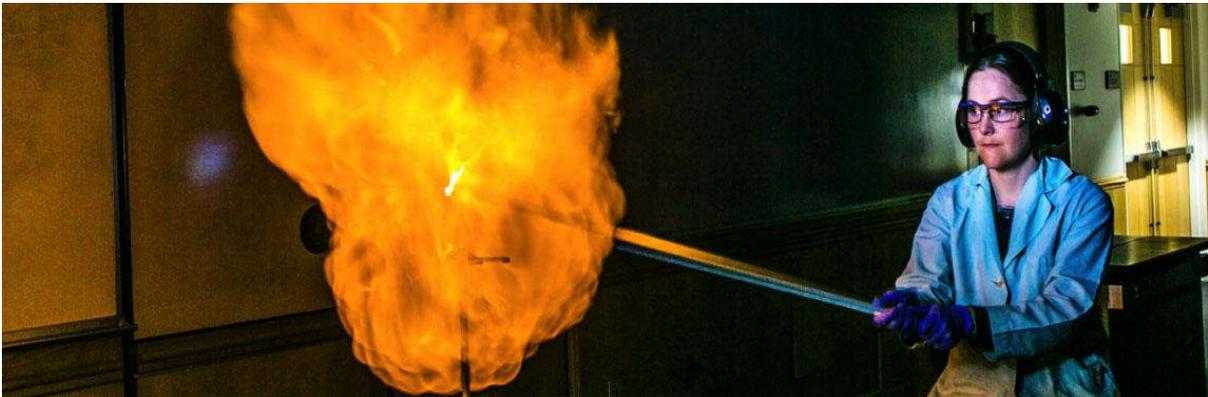


# The Alaska Science and Technology Plan

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## The Alaska State Committee for Research



Effective Date: October 1, 2022

Approved by the Alaska State Committee for Research September 19, 2022

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Paul W. Layer, Alaska State Committee for Research Co-Chair

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Lt. Governor Kevin Meyer, Alaska State Committee for Research Co-Chair

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## Executive Summary

Alaska's economy is based on knowledge. Research – the expansion of knowledge – can improve the state's resilience and competitiveness and contribute to human progress. While Alaska's vast size, extreme climate, and scattered population present challenges for science and technology development, the state also offers many advantages: a rich resource base, a unique Arctic location, an educated populace and increasingly well-regarded university system, and a landscape ideally suited for the study of human and natural systems undergoing climatic and social change.

This report was prepared by the Alaska State Committee for Research (SCoR) and presents a road map for the future of Alaskan science and technology (S&T) development. Improving Alaskan S&T requires a collaborative effort between the state, the University of Alaska (UA), federal agencies, communities, Alaska's indigenous peoples and the private sector. The state has a limited ability to broadly fund research, especially in lean financial times. Its role is rather to help provide infrastructure and basic research; education and training; incentives for industrial development; cost matching and focused funding; and research oversight and coordination. By adopting in-state innovations, the state can also leverage and validate Alaskan research. It is also incumbent on the state to refine research efforts to help industry to develop the state economy, and to foster relationships with communities and businesses to better leverage state funds.

To offer an analogy, the state seeks to build a fire under research. The “spark” is education and incentives for innovation. The “tinder” is infrastructure and capacity. The “fuel” is match funding and other support, and the “bellows” represents long-term planning and coordination by the State Committee for Research (SCoR) and other bodies.

Alaska's unique characteristics lend themselves to seven specific S&T research arenas, as detailed in this report. An overarching theme that ties these arenas together is Alaska's role in understanding the changing arctic and subarctic onshore and oceanic environments which offer challenges and opportunities for Alaska. These arenas take advantage of Alaska's natural and human assets and address research questions crucial to the state's economy, ecology and society:

- 1. *Community Resilience and Sustainability.*** Communities' capacity to adapt to environmental change; preserve arts and culture; and revitalize Alaska Native languages, culture, and knowledge.
- 2. *Resource Extraction.*** Technology and processes for safe and efficient exploration, extraction, transportation and use of oil, gas, coal and minerals, including rare earths elements and other critical minerals
- 3. *Energy, Food and Water Nexus.*** Create sustainable approaches to ensure food security, access to clean water, and energy independence for Alaska's communities and all Alaskans.
- 4. *Renewable Resources.*** Innovations and strategies to effectively harness the state's renewables, including fisheries, mariculture, wildlife, timber, and agriculture.
- 5. *Environmental Monitoring and Management.*** Monitoring and mitigation of environmental change, mapping and remote sensing, fire prevention and response, hazards, marine ecosystem monitoring and geophysical research.

**6. *One Health.*** Human health, animal health and environmental health are all inextricably linked, necessitating multidisciplinary approaches and delivering effective physical and behavioral health care in the Arctic and subarctic.

**7. *Transport, Communications and Information.*** Land transport, shipping, aviation, aerospace, telecommunications and information technology in northern environments.

As Alaska addresses these critical S&T research arenas, quality kindergarten through twelfth grade (K-12) and university education, with a focus on science, technology, engineering and math (STEM) instruction is crucial to our success. This report presents a summary of innovative programs and strategies to build the STEM education pipeline. The report concludes with a discussion of how the State and UA can collaborate to partner with the private sector to build a culture of entrepreneurship in Alaska.

## Introduction

Developing Alaska's science and technology capabilities is critical to the state. Research is widely recognized as the most significant engine of economic growth, and also constitutes an economically significant "industry" in its own right: The University of Alaska, for example, conducted \$154 million in sponsored research in 2021-22, including \$136.5 million at the University of Alaska Fairbanks (UAF), \$17.6 million at the University of Alaska Anchorage (UAA), and \$1.2 million at the University of Alaska Southeast (UAS) in Juneau. This research activity generates more than 1,500 jobs, attracts talent from around the nation and the world, and improves our ability to "grow our own" and to keep our best and brightest in Alaska.

The other reason science and technology is important in Alaska is the state's unparalleled richness of human and natural resources. A common saying is, "If we can solve it in Alaska, we can solve it anywhere." Our goal is S&T that enables us to affordably and sustainably meet socioeconomic needs while preserving the health of our environment and improving our quality of life. These results are exportable as well: better solutions for basic needs such as clean water, green energy and remote health care are needed around the world.

**Challenges.** Alaska offers unique S&T challenges. The state's vast size, scattered population, extreme climate and limited transport infrastructure complicate logistics and increase costs. Another hurdle stems from land ownership: Research questions don't respect the jurisdictional boundaries of the various federal, state, and Alaska Native organizations that own 99% of land in Alaska, complicating the process of obtaining permits and approvals. A further consideration is the significant research conducted on Alaska Native-owned lands, or involving Native communities or populations, which requires special attention to ethics and to intellectual property issues concerning the use of traditional local knowledge.

**Opportunities.** At the same time, the Great Land has abundant potential for S&T development. The state's expansive wilderness and coastline, Arctic and subarctic location, abundance of traditional local knowledge, and position at the forefront of climate change all make it a natural laboratory for innovation in environmental monitoring and management. Its isolated rural communities are ideal sites for social and economic research addressing cultural preservation, migration, and community sustainability, and for testing alternative energy technologies and solutions.

Perhaps most of all, Alaska offers motivation: nowhere else in the U.S. presents a more pressing need for innovation in areas like energy production and adaptation. And never before has there been such intense interest in the North, as factors such as climate change, resource potential, and new shipping lanes focus attention on the eight Arctic nations. As America's only Arctic state, Alaska offers strong opportunities for national and international research, stakeholder collaboration, energy development, and governance initiatives.

## Other Segments of the State Economy

Several other Alaskan industries are worth noting due to their contributions to the state, though they are not generally foci of scientific research.



- **Tourism:** Tourism has an economic impact of \$3.9 billion a year. 1.93 million people visited the state in 2013-4 (half by cruise ship) and around 46,000 people were employed in tourism jobs during peak season.

- **Military:** Alaska is home to about 23,000 active-duty military personnel, and veterans comprise 10% of the state population, the highest per capita in the nation. The University of Alaska increased cooperation with the military in 2013 by signing an agreement with the multi-services Joint Task Force-Alaska to share information in areas like energy, engineering and communications initiatives. Among other developments, this led to an Arctic Collaborative Workshop in 2014 that drew civilian and military Arctic experts from five countries.

- **Advanced Business Services:** Alaska houses numerous firms that provide customized problem-solving to other businesses, such as consulting and research companies.

## The State Committee for Research

This report is a product of the Alaska State Committee for Research (SCoR), an advisory body created to function as the state committee for Alaska EPSCoR (Established Program to Stimulate Competitive Research) and EPSCoR-like programs. This responsibility includes:

- Oversight and guidance for EPSCoR and EPSCoR-like programs in Alaska as competitively funded by the National Science Foundation and other federal agencies;
- Promoting research and development as an enterprise and as an engine for economic development in Alaska.

SCoR membership includes representatives from the State of Alaska, the University of Alaska, federal agencies and the private sector. It is co-chaired by the UA Vice President for Academics, Students and Research and by the Lieutenant Governor of the State of Alaska. Information about SCoR and a full list of committee members is available at <https://alaska.edu/research/scor/>.

**The Role of the State.** Alaska's unique economic structure and research needs foster a climate dominated by state and federal agencies and the University of Alaska. The function of the state is thus to conduct appropriate research through the UA and state agencies; to bolster research taking place at the federal, tribal, and local levels, and to identify ways to facilitate increased research by private industry. There are five roles the State of Alaska can play in the development of science and technology:

- 1. Education and training.** Through the Department of Education and the UA, the state takes a lead role in educating tomorrow's innovators. In addition to state efforts, tax credits and other support mechanisms can promote private education programs.
- 2. Incentives for commercial S&T development.** Alaska seeks to expand private-sector participation in S&T to spur economic growth. Tax incentives, direct financial support, and purchasing and early adoption of innovations contribute to this goal. Industry and government can also share the costs of research and exploration to identify opportunities and to improve feasibility.
- 3. Infrastructure and basic research.** Adequate laboratory space at the UA is critical to science and technology development, as are cyberinfrastructure, faculty retention and recruitment, and independent research by state entities. The state can also support and conduct the basic research that undergirds all applied science efforts, but that is unlikely to attract private funds.
- 4. Cost matching.** Many federal programs require a cost match; to the degree that the state seeks to attract such funds, it must provide the needed resources. Similarly, the state bears the burden of building capacity and maintaining excellence in areas where it wishes to attract federal support and private investment.
- 5. Oversight and coordination.** It is incumbent upon the state to pull together various elements of

S&T by developing a thorough understanding of what is already occurring and the mechanisms by which it occurs, including economic factors. Through participation in the State Committee for Research and other collaborations with the UA and the private sector, the state is actively involved in encouraging partnerships, providing incentives, and improving the S&T climate.

## To Build a Fire

“Building a fire” under research is critical if the state is to diversify and grow its economy.



Infrastructure, basic research and capacity-building provide **tinder**.



Education and incentives are the **spark**.



The **fuel** is cost-matching, as well as other financial support and guidance to help new technology to leave the laboratory.



The **bellows** represents coordination and long-term planning by the State Committee for Research and other state bodies to foster continued development.

Once a fire is lit under S&T, it takes the continued development and application of sound policy to **keep the blaze going**.

## Research Arena 1: Community Resilience and Sustainability

*Introduction.* More than two-thirds of Alaska’s 737,000 residents live in or near the principal cities of Anchorage, Fairbanks and Juneau, while many of the remainder occupy remote “mixed-subsistence” villages, in which residents obtain food from the land and waters but also participate in the cash economy. In recent years there has been a slow migration of village residents toward population centers, driven by jobs, schooling, health facilities, and increasing reliance upon modern technology. The continued viability of these isolated communities is dependent on numerous local and global variables, from the price of gasoline to the adaptability of wildlife to climate change. Understanding these variables and ways to respond to them is thus critical to preserving the rural Alaskan way of life.

Many of Alaska’s rural communities are located in areas of the state where natural disasters such as coastal storms, floods, fires, landslides, earthquakes, landslides, and tsunamis are threats to the residents. Many of these threats are increasing due to the climate driven changes including loss of sea ice and permafrost, increased storm activity, and earlier snow melt.

*Research Initiatives. Community Resilience.* A focus of Alaskan research is the ability of communities to effectively respond to environmental and social change. One key question is how communities and institutions can proactively address major climate-driven landscape changes. Such shifts can profoundly impact food webs and hence resource availability, and can also impact safety by altering characteristics of natural hazards such as forest fires.

Alaska NSF EPSCoR (National Science Foundation Established Program to Stimulate Competitive Research) is implementing a “Track-1” award that incorporates research into community adaptation to forest fire impacts and to changes to marine resources. UAF is also home of the Center for Arctic Policy Studies and the Alaska Center for Climate Assessment and Policy, networks for interdisciplinary research and education. UAA hosts the Alaska Center for Conservation Science, which fosters research and education on northern biological conservation and natural resource management.

**Social Research.** Many of the challenges facing rural Alaska are rooted in economics. The Institute of Social and Economic Research (ISER) at UAA conducts research into subsistence, rural-urban migration, sustainable communities, risk perception, and other aspects of social, economic and cultural change. The UAA Justice Center conducts basic and applied research into pressing issues of crime, justice and law that impact community resilience.



Figure SEQ Figure \\* ARABIC 2 –  
Photo provided by University of Alaska  
Fairbanks

**Arts, Language and Culture.** There is a growing global awareness of the importance of traditional local knowledge, especially in regards to a changing climate – but as Alaskan elders age, important knowledge is in danger of being lost to history. Culture, language and the arts in general are important facets of resilience and identity, and also contribute to the economy through tourism.

## Strategies

Alaska NSF EPSCoR has crafted a 5-year (2023-28), \$20 million research proposal, entitled “Glaciers to Gulf,” to study how climate-induced landscape change is impacting marine resources critical to communities on the Gulf of Alaska. Members of impacted communities were extensively involved in crafting the proposal and will serve as advisors and collaborators throughout the project. Outcomes of the research will include valuable new data streams as well as web tools, reports and visualizations for communities to use in preparing for, and responding to, climate-driven changes to critical harvested and farmed marine species.

SCoR was actively involved in crafting the EPSCoR proposal, and provides oversight and coordination to the program’s various elements. The state also provides an award match. With SCoR oversight, Alaska NSF EPSCoR regularly submits funding proposals for other activities that address community sustainability and contribute to local capacities to respond constructively to change.

A major UA initiative toward sustainability of Indigenous communities and cultures is a planned Troth Yeddha’ Indigenous Studies Center on the UAF campus. UAF is actively raising funds for the \$40 million center, which will serve as a central Alaska Native gathering place with classes, services and activities, and as an affirmation of Alaska Native culture and contributions across Alaska. It will serve as the administrative hub for UAF’s College of Rural and Community Development, which includes the Alaska Native Language Center, the Department of Alaska Native Studies and Rural Development, and the Center for Cross-Cultural Studies, among other programs. Another effort underway at the UA is the Alaska Native Success Initiative (ANSI), a multilayered plan to attract and retain Alaska Native students, faculty and staff across the UA system. ANSI consists of different strategies for each of the three main UA universities, including activities designed to foster a culture of belonging, to increase offerings and services for Natives, and to heighten visibility of Native language and arts across campuses.

The Alaska State Council on the Arts provides assistance and services to artists, art organizations and arts supporters across the state, including direct support for artists and a variety of programs to bring artists and art curricula to schools. The Council’s strategic plan calls for the organization to build an Alaskan arts and culture sector for the future; to illustrate the value of the arts through arts-integrated approaches; to grow Alaska’s creative economy and develop the workforce of tomorrow; and to enable all Alaskans to lead expressive lives. The nonprofit Rasmuson Foundation also provides major funding and support to Alaskan artists, totaling \$479 million in grant funding since 1955.

## Examples of Alaska Native Language and Culture Preservation Efforts



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Alaska Fairbanks

- The **Alaska Native Science Commission**, formed by the Alaska Federation of Natives, works to integrate Native knowledge into research.
- The **First Alaskans Institute** is a non-profit organization that helps to develop the capacities of Alaska Native people; its efforts include a Native policy think tank and leadership development programs.
- The **Sealaska Heritage Institute** is a non-profit organization that works to preserve and enhance Southeast Alaska Native cultures. It is partnering with UAS on “Haa X’atangi Deiyi: Our Language Pathway,” a three-year project to provide full scholarships to 18 students studying Alaska Native heritage languages with the goal of passing them to others.

- The **UAF Oral History Program** preserves more than 15,000 audio and video recordings about Alaska’s history and people, many of which are available online.
  - The **UAF Alaska Native Language Center** researches and documents Alaska’s 20- plus Native languages and raises public awareness of language loss.
  - UAF is partnering with Google in the **Endangered Languages Project**, which enables people worldwide to find and share information about endangered languages.
- The **Alaska Native Language Preservation and Advisory Council** makes findings and recommendations to the State of Alaska on how to support the continued survival of Alaska’s Indigenous languages.

## Research Arena 2: Resource Extraction

**Introduction.** Oil has been the linchpin of Alaska's economy for a half-century, but Alaskan production is down significantly from its 1988 peak. However, according to the U.S. Geological Survey (USGS), Alaska still contains the largest undiscovered conventional oil and gas potential in the nation and also has significant unconventional resource potential in tight gas, shale oil, and coal reservoirs. Alaska also has large reserves of strategic minerals, which have received considerable recent attention at both the state and national levels. The state seeks to provide innovative solutions to extractive industries to improve efficiency, especially during financially difficult times.

**Research Initiatives. Oil and Gas.** The state strives to improve technology and data to develop a scientifically sound and efficient oil permitting process, and to improve understanding of the impacts of development and climate change on wildlife, infrastructure, and vegetation. Alaska also facilitates oil development by gathering geologic and engineering information for potential oil and gas basins.

The state seeks to collaborate with oil and gas multinationals to develop and implement advanced exploration and production technology, such as directional drilling techniques, 3-D seismic surveys, and reinjection techniques to improve recovery. It is incumbent on the state and industry to identify and "design out" potential environmental problems before development takes place. One key area is production techniques for viscous and heavy oil, which constitute a huge, largely untapped reserve, and for oil shale. The potential for increased Arctic Ocean exploration and drilling means the state must develop and implement better methods for offshore oil spill prevention and response, including research into skimmers and treatment technology.

Alaska can also facilitate natural gas research. High priorities include arctic engineering; cold-climate propane transportation and delivery; resource and reservoir identification studies focused on coal bed methane, natural gas hydrates, and conventional natural gas; gas-to-liquids engineering; and public policy issues. New technologies hold the potential to unlock vast reserves of coalbed methane and hydrates in particular. As a low carbon fuel, demand for natural gas is expected to continue to grow through the next several decades. In the longer-term, methane will also be used to create blue hydrogen and blue ammonia fuels. Coupled with the sequestration of produced carbon dioxide in co-located depleted oil and gas reservoirs, Alaska's natural gas resources could make a significant contribution toward providing domestic and international markets with very low carbon fuels. Research is needed in order to better quantify Alaska's carbon dioxide sequestration potential, future hydrogen, and ammonia fuel markets, as well as production and transportation infrastructure requirements.

**Minerals.** Alaska has deposits of gold, silver, lead and zinc mined at an industrial scale and potentially commercial quantities of more than a dozen strategic minerals. This includes abundant rare earth

elements, which have been found in more than 70 different deposits across the state. Making informed mineral permitting decisions that minimize harm to the environment is a priority of the state. Assessing public lands for mineral potential, constructing ore deposit models, developing new techniques for mineral deposit exploration, and conducting research into mine ventilation, remediation, tailings handling, systems engineering and technologies are also goals of the state. In addition, Alaska has the potential to further profit from its mineral resources through in-state processing and use.

**Coal.** It is estimated Alaska contains half of total U.S. coal reserves, but little is currently economically recoverable; exceptions are the Usibelli Coal Mine in Healy and the undeveloped Chuitna River Mine on Cook Inlet. Although most known deposits are not of the scale to merit development for export, many regions could be developed for local use. For example, natural gas generated from coal in Tertiary basins, as well as coal suitable for surface mining, have been identified in regions that rely primarily on imported diesel for heat and electricity. Clean coal, coal gasification, tight reservoir gas production and other emerging technologies could be developed for application in these regions. Further delineation of deposits, in combination with development of technologies for extraction and generation, are needed in these areas.

## **Strategies**

The Institute of Northern Engineering at UAF hosts Petroleum Development and Mineral Industry Research laboratories. Other key analytical labs at the UA are listed below. The state recently funded engineering buildings at UAA and UAF, concurrent with a highly successful push to increase UA engineering student numbers. The 2022-23 state budget contained a dedicated appropriation for UA research into heavy oil recovery.

State oil and gas exploration efforts combine detailed stratigraphic and structural outcrop studies, surface geologic mapping, and subsurface well and geophysical interpretation. Recent projects have focused on the National Petroleum Reserve-Alaska, which has seen significant development in recent years, as well as the 1002 Area of the Arctic National Wildlife Refuge, which was recently opened for exploration. Other recent mapping includes Gilead Creek, the Northern Foothills, Big Bend, Happy Valley, and Rooftop Ridge/Racetrack Basin on the North Slope, and the Iniskin Peninsula, Red Glacier and Tuxedni Bay in Lower Cook Inlet. The state is also exploring the Susitna and Nenana basins for natural gas potential.

UA collaborated with the state to adopt a strategy to develop rare earths, including mineral assessments, industry incentives, permitting changes, coordination with stakeholders, and an information campaign. In August 2022, UAF convened “Alaska’s Minerals: A Strategic National Imperative.” The two-day event gathered national-level policymakers, agency representatives and industry leaders to discuss Alaska’s potential to supply minerals to support national clean energy and

economic security goals. The 2022-23 state budget also included specific appropriations for critical mineral and rare earth element research at the UA.

The Alaska State Geological Survey is collaborating with the USGS and the UA on strategic and critical minerals evaluation, which seeks to identify the regions of highest potential for rare earths and other strategic and critical minerals. Recent exploration has focused on areas of Eastern Interior Alaska, as well as the Richardson mining district southeast of Fairbanks, the Ray Mountains north of Fairbanks, the Styx River in Southcentral Alaska, and the Kugruk fault zone on the eastern Seward Peninsula. The 2022-23 state budget included support for the U.S. Geological Survey's Earth Resources Mapping Initiative, which is conducting geophysical and LiDAR surveys of 102 focus areas across the state with the potential for rare earths and other critical minerals. The state and USGS also recently conducted a review of potential deep-sea mineral deposits in the waters surrounding Alaska, as well as studies of potential deposits of lode gold, lead and zinc. The state funds the Geologic Materials Center facility to archive Alaska's legacy collection of geologic samples and data.

Improving oil spill response through better mapping, communications, cooperation and investment is a key recommendation of Alaska's Arctic policy. The Arctic Domain Awareness Center, a UA research center funded by the Department of Homeland Security, has been supporting a UAA engineering team to conduct focused research on how ice and oil might interact in Arctic waters. Their findings are improving NOAA predictive models used by the U.S. Coast Guard. The Oil Spill Recovery Institute, a federally-funded research facility in Cordova, develops research into oil spill prevention and mitigation. The Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine collaborated with Alaska Sea Grant to hold an Anchorage workshop aimed at improving community preparedness for oil spills. The summary report for the event is a valuable roadmap for addressing potential health, social and economic disruptions resulting from an Alaskan spill.

### Examples of UA Laboratory Facilities



High-frequency Active Auroral  
Research Program (HAARP) at UAF

- The **UAF Advanced Instrumentation Laboratory** specializes in surface and elemental analysis and electron microscopy, and also houses sample preparation facilities
- The **Alaska Stable Isotope Facility** at UAF and the **Stable Isotope Laboratory** at UAA analyze a wide range of isotope samples.
- The **UAA Applied Science, Engineering and Technology Laboratory** serves researchers studying health, safety, welfare and climate change issues, including toxic substances and chemical environmental changes resulting from glacier and permafrost thaw.
- **Research Computing Systems** at the UAF Geophysical Institute provides advanced computing, storage, data sharing solutions and research information technology support to University of Alaska Research communities, collaborators and supporters.
- The **Southeast Alaska Geospatial Environmental Analysis Lab** at UAS provides educational and analytical research capacity in the geospatial sciences, while the **UAS Spatial Ecosystem Analysis Lab** enables the analysis of inorganic and organic samples that are harbingers of socio-ecological and biophysical change.
- The Geophysical Institute's **HyLab** at UAF is the only hyperspectral imaging facility in the state, which can not only benefit the local, Alaska and national economies, but also national defense by helping delineate Alaska's deposits of critical minerals.
- The **High-frequency Active Auroral Research Program (HAARP)** at UAF is a research observatory dedicated to exploring Earth's upper atmosphere and geospace environment

## Research Arena 3: The Food-Energy-Water Nexus

*Introduction.* The Food-Energy-Water (FEW) nexus is the intersection of three interdependent components that, together, are needed to sustain life. FEW research in Alaska focuses principally on the interrelated ways to provide these three necessities to the state's isolated towns and villages. These unique communities have ample supplies of clean water; electrical microgrids separated from larger grids; and a history of hunting and fishing but little agriculture.

*Research Initiatives. Agriculture.* Alaska's isolation and climate make it extremely "food-insecure" and it is estimated that less than five percent of food eaten in Alaska is produced in the state. Alaska's short but highly productive growing season has strong potential for large-scale agriculture, but less than 1 million acres statewide are used for farming. There are also economic opportunities in certain high-value agricultural products for which Alaska's high latitude is an advantage, such as reindeer antlers, peonies, and golden root. Research into bolstering local food production and improving food security is thus critical to the state as a whole, as is continued study of the nexus of food, energy and water. (Mariculture is discussed in Arena 4.)

**Renewable Energy.** Generating renewable energy is a primary focus of Alaskan FEW research: Energy prices in parts of Alaska, especially rural Alaska, are astronomical; more cost-effective methods of energy production and distribution are crucial to ensuring the future of the state's remote communities. In addition to conventional energy resources (see Arena 2), the state's landscape holds significant potential for alternative energy: Alaska contains abundant fossil fuel alternatives, including more than 50% of the nation's wave energy resources and over 90% of its river current and tidal energy resources. Renewable energy possibilities for Alaska include the use of shrubs and trees or waste to power small biomass generators (see Arena 4), wind turbines, seasonal solar power; geothermal power generation, and hydropower from dams and from river, wave and tidal generators.

Many options for renewable generation in Alaska have been identified and mapped, but further identification of resources and optimal sites for power generation is needed. Even more important will be continued research into power transmission, in order to bridge the long distances between resources and communities. Improvements in energy storage are needed to increase the feasibility of renewables and to lower their cost. Another major challenge for renewables lies in Alaska's climate, which can devastate equipment built for milder weather. Alaskan scientists are continuing research into materials and their performance under Arctic conditions, including wind power systems backed up by diesel generators. Research is also needed into the potential for using abundant clean energy resources as an incentive to attract energy-intensive industries to the state.

The Alaska Center for Energy and Power (ACEP) based at UAF conducts applied energy research and testing focused on lowering the cost of energy throughout Alaska and developing economic

opportunities for the State of Alaska, its residents, and its industries. ACEP provides leadership in developing energy systems for islanded, non-integrated electric grids and their associated oil-based heating systems, and researches alternative energy sources as well as more efficient use of non-renewables. ACEP facilities include a power systems integration lab, a wind-diesel generator testbed, and a river generator test site.

The other side to the Alaskan energy challenge is conservation. Reducing power and heating costs in rural Alaska is a high priority for the state. The state leader in home energy-efficiency research is the Cold Climate Housing Research Center, now part of the Department of Energy National Renewable Energy Laboratories, which develops facility designs, materials, and construction techniques for the subarctic and Arctic.

Renewables can feed back into the nexus in several different ways: among the possible solutions that can be powered by renewable energy sources are Arctic-designed greenhouses, modular water treatment systems installed in individual homes, and advanced algorithms to optimize usage of variable renewable energy generation, such as wind and solar.

**Water.** Alaska contains abundant water resources, but challenges still remain in supplying clean water and treating sewage in extreme climates. Additionally, as Alaska's climate warms the timing, form quantity and distribution of Alaska's freshwater resources is changing and in doing so is dramatically affecting ecosystems and communities including subsistence food resources, community water supplies, agriculture, and energy production. The Water and Environmental Research Center (WERC) is part of the UAF Institute of Northern Engineering and conducts basic and applied research related to water and environmental resources. Research disciplines at WERC include: environmental, civil, and arctic engineering; environmental science; oceanography; limnology; hydrology; microbiology; geochemistry; and hydraulics. Current research projects include hydrologic, meteorological and habitat monitoring of various North Slope rivers; an examination of long-term mercury levels in the Aleutians; and a study of catastrophic thermokarst lake drainage in the Arctic.

## **Strategies**

UAF runs experimental farms in Fairbanks and Palmer, and the UA Cooperative Extension Service has taken the lead at the university level in researching and advocating local food production. A state organization, the Alaska Food Policy Council, works toward a goal of creating a healthier, more secure, and more self-reliant Alaska by improving the state's food system. The council conducts research and makes policy recommendations in areas such as local food purchasing programs, food production and transport infrastructure, and workforce development. Two current working groups sponsored by the council are focused on Indigenous foods and on food waste. UAF, the Alaska Climate Adaptation Science Center, and the U.S. Department of Agriculture (USDA) recently collaborated to produce the Alaska Garden Helper, an easy-to-use tool that enables Alaskans to see

projected changes to their communities' growing conditions, such as changes in growing season length, annual minimum temperature and hardiness zones. The state Division of Agriculture received a recent USDA award to increase its technical assistance capacity within the state, focusing primarily on the peony industry, which is one of the fastest growing and promising industries in Alaska agriculture.

In 2017 the Alaska Energy Authority (AEA) - an organization charged with coordinating state energy priorities - produced the Alaska Affordable Energy Strategy, which outlines ways to deliver cost-effective energy to rural areas of the state. The authoritative report identifies new infrastructure opportunities for delivering more affordable energy, and examines the efficacy of existing energy programs and of potential policy or regulatory changes that could contribute to more affordable and reliable consumer energy in rural communities. AEA more recently produced a Renewable Energy Atlas highlighting potential energy sources statewide, and also discussing energy efficiency.

In recent years, various state funds have been used for widespread biomass, geothermal, wind, hydropower, waste heat recovery, and energy efficiency projects, including capital funding in the 2022-23 state budget. Most significantly, a Renewable Energy Grant Fund established in 2008 has awarded \$275 million to 244 renewable energy projects. ACEP has been the central vector for renewable energy research, including recently funded projects focused on hydrokinetic turbine designs for tidal and riverine currents and on home heaters that store renewable electric energy.

In the private sector, more than 100 small businesses in Alaska have worked on microgrid energy solutions. Alaska has more than 200 microgrids, and includes 45 hydroelectric projects, 27 wind projects, and 14 biomass projects with 11 more of the latter planned or under construction as of 2019. Solar is also growing quickly, and the state is increasing emphasis on the potential for nuclear microreactors, including streamlining permitting and providing funding to ACEP for research. Eielson Air Force Base hopes to have a microreactor operating by the end of 2027, and the Copper River Electric Association commissioned a feasibility study for a microreactor as well. The state also recently funded an initiative to apply for Department of Energy funding to establish a research hub for hydrogen power.

A team of researchers from UAF and UAA, as well as from the University of Calgary, Stanford University, and industry, has spent the last several years on an NSF-funded project seeking approaches to optimizing FEW systems in isolated communities in Alaska and elsewhere. The team found significant room for growth, noting that food, water, energy and transportation systems are often managed separately, allowing limited opportunities for coordination to maximize their benefits. In each community they studied, renewable energy offered the potential for broader benefits: excess



Figure SEQ Figure \\*ARABIC 4 - Photo provided by University of Alaska Fairbanks

electricity could be used to heat thermal stoves or grow produce in greenhouses, for example, and gathering wood for biomass systems could add local jobs.

## Research Arena 4: Renewable Resources

*Introduction.* Alaska's waters are among the most productive in the country, with fishing employing more people in Alaska than any other industry and mariculture growing in importance. Monitoring and managing the state's waters is crucial, as climate change and increased human use influence land-ocean connections, ocean circulation, and ecosystem dynamics, all of which impact biological productivity, fish stocks, marine mammals, and other marine resources. Timber is another area where S&T can bolster renewable resource use.

*Research Initiatives. Fisheries and Marine Life.* Informed state regulation of commercial, subsistence, and sport fisheries, as well as mariculture, is necessary to assure sustainable harvests. To this end, the state collaborates with fishers, farmers, processors, and regulatory bodies to develop and improve science-based management of fish and shellfish stocks and other marine resources. A focal point of state research is the resilience of coastal and oceanic food webs and the fisheries they support to increasing changes in the environment. This includes potential large-scale shifts in coastal ecosystem services due to glacial retreat. Ocean acidification is another major cause for concern in Alaska; habitat studies (see Arena 5) are key to charting the effects of acidification and climate change on fisheries and other marine resources.

Understanding abundance and distribution dynamics of fish, shellfish, aquatic plants, and marine mammals would allow for more responsive resource management and support current subsistence needs and fishing opportunities important for food security. Fisheries priorities include species-specific assessment and modeling for salmon, sablefish, Pollock, halibut, forage fish, and other species. Another critical area for research is the potential for increased mariculture and aquaculture, including the production of oysters, mussels, clams, invertebrates, aquatic plants, salmon and sea urchins. Research challenges include *in situ* data collection and acquisition of both temporal and spatial "big data," data management and public accessibility, and habitat mapping. Key fisheries research areas include the decline of western Alaska chum salmon, and Chinook salmon populations, Bering Sea snow crab, and Bristol Bay red king crab.

There is also great potential within the seafood industry for advances in product use and processing to increase the share of seafood processed locally and in-state. Areas of interest include advances in processing, refrigeration, dehydration, genetics and acoustics, spatial information software, and value-added processes, as well as ways to detect harmful algal blooms and to minimize or mitigate bycatch and use fish waste.

**Timber and Forestry.** Alaska's timber industry is constrained by changing market conditions and by the small amount of commercial-quality old-growth hardwoods available for harvest. The state can contribute to the industry through innovations: for example, the Ketchikan Wood Technology Center, a government-industry collaboration, developed new strength values for Alaska softwoods,

earning them recognition for their aesthetic and structural properties. Market research can also help in the development of value-added products. The state also works to facilitate wood energy, including the use of low-grade timber, wood waste and wood pellets for biomass projects. Field trials of alternative systems, including bailers, forwarders, and in-field chipping systems, could help reduce biomass harvest and transportation costs.

## Strategies

UA has made recent strides toward becoming a world-class ocean-change research engine, including establishing an Ocean Acidification Research Center and operating *R/V Sikuliaq*, a global-class ice-capable research vessel; the latter is slated for \$94 million in improvements to its home port in Seward. In 2018, the Northern Gulf of Alaska Long-Term Ecological Research (LTER) was established to perform oceanographic observations to better understand climate change at established station locations in the Gulf of Alaska.

In 2016, the state created a Mariculture Task Force, which delivered a final report in 2021 with recommendations to boost Alaska's mariculture industry. This final report indicates that further maricultural research is needed to facilitate growth of the aquatic farm industry, including studies of maximizing growth rates, identifying innovations for efficiency, identifying and mapping natural limiting factors to production such as weather and water current exposure, and understanding genetic relationships among areas to ensure permitting of sustainable mariculture.

Alaska NSF EPSCoR's proposed "Glaciers to Gulf" project will directly address research needs indicated in the state mariculture plan. The five-year project would use remote sensing, modeling, environmental data, field surveys, and lab and field experiments to understand and quantify changes to freshwater and material export into the Gulf of Alaska, and how this impacts species critical to mariculture and subsistence harvests. The effort would materially improve the ability of marine harvesters and farmers to respond to climate-driven landscape change.

The state Mariculture Plan also led to the creation of an Alaska Mariculture Alliance and a number of legislative actions designed to foster development of the industry, including streamlining permitting processes and establishing a state revolving loan fund for mariculturalists. The state earmarked funds in its 2022-23 budget for mariculture research, industry support and workforce development. Another major development was a 2022 UA conference, "Mariculture for Alaska's Future: Status, Challenges and Opportunities," that brought together practitioners, regulators, policymakers and scientists to support expansion of the industry. A UA researcher also collaborated with Alaska Sea Grant and the Native Conservancy to develop a site assessment toolkit to help help farmers test locations for potential placement of their farms, which has since been licensed for production by a California company.

Other recent initiatives at the UA level include an Alaska Aquaculture Semester at UAS-Sitka, through which students gain hands-on experience in fish culture and aquatic plant farming. UAF recently established a Master's-level degree program in Fisheries and Marine Policy, in which students learn about living marine resources and their management; methods; law and policy; and economics, development, and sustainability. UAF administers "Tamamta," an NSF-funded graduate-level fisheries program that bridges Indigenous and Western sciences.

Another critical link is the UAF/National Oceanic and Atmospheric Administration (NOAA) Alaska Sea Grant Marine Advisory Program, which conducts fisheries and aquaculture research. The subjects of current Sea Grant studies range from red seaweed cultivation, oyster farm-sea otter interactions, and seaweed wrack to pink salmon, walrus and coastal storm hazards. Sea Grant has held introductory workshops on aquatic farming, navigating the permitting process, and processing aquatic plants, and is participating in a multi-agency collaboration to implement the NOAA Alaska Aquaculture Permitting Portal, which was launched in 2021 to help prospective and current aquatic farmers navigate the permitting process.

ISER has also been a center for research on the economic impact and future of fisheries and other natural resources, including allocation impacts. The UA Fisheries, Seafood, and Maritime Initiative collaborates with industry to research sustainable fisheries and to develop a skilled workforce. The Southeast Alaska Tribal Ocean Research organization coordinates Southeast Alaskan Tribal responses to the threat of toxic shellfish and harmful algal blooms.

Through initiatives such as an Alaska Wood Energy Development Task Group, the state is supporting new timber and resource roads and working to coordinate timber sales with biomass power projects funded through the Renewable Energy Grant Fund (see Arena 3). UAS researchers recently completed a study into whether standing dead yellow cedar trees might provide an economic opportunity for small lumber mills in Tongass National Forest.

### Alaskan Ocean Research

Alaska is home to multiple ocean research efforts undertaken at the state, federal, industry and university levels.

- **Alaska Sealife Center** (Seward)
- **UAF College of Fisheries and Ocean Sciences** (Fairbanks and Juneau)
- **Gulf Watch Alaska** (Anchorage)
- **Kachemak Bay National Estuarine Research Reserve** (Homer)
- **Kodiak Fisheries Research Center**
- **Barrow Arctic Research Center**
- **Center for Alaska Coastal Studies** (Homer)
- **Mariculture Research and Restoration Consortium** (Fairbanks)
- **NOAA Alaska Fisheries Science Center** (Juneau)
- **Prince William Sound Science Center** (Cordova)
- **Alaska Department of Environmental Conservation** (Juneau)
- **Alaska Fisheries Development Foundation** (Anchorage)
- **Alaska Department of Fish and Game** (Juneau)
- **North Pacific Research Board** (Anchorage)
- **Sitka Sound Science Center** (Sitka)

## Research Arena 5: Environmental Monitoring and Management

*Introduction.* Alaska's 586,412 square miles encompass a wide array of terrestrial and marine ecosystems, which support diverse wildlife and abundant commercial, recreational, and subsistence resources. The Alaskan environment, to a large extent, defines the people of Alaska, and ensuring the health and sustainability of this environment is crucial to the state as a whole.

*Research Initiatives. Monitoring Environmental Change.* High-quality climate observations over extended periods are the only way for researchers to tease out natural versus human-induced change, a necessary element of understanding and predicting climate patterns. The state seeks to facilitate this effort by coordinating an environmental land and ocean monitoring network consisting of linked *in situ* and remote sensing nodes with a common data portal, building on and coordinating existing monitoring by state and federal agencies, tribal governments and local communities. The system would track terrestrial conditions, as well as water quality, quantity and availability, glacier and ice extent, and ocean water quality and productivity. This improved information stream would enable enhanced environmental models and forecasts for use in adaptive resource management and refined decision-support tools.

**Habitat and Wildlife.** The state manages wildlife to support diverse populations and to enable hunting, fishing and viewing. Research into basic biology and ecology, habitat and population mapping, monitoring, and modeling is important to track wildlife information and to understand how climate change affects flora and fauna. The state also seeks to identify means to incorporate local and traditional knowledge into resource management. The state must also take a lead role in preventing and, when practicable, eradicating invasive species. Long-term monitoring, process studies, and models of wildlife, fish, and other harvested species and their habitats are a priority, as are research into marine ecosystem structure and processes, endangered and stressed species, contaminants, effects of water system changes on aquatic communities, and marine mammal management.

**Mapping, Sensing and Unmanned Aerial Systems.** An Alaska Geospatial Council brings together the UA, state agencies and numerous stakeholders to improve Alaska's mapping and Geographic Information Systems (GIS) capabilities. A major UA focus is remote sensing. Agencies like the Alaska Satellite Facility, the Geographic Information Network of Alaska (GINA), and the UAF Hyperspectral Imaging Laboratory are ideally located to acquire, process, archive and distribute remote sensing data. Many engineering challenges presented by remote sensing open the door for new Alaska industries in sensors and space-based engineering, including the development and launch of small CubeSAT-type satellites.

The Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) at UAF is an international leader in drone research and was designated by the Federal Aviation Administration as one of six official drone test centers nationwide. Areas of research at UAF include advanced approaches to *in*

*situ* environmental monitoring, resource assessment, autonomous underwater vehicles and small satellites.

**Fire and Earth Science.** Mammoth fire years in 2004, 2005, 2015 and 2022 burned millions of acres, and evidence is mounting that temperature and precipitation changes are impacting fire frequency and severity and altering forest composition. Research is needed to improve community capacity to model and anticipate forest fires and to take preventative measures. Increasing earth science research in general enables more accurate predictions of changing environmental conditions that contribute to permafrost thaw, flooding, and coastal erosion. This will enhance monitoring and response strategies to emergency situations, as well as realistic analyses of their socioeconomic impacts.

### **Strategies**

Alaska-wide collaborations such as the National Ecological Observatory Network, the Arctic Observing Network, and the Alaska Ocean Observing System provide large-scale environmental observation and monitoring. The Alaska Native Tribal Health Consortium's Local Environmental Observation Program recruits citizen scientists to report unusual plants and wildlife, flooding, wildfires and more. The Utqiagvik-based interagency North Slope Science Initiative collects and disseminates Arctic ecosystem information, and the federal Alaska Climate Science Center and Landscape Conservation Cooperatives collaborate in climate efforts. The UAF Cooperative Extension Service and state and federal agencies are partnering on a statewide Alaska Invasive Species Partnership working to prevent and reduce impacts from invasives. The NOAA Auke Creek Research Station collaborates with UAS to maintain the longest running data set on wild Pacific salmon in existence.

UA engages with numerous other institutions to monitor the Alaskan environment. UAF operates Toolik Field Station, the largest scientific research station in the Arctic, which had its NSF funding renewed in 2022 for five years. UAF, Alaska Pacific University, and the University of Colorado Boulder were selected to host the NSF Navigating the New Arctic Community Office, which will help to build an integrated network of researchers, stakeholders and communities tackling the pressing challenges of a changing Arctic. UAF is partnering with the University of Washington and Oregon State University to lead the NOAA Cooperative Institute for Climate, Ocean, and Ecosystem Studies, a 5-year, up to \$300 million effort to address climate, ocean and coastal challenges.

The USGS recently completed the Alaska Mapping Initiative, which mapped Alaska at a 5-meter resolution level, replacing the former 60-meter statewide elevation grid. Alaska NSF EPSCoR has sponsored LiDAR surveys, aerial photography, and hyperspectral imagery across numerous areas of the state, and EPSCoR data portals provide access to sensor and mapping data and facilitate model development. The 2022-23 state budget included \$10 million for UAF drone programs to secure beyond-line-of-sight and industry development, and UAF and its commercial partners were the first U.S. team to measure carbon dioxide, the driving factor in ocean acidification, with an autonomous underwater vehicle.

Fire research in Alaska is spearheaded by the Alaska Fire Science Consortium, an interagency group headquartered at UAF's International Arctic Research Center. The mission of the consortium is to coordinate fire science delivery efforts and to facilitate communication between scientists and resource managers. The current NSF EPSCoR project is examining regime change in fire-prone Alaskan boreal forests, with a goal of improving Alaskans' ability to predict fire behavior and proactively respond to it. GINA, with support from the federal Joint Polar Satellite System program, provides fire managers with information vital to fighting wildfires in Alaska through the use of data from two polar-orbiting satellites, with a third scheduled for launch in late 2022.

The UAF Geophysical Institute studies earth science phenomena, including space physics and aeronomy, atmospheric sciences, snow, ice, and permafrost, seismology, volcanology, and tectonics and sedimentation. The State Division of Geological and Geophysical Surveys partners with the GI, USGS and NOAA in earthquake, tsunami and volcano research and monitoring, and works to maintain, expand and upgrade those networks. Alaska recently benefited from the federal EarthScope program, which operated 260 seismic sensors in a grid across the state. UAF has received funding to continue operation of many of these sites and also incorporated enhanced NOAA weather monitoring systems at these sites, providing crucial seismic and environmental monitoring. Space research is organized by the Alaska Space Grant Program and by Alaska NASA EPSCoR, which awards research grants in the areas of earth system science, technologies for space and extreme environments, and aeronautics.

### Examples of UA Biology Research Units

- The UAF **Institute of Arctic Biology** advances basic and applied knowledge of high-latitude biological systems.
- The **Alaska Cooperative Fish and Wildlife Research Unit** at UAF is part of a nationwide cooperative university-state-federal program to promote research and training in the ecology and management of fish, wildlife and their habitats.
- The UAA **Environment and Natural Resources Institute** researches arctic tundra, boreal forest and coastal rainforest regions, including environmental contaminants, geochemical resources, and terrestrial-marine ecosystem linkages.
- The UAF-affiliated **Arctic, Bonanza Creek, and Beaufort Lagoons Long-Term Ecological Research** stations support research into the consequences of changing climate and disturbance regimes on tundra, boreal forest, and northern coastal ecosystems, respectively.
- The UAF **Agricultural and Forestry Experiment Station** focuses on natural and manipulated ecosystems, sustainable soil productivity, food safety, plant genetics, enhanced livestock production, economic and legal aspects of resource use, silviculture and forest management.
- The **Alaska Coastal Rainforest Center** at UAS is a university-agency effort to research coastal temperate rainforests; the center recently released a comprehensive report on the impacts and response to climate change in Juneau.
- The UAF **Toolik Field Station** provides housing, meals, laboratories and support services for Arctic research and education to scientists and students from universities, institutions, and agencies from throughout the US and the world.
- The UAF **Large Animal Research Station** conducts research, education and outreach in high-latitude biology and provides facilities for and expertise in maintaining colonies of large animals.

## Research Arena 6: One Health

*Introduction.* “One Health” refers to integrated research into the interrelated subjects of human, animal and environmental health - a critical area of research, education and outreach that has seen increased emphasis in Alaska. Major Alaskan health issues include environmental contaminants and infectious diseases, as well as chronic maladies like heart disease, cancer, and diabetes, and preventable conditions like obesity and substance abuse. Alaska’s location on bird migration routes makes it susceptible to avian-borne pathogens, while climate change may increase the distribution, spread, and virulence of some infectious diseases. Other issues include behavioral and mental health problems (such as suicide, fetal alcohol syndrome, and violence) and the challenge of providing services to a dispersed population. Further, there are glaring health disparities between Alaska Natives and other Alaskans.

*Research Initiatives. Basic, Translational, and Clinical Research.* UA has growing expertise in biomedical and population health fields, including cell biology, neuroscience, physiology, immunology, genetics and computational bioinformatics.

**Environmental and Animal Health.** Disease, parasite and virus vectors are major issues in Alaska. Hepatitis and other STDs, tuberculosis, pneumonia, COVID-19, and *Helicobacter pylori* bacteria are public health concerns. Unusual epizootic diseases erupt in rural villages where people are exposed to feral animals. Severe and catastrophic weather events can render animals and people susceptible to opportunistic infections. Climate change causes new animal migration patterns and human-animal interactions that may increase the incidence of zoonotic diseases, such as West Nile virus. Bioterrorism threats present unique challenges in Alaska because of the distances and isolation. Melting and receding glaciers could unleash new types of pathogens.



Figure SEQ Figure \\* ARABIC 8-Briggs  
Lab COVID testing materials - JRE-0474  
UAA Photo Bank – James Evans

Other important environmental, health-related topics in Alaska include the impact of contaminants on food safety and security; improved infrastructure for water supplies, sewage and waste disposal, air quality, maternal and child health, and occupational health and safety. Ecosystem and human health ties are also important, including toxicology, zoonotic diseases and other infectious agents, and methods for monitoring food and water safety.

**Rural Health Delivery.** Science and technology research can contribute significantly to rural health care. Areas of emphasis include epidemiology in sparse populations and in harsh winter conditions, emergency treatment in the wilderness, seasonal syndromes and cold-induced injuries, health care and social services delivery to remote regions, and advances in telemedicine, including telepsychology.

**Behavioral Health.** Alaska has staggering rates of suicide, child abuse, alcoholism, substance abuse, sexual assault and violence. Yet, some communities in Alaska are virtually free of these problems.

Alaska also experiences high numbers of homeless people with greater concentrations in the larger communities of Anchorage, Fairbanks and Juneau. However, some areas of the state appear to have significantly lower populations of people without a fixed residence, such as the Mat-Su Valley.

Alaska researchers must parse out what makes these communities resilient compared to their neighbors, and identify effective methods to implement these findings incorporating both cultural values and traditional Western concepts. Since many significant disparities among segments of Alaska's population are in the areas of behavioral health, the intersection of indigenous and Western beliefs and practices are important issues.

**Alaska Native Health.** Alaska Natives, who make up 15 percent of the state population, have a unique set of health needs. In addition to behavioral health challenges, Natives are subject to heightened levels of chronic disease due to rapid environmental, social, and economic change. Rural-urban migration, in particular, can have profound health ramifications. Alaska has a unique tribal health system incorporating both university and community partners, which is well-suited for collaborative, translational health research projects. UA also focuses on public health and social services, including studies of rural-urban health disparities.

**Veterans.** Alaska has a large veteran population, and must further research veterans' needs, including physical and psychological therapies for traumas and stresses. This includes the development and refinement of prosthetic devices for veterans. These research goals may be best met through university partnerships with military agencies.

### **Strategies**

The UAF Center for One Health Research (COHR) engages participants from UAF, Alaska and the circumpolar North to collaborate on research programs to address One Health issues. COHR is building interdisciplinary research teams that approach their investigations from a One Health perspective to help manage problems at their source rather than their outcome, and that focus on community involvement and promote health and well-being for people, animals and the environment. COHR's educational programs include a Master's degree and online EdX course, and the organization offers an outreach program that provides preventive veterinary care to animal owners in the remote Yukon-Kuskokwim Delta.

Biomedical research in Alaska is spearheaded by the NIH INBRE (National Institutes of Health IDeA Network of Biomedical Research Excellence) program, which is administering a 5-year award built around a One Health framework. Current research topics include COVID-19 transmission; cancer vaccines prevention and control; mercury and selenium contamination; and behavioral topics including diet, suicide, and reproductive health. The NIH-funded Biomedical Learning and Student Training (BLaST) program at UAF and UAS (as well as out-of-state tribal college partners) trains diverse students for biomedical research careers and also conducts research along themes of

biomedicine, subsistence, and One Health; the program was recently refunded for 5 years. UAF's NIH-funded Bioinformatics Core provides computational services to UA life science researchers.

Alaska has a critical lack of homegrown health care workers, which is it seeking to address through continuing expansion of the UAA College of Health. The college has received recent funding support from numerous public and private sources, including direct state support in 2021-22 to increase capacity to train registered nurses, and state support in 2022-23 to hire more health faculty, purchase health program equipment, bolster regional health education centers, and support clinical students. While Alaska has no medical school, UAA has expanded partnerships to enable students to complete half of their physician's training in Alaska through the UAA WWAMI School of Medical Education, and an entire Doctor of Pharmacy degree in Alaska through Idaho State University. Similarly, UAF has established a joint veterinary medicine program with Colorado State University that enables UAF students to receive their Doctor of Veterinary Medicine degree after two years at each campus.

Major players in Native and rural health are the Alaska Center for Rural Health and Health Workforce at UAA and the Center for Alaska Native Health Research (CANHR) at UAF. CANHR conducts research into Native nutrition and obesity, genetics, environmental contaminants, behavioral issues, and other topics. The Alaska Native Tribal Health Consortium (ANTHC) conducts research into Indigenous health concerns and is a partner with Alaska INBRE, as is a fellow Native health nonprofit, the Southcentral Foundation. A recent private grant to UAA and ANTHC will bolster a Recruitment and Retention of Alaska Natives into Nursing program, principally at UAA community campuses. The State of Alaska has taken steps to boost telehealth availability in rural Alaska through streamlining regulations. A UAF research site is one of 12 sites nationwide in the Atmospheric Science and Chemistry Measurement Network, a \$12 million multistate project to determine the content of airborne particulate matter. The state Department of Environmental Conservation sponsors the Alaska Water and Sewer Challenge, which organizes teams to brainstorm and build innovative rural sewage treatment systems.

The UAA Justice Center engages in research on violence and substance abuse. The statewide Alaska Network on Domestic Violence and Sexual Assault evaluates and tests innovative practices, and suicide prevention efforts are stewarded by a state panel, the Alaska Suicide Prevention Council. A state virology lab at UAF has greatly increased the state's capacity to track viruses and disease vectors.

### Examples of UAA Health Research Efforts



Figure SEQ Figure \\* ARABIC 9- Phlebotomy  
Lab - JRE-0286 UAA Photo Bank - James Evans

- The **Institute for Circumpolar Health Studies** researches health problems throughout the world's northern regions, including current studies of medical and mental health impacts of wildfires; local and traditional foods; prenatal health; and sexual health.
- The **Center for Behavioral Health Research and Services** is undertaking studies related to alcohol harm prevention, cancer education, COVID, health and wellness and suicide prevention.
- The **Alaska Center for Rural Health and Health Workforce** helps to strengthen systems to deliver comprehensive and culturally relevant health care to rural Alaskans.
- The **Center for Human Development** conducts research, education and service in the field of developmental disabilities.

## Research Arena 7: Transport, Communications and Information

*Introduction.* Alaska has less transport and communication infrastructure than any other state. The state has potential for pioneering approaches to land and sea transport, aviation, aerospace, and information technology. In addition, improved telecommunications through the Arctic would place Alaska at the crossroads of global telecommunications, data, and financial networks and position the state for economic growth and new technology industries.

*Research Initiatives. Shipping.* Alaska is heavily involved in addressing safety, environmental and security concerns engendered by increased Arctic shipping. One research focus is feasibility studies of expanded shipping and related construction of ports and infrastructure. Other shipping S&T includes engineering studies to improve port design and operations and integration of marine transportation into intermodal systems. Researching global supply chain logistics to decrease the amount of perishables spoiled or damaged en route to communities is an increasing need for Alaskans.

**Land Transport.** Areas for development include intermodal operations, maintenance methods, construction techniques, engines and fuels for extreme weather, improvement of road traction in snow and ice, and engineering practices to reduce road maintenance and improve longevity.

**Aviation.** Alaska's remote areas with minimal surface infrastructure, varied terrain, severe weather, mix of aircraft, low density of air traffic, contained airspace, and areas of minimal flight restrictions make the state ideal for development of both civilian and military aviation S&T. Research supports Alaska's domestic aviation needs by providing safer and more efficient technology, and can also identify ways to better export goods and services to global customers. Alaska is also a center for UAS research (see Arena 5.)

**Aerospace.** Aerospace S&T initiatives in Alaska include the launch of sounding rockets for auroral and atmospheric research, a low earth-orbit launch complex at Kodiak, and study of the physical and electrical properties of the ionosphere. Alaska's sophisticated radars and other ground- and satellite-support instrumentation, the research capabilities of UAF's Geophysical Institute, and the state's geographic advantage for accessing polar satellites afford it considerable potential for expanded aerospace S&T research.

**Telecommunications and Information Technology.** An important state telecommunications priority is increasing broadband connectivity to support the data and computer operations of NASA, the Department of Defense, NOAA, and the university, as well as other state and federal agencies. Furthermore, improving broadband service in rural areas will enable better remote delivery of healthcare, education, and governmental services, and it will provide better personal Internet service in rural communities to help combat the "digital divide." Another advantage of increased connectivity will be improved long-term environmental monitoring.

Thus, scalable networks taking advantage of microwave, optical fiber cable, and satellite technologies will offer a variety of new opportunities. An important technology in this context is low-earth orbiting (LEO) communication satellites, which can enable a wide range of data speeds in unpopulated areas. This technology can be improved by research aimed at solving problems of space debris, light pollution, and satellite-to-satellite radio interference. Also important will be research aimed at techniques for laying optical fiber cable over permafrost soil, through river crossings, and in riverbeds.

## **Strategies**

Alaska's priorities for the Arctic entail promoting economic and resource development, including facilitating new port systems and improving marine infrastructure to strengthen Alaska's capacity to respond to marine accidents and emergencies. UAA operates the Department of Homeland Security-funded Arctic Domain Awareness Center, which works with more than 50 partners to conduct research in maritime domain awareness, situational awareness and response support, technology research, and integrated education. Alaska has funded Arctic vessel tracking system upgrades, digital mapping, and an Arctic deep-water port study, which contributed to plans to build a deep-water port in Nome.

UAF has evolved its transportation-focused research center, the Alaska University Transportation Center, into a broader Arctic Infrastructure Development Center (AIDC). The new center includes a continued focus on building northern roads, bridges and airports, and now also incorporates other elements of cold-region engineering. Those include the effect of thawing permafrost on communities and city services, techniques to address climate change impacts, and building design. Several existing UAF laboratories work on AIDC research, including labs at UAF's Institute of Northern Engineering that test frozen soils, study traffic and safety, advance the design of asphalt and other materials, and test building technology. The state is also implementing the Arctic Slope Transportation and Resources project, a collaborative effort initiated by the state Department of Natural Resources to collaborate with stakeholders in the North Slope to guide the development of future infrastructure projects, to identify material sites critical to resource development, and to provide access to areas that may require remediation from previous exploration activities.

UA was central to developing the revolutionary NextGen air traffic control system and is one of four founding FAA Centers of Excellence for General Aviation. Sounding rocket and UAS testing takes place at UAF's Poker Flat Research Range. UAF operates the High-Frequency Active Auroral Research Program, a former Air Force operation used to study the ionosphere. The Alaska Aerospace Corporation operates the Pacific Spaceport Complex-Alaska, a state-of-the-industry launch site on Kodiak Island, that provides access to planetary orbital space for commercial and government interests. The facility has built two new launch pads since 2018, developed to accommodate the emerging commercial small launch vehicle market. Their main customer is Astra, one of only four commercial launch companies (along with SpaceX, Rocket Lab, and Virgin Orbit) to have achieved

orbit using a privately-owned rocket, which has staged five launches at the facility.

Alaska Governor Mike Dunleavy established a Governor's Task Force on Broadband in 2021, which issued a final report in December 2021. The panel identified communities most in need of upgraded or new infrastructure, recommended a buildout plan for bringing high-speed broadband to all Alaskans, evaluated broadband technologies, identified hurdles to deployment, and provided recommendations for state participation and funding. As a result, the Alaska Legislature established a State Office of Broadband as well as a Statewide Broadband Advisory Board to implement recommendations in the report. Legislators also created a fund to support broadband parity across Alaskan communities.

A major recent expansion of broadband has come via Terra, a federally-supported project by General Communications Inc. that linked about 45,000 residents in 80 rural communities in western Alaska. Multiple firms have announced plans for undersea cable networks linking Asia and Europe via the Arctic and offering access to remote communities along the way, the most recent being a collaborative between Finnish telecom company Cinia, Alaska-based Far North Digital, and Canada's True North Global Networks LP.

Alaska Tribal Spectrum, a nonprofit representing 104 Alaska Native Tribes, plans to create a statewide Alaska Tribal Network to include tribally-owned, last-mile village infrastructure that can connect with existing high-speed satellite service to deliver broadband and cell service to unserved and underserved rural Alaskans. Their efforts take advantage of a 2021 FCC offering of free broadband licenses to tribal entities; also taking advantage of the opportunity was the Tlingit and Haida Central Council, which has announced plans to bring broadband to the communities of Wrangell and Sitka.

## Education

*Introduction.* The most significant way for the state of Alaska to contribute to S&T innovation is through ensuring quality K-12 and university educations, especially in science, technology, engineering and math (STEM) fields. The contributions of engineers, scientists, and other STEM workers are critical to the state, as they solve pressing problems and bolster the economy.

*Research Initiatives. K-12 Education.* Alaska's biggest educational challenge is K-12 teacher retention, especially in rural areas. At issue is not just retention in general, but the need for teachers with expertise in given areas, such as math, science and special education. A closely related issue is professional certification for teacher aides, and methods to transition these aides, who are often the most stable element in their schools, into teaching.

**Distance Delivery.** Distance delivery of education is essential in Alaska, both because of its size and dispersed population, and because of the need for students to accommodate other endeavors while learning, such as subsistence activities and jobs. Challenges for distance delivery include communications systems, teaching methods, faculty proficiency, integration of distance and traditional programs, and cultural relevance and acceptability.

**STEM.** Guiding students into STEM careers begins at the K-12 level. Many different state, university and private programs work to increase STEM awareness in Alaska through a variety of methods, including incorporating STEM research into instruction and increasing STEM identity among students. (See boxes, below.)

**University of Alaska.** About 75 percent of STEM workers need a bachelor's or graduate degree for their positions, compared to only 20 percent of non-STEM workers. The UA, with around 25,000 students statewide, is crucially important to the state as a STEM teaching institution. The UA in recent years has concentrated on training Alaskans for high-demand jobs in engineering, health, biomedicine, teaching and workforce development, which strongly correlate to STEM fields.

UA awards about 50 doctorates per year, of which more than half are in STEM disciplines. Students themselves are also key conductors of research at the UA. One goal for the state is to improve the enrollment and retention of disadvantaged (i.e. minority, low-income or first-generation) students in STEM majors. Another state goal is to gauge the success of specific programs at the UA, such as the Alaska Native Science and Engineering Program, the Alaska Summer Research Academy, the Rural Alaska Honors Institute, the Della Keats Health Sciences Summer Program, the Alaska Upward Bound Program, and the federally-supported TRIO programs, and work to optimize their impact on STEM students and others.

### Examples of Alaska STEM education efforts



- The **Alaska Native Science and Engineering Program** at UAA (with UAF and UAS units as well) supports Alaska Native students from sixth grade through graduate school, including academics, academic support, professional development, and financial aid.
- The **Rural Alaska Honors Institute** brings high school seniors from rural Alaska to the UAF campus for six weeks of summer classes to expose them to collegiate life.
- **GeoFORCE Alaska** at UAF excites high-school students about Earth science through a series of events culminating in annual weeklong field trips to sites across the country.
- The **Center for Alaskan Coastal Studies** in Homer offers opportunities to connect with the outdoors through tours, overnights, and educational and school programs.
- The **Sitka Sound Science Center** increases understanding of Alaskan terrestrial and aquatic ecosystems through education and outreach, including academic residencies.
- **Inspiring Girls Expeditions** takes high school girls on extended backcountry trips to increase their confidence, STEM identification and knowledge. EPSCoR offers Inspiring Girls programs in Kachemak Bay and Interior Alaska and plans to offer them in Kenai Fjords.
- The **T3 Alliance** excites high school students about STEM through afterschool programs incorporating computer programming, drones, and 3-D printing.
- NASA's **Challenger Learning Center of Alaska** provides space science-oriented camps, custom programs and workshops to K-8 students.
- The UAF-based **Alaska Summer Research Academy** offers 2-week STEM learning academies for middle- and high-school students and a year-round Saturday program.

### Strategies

In 2020, Alaska Governor Mike Dunleavy formed a Teacher Retention and Recruitment Working Group, which identified six essential areas to address to improve retention and recruitment: strengthening working conditions; developing leadership; restructuring retirement options; enhancing recruitment efforts and opportunities; creating paraprofessional pathways; and streamlining certification and recertification. The group generated a number of practical, professional and policy recommendations to address the underlying issues, and began implementation in 2022.

The UAF School of Education's SILKAT (Sustaining Indigenous Local Knowledge Arts and Teaching) project addresses rural Alaska teacher recruitment and retention by supporting the recruitment of local teachers and providing preservice and early career teachers with training in

teaching through arts and culture. Through the program, which was recently renewed for three years, the UAF School of Education has partnered with the Bering Strait School District to help paraprofessionals in the district work toward teaching licenses, and to collaboratively design professional development opportunities for early-career teachers. A major outcome from these efforts has been the development of core practices for culturally responsive teaching and arts and culture units for grades K-12. The new three-year award will also increase support for the Alaska Indigenous Teacher Corps, which was started in 2018 using a cohort model to support Alaska Native students pursuing teaching degrees from high school through to degree completion. The School of Education will additionally form an Alaskan Indigenous Teacher Network working to support Indigenous educational leaders and facilitate post-graduation community building and professional development. The School of Education also provides stipends for interns demonstrating financial need and is engaged in collaboration with school districts and government entities to establish sustainable funding support for teacher candidates.

At the state level, improving teacher retention is the main goal of the Alaska Statewide Mentor Project, which mentors instructors and administrators in 70 percent of Alaska's public schools. Other recent education innovations by the state include Alaska Performance Scholarships and UA Scholars awards for high-performing students (as well as needs-based Alaska Education Grants) to attend in-state college or training, and rigorous new K-12 academic standards. The state recently made structural changes to its budget process to secure stable future funding for the Alaska Performance Scholarship, Alaska Education Grants and students in the Alaska's WWAMI interstate education compact. The Alaska Commission on Postsecondary Education spearheads an Alaska Postsecondary Access and Completion Network, which aims to increase the percentage of Alaska's adult population with a postsecondary credential and/or degree to 65 percent by 2025 through synergy among service providers, professional development, public outreach, and research.

Educator training at the UA is overseen by a recently-created statewide Alaska College of Education Consortium, the goals of which are to coordinate and strengthen the educational programs at all three major UA universities and to increase the number of UA-educated teachers in Alaska, with unique programs made available at each university in order to strengthen cooperation throughout the UA system. One of the first acts of the Consortium was to create a web portal to help potential students easily access the full scope of teacher education programs available across the system.

In terms of remote learning, UAF's extensive eCampus program offers dozens of online degrees at the Associate's, Bachelor's, and Master's levels, as well as certificates, endorsements, and hundreds of individual classes at the college and high school levels. Alaska's Learning Network offers a number of remote core courses across the state's school districts.

Recent state investments in UA science infrastructure include engineering buildings at UAA and UAF, health and integrated sciences buildings at UAA, the Murie Life Sciences Facility at UAF, and a NOAA-UAF fisheries facility in Juneau. The 2022-23 state budget also included funds to modernize the UA's student information technology system. UA operates the Delta Mine Training Center, a world-class training and research center that features an underground mine, rock and gravel quarries, an equipment fleet, and modern mining and construction machinery.

UA also improves infrastructure through collaborating with federal programs: the current Alaska NSF EPSCoR award includes STEM education programs and funding for five new faculty hires, and EPSCoR's 2023-2028 proposal includes four more hires; both also fund multiple postdocs and graduate and undergraduate students. The proposed EPSCoR program also includes research into art-science integration, place-based inquiry, and intentional practices in broadening participation, proven ways to promote interest in STEM among diverse learners and the general public. The NIH BLaST program offers funding opportunities and programs for undergraduate and graduate UA students in biomedical fields, with a focus on rural Alaskans.

## Building an Entrepreneurial Culture in Alaska

Improving Alaska's S&T landscape requires cooperation between leaders in government, academia, research groups, business, and organizations. Perhaps the most important way state and local agencies can foster increased S&T development is to provide entrepreneurs with support to cross the "valley of death," the challenging step between developing a product and actually producing and marketing it. This support can take the form of instruction and business connections, or the more direct form of venture capital. Several programs already exist in Alaska that provide financial support and other services to inventors hoping to establish a market for their innovations.

At UAA, the Business Enterprise Institute links economic development programs across the UA system. These include the Alaska Technology Research and Development Center (TREND), which provides workshops, one-on-one counseling, and grant assistance to small businesses attempting to secure federal Small Business Innovation Research and Small Business Technology Transfer grants, which can be used to bring technology to market. The UAA Office of Research and Graduate Studies has formed a commercialization infrastructure that includes the Seawolf Venture Fund, LP, a for-profit private equity fund which provides early-stage funding for start-up companies based on research from UAA and the community, as well as Seawolf Holdings to oversee the fund. More recently, a charitable gift was used to found the Seawolf Investment Fund, which is managed through recommendations by UAA undergraduate business students. Also in Anchorage, the Municipality of Anchorage's 49th State Angel Fund provides capital to local entrepreneurs to spur economic development.

The UAF Office of Intellectual Property and Commercialization works with UAF faculty, staff and student inventors to guide them through the process of intellectual property licensing and protection. It also works with industry partners interested in sponsoring research, licensing technology, or forming startups around UAF innovations. A partner organization, the Nanook Innovation Corporation, is responsible for licensing UAF intellectual property, and owns a majority share of Nanook Tech Ventures, Inc., a for-profit corporation that works with UAF faculty, staff, and students to create startup companies and viable businesses based on their research. Recent startups have focused on treating contaminated wastewater and on molecular drug development.

Also located at UAF is the Alaska Center for Innovation, Commercialization, and Entrepreneurship (Center ICE), which seeks to foster an innovative academic environment and to provide early-stage entrepreneurs with funding and training opportunities. One recent Center ICE success story is the licensing of a kelp site assessment toolkit to a California company. The toolkit, developed by a UAF scientist with a Center ICE grant, is designed to make mariculture farming easier and less expensive by enabling mariculture farmers around the country to more efficiently select farming sites.

Center ICE runs an Innovation Accelerator to support the development of academic research into real-world solutions. Center ICE also offers a “Students2Startups” experiential learning internship program as well as training programs for customer discovery and early-stage ideation. UAF also houses the Alaska Blue Economy Center, which serves as a resource and support center for research, instruction, and outreach related to Alaska's vast aquatic resources and ecosystems.

The Alaska Marketplace is an annual competition sponsored by the Alaska Federation of Natives to identify innovations with the potential to create jobs and to stimulate state and local economies. Winners receive substantial grant funding, as well as entrepreneurial training to refine their concepts. The UAF School of Management hosts an annual Arctic Innovation Competition with similar aims. Alaska Startup Week is an annual statewide event that highlights entrepreneurship activities, including a Startup Weekend in which teams of community members and students of all levels conceptualize and market a new business over a 54-hour period.

The Southeast Conference, the regional economic development organization for Southeast Alaska, was recently awarded \$49 million to fund the Alaska Mariculture Cluster, which will catalyze a sustainable mariculture industry in Alaska. Funding will support a collection of complementary projects designed across the value chain and in partnership with the Sealaska Alaska Native Corporation, a for-profit Alaska Native Corporation. Projects include equipment and technology for seed supply, processing, and regulatory testing, a revolving loan fund to support business expansion, workforce development efforts with the region's tribes, and R&D funding.

Also worth noting is the Alaska Higher Education Income Tax Credit, which encourages private industry to support university research and education by tying donations to tax credits. A similar credit exists for K-12 education as well.

## Appendix: Acronyms

ACEP	Alaska Center for Energy and Power
ACUASI	Alaska Center for Unmanned Aircraft Systems Integration
AEA	Alaska Energy Authority
AIDC	Arctic Infrastructure Development Center
ANSI	Alaska Native Success Initiative
ANTHC	Alaska Native Tribal Health Center
BLaST	Biomedical Learning and Student Training
CANHR	Center for Alaska Native Health Research
COHR	College of One Health Research
EPSCoR	Established Program to Stimulate Competitive Research
FAA	Federal Aviation Administration
FEW	Food, Energy and Water
GINA	Geographic Information Network of Alaska
GIS	Geographic Information Systems
ICE	Innovation, Commercialization, and Entrepreneurship
ISER	Institute for Social and Economic Research
LiDAR	Light Detection and Ranging
LTER	Long-Term Ecological Research
K-12	Kindergarten through 12th Grade
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
INBRE	IDeA Network of Biomedical Research Excellence
NOAA	National Oceanic and Atmospheric Administration

NSF	National Science Foundation
R&D	Research and Development
R/V	Research Vessel
S&T	Science and Technology
SCoR	Alaska State Committee for Research
SILKAT	Sustaining Indigenous Local Knowledge Arts and Teaching
STEM	Science, Technology, Engineering and Math
TREND	Technology Research and Development Center
UA	University of Alaska
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
UAS	University of Alaska Southeast
UAS	Unmanned Aerial Systems
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WERC	Water and Environmental Research Center
WWAMI	Washington, Wyoming, Alaska, Montana and Idaho