COVER PAGE

Project Title: FireAID: An Undergraduate Research Training Program to Develop Technologies to Fight Wildland Fire with Artificial Intelligence and Deep-Learning in Alaska	
Federal Award Identification Number: DE-SC0025715	
Agency Code: 8900	**Organization:** Office of Advanced Scientific Computing Research
Recipient Award Identification Number: DE-SC0025715	**Project Period:** 12/01/2024 - 11/30/2028
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Report Term: Once per Budget Period	**Submission Date and Time:** 09/01/2025 06:30 AM ET
Principal Investigator Information: Arghya K Das	**Recipient Organization:** University of Alaska Fairbanks PO BOX 757880 Fairbanks, AK 99775-7880 Country: USA **UEI:** FDLEQSJ8FF63

ACCOMPLISHMENTS

Research goal
1) Identifying high-risk fire zones with precision
2) Detecting changes in microbial community compositions
Research-traineeship goal:
1) Maximize the reach of our training to Alaska's next-gen innovators by recruiting undergraduate trainees from universities across Alaska
2) Build commitment towards addressing Alaska-specific challenges by designing a one year long training program that cultivates a value system among trainees focused on addressing Alaska-specific challenges.
Accomplishment towards research goal
a) Technical approach

- Overview: Develop an AI-powered unified framework to analyze wildfire of a particular area of Alaska utilizing multimodal data including historic fire records, satellite data, weather data, drone footage, Lidar data and metagenomic data.
- Activity #1 Identify the areas for analysis
- Activity #2: Collect and archive multimodal data including historic fire records and satellite and metagenomic data
- Activity #3: Develop wildfire risk index with key ignition and spread metrics

b) Progress towards major activities towards research-goal

- Progress towards activity #1: Identify the areas for analysis
  - We selected the areas for which all types of major types of data that is satellite data , weather data, and soil metagenomic samples are available or can be collected.
  - We have identified **Lost Horse Creek fire, Himalayan Fire, Bonanza Creek Fire** for which we have access to all satellite data, weather data, and metagenomic data.
  - For the first year, we focused on Lost Horse Creek site for which we have all types of data available.
- Progress towards activity #2: collect and archive data
  - Allocate storage and computational resources to archive and analyze the data
    - UAF HPC system admin group a.k.a. Research Computing System (RCS) group has allocated 15 TB of storage for this research on UAF Chinook HPC. More storage is available based on needs.
    - At UAF Chinook HPC, we have access to modern Nvidia GPUs (Forty L40 and Eight H100) which are sufficient for the analysis
    - Access ALCF resource for more storage and computation
      - As a pilot, we sent an undergraduate trainee to ALCF Introduction to HPC Bootcamp hosted on Aug 10 - 15. The travel was supported by ANL. That trainee will be working as a peer-mentor for ALCF resource
      - We decided to use Director's Discretionary award pathway for the first year which gives us access to major resources that are sufficient for the first year
  - Research over Internet and build partnership to collect wildfire data
    - Historic fire records: Collected from Alaska large fire database (https://www.frames.gov/catalog/10465). It has fire records from 1939.
    - Satellite data: PI Panda has access to Sentinel 1 data from Alaska Satellite Facility (ASF) and VIIRS satellite data from Alaska Geographical Information Network Association GINA.
    - Metagenomic data: PI Muscarella has collected soil samples from the identified locations of Alaska (Lost Horse Creek fire, Himalayan Fire, Bonanza Creek Fire).
      - Lost Horse Creek soil sample has been sequenced and the metagenomic data is available with us. This will be utilized for first year training
      - PI Muscarella negotiated with multiple companies for generating high quality metagenomic

sequencing for other areas. We got competitive pricing from SeqCoast.

- Sequencing with third party (like SeqCoast) can be significantly time consuming. PI Das has an Oxford Nanopore sequencing machine avaiable at his lab. Although this instrument has quality constraint, it will mitigate the risk.

- Other data sources to enhance the quality of research
  - We went beyond our commitment of focusing on only satellite and metagenomic data and built multiple other partnerships to collect different types of data to improve our proposed fire risk index. Examples are as follows:
    - LiDAR Data: PI Das Collected LiDAR data near Fairbanks area from Fairbanks North Star Borough (FNSB).
    - Weather data: Collected data from 30 major weather stations covering most parts of Alaska
    - Aerial video footage: Not yet collected. PI Das made connection with Alaska Venture Fund who has access to helicopter video footage of rescue missions.

- Progress towards activity #3: Develop wildfire risk index
  - This project aims to develop a wildfire risk index by integrating multiple data sources. We have analyzed Alaska Large Fire Database (available at frames.gov) to identify major wildfire predictors. Our analysis reveals vegetation (mainly the spruce) and some weather parameters (temperature and relative humidity) as the major predictor for the wildfire.
  - We have also developed AI powered image processing techniques to identify and track wildfire and smoke accurately in a video and generated some key spread metrics including the spread-direction and speed. We are currently exploring how to utilize it better on a sequence of satellite images.
  - We developed Canopy Height Model for the vegetation across some areas nearby Lost Horse Creek area. We observed that the young trees are showing more vulnerability as they are growing long and narrow. This is new trend that we observed and currently validating it with the engineers at Fairbanks North Star Borough.
  - We have developed a metagenomic assembly pipeline and currently working towards building an AI-powered binning technology for identifying different microbiome species in the assembled sequence.

c) Plan for next reporting year towards accomplishing the research goal

- Integrate the biomarkers of different microbiome species and the vegetation together to generate wild fire risk map.
- Expand the research beyond Lost Horse Creek to at least one other location (e.g., Himalayan fire). We will observe the commonalities among vegetation and microbiome species in these regions. This activity will contribute towards validation and robustness of our AI-product.
- Integrate the weather component for better modeling. Our initial analysis shows that some weather parameters impact wildfire. Although we did not commit it in the original proposal, we think that would improve the quality of our research.

Accomplishment towards research-traineeship goal:
a) Technical approach

- Overview: Reach out to the major education providers at different parts of Alaska to identify and recruit the talented trainees and develop accessible, high-quality training materials and disseminate them using accessible technologies.
- Activity #1: Reach out to all the universities across University of Alaska (UA) statewide system and a few major research organizations that have access to UA students.
- Activity #2: Recruit trainees
- Activity #3: Develop training materials and learning pathway

b) Progress towards major activities towards research-traineeship goal

- Progress towards Activity #1: Reach out to all the universities across University of Alaska (UA) statewide system and a few major research organizations that have access to UA students
  - Reach out to University of Alaska Fairbanks, University of Alaska Anchorage, and University of Alaska

Southeast (at Juneau)

- Reach out to major research organizations such as Toolik Field station, Alaska Center of Innovation, Commercialization, and Entrepreneurship, Alaska Satellite Facility, Alaska Geographical Information Network Administration, among others.

- Progress towards activity #2: Recruit trainees
  - We recruited 7 undergraduate trainees. Originally, we committed 6 trainees in the proposal. We received the applications through google form and evaluated the responses based on the merits and commitment of the trainees.
  - We recruited one MS student to advance the research outcomes. We recruited one international Ph.D. student, but his F1 Visa has been rejected. So, we recruited an existing MS student in his place.
- Progress towards activity #3: Develop training materials and learning pathway
  - We worked closely with university's office of IT (a.k.a. Nanook Technology Service) to create a managed pathway for learning
  - We developed multiple training modules to train Python, HPC, Data Science, Data Engineering, and Big Data leveraging the materials from ANL as committed in our proposal.
  - We utilized Canvas to better manage the training materials. Each module made one canvas course. We post all the materials and a weekly plan for training for a seemless learning environment.
  - We meet once every week at least for an hour to help the trainees to support the trainees and engage in research dscussions.
  - We delivered a GPU-powered laptop to each trainee for this training with pre-installed Docker, Jupyter notebook, licensed version of ArcGIS, Nvidia CUDA, and other important software. The university's office of IT has configured the laptops with all the trainees.
  - All trainees got access to UAF Chinook HPC and learned how to utilize it for analyzing data at scale.

c) Plan for next reporting year towards accomplishing the research-traineeship goal

- We will reach out to UAF rural campuses (e.g., Bristol bay and TOK) to recruit and disseminate our research
- We will incrementally improve the training modules building on the research outcomes of this year

Dissemination

1. One Paper has been accepted at IEEE Conference of Artificial Intelligence, Blockchain, and Internet of Things
2. Two manuscripts has been prepared to submit to Journal of Bioinformatics and Computational Biology and IEEE Access Journal
3. One poster has been submitted to ACM International Conference on Bioinformatics and Computational Biology
4. Multiple formal and informal presentations

Mitigating the initial pause and visa rejection of the international student

- Activity #1: Institutional commitment
  - The unexpected interruption in early 2025 prompted a shift in our strategy. We engaged existing graduate students across multiple departments, generated university-wide interest through active outreach, and built a highly motivated cohort through rigorous training over the spring and the summer—contributions that went beyond our initial proposal.
    - Two TAs from UAF Computer Science is now working on this project and decided to continue working on it for their Ph.D thesis.
    - One TA from Institute of Arctic Biology worked on this project
- Activity #2: Building partnership with existing scholarship grant-programs to mitigate recruitment/workforce risk
  - We actively participated in Google Summer of Code 2025 (funded by Google, hosted by UAA) collaborating with one international student temporarily over summer
  - We have built a strong partnership with UAF Center for Innovation Commercialization and Entrepreneurship on their RISE-UP student fellowship program sponsored by Office of Naval Research to partially mitigate future funding issues.

- Activity #3: Requesting no-costextension for the training
  - We could not recruit the undergraduate students in the Spring because of the uncertainty in fund availability. We started the entire recruitment process in April after we received DOE's notice from our OGCA confirming the continuity of the grant. So, by November, the trainees will cover only half of the training. So, we would like to request a no-cost-extension for the training. We envision to complete the training by July 2026.
  - We originally opted for a start-date in August 2025 and end-date in July/Aug 2026 for our year-long training. The idea was to educate the students across Alaska over the regular academic year utilizing online mode of training. And then, arrange the in-person training at UAF and ANL in summer. This arrangement was to avoid the harsh winter for in-person activities. The program manager agreed to that also. But the award notice did not reflect that.

Links to our Google drive folders, GitHub, websites, and Canvas course modules can be shared if requested showcasing our minutes of meetings, recruitment process, course materials, source codes, etc..

PRODUCTS

The products shown below include only Publications with a 'Published' status and Intellectual Properties with a 'Granted' status. Products with other statuses are not included in this report. The Revision Type indicates whether a product is New (newly added), Updated (existing product modified), or No Change (existing product reported without modifications) during the current budget period. Note that 'Updated' statuses may appear more frequently as products progress through the publishing process. All products listed have been reported for the current project period of this award.

PUBLICATIONS

There are no publications to report.

INTELLECTUAL PROPERTIES

There are no intellectual properties to report.

PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

The table below only contains participants who have identified an affiliation with the Awardee Institution. Participants from any associated subawards may not be included in this count.

PARTICIPANTS DETAIL

Project Role	Number of People	Total Person Months Worked
Co-Investigator	7	7
Consultant	1	1
Principal Investigator/Project Director	1	1
Total Responses	**9**	**9**

PARTNERS DETAIL

Partner: Argonne National Laboratory, Lemont, IL, USA

IMPACT

- What was the impact on the development of the principal discipline(s) of the project?
  - The project is housed at Computer Science department of UAF.
    - The Department of Computer Science has had extremely limited research activity. This project provided valuable exposure to cutting-edge developments in the field.
    - This project revitalized the Ph.D. student recruitment in this department leveraging the Interdisciplinary Ph.D. program of UAF. We recruited 3 Ph.D. students after a decade-long pause.
    - This project helped the department of computer science to be recognized as a hub for interdisciplinary AI research. We enabled multiple collaborations across the university and the state of Alaska especially with those groups that are actively working towards improving Alaska's wildfire resilience. Example collaboration includes Fairbanks North Star Borough, Alaska Venture Fund, Alaska Center for Innovation Commercialization and Entrepreneurship (Center ICE), Alaska Center for Energy and Power (ACEP), Foundation Health Partner, and so on.
    - Broadly, these collaborations enabled us to compete towards multiple other grant proposals. Examples include RISE-UP entrepreneurship grant together with Alaska Center ICE sponsored by Office of Naval Research, Arctic Domain Awareness Center grant together with ACEP sponsored by Department of Homeland Security, etc.
- What was the impact on other disciplines?
  - The other departments that are involved in this project are as follows:
    - Department of Agriculture and Natural Resource
    - Geophysical Institute
    - Department of Biology and Wildlife
  - At UAF, interdisciplinary AI research is very limited. This project helped these departments to collaborate with Computer Science fostering their data analysis and accelerating AI research
  -
- What was the impact on physical, institutional, and information resources that form infrastructure?
  - Although at this project is mostly focusing on computer science and AI-powered model development for wildfire risk prediction, the result may have far reaching impact on multiple physical infrastructure including urban planning, Agriculture, tourism.
  - With the new publications and products, and newly formed collaborations, we believe that we can produce better impact in the successive years of this project.
- What was the impact on technology transfer?
  - Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use.
  - Include transfer of results to entities in government or industry, instances where the research has led to the initiation of a start-up company, and adoption of new practices.
- What was the impact on society beyond science and technology?
  - Wildfire is the most serious natural hazard across the nation. In Alaska, it's impact is inexplicably bad. Wildfire causes loss of life, destruction of property and critical infrastructure, adversely impact tourism in the national park, and destroy the state's economy. By addressing this issue through AI and advance computational methodologies, we are broadly impacting almost 700K Alaska resident's life.
- What was the impact on the development of human resources?
  - 7 undergraduate students and 4 graduate students across University of Alasks (UA) Statewide System have been supported by this project.
  - A majority of this fund is spent for student recruitment including salary, graduate tuition, and health insurance. Clearly, this project has an immense impact on development of human resource.
  - We recruited students from all universities within the UA statewide system—including UAF, UAA, and UAS—extending the impact of human resource development beyond our campus to the broader Alaska region
  - Collaborating with a student scholar through Google Summer of Code expanded the project's impact beyond national borders, reaching an international audience helping human resource development utilizing Google's fund.
- What percentage of the award's budget was spent in foreign country(ies)?
  - Zero. No money has been spent in foreign country(ies).