Backstory

A community based PFAS phytoremediation project at the former Loring Airforce Base

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The Loring Airforce Base (AFB) in Aroostook County, Maine, USA was active from 1947 through 1994. Like many military sites, it has a substantial history of pollution from a wide variety of toxins. Currently, some of the AFB land belongs to the Micmac Nation, an Indigenous tribe, who are very concerned about the contamination on the land. Starting in 2019, a group of community activists, research scientists, and tribal members came together to test methods for cleaning the land. This backstory features perspectives from six project participants.

BEGINNINGS

What are the goals of this project? How did you decide what to investigate?

Dr. Sara L. Nason (Connecticut Agricultural Experiment Station): The overall goal of our work is to improve the quality of the land on the former Loring AFB, which now belongs to the Aroostook band of the Micmac Nation. Specifically, we are testing the use of fiber hemp plants for phytoremediation of per- and polyfluoroalkyl substances (PFAS). PFAS are a class of emerging contaminants that are highly toxic at low concentrations and are frequently found on former military bases owing to their use in fire-fighting foams (Hagstrom et al., 2021). They are often called "forever chemicals," as they are highly resistant to degradation. Part of the land acquired by the Micmac people was formerly used as a firefighting testing area. The US Airforce has detected concerning levels of PFAS in groundwater at this site, but did not conduct any remediation (Baker, 2018). There are limited technologies available for removing PFAS

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A former firefighting training site at the Loring Airforce Base (2019), now the site of a collaborative phytoremediation project.

from soil (Mahinroosta and Senevirathna, 2020). Phytoremediation, although minimally tested for PFAS, is an appealing option due to low costs and the potential for community involvement. Hemp is a large, fast-growing plant that has been reported as an effective remediator for other types of contaminants (Campbell et al., 2002; Linger et al., 2002; Ahmad et al., 2016). Therefore, we set up a series of field tests to assess the potential for hemp to remove PFAS from the soil at Loring AFB. This topic is interesting to me from a research perspective and also fits the interests of community members involved and the goals of the Micmac people.

Ms. Chelli J. Stanley (Upland Grassroots): The goals are to learn if fiber hemp can clean PFAS chemicals from soil and to learn what hemp does with the chemicals—where does it store them, does hemp break them down at all—and then use that knowledge to clean polluted soil. We decided to work on PFAS because it was the chemical that best fit everyone's needs. It was within the research interests of the scientists at the Connecticut Agricultural Experiment Station (CAES) we are working with and has polluted the land that the Micmac Nation are concerned about. We discussed several options like petroleum, pesticides, asbestos and heavy metals and collectively decided to start with PFAS. Although our ultimate goals are the same, each team has different specific short-term goals. The scientists need good samples. Upland Grassroots would like to understand what fiber hemp is doing with the chemicals. People at the Aroostook Band of Micmacs want to know the levels of pollution in different places and if other wild plants are taking up PFAS.

PROXIMITY

Who are the players in this project, and how did you bring everyone together?

Mr. Richard J. Silliboy (Micmac Nation): The Aroostook band of the Micmac tribe worked for many years to gain federal recognition in 1991. We are a tribe of about 1500 people living in Aroostook county, Maine, USA. We are part of the larger Micmac Nation of northeastern North America. There are 30 Micmac reservations in 5 provinces of eastern Canada and one in the United States, which is here in Aroostook County. We received 800 acres from the United States Air Force, which included part of the Loring AFB. The part that we received was supposed to have been cleaned, but there's still a lot of ground there that I believe is contaminated. We need to study that before we can plan to use the property. To start this hemp project, Chelli contacted me and then I recruited people who would be supportive of this project, such as the Chief, and other environmentalists.

Ms. Stanley: Upland Grassroots is a grassroots organization that I helped found to find solutions to clean polluted land. I contacted Richard, who was immediately interested in being part of it, as were many others from the Aroostook Band of Micmacs. I contacted CAES after it was recommended by another scientist I

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One hemp growth plot in August 2020.

was in touch with. We've all been working well together. Both Richard and Fred Corey from the Aroostook Band of Micmacs are on the advisory board of Upland Grassroots.

Dr. Nason and Dr. Nubia Zuverza-Mena (CAES): We are research scientists at CAES, which was the first state agricultural experiment station in the United States and is one of the land grant institutions in Connecticut. We both have a background in studying plant interactions with environmental contaminants. Chelli originally contacted our colleague Dr. Jason White, who is now director of CAES, based on his publication history on phytoremediation, and he forwarded the opportunity to us. Our role unraveled as we spoke to Chelli: we would advise on hemp growth, sample handling, and shipping and then analyze plant tissues. We have expertise in the use of different analytical instruments, Sara's strength is the study of organic chemicals, whereas Nubia has more experience in the analysis of inorganic components.

SCIENCE AND COMMUNITY

Why did you decide to participate in this project? How does this project relate to your beliefs or other parts of your work?

Chief E. PeterPaul (Micmac Nation): Protecting the land is part of the Micmac beliefs. Anything we can do to contribute to making the environment better, we want to be a part of. That's what sustainability is—if you don't have anything to sustain, then we're going to be in trouble, so we need to make every effort to practice it. We want to be sovereign, and keeping our sovereignty means protecting the earth. Everything from the air quality to the water quality is impacted by the soil, so any help we can bring, we want to do that.

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Richard Silliboy (left) and Norman Barnard (right) during planting, 2020.

Mr. Silliboy: Having the earth as clean as possible is the job of all Native Americans. It is our job to take care of Mother Earth, and it is a very difficult job for all the tribes to do this because there is so much contamination that's being put into the ground. The ground is being abused in many ways by companies that dump waste all over the place. It's very concerning to tribes across the country, and it's up to Native Americans to take care of Mother Earth. That is our goal and always has been and always will be.

Ms. Stanley: I am involved because I want to push for solutions that can be passed down to the people of the future, who will definitely need them. I have a relationship with water, land, and nature, and want to repay my debt of gratitude. Doing this work is one way I can do it.

Ms. Maggie F. Blumenthal (Upland Grassroots): I decided to participate in this project because I have a huge passion for soil health as well as community and land restoration. This project has really helped me see the reality of many farmlands and spaces in the state of Maine that have been contaminated with these forever chemicals (PFAS).

Dr. Zuverza-Mena: There are not many times when scientists participate directly with a community. I had been involved in phytoremediation research, but never actually conducted field work on the topic. This was an attractive opportunity to engage in a community-based research project. I became aware of the issues with PFAS in 2018 and started studying the science behind them as well as reviewing online records of city meetings with PFAS on their agendas. I heard a specific request/demand from a resident of a PFAS-affected town asking scientists to step in, claiming that we were the ones who knew and had the equipment to do something about it. That made me feel powerless and realize that in a way she was speaking to people like me. Unfortunately, analyzing PFAS is complicated, and removing them from the environment even more so; scientists do not have all the answers.

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Dr. Nason: When Chelli reached out in early 2019, I had just accepted my job offer from CAES. I knew that PFAS was a research topic that I wanted to get into, and this seemed like an interesting and meaningful opportunity to both help the Micmac community and dive into a new research area. I went into environmental science to help protect the earth and its citizens, and this project puts those values into action. My PhD work focused on plant uptake of pharmaceutical contaminants, so it was a relatively small jump to start working on PFAS phytoremediation. Additionally, new researchers

Maggie Blumenthal watering the hemp plants, 2020.

at CAES typically start out working alone, so this was a great chance for me to have a team-based project right away.

How were the research methods tailored for working with community members?

Dr. Nason and Dr. Zuverza-Mena: Field studies are complicated, and we worked closely with Upland Grassroots to develop a plan for soil sample collection and hemp planting that could result in scientifically useful data. We have not had the opportunity to visit the field site or meet with the rest of the team in person, so we focused heavily on clear communication and straightforward organization. We talked about the importance of field blanks and controls and using only materials that are unlikely to introduce additional PFAS to the samples. We ended up using a grid pattern for sampling and limiting the field plots to 9 m squares, which has been both manageable and successful. We relied on Chelli as our contact person to ensure that the field site was managed as we planned. We all learned together for this project.

AN ONGOING STORY

What have you learned so far? Has any of your work been published?

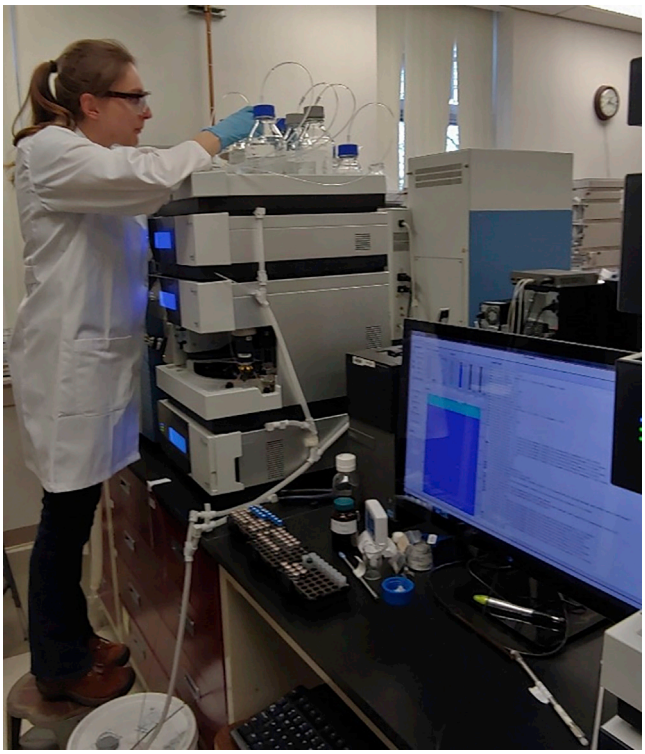
Dr. Nason: The primary contaminant at the study site is PFOS (perfluorooctane sulfonic acid), which we have found at up to 150 ppb in the soil, but many other PFAS are present as well. We have a publication out that focuses on analysis of soil from the site, where we identified over 70 total PFAS, but we also determined that that the PFAS levels at the site are highly variable (Nason et al., 2020). This variability limits the quality of our phytoremediation data, but in our 2020 field test, PFOS soil concentrations decreased in both hemp growth plots. Earlier data from 2019 showed that several PFAS were accumulated in hemp tissue, and

Chelli Stanley at the hemp plot, 2020.

that the shorter-chain compounds showed greater bioaccumulation than long chain, similar to what has been reported in other literature (Ghisi et al., 2019). These data have been presented at several conferences but have not yet been published.

Personally, this project was my introduction to research on PFAS. We began in the spring of 2019, and I learned a lot about analysis methods very quickly. Later in 2019 when Connecticut Governor Lamont established a statewide PFAS Taskforce, I was one of the only state employees with experience measuring these contaminants. I served on two taskforce committees and was able to provide helpful information about how PFAS measurements could fit in with the broader statewide plan for dealing with PFAS. I met several other scientists via the taskforce, who I now have active collaborations with. So far, we have four publications related to PFAS (Koelmel et al., 2020, Koelmel et al., 2021; Nason et al., 2020; Hagstrom et al., 2021) and two funded grant proposals, with more in progress! My work on this collaborative community project kick started all these additional activities. I am grateful to have learned so much.

Dr. Zuverza-Mena: We analyzed soil from Loring AFB for 25 elements, which included heavy metals (e.g., Ca, Cu, Fe, Ag, As, Cd, Pb, Ce, Se). We compared our measurements to reference levels reported by agencies such as the Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Registry, and the United States Geological Survey, although we would need more time and resources to fully determine if the levels of each element are of concern or not. Most concentrations were within levels typically found in natural soils, although in some instances we could not find specific guidelines of what thresholds are considered toxic. Surprisingly, As, Cd, and Ti levels were higher in our control site samples, but when compared with the soil in our Connecticut farm, the Loring soil had higher amounts of certain nutrients and heavy metals (more B, Ca, Mg, S, Ni, Co, Cr, Cu, Fe, and Zn). We shared our results with Upland Grassroots and the Micmac people, but they are not published.



Sara Nason in the laboratory, 2020.

CHALLENGES

What are some of the challenges you have faced during this project?

Ms. Stanley and Ms. Blumenthal: Lack of seasonal rain was a huge challenge during our first 2 years on this project. The EPA does not allow us to use the surface or ground water at Loring because it is so polluted. That has made it hard to scale up the project because we have to bring water to water the plants. This is a challenge to be solved for anyone doing phytoremediation because if the soil is contaminated, the water will likely be contaminated also. We are continuing to discuss creative ways to address this challenge and will continue trying various strategies.

Chief PeterPaul: The challenge I see is the possibility of not being able to do this on a scale that's large enough to make a difference. With the difficulty of funding the scientific research, that's my biggest fear, that we don't get to complete all this and don't get to see where it is going. Now that we know there's a possibility of something, I want to see what that something is.

Dr. Nason: This project hits a lot of difficult topics. Even fully professional teams have difficulty getting statistically significant results from field studies with plants, and taking PFAS samples that are fully clean is a well-known challenge. To have a complete phytoremediation study, we need more soil and plant samples to more thoroughly assess the variability at the site, as well as additional blank and control samples. It would be easier if we were able to have a scientist on site during sampling, planting, and harvesting. We had minimal funding for this work, so travel was not possible, even before the pandemic hit. The other big struggle has been with time—I am involved in many projects and it has been increasingly difficult to carve out time for this important and interesting work. More work would be feasible if we had funding to hire a laboratory assistant to help with sample analysis.

Dr. Zuverza-Mena: In this project we experienced many challenges working with PFAS field samples. PFAS are becoming ubiquitous in the environment; we struggled with obtaining site controls/blanks, which should be "clean" PFAS-free soil samples. It was challenging to coordinate remotely, particularly because

Sara and I were also learning how to handle PFAS samples. We were fortunate to be working with Chelli, who provided objective updates and knew how to follow specific procedures. At CAES I had started to work on PFAS before this project; we had the resources to make such analysis, but our instruments were not well suited to deal with PFAS, which was a limitation. It was not until Sara came on board that we started adapting our instruments, which needed to be modified specifically for PFAS analysis.

WORDS OF ADVICE AND FINAL THOUGHTS

What did you learn about collaborative community research from the project and what tips would you give to anyone considering undertaking such work?

Chief PeterPaul: I like that we get to learn. These types of projects are good for everyone who's involved. There are always positive things that come out of it like learning to work together and building trust and the infrastructure to do these types of things. We get to do a lot of things with a lot of different people, and when you do business with us, it's something that will be there forever. This is a long-term thing, and the people involved are going to be part of Micmac history.

Ms. Stanley: I think good communication is key. Keeping the communication open to make sure everyone has what they need is important. Also, everyone was an equal player, everyone's voice carried the same weight coming from its unique perspective, and because it's a diverse group it made things much deeper than they otherwise would have been.

Also, everyone was an equal player, everyone's voice carried the same weight coming from its unique perspective, and because it's a diverse group it made things much deeper than they otherwise would have been.

Ms. Blumenthal: Working on this project made me appreciate what small groups of driven people and communities are capable of and the extremely beneficial results that can come from community collaboration. Many times, researchers come into an area as outsiders; this can result in skewed data or projects that don't actually help many of the people the research might be based around. I think involving passionate community members and leaders to create projects within their own communities is the best way to have results that can help solve problems on the local level. My advice would be to always involve the community, in every step of your research project. That way you will know what is important for that community; not all are alike, and it is important to have input to make your project as impactful as possible.

Drs. Nason and Zuverza-Mena: Working on this project has encouraged us to always keep in mind the practical applications of our work and helped us to improve the way we communicate with local residents and people outside the scientific community. Our advice would be to not underestimate what can be done through community-driven projects—motivated volunteers can be incredibly effective in the field. Additionally, we emphasize the importance of having a feasible plan for personnel and budgeting for all aspects of the project. We had a great team in the field, but we have run into more problems on the laboratory analysis side of things, which has limited the results we can provide.

Any final thoughts you would like to share?

Drs. Nason and Zuverza-Mena: Working on this project has been both interesting and very rewarding. More projects like this would be feasible with more accessible funding for interstate, interdisciplinary work. We are lucky that our institution supports our involvement in a wide variety of project types. This project made us think about being responsible and accountable for our actions at a personal and professional level to avoid finding ourselves trying to revoke the consequences of our actions.

Chief PeterPaul: The application potential for this project is very exciting. It's such an amazing project to be a part of. This is just the beginning. We're in the beginning stages of learning what can be done with this land that the United States has not been wanting to deal with for one reason or another. How do we fix this problem? What other chemicals can hemp extract from the ground? Can we help make it a productive habitat again?

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