constructed after 1929 whenever there is less than 400,000 AF of usable water in project storage...

El Vado Reservoir / Abiquiu

ARTICLE VIII During the month of January of any year the Commissioner for TX may demand of CO and NM, and the Commissioner for NM may demand of CO, the release of water from storage reservoirs constructed after 1929 to the amount of the accrued debits of Colorado and New Mexico, respectively...

Acequia and Community Ditch Systems

- Local government entity or political subdivision recognized by New Mexico law
- Maintenance cost of ditches is borne by individual acequia members, collectively
- Employ shortage sharing agreements to evenly distribute the burden of drought conditions
 - Codified through Active Water Resources Management law



MRGCD MISSION



River Flood Control



Drainage (ground water)



Irrigation



Recreation
(Partner Agreements)

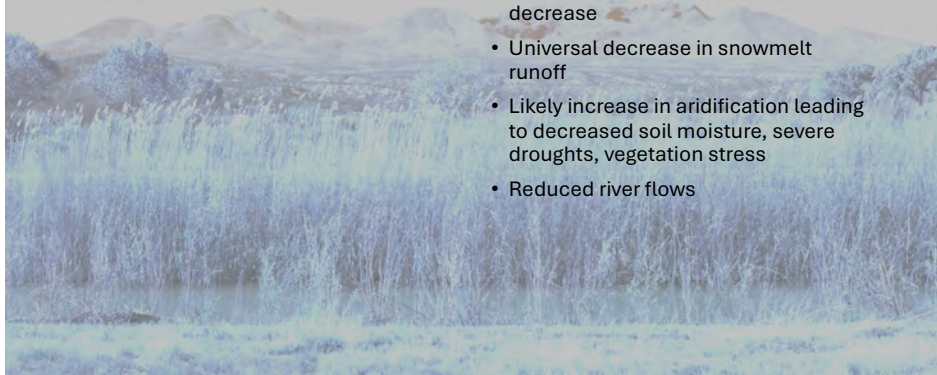
Priority Administration in the Middle Valley



- New Mexico water law follows the prior appropriation doctrine
- Middle Rio Grande is not adjudicated, priority administration is not practiced among non-Pueblo irrigators
- Water rights associated with lands irrigated since “time immemorial” by the 6 Middle Rio Grande Pueblos are called Prior and Paramount (P&P) lands
 - These lands are delivered water in priority to non-Prior and Paramount lands.

21st Century Climate Realities

- Temperatures in NM will increase between 5 and 7 degrees over the next 50 years
- Precipitation in northern mountains may increase, while precipitation in the southern half of the state will decrease
- Universal decrease in snowmelt runoff
- Likely increase in aridification leading to decreased soil moisture, severe droughts, vegetation stress
- Reduced river flows

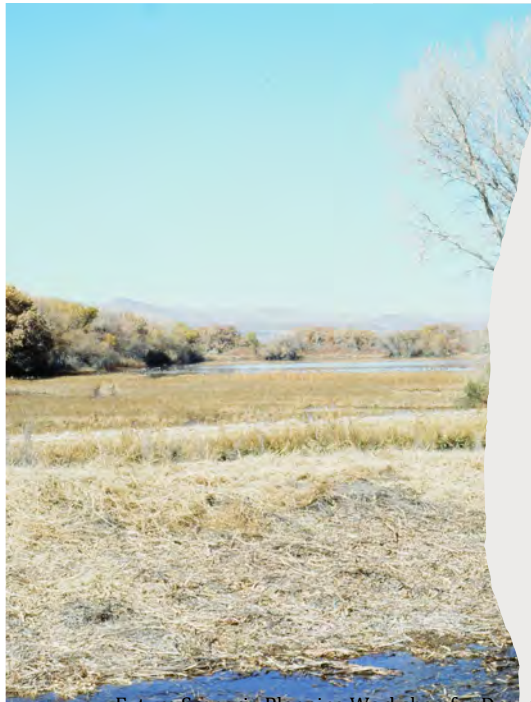


Management for the future

- Climate change will bring dramatic changes to water availability in the state
- What water management tools will serve the state for the future?

Changing agricultural practices for a more arid climate

- Irrigation canals for agricultural fields
 - Centralized management of canals and ditches
- Terrace farming to collect rainwater runoff
- Lithic mulch to prevent evaporation
- Floodplain cultivation with drought-adapted crops
- Broad spectrum of food sources
 - Predominantly crops already adapted to a dry climate
- Migration
- Legacy Fund
- Soil and Water Conservation Districts
- MRGCD Conservation Program



Active Water Resources Management

- Office of the State Engineer manages water rights and allocation using the AWRM initiative
- Manages six unique water basins, called "priority stream systems" which include the Rio Chama basin
 - does not include the MRG basin because of the MRG's unique management under the MRGCD
- Outlines rules for metering water, local water management by Water Masters within communities
- Explicitly developing rules for shortage sharing within basins



Active Water Resources Management and Water Shortage Sharing Agreements

Shortage Sharing Agreements



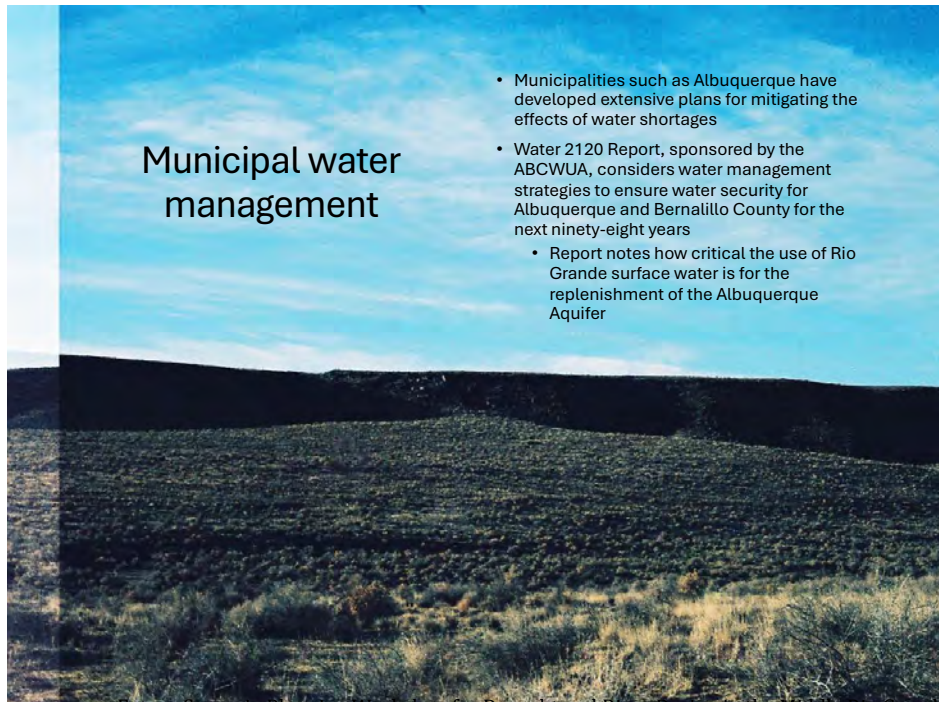
Chama Basin, The Brazos, picture courtesy of Holly Wilkie, Upper Chama Water Master

- Voluntary agreements
- All users get water and share in the shortage
- Contrasts with traditional priority date administration in which senior water rights holders must make a "call"
- Priority administration can and are often still taken into consideration
- These voluntary agreements can still give the senior users the better priority, while still allowing junior users to receive water
- Formalized agreements.
- Determine procedure for reducing water use universally in case of shortages
- Results in significantly fewer days in which ditches are dry
- Benefits to entire community
- For more information, see Utton Center's shortage sharing project <https://uttoncenter.unm.edu/resources/shortage-sharing-project.html>



Strategic Water Reserve

- Strategic Water Reserve for purposes such as complying with interstate water compacts
- Implemented and administered by New Mexico's Interstate Stream Commission
- Allows the state to buy water rights to use as system water



Municipal water management

- Municipalities such as Albuquerque have developed extensive plans for mitigating the effects of water shortages
- Water 2120 Report, sponsored by the ABCWUA, considers water management strategies to ensure water security for Albuquerque and Bernalillo County for the next ninety-eight years
 - Report notes how critical the use of Rio Grande surface water is for the replenishment of the Albuquerque Aquifer

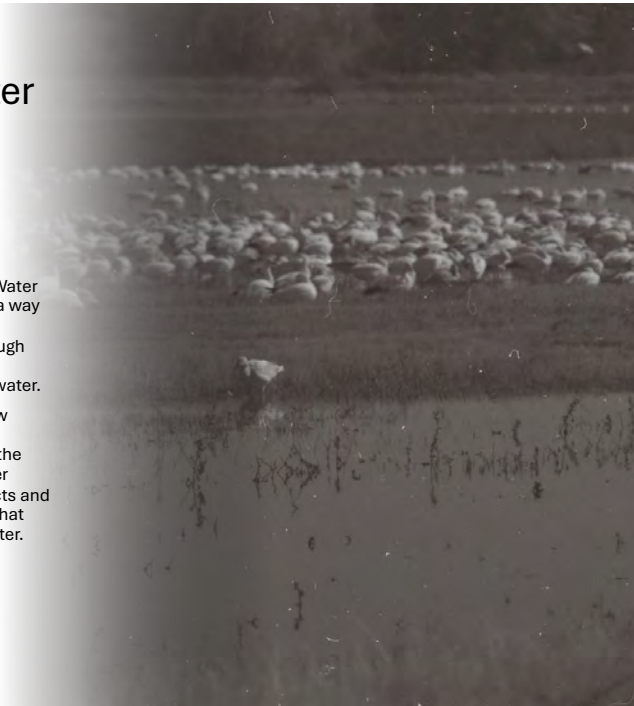


Produced Water

- Water generated as a byproduct of oil and gas production
 - Naturally occurring in pore space
- High salinity, not useful in its untreated form
- 2018 New Mexico Law governing recycling and processing for produced water
- Governor's 50 Year Water Plan aims in to increase utility for produced water

Strategic Water Supply Act

- NMSA 72-12C-1 et seq.) establishes the Strategic Water Supply (SWS) Program as a way to protect New Mexico's freshwater resources through the development and management of brackish water.
- The Act authorizes the New Mexico Department of Environment (NMED) and the Office of the State Engineer (OSE) to enter into contracts and award grants for projects that utilize treated brackish water.



Aquifer Storage and Recovery

- 1999 legislation and regulations permit the storage of surface water supplies in aquifer space underground
 - Eliminates evaporative losses from reservoirs, which are increasing with increased temperatures
- Albuquerque Bernalillo County Water Use Authority has implemented an ASR program



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<http://uttoncenter.unm.edu/index.php>



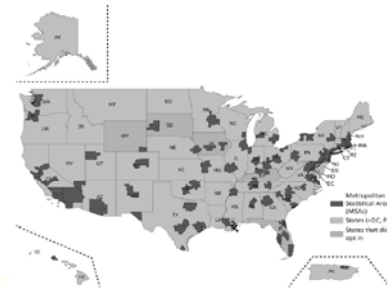
Mailing address
UNM School of Law, MSC 11-6070
1 University of New Mexico
Albuquerque, NM 87131-0001



Physical location
UNM School of Law
1117 Stanford Dr. NE
Albuquerque, NM 87106



CLIMATE POLLUTION REDUCTION GRANTS PROGRAM



U.S. Environmental Protection Agency's Climate Pollution Reduction Grants Planning Program

Awarded to:

- 207 entities across the USA
- Represents over 97% of the US population
- New Mexico has 6 awardees, including the **City of Albuquerque** (Grant Number 02F38401)



CITY OF ALBUQUERQUE | RESILIENT FUTURES INITIATIVE | 2025.10.29

A Blue-Print for Local Action



EPA Requirements

- GHG Inventory, Targets, & Projections
- LIDAC Benefits Analysis
- Quantified Measures

Updates

- No federal funds for project implementation.
- Can deviate from EPA template to meet other goals.

Goals

- Reduce Pollution
- Benefit Communities
- Build on Local Strengths
- Inspire Action

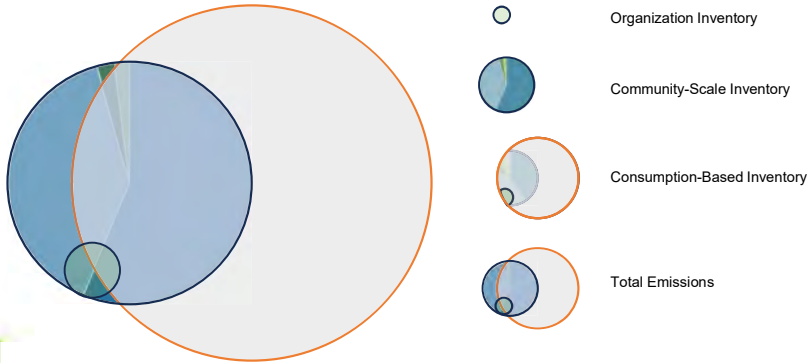
CITY OF ALBUQUERQUE | RESILIENT FUTURES INITIATIVE | 2025.10.29



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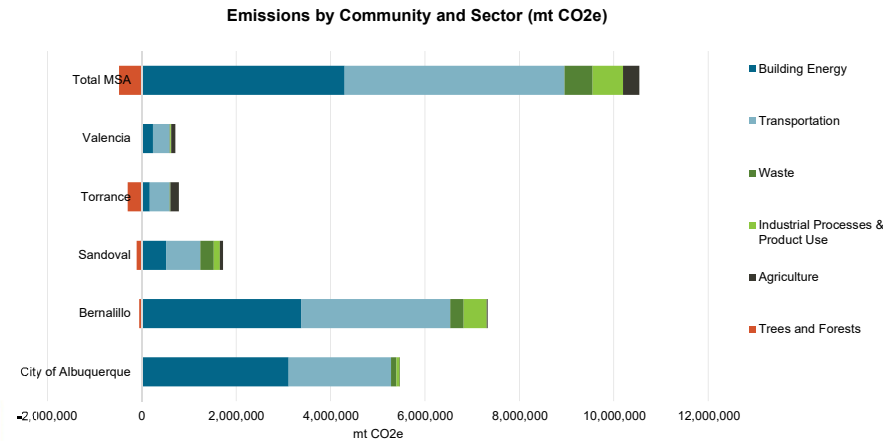
RELATIVE SIZE & RELATIONSHIP OF GHG INVENTORIES



Measurement Type	What it Measures	Pros	Cons	Best Use
Individual Carbon Footprint	Emissions from a single individual, typically estimated from a model based on national data with selections for income, travel mode, and diet.	Helps individuals see where they can cut emissions and save money; raises awareness, especially in developed nations.	Does not solve systemic issues ; underemphasizes the role of institutions and civic engagement in developed democratic countries.	Building individual climate literacy ; empowering individuals who earn the top 10% of global income; encouraging diet and transportation shifts.
Organizational	Emissions from a single organization (city government, business, school), usually split into Scope 1, 2, and 3.	Clear control and accountability; actionable for internal operations; strong baseline for sustainability targets; standard methodology.	Narrower focus; doesn't capture community-wide effects; scope 3 can be very hard to track.	Tracking local government's own footprint, guiding institutional sustainability, and leading by example.
Community-Scale	Emissions from activities happening within local boundaries (e.g., communitywide fuel use, buildings, waste, transport); usually split into scope 1 and 2, with some scope 3 to avoid double counting in other jurisdictions.	Easier to measure with local data; aligns with a government's powers and regulations ; clear accountability; standard methodology.	Misses impacts from imported goods/services; understates the community's full footprint.	Setting local policy; tracking progress on local government's goals; aligning with international standards.
Consumption-Based	Emissions tied to goods and services used locally, no matter where they are produced. Includes full lifecycle (i.e., production, shipping, disposal).	Full picture of community responsibility; highlights global supply chain impacts ; includes "outsourced" emissions	Data-intensive, complex, less precise ; risk of double-counting; harder to tie to local policy levers; no standardized methodology.	Raising awareness of lifestyle impacts; shaping demand-side policies ; promoting the circular economy.



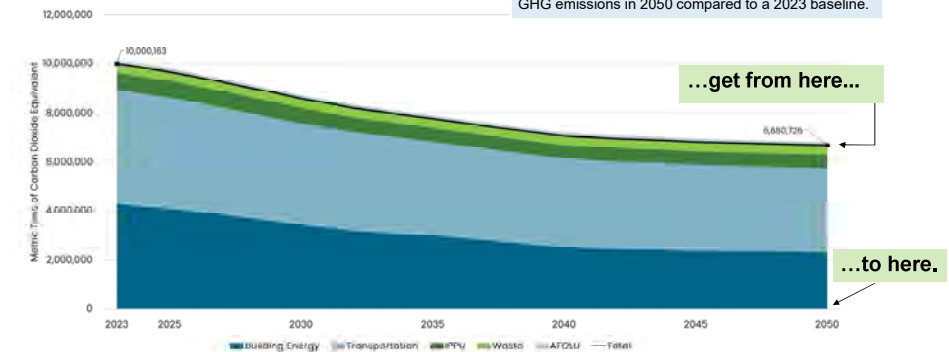
2023 COMMUNITY-SCALE GHG INVENTORY



BUSINESS-AS-USUAL

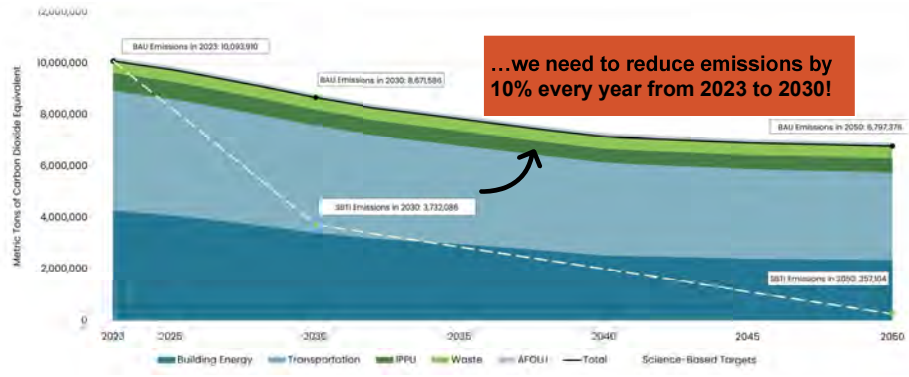
Helps us identify how to...

Did you know? This estimates that without any additional action, we will see a 33% reduction in GHG emissions in 2050 compared to a 2023 baseline.



CITY OF ALBUQUERQUE | RESILIENT FUTURES INITIATIVE | 2025.10.29

But to meet international best practices...



RESILIENT FUTURES INITIATIVE | 2025.01.06



COMMUNITY ENGAGEMENT

- Campaign Website:**
 - 3,900+ visits
 - 2,800+ unique visitors
- Community Task Force:**
 - 13 Members
 - 72% Average Participation Rate
- Workshop Series:**
 - 9 Webinars
 - 598 Registrants
 - 400+ Attendees
- Newsletter:**
 - 50% Average Open Rate
 - 926 Contacts

<https://www.resilientfuturesnm.org/>



FRONTLINE COMMUNITIES

- EJScreen & CJEST Data:**
- Poverty
 - Low high school education
 - Climate change disadvantaged
 - Training and workforce development disadvantaged
 - Fire risk in 30 years
 - Diesel particulate matter
 - Agricultural loss
 - Clean transit disadvantaged
 - Affordable and sustainable housing disadvantaged
 - Homes without indoor plumbing or a kitchen
 - Proximity to superfund sites

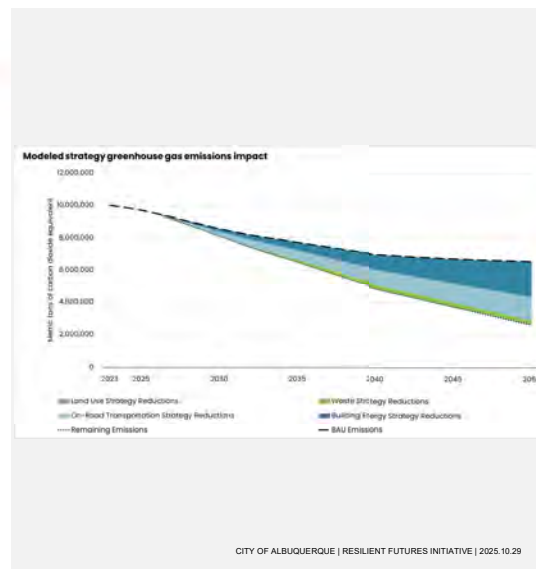
COMMUNITY SELECTED STRATEGIES

Cross-Cutting Strategies	
Priority 1: Increase Climate Education	
Priority 2: Expand Climate Governance	
Priority 3: Improve Climate Finance	
Priority 4: Support the Green Workforce	
Priority 5: Advance Sustainable Economies	
Water & Waste	Mobility & Transportation
Priority 1: Reduce Water Use	Priority 1: Expand Public Transit & Ridership
Priority 2: Reduce Food/Organic Waste	Priority 2: Increase Active Transportation
Priority 3: Increase Composting & Application	Priority 3: Promote Micro-Mobility
Priority 4: Reduce Nonfood Waste	Priority 4: Promote Shared Transportation
Priority 5: Increase Material Reuse & Repurposing	Priority 5: Develop EV Infrastructure & Electrify
Buildings & Energy	Land Use & Agriculture
Priority 1: Energy Efficiency & Electrification	Priority 1: Expand Urban Tree Coverage
Priority 2: Develop Distributed Renewables & Microgrids	Priority 2: Preserve Natural Lands
Priority 3: Promote Sustainable & Natural Buildings	Priority 3: Reduce Impermeable Surfaces
Priority 4: Develop Energy Storage Systems	Priority 4: Densify communities
Priority 5: Benchmarking, Disclosure, & Performance	Priority 5: Promote Sustainable Agriculture



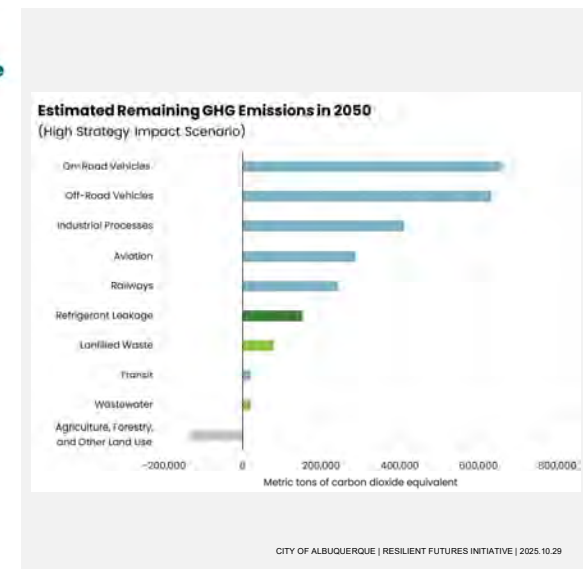
GAPS

- Current strategies target main emission sources.
- They **will not achieve net zero** emissions by 2050.
- Remaining emissions are from **challenging** sources.
- Limited available **technology**:
 - Heavy-duty vehicles.
 - Heavy-equipment (off-road).
- Limited **jurisdictional control**:
 - Aviation.
 - Railways.



OPPORTUNITIES

- Take advantage of existing efforts:
 - **Airline** emission reduction **goals**.
 - **Sunport** fleet electrification.
 - **Sustainable Aviation Fuel** market growth.
 - Encourage deployment of low GWP refrigerants.
- Expand existing strategies:
 - **Include heavy-duty** and fleet vehicle subsets in the EV strategy.
 - **Zero-waste** and **circular economy**.
- Additional strategies:
 - Fossil fuel **lawn and construction equipment** electrification.
 - New technology for **cement production**.





CCAP Release December 1

- Celebrate progress
- Request public comment
- Release tools

Our Ask:

1. Share the CCAP and take the Community Survey



<https://ip.constantcontactpages.com/s/a6fee2/RF/ABQ>





Breakout Sessions 3 & 4: Categories of Water Use

Categories of Water Use

- Environmental, including Ecosystem Services (2)
- Tribal (2)
- Agricultural and Food (2)
- Recreational (2)
- Municipal (1)
- Energy / Technology Development (1)

Two breakout sessions.

Flip charts around room for additional input on all categories.

Breakout 3 & 4 Instructions

- Step 1: Brainstorm subcategories of water use
 - Ex: Recreational water use: fishing, rafting, etc.
- Step 2: As a group, pick a subcategory to work through
 - What are specific impacts of water future?
 - Ex: Fishing: Hydrograph does not match with fish stocking, which compromises fish survival
- Step 3: Brainstorm adaptation strategies (could be short- or long-term)
 - Ex: Change when fish are stocked
 - Ex: Change timing of fishing season

Repeat Steps 2-3 for another subcategory as time allows.

Breakout 3 & 4 Instructions

- Step 4: Pick three priority strategies (one flipchart each). For those, identify:
 - Key information and data gaps needed to implement
 - Resources or expertise needed
 - Potential partners
 - Related actions already planned or underway
 - Institutional barriers to implementation (laws, regulations)



Report Outs Open Discussion on Strategies



Outcomes and Next Steps

Next Steps

- Collaboration Board
 - Topics for further conversation - sign up
 - Volunteers to lead or be part of efforts
- Upcoming Opportunities
 - Points of contact?
 - Opportunities to engage?
- Workshop summary report - by end of 2025
 - Strategies
 - Research questions/information gaps
- Future conversations
 - Pueblos
 - Agricultural community (WWF/Lincoln Institute 2026 workshop)

Outcomes

- Impacts to ecosystem and species
 - Provided to land and water managers
 - Middle Rio Grande Endangered Species Collaborative Program
- Adaptation strategies
 - Provided to planning efforts
 - Rio Grande Basin Study
 - Valencia Soil and Water Conservation District
- Research questions
 - Incorporated into a New Mexico resilience research plan
 - Provided to researchers and students
 - Long-term: Link research with management outcomes