Volume 1: What's Abundant Here?

Forming: Environment as Material, Landscape, Art

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Preface
Forming is a collaborative project that investigates the use of environmental forming factors to generate novel materials and fabrication processes that have broad application in sculpture, landscape architecture, and design.

Through explorations and designed interventions, we created a series of artworks and generated protocols for leveraging geomorphic phenomena such as erosion, flooding, decontamination and more.

This project has been generously supported by the Dietrich Inchworm Grant at Hamilton College.

Forming

Vol 1: What’s Abundant Here?
Rebecca Murtaugh

Where did you begin?
I began by pursuing the material intelligence of locally harvested clay from Long Island and Central New York to investigate the environmental forming factor of erosion.

Clay #7
Central New York
Photo: the author

My work has been driven by material investigation, studio experimentation, and scientific research to answer these questions:

- How can my artistic process intertwine with this natural phenomenon?
- What is the aesthetic of soil?
- How can the unseen be revealed and engage our sense of curiosity and wonder?
- How can I leverage the transformational nature of clay which is dependent on earth, water, and fire.

Clay is abundant and all clay is soil.

Soil

- is more than a composition of inorganic clay, silt, sand, and rocks.
- carries organic matter of water, air, and living organisms.
- is imbued with a sense of history traversing place and time.

Clay #4
Long Island
Photo: the author

Clay

- is a naturally occurring material of fine-grained sediment that has been broken down through erosion and weathering.
- sediment is transported via water, wind, ice, and gravity to new locations.
- is abundant, mainly found on or near the surface of the Earth.

I began with a two-prong approach:

- How might I consider each soil to have its own visual representation?
- How might I impart a mechanical action in the studio that replicates the action of erosion?

Right:
Clay #5 Chromatogram
Central New York

1a. Soil Chomatograms
I began by making chromatograms to explore the “portrait” or “fingerprint” each local clay.

Soil chromatography creates a visual image on qualitative filter paper treated with silver nitrate using capillary action and the solvent movement of sodium hydroxide treated soil to separate the chemical, biological, and physical composition of soils. This technique aims to better understand soil health in regard to organic matter, minerals, and microbial activity. More complex chromatograms are thought to indicate healthier soils, such as images that have more channels and spikes. While not a well proven scientific method, it provides a unique and distinctive image for each soil.

1b. Clay Prints
Each clay has a distinct texture, plasticity, and color. After digging a clay I process a small amount to make a round test tile to measure these physical characteristics in addition to its shrinkage.

These prints are remnants of the process and serve as a means to leave a trace.

Clay Prints
#3, #17, #14

2. Mechanical Erosion Explorations

Erosion Exploration
detail
terra cotta
15.5” x 14.5” x 3”
2024

In my approach to imparting a process in the studio that was making the clay susceptible to erosion I was inspired by my studio surroundings. I had recently power-washed a modest deck in front of my home studio on Long Island.

I proceeded to create a number of sculptures that were formed by compressing a large amount of clay between two wood boards and placing clamps at varying tensions along three corners- imparting compaction, which is a geologic occurrence in nature. These pieces were left to dry for some time, then brought outside and power washed to create the aperture and texture that is present.

Erosion Exploration Trio
terra cotta
variable dimensions
2024

Where are you headed now?
Investigating how to best leverage materials and continue using erosion as a driving factor.

Each clay has its own distinct characteristics, notably in its plasticity and water content for it to be ideally malleable. Malleability is something I have greatly appreciated working in clay, but many harvested clays have very low plasticity, a lot of stickiness, and a short window to work as it dries especially fast. I will pursue working with harvested clays in the liquid form to determine if the process is aligned with the material intelligence of the clay.

Volume 1 References:

"Glenn Adamson — the Case for Material Intelligence." Glenn Adamson, www.glennadamson.com/work/2018/11/18/materialintelligence.

Landa, Edward R, and Christian Feller. Soil and Culture. Springer Science & Business Media, 28 Jan. 2010.

Photo Credit:
Jason Mandella for Rebecca Murtaugh's photographs that are not attributed to author.

Forming

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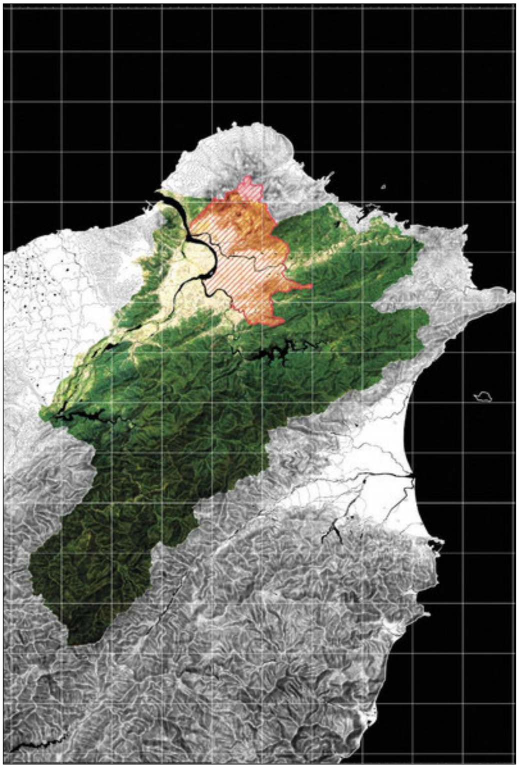
Melody Stein

Where did you begin?
I began by focusing on flood resilience in the Tamsui river basin in Taipei, Taiwan.



Above: Map of Tamsui watershed with Taipei City hatched in orange.
Source: the author

Throughout, I've approached this project with a three-pronged methodology grounded on the following activities:

- Site visits and experiential documentation
- Conversations with researchers, historians, subject-matter experts, and other stakeholders
- Archival and historical research

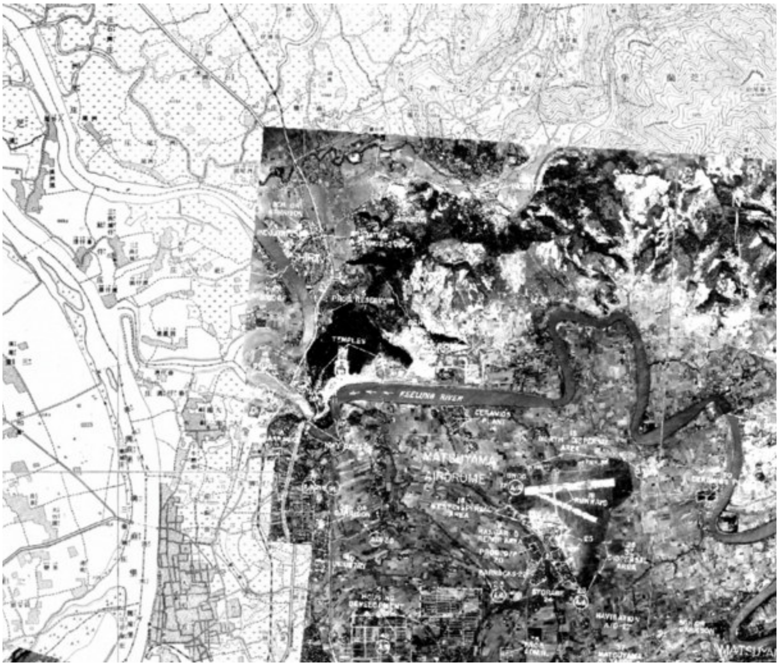
...driven by the goal to answer the following questions:

- What are the forces and who are the stakeholders involved in river flooding at the scale of the region, the site, and the material?

Below: Japanese-Occupied Taiwan Map from 1904 overlaid with US Army Aerial photographs from 1944 Source: Academia Sinica

- How has the urban and landscape development of the Taipei Basin evolved and how have these changes impacted rivers and floodplains?
- What are the hydraulic, ecological, urban, and cultural conditions that define the Taipei Basin today?

The research design is intended to generate a multitude of “leads,” or potential project ideas that can be followed and synthesized in later phases.



Two facts quickly emerged: first, that based on all geographic and ecological evidence, Taipei should flood, and second, that it almost never does.

The story of the urbanization of Taipei is the story of the production of rivers. Centuries of flood control infrastructure have harnessed and domesticated the meandering wetlands and riverine systems that once filled the basin.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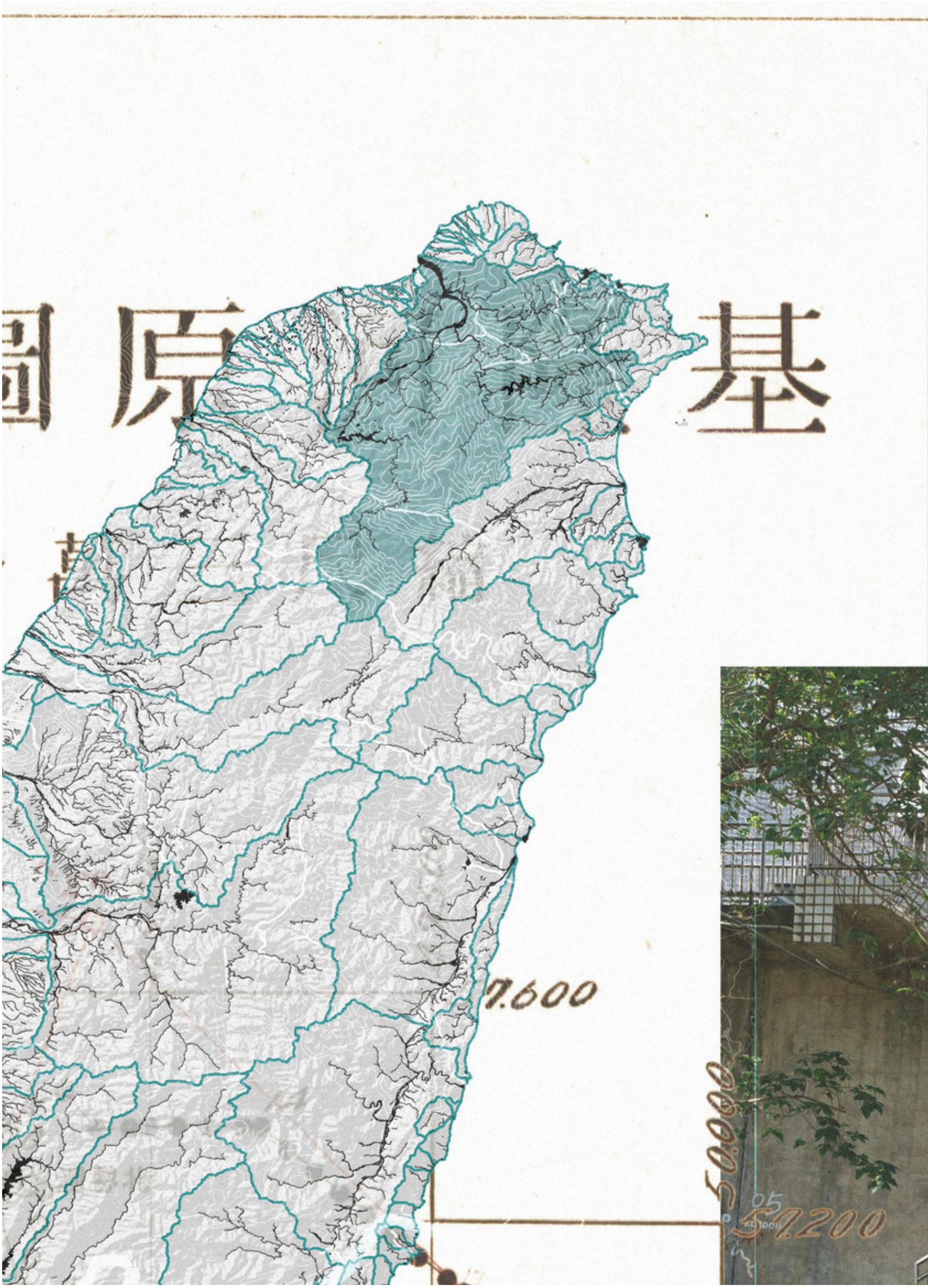
What unexpected connections formed?
Flood risk management is still an important conversation in Taipei. The impacts of climate change are calling engineered safety into question. But most agree: Taipei is a city that once but no longer floods.

I became increasingly interested in the environmental process of flooding, asking "When we get rid of flooding, what do we lose?

Below: Documentation of the Flood Control Infrastructure in the Keelung River.
Photo: the author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What is good about flooding?

...and how does it relate to soils?

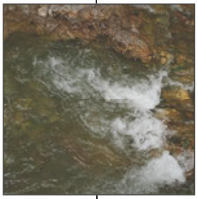
Types of Flooding:

1 - Pluvial
(rain doesn't drain fast enough--
causing bodies of water to form)

2 - Fluvial
(rain causes rivers to swell and
overtop their banks)

What does flooding do?

1 - Deposits in-river
compounds and materials
outside of the river extents



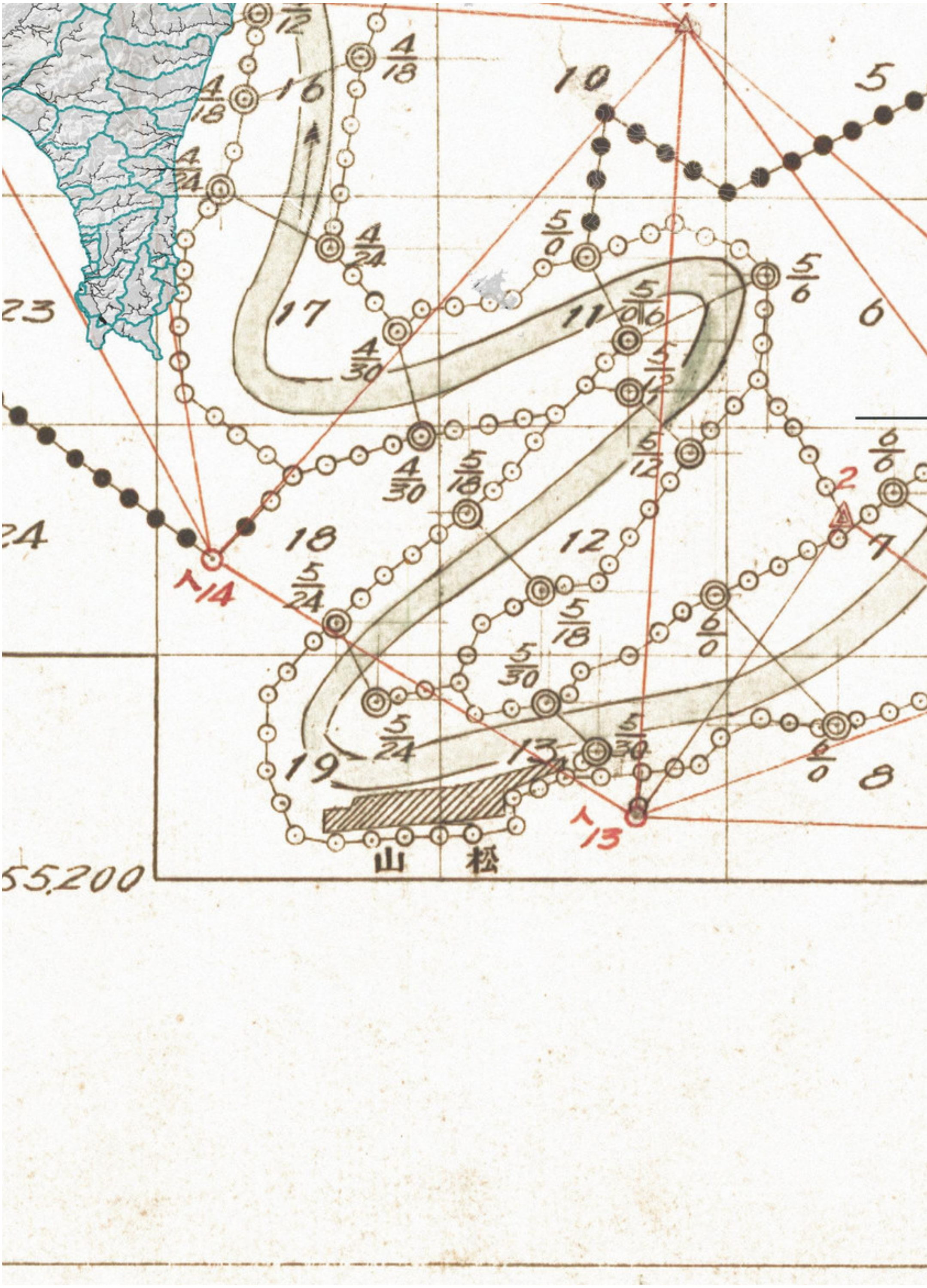
2 - Generates a floodplain

What do floodplains do?

1 - Filter water
2 - Retain more flooding
3 - Create fertile soil through alluvial deposition
4 - Shape topography through erosion and accretion
5 - Alter ecosystems / destroy constructed spaces

How can we leverage the positive affordances of flooding and floodplains?

What's possible in urban spaces?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Where are you headed now?

Floodplains have the ability to filter water

Most existing research focuses on how floodplains can be used to filter excess nutrients from agricultural runoff.

But floodplains can also filter other compounds, like pharmaceutical contamination.

Can you design a floodplain as a filter?

What do the ideal floodplains designed for the following look like?

1 - Nutrient filtering
2 - Pharmaceutical filtering
3 - Flood control

How are they different or similar?
Can a floodplain do more than one thing?

Nutrients like phosphorous and nitrogen present in commercial fertilizers can cause a nutrient overload called eutrophication that is harmful to aquatic life. Eutrophication provokes algae blooms that are then decomposed by microbes in a process that sucks oxygen out of the environment.

> Environ Sci Technol. 2020 Mar 17;54(6):3278-3287. doi: 10.1021/acs.est.9b06850. Epub 2020 Feb 27.

Effect of Floodplain Restoration on Photolytic Removal of Pharmaceuticals

Erich T Hester [1], Angela Y-C Lin [2], Christina W Tsai [3]

Affiliations + expand

PMID: 32062974 DOI: 10.1021/acs.est.9b06850

Abstract

Floodplain restoration is popular to address excess nutrients, but its ability to enhance photolysis of emerging contaminants has not been evaluated. We used the numerical model MIKE-21 to simulate photolysis reactions within the inundated surface water of restored floodplains along a mid-size river. We examined both "high" and "low" floodplain scenarios where inundation occurs 5% (storms) and 50% (baseflow) of the year, respectively. We simulated photolysis of the pharmaceuticals morphine, codeine, and methamphetamine and, for context, compared it with nitrate removal (denitrification and plant uptake). Pollutant removal due to floodplain restoration was greater for the low floodplain (e.g., 18.8% for morphine) than for the high floodplain (5.6% for morphine) due to greater water exchange relative to channel flow. The fastest- and slowest-reacting pollutants (morphine and methamphetamine, respectively) were always transport- and reaction/kinetics-limited within floodplain surface water, respectively. Yet, those with intermediate decay-rate constants switched from reaction limitation to transport limitation as the floodplain length increased, and removal leveled off at an optimum length of ~1000 m. However, as the floodplain width increased, the required floodplain length for 30% removal decreased. Optimal restored floodplain conditions for photolysis would maximize light exposure, which may differ from those for nutrients.

Pharmaceutical contamination in waterways is a significant environmental and public health concern.


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Forming

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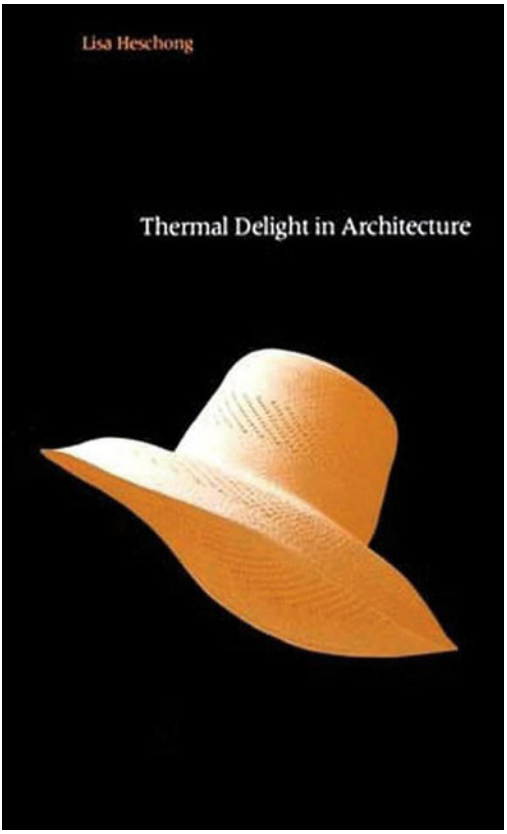
Justin Morris-Marano

Where did you begin?
I began with a handful of preliminary questions: How are soils contaminated? What's interesting about contamination? How can contamination be leveraged? What do contaminates afford? In June, I began building a project network. I think of a project network as an informal community of researchers, designers, technologists, and friends who engage with the topic I'm exploring.

June 2024
A friend in New York introduced me to Max R., a Cornell researcher at the Regenerative Architecture Lab. When Max and I jumped on a call, he spoke about his interest working with the material and sensory experience of architecture. We discussed how he thought about earthen materials and the historic and novel construction methods that leverage them. The major challenge of building with earthen materials is scale. If architectural size is a significant constraint, what other characteristics do these materials afford that

Above: Martin Rauch, Schlins, Austria, Photo:Beat Bühler Source: Architectural Association of Ireland could be applied beyond architecture? What is supposed to scale anyway? What if the tendency for soils to be on the move, to be impacted by their environment through transformative processes like weathering and erosion, could be leveraged in some way? My preliminary questions dealt with contamination in soils. Max wasn't specifically working with contaminants, rather soil, but he suggested I speak with Jonathan, another Cornell researcher who could tell me more.

Below: *Thermal Delight in Architecture,* 1979
Lisa Heschong
Source: Google Books

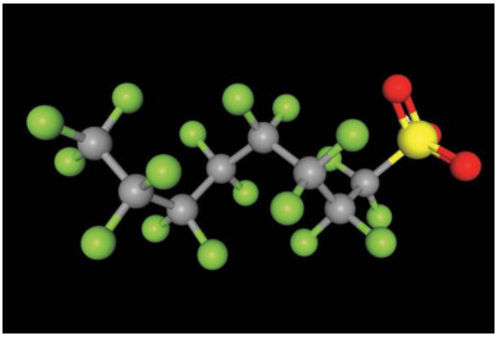


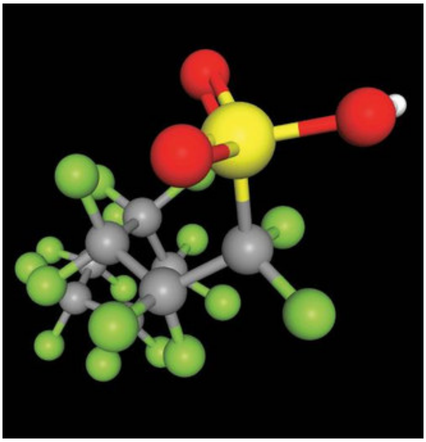
Above: Aït Ben Haddou, Morocco
Photo: Petar Miloševi
Source: Wikipedia

July 2024

Jonathan A-R called in from Cornell's College of Agriculture and Life Sciences. Jonathan's work deals more specifically with heavy metals in soil; like cadmium, chromium, lead and zinc. I explained that I was interested in leveraging contaminants in some way, and as I did, the conversation shifted toward value. Jonathan described how zinc was, of course, harmful in excess quantities, but that it was also an important micronutrient for plant life. Jonathan also explained how he had more recently been working with PFAS or per- and polyfluoroalkyl substances. These are chemical contaminants that originate in nonstick surfaces, waterproofing treatments, and packaging materials. They are increasingly prolific in soil and water and carry harmful health impacts to humans and other life forms. In contaminated soils, the goal is to remove the PFAS, discard or destroy it, and use the clean soil. In a remediative process, the soil is where the value is. Was there any process that worked in the opposite direction, where the 'contaminant' was the valuable material? Why was de-contaminating soil always focused on working against contaminates, instead of with them? What contaminated in soils afford? Jonathan mentioned an approach for extracting metal from soils, specifically Rare Earth Elements. He referred to it as phytomining.

Below:
Perfluorooctanesulfonic Acid (PFOS)
Source: National Center for Biotechnology Information





October 2024

The project network eventually led to Daniel D., who researches phytomining at Columbia's Banta Lab. When Daniel and I met uptown, he made it clear that part of the reason phytomining is so exciting is because it's practiced as a symphony of disciplines like biology, agronomy and metallurgy. Together, those knowledges form phytomining: the harvesting or 'mining' of metals from contaminated soils via plant uptake. In short, plants suck up metals from the ground and store them throughout their bodies, which are then harvested and put through an ashing process that burns off biomass and leaves behind the metal. Fundamentally, a waste-to-resource approach to contamination. Daniel's work is focused on finding more efficient and sustainable alternatives to metal extraction from the plant body. He recommended I reach out to Dr. Colleen D., an accomplished researcher and lab lead at North Carolina State University who has a holistic body of research in phytomining and vision for its future.

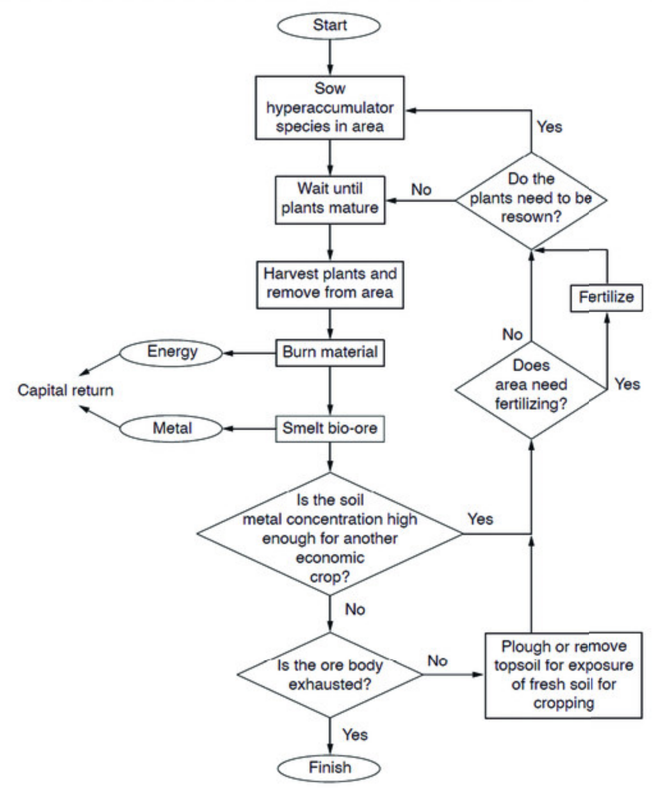


Fig. 2. Model of a possible economic phytomining system.

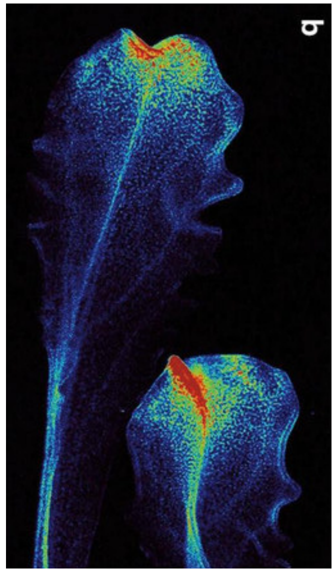
What unexpected connections have formed?
The ways in which environmental contaminants are leveraged are extremely limited. Contaminants are often approached through a lens of remediation, in which the focus is on cleaning the material that has become contaminated.

Above: Phytomining Economic System Proposal Source: Trends in Plant Science, September 1998, Vol. 3

Typically, contaminants are of low value. However, as the human-centered use-case for contaminants becomes more valuable, what were once contaminants may now be reframed as resources. The language that is applied to the harvesting of these contaminants is often an evolved biological process cloaked in a new term that points to its relative value; plant uptake becomes bioremediation for cleaning soils, or phytomining for extracting those same metals.

Where am I headed now?
Phytomining

Above: Planted field for phytomining nickel.
Source: Trends in Plant Science, September 1998, Vol. 3



Above: Trace metals in rosette leaves.
Source: Ana Mijovilovich, Plant Methods, 2020


Phytomining Workshop - Next Steps
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CHANGING WHAT'S POSSIBLE
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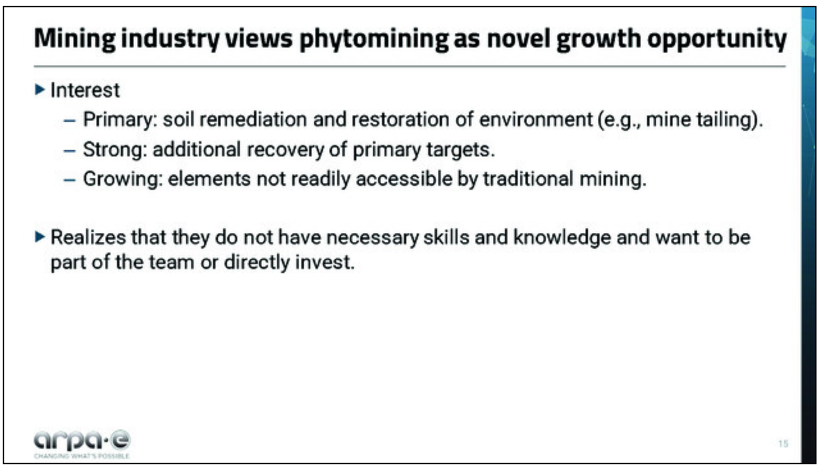
July 12, 2023
Dr. Philseok Kim
phil.kim@hq.doe.gov


Mining industry views phytomining as novel growth opportunity
▸ Interest
– Primary: soil remediation and restoration of environment (e.g., mine tailing).
– Strong: additional recovery of primary targets.
– Growing: elements not readily accessible by traditional mining.
▸ Realizes that they do not have necessary skills and knowledge and want to be part of the team or directly invest.
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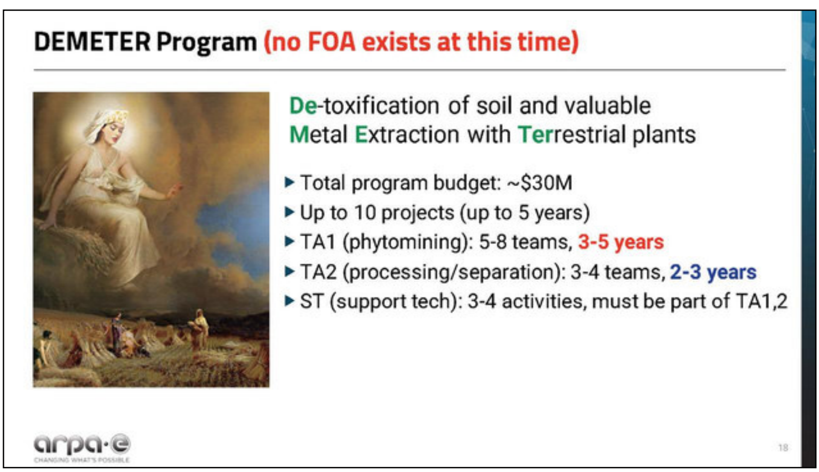
DEMETER Program (no FOA exists at this time)
De-toxification of soil and valuable
Metal Extraction with Terrestrial plants
▸ Total program budget: ~$30M
▸ Up to 10 projects (up to 5 years)
▸ TA1 (phytomining): 5-8 teams, 3-5 years
▸ TA2 (processing/separation): 3-4 teams, 2-3 years
▸ ST (support tech): 3-4 activities, must be part of TA1,2
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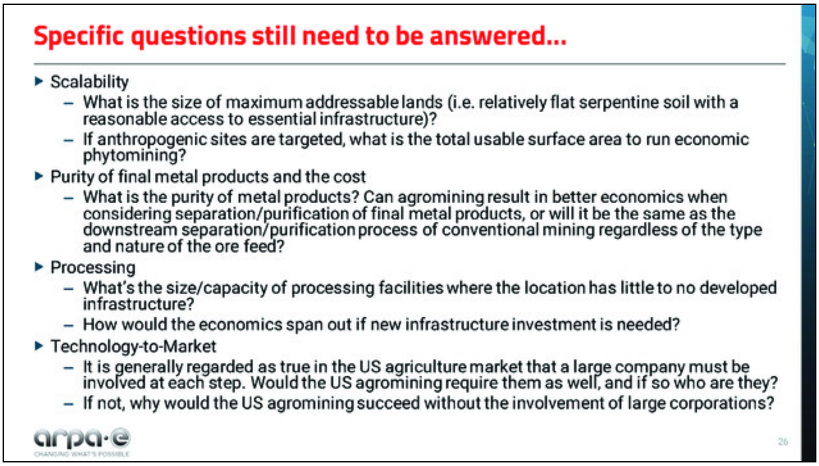

ARPA-E Phytomining
Workshop Outcomes,
Select Slides, July 2023
Source: ARPA-E

What's Abundant Here?