Learning from the Land

AGCI Strategic Plan for the Roaring Fork Observation Network 2022-2032
When we see land as a community to which we belong, we may begin to use it with love and respect.

Aldo Leopold, *A Sand County Almanac*
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Foreword

In the early 1970s, future co-founder of AGCI John Katzenberger arrived in the Roaring Fork Valley of Colorado full of curiosity about the flow of life through systems—how water, energy, and nutrients made their way across the trophic levels of a watershed. Within his first weeks in Aspen, John encountered Bob Lewis and Stuart Mace, local biologists who advocated for understanding the region from a watershed-wide perspective and for approaching ecology through a lens of systems interdependence.

In 2012, an opportunity sprang up to apply these foundational ideas in a concrete way. At a meeting on forest health, scientific experts identified soil moisture as a critical, understudied component of ecosystem vitality. Local community partners expressed interest in establishing research stations to measure soil moisture and other relevant variables. AGCI eagerly leveraged this opportunity to secure funding and set the Roaring Fork Observation Network (iRON) underway.

When I joined AGCI in 2013, the network consisted of just two stations, but John’s thinking was Bob Lewis-broad: he envisioned a program that would span the watershed, allowing for exploration of bioclimate impacts across system components, elevational gradients, and between distinct ecosystems.

In the decade since the program’s establishment, AGCI staff, research partners, funders and community collaborators have together created a network that runs from the Continental Divide on top of Independence Pass to Glenwood Springs, overlooking the confluence of the Roaring Fork and the Colorado Rivers. With 10 stations established, our sights now turn to applying the ever-growing data record to answering questions about hydrology and ecology in mountain systems. As we move forward into the next decade of research for the Roaring Fork Observation Network, we plan to bolster our scientific rigor in data collection and management, expand data use and application in answering pivotal research and societal questions, and explore new pathways for bringing diverse perspectives to bear on critical water challenges.

Community and research partners continue to be essential in determining the direction and success of this program. It has been an honor and a pleasure to work with many of you in the years leading up to this point, and I look forward to growing and deepening collaborations as together we seek to explore, understand, and protect this vibrant, connected, and complex mountain watershed.

~ Elise Osenga, AGCI Community Science Manager

Elise Osenga and John Katzenberger consider site locations on Independence Pass, 2016.
The Strategic Plan

Over the past 10 years, the Roaring Fork Observation Network has grown from the seed of an idea to a fruitful research program that spans a 5,880ft elevational gradient and encompasses: ecology, hydrology, climate-change, and community engagement. With this growth, we saw the need to develop a strategic plan.

Ahead lie challenges and choices about research priorities, funding, collaboration, education, data management, and site maintenance. The strategic plan for the network will provide a framework for navigating those efforts in a coordinated way. The following pages describe both program ideals (such as mission and vision) and the more pragmatic needs of the research program (such as budget, personnel needs, and data management).

Following AGCI’s institutional vision, outlined in *Spanning Boundaries: Aspen Global Change Institute Strategic Plan 2020-2025*, the Roaring Fork Observation Network strategic plan is organized around three intersecting global change goals: **advancing science**, **catalyzing solutions**, and **nurturing a community** of solutions-seekers. We invite you to join us as we move forward into our next exciting decade of mountain watershed research.

Vision

Mountain landscapes like the Roaring Fork Watershed have long captured human imagination, offering a refuge for survival and a place of spiritual inspiration. Their snowpacks act as reservoirs whose impact extends far into the downstream plains, and the cooler temperatures of mountains’ high elevations support rare plant and animal life. With the advent of global climate change, however, systems in the Roaring Fork Watershed are shifting. What new patterns will emerge in mountain communities, and in this region specifically, is unclear. Engaging with local stakeholders to fill gaps in scientific understanding can help communities better prepare for and adapt to these changes.

Our vision for this network is to provide a continuous, long-term record of bioclimatic and soil moisture data in the Roaring Fork Watershed as a **usable basis** for **research**, **resource management**, and **community engagement**.
Mission

To become an enduring and meaningful contributor in supporting local resource management and improving understanding of mountain systems by:

- advancing scientific understanding of mountain hydrology and ecology,
- building community across mountain watersheds and among researchers and resource managers,
- and mobilizing data application from monitoring networks, including our own.

Network Description

Soil moisture is crucial to understanding water supply and potential ecological impacts of climate change. Yet it has been repeatedly identified as under-represented in in-situ monitoring. AGCI's Roaring Fork Observation Network, or the interactive Roaring Fork Observation Network, “iRON,” is a long-term mountain climate research program operated by the Aspen Global Change Institute (AGCI) and established to help address this critical data need.

The network consists of 10 research sites located in representative ecosystems at various elevations across the Roaring Fork Watershed (map, left). Most stations are equipped with a similar suite of instruments, including: soil moisture sensors (5, 20, and 50cm depths), a soil temperature sensor (20cm depth), an air temperature and relative humidity sensor, and a tipping bucket rain gauge. Some stations also measure wind speed and direction or snow depth. Each station takes recurrent, automated measurements multiple times daily and transmits those data via a satellite or cell phone connection. In addition to the recurring, automated data collected by each monitoring station, periodic surveys of vegetation are also conducted at each of the iRON sites. A full description of site locations and equipment can be found in Osenga, Vano, and Arnott's 2021 article in Hydrologic Processes¹. Community partners and members of the public are invited to explore general information about the project and all data sets at agci.org/iron.

Advancing Science

Hydrology

Water has long been a source of contention and concern in the Western US. In the Colorado River Basin, which includes the Roaring Fork, temperatures are already rising and reservoirs are hitting record-low levels. Climate projections foretell an increase in drought frequency and intensity in the Western United States.

Stakeholders from numerous sectors rely on a nuanced understanding of climate-landscape interactions and water balance to help them manage and adapt to changes in future water supplies.

In hydrology models and research, soil moisture is often provided by proxy or via satellite products, which struggle to accurately represent complex mountain terrains. The Roaring Fork Observation Network seeks to advance hydrologic research by providing on-the-ground data on soil moisture within the context of additional relevant meteorological measurements. In the coming years, we will explore and further refine the following research directions:

Key Research Questions:

1. How will climate change impact water availability and water supply timing in the Roaring Fork Watershed?

2. How is water partitioned between snowpack, soil moisture, and streamflow, and how does this change throughout the year?

3. How can in-situ soil moisture data be assimilated into water supply forecasts and models to better support informed decision making for water managers and municipalities?
Ecology

The Roaring Fork Valley is characterized by forested slopes and dramatic scenery. Local communities rely on these ecosystems in a myriad of ways: ranging from economic livelihoods to health and safety to spiritual connections. Understanding how climate change might impact or alter these distinct ecosystems is of significant consequence to AGCI’s local community partners. Because soil moisture is an important determinant in plant survival and germination, local land managers are interested in applying data collected by the Roaring Fork Observation Network to make science-informed management decisions.

The elevational gradient spanned by the network provides a lens through which “upward” elevation of plant species or communities may be observed, should they occur. To this end, Modified Whitaker Plot vegetation surveys and tree surveys are conducted at network sites on a recurring basis. Vegetation and climatic data can also be considered at a site-specific scale: considering current and potential future habitat suitability for species of particular interest.

Key Research Questions:

1. What is the role of soil moisture as a link between system processes in the atmosphere, hydrosphere, and biosphere? How can an improved understanding of these dynamics help support informed decision-making for restoration and conservation based management strategies?

2. Is there evidence of upward migration across elevations by native or introduced plant species in response to warming temperatures?

3. Can soil moisture data improve understanding of shifts in vegetation abundance, phenology, health, or distribution?
The natural world is dynamic, not static, and the older each of us gets, the more apparent is this truth....

John Magnuson, *Long-Term Ecological Research and the Invisible Present*
Catalyzing Solutions

In alignment with AGCI’s commitment to interdisciplinary approaches, collaboration is integral to the Roaring Fork Observation Network’s research vision. Meaningfully advancing science on the research questions outlined above will require developing productive and innovative partnerships across research disciplines and across mountain watersheds.

Individual Relationships

Throughout the program, input has been solicited from individuals across science communities, particularly from scientists who participated in the forest health workshop at which the network was conceived.

Moving forward, we aspire to expand our list of advisory collaborators, targeting areas specific to our key research questions and other network needs, such as: soil moisture, mountain ecology, data validation and assimilation, snow science and mountain headwater hydrology, and long-term field-equipment maintenance.

We propose a variety of mechanisms for individual engagement with the Roaring Fork Observation Network, ranging from independent use of our data to joining the team as a summer intern to serving as a co-investigator on grant proposals for the program. Other forms of engagement are currently under consideration, and we welcome your ideas.

Institutional Collaboration

In addition to broadening relationships with individual experts, we also aim to expand and strengthen institutional research partnerships. Promising efforts underway include a cross-basin collaboration with partners in the Yampa Watershed and a NASA funded, collaborative testbed program for the Upper Colorado River Basin that focuses on the integration and application of hydrologic data.
Nurturing Community

Building productive affiliations among scientific and community stakeholders is core to the success of the Roaring Fork Observation Network and to ensuring that the science carried out by the program is applicable to current and future societal needs.

Since its inception, engagement with the local community has been essential to the network. To date, the bulk of external funding for the Roaring Fork Observation Network has come from local partners. Additional community partners support the program through in-kind expertise, land use permissions, or other contributions. Ongoing, active engagement of community partners on research directions funding, and public engagement are critical to the viability of this program going forward. Surveys and conversations with local stakeholders will continue to be carried out in process with the development of this 10-year plan.

Looking forward, fostering local participation with the program will include: exploring the initiation and integration of community collected data sets, refining internship design and opportunities, and developing public-friendly data products and methods for communicating key findings.

Roaring Fork Valley Partners to Date

- Alpine Bank
- Aspen Center for Environmental Studies
- Aspen Community Foundation
- Aspen Field Biology Lab
- Aspen Valley Land Trust
- City of Aspen
- City of Glenwood Springs
- Colorado Mountain College
- Colorado Natural Heritage Program
- Healthy Rivers and Streams
- Independence Pass Foundation
- John Denver Aspenglow Foundation
- The Environment Foundation
- Pitkin County Open Space and Trails
- Pitkin County Public Works
- Roaring Fork Conservancy

A Team Internship

In the summer of 2021, AGCI co-hosted summer interns with the Yampa Valley Sustainability Council (YVSC), Colorado Mountain College (CMC), and CW3E at Scripps Institute. The program followed an REU approach to providing undergraduate students a scientifically rigorous experience designing and carrying out their own research projects. Between YVSC and AGCI, we hosted two Sustainability students from Colorado Mountain College campuses who had been accepted into the CW3E program.

The interns received field and research experiences that would not have been otherwise available to them through their home institution, providing important exposure to careers in science and a key resume component should they choose to apply to graduate programs in the future.

AGCI and our partner institutions benefitted from the opportunity to share funding for intern support and to be able to cross-germinate expertise across organizations.

Additionally, intern projects contributed important baseline information for parallel soil moisture monitoring projects in the Roaring Fork and Yampa Basins, and the process of co-mentoring the interns bolstered connections between the host institutions. Continuation of the partnered internship program is planned for the coming year.
Diversity, Equity, and Inclusion

Recognizing that many groups have been historically excluded from participation in the sciences, ongoing and future program development for the Roaring Fork Observation Network seeks to promote diversity, equity, and inclusion (DEI). Currently, interns within the program are provided learning materials on inherent bias and multiple ways of knowing. They are additionally encouraged to reflect upon their own experiences through group discussions. Summer internship solicitations have been redesigned to be more welcoming to people of all physical abilities, and to promote access to those without gear, a “loaner kit” of field gear is now available for any intern, citizen science volunteer, or visiting partner to borrow for local field work.

In the coming years, DEI goals for the program include: seeking to broaden where and how internships are advertised to attract a candidate pool that is economically, experientially, and culturally diverse; securing funding for full-time work for summer internships; and identifying housing options for seasonal interns or visiting researchers. An additional goal for the Roaring Fork Observation Network in the coming years is to embed an awareness of the roles of past and current communities in this region, such as agricultural, tourism, recreation, long-time residents, and recently arrived residents.

The Roaring Fork Watershed is the ancestral homeland of the Parianuche and Tabeguache Utes and a place of powerful spiritual significance for these groups. Today few registered members of the tribe live in this area. Planning for the Roaring Fork Observation Network program includes developing an approach to respectfully acknowledge Indigenous relationships with this area.
Data Management

The data archive is a foundational component of the Roaring Fork Observation Network, and it is a high priority moving forward that the program support a high standard of data and metadata credibility in the scientific community while maintaining ease of public access.

To this end, a data management plan was drafted in 2021 outlining where data can be found, standards for quality assurance and quality control, and data collection processes and standards. A detailed outline of the status of data availability and data collection methods is available in the Data Note published in Hydrologic Processes in early 2021 (right).

Because the data are provided through free, open access, they are available to casual users, resource managers, and researches on a local to an international scale.

For upcoming years there are several key priorities for the Roaring Fork Observation Network data, including:

- validate sensor accuracy, particularly for soil moisture measurements
- streamline and automate data storage, screening and flagging, conversions, quality control, and sharing
- identify techniques and instrument maintenance plans to prevent data gaps or data loss
- improve and expand both stakeholder-friendly and research-focused data analysis and visualizations

Targeted assistance from research partners, as well as contracted service providers, will be key to meeting these data management and visualization goals.

Data Access Points:

- The Roaring Fork Observation Network API
  irondataboard.org
- CUAHSI HIS
- ISMN
  https://ismn.geo.tuwien.ac.at/en/networks/?id=iRON
Deep snow accumulates at higher elevation sites, storing water that will become spring runoff. Time for big-picture planning, report and grant writing, and data management tasks.

Snow melts and soils thaw. Soil moisture reaches peak values for the year before summer drying begins. Hibernating animals awaken. Field season planning and seasonal hires take place.

Peak bloom occurs. Soils are drying, with deeper soils only recharging after intense rain events. Wildlife is active. Vegetation surveys are conducted, and field season is in full swing.

Deciduous trees change colors and lose their leaves. Many plants enter dormancy, and hibernating animals build fat stores. Final field repairs are conducted prior to winter.

Soils freeze at an 8in depth at higher elevation sites. Remote sites become inaccessible due to snow, and some trails close for winter to protect elk during gestation and calving. Focused field data analysis and annual planning start. Budget is developed.
Financial Sustainability

Local partners have provided the majority of external funding for establishment of the iRON program and continue to provide essential financial support. During its evolution from an installation of two monitoring stations to a watershed-wide program that also includes outreach, network building, and data applications, AGCI has also drawn on internal funds to support this program.

Activities Supported by Program Funds

<table>
<thead>
<tr>
<th>Current Operations</th>
<th>Future Operations</th>
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<tbody>
<tr>
<td>• Career building experience (high school, undergraduate internships)</td>
<td>• Additional field-work assistance</td>
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<tr>
<td>• Data management and sharing</td>
<td>Advanced data analysis and visualization</td>
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<tr>
<td>• Data analysis and visualization</td>
<td>• Advanced data validation and calibration, comparison to remotely sensed data</td>
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<tr>
<td>• Community outreach</td>
<td>• Automation of data QA/QC</td>
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<tr>
<td>• Equipment maintenance and upkeep (10 field sites)</td>
<td>• Career building experience (graduate, and post-graduate internships and fellowships)</td>
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<tr>
<td>• Research/scientific communications</td>
<td>• Cross-basin partnership expansion (research, education)</td>
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<tr>
<td>• Site assessment and vegetation surveys</td>
<td>• Data application (models and forecasts)</td>
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<td>• Travel for conferences and program collaborations</td>
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<tr>
<td>• Partnership development</td>
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<tr>
<td>• Program management</td>
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<td>• Public website upkeep</td>
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Financing long-term research is a widespread challenge, but extended data records are essential tools for understanding the natural world in the context of a changing climate. The continuity of the Roaring Fork Observation Network is, therefore of high priority to AGCI, and we are seeking to expand and diversify our funding sources to ensure the perpetuity of the program for this decade, and, we hope, for additional decades to come.

With the western US entering this decade in a state of severe drought, hydrology and climate change impacts are topics of widespread and urgent interest. This timing places the Roaring Fork Observation Network in a strong strategic position for requesting funding, as we begin to demonstrate the utility of the data from the Roaring Fork Observation Network in addressing these pressing challenges. Over the coming years, we will work to secure continued support from prior financial partners and to broaden engagement with new municipal, county, private, and non-profit entities. Additionally, we are pursuing grant funding for research at regional, state, and federal levels.
Join Us

We are excited to celebrate the 10th anniversary of the Roaring Fork Observation Network. It has been truly inspiring to see ideas and collaborations bud forth as this project grows.

Thank you to everyone who has made this possible. We look forward to another decade of shared learning and collaboration. To those new to this program we extend an earnest welcome to connect with us using the information below.

Through our long-term research, we hope to unveil a deeper understanding of the relationships between ecology, hydrology, and human society. Through your partnership, we hope to promote science-informed and conservation-minded tools for management that help us sustain these mountain communities for decades to come.

To learn more about partnering with this program or to provide feedback on this report, please contact Elise Osenga, Community Science Manager at eliseo@agci.org or visit our program a website at agci.org/RON/about.