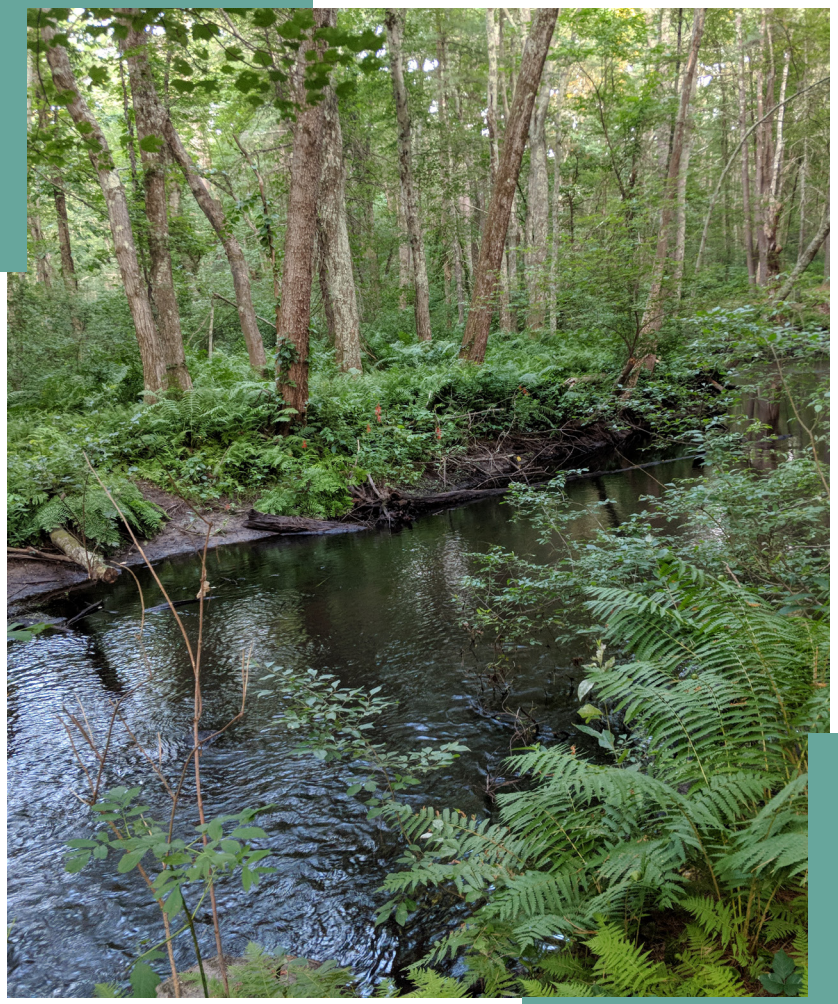
Healthy Soils Vocational Curriculum

Contract # CT-HSOILSIMPENVC142FY25



This report was written by Linnean Solutions, LLC, with Andre StrongBearHeart Gaines, Jr. and Jennifer Albertine of No Loose Braids, and Dr. Sarah Cammer of Minuteman Vocational Technical High School.

Contents

Introduction

This pilot project brought together vocational environmental science education and Indigenous stewardship perspectives to develop and implement a series of creative lessons about soil health that offered students the opportunity to engage in critical questions about land management, ecological health, and cultural histories. The project was led by Linnean Solutions with No Loose Braids (NLB) and Minuteman Vocational Technical High School working together. The goal of the project was to equip students with technical skills while deepening their understanding of land care through a relational, historical, and cultural lens rooted in local Indigenous knowledge.

The HSAP Voc-Tech Curriculum project was initially framed as an attempt to integrate Traditional Ecological Knowledge (TEK) with western soil and conservation science. The project evolved significantly over the course of the collaboration: from comparing Western and Indigenous land management practices, to examining contemporary conservation and land management practices and introducing new paradigms for working toward environmental health through indigenous wisdom. Logistical constraints led to an asynchronous planning model, and early meetings revealed the need for deeper collaboration. Rather than immediately co-developing lessons, the team shifted focus to shared learning—engaging in foundational training led by NLB on Indigenous land relationships, colonization, and the values underpinning stewardship.

This shift reoriented the project. Partners prioritized relationship-building over content creation, designing learning experiences that upheld cultural integrity and centered Indigenous leadership. Through readings (e.g., Fresh Banana Leaves), classroom discussions grounded in respectful engagement agreements, and immersive field experiences, students engaged meaningfully with both Indigenous and scientific perspectives.

Students' reflections showed evidence of perspective shifts, increased curiosity, and a more nuanced understanding of environmental responsibility. As one student shared:

"I used to think conservation meant removing people from nature. Now I understand that real stewardship comes from being in relationship with it."

The project highlighted key principles for future work: invest early in relationship-building; prepare educators through Indigenous-led training; design for mutual benefit; and create space for reflection, not just instruction. The project affirmed that TEK cannot be extracted or taught without Indigenous partnership—and that working in this way enhances both educational outcomes and ethical practice.

Looking forward, the partners see opportunities to expand this model across more classrooms and institutions. With further support, they hope to offer additional teacher training, deepen partnerships, and share tools and documentation that can guide others in pursuing culturally grounded environmental education. This pilot affirmed that when Indigenous partners, educators, and consultants collaborate with trust and humility, the result is not merely a curriculum—it is a step toward transformative, just, and reciprocal learning.

The Project Team preparing for a student field trip in the forest at the Minuteman campus.

Project Components

Project Description

This project brought together No Loose Braids (NLB), Minuteman Vocational Technical High School, and Linnean Solutions to pilot an approach to soil health education that bridges vocational environmental science training with emerging soil carbon science, building on Indigenous perspectives on land stewardship. The curriculum offered students the opportunity to engage in critical questions about land management, ecological health, and cultural histories.

The goal was to deepen students' technical and ethical understanding of soil and land through hands-on activities, historical context, and cultural frameworks that are different from an environmental science-based understanding. Students were invited to reflect on their own relationships with land while learning from Nipmuc cultural stewards and engaging directly with local ecosystems. The project team wrestled with defining "soil health" in a way that embraces soil as part of a living system, interconnected with water, plants, animals, and people. Soil health, in this framing, is about the vitality of relationships—between organisms, ecosystems, and communities—and the cultural and ethical responsibilities that come with tending to those relationships.

This collaboration was supported by a Healthy Soils Action Plan implementation grant. The project was built on prior partnerships among the three core groups. Dr. Sarah Cammer, a Minuteman environmental science faculty member, had previously worked with Linnean and NLB on soil and land health initiatives.

This project was envisioned as an experiment in cross-disciplinary and cross-cultural curriculum development. However, it quickly became clear that developing a curriculum that meaningfully integrates Indigenous knowledge systems requires not just collaboration but deep relational work, shared learning, and time. The hope is that this pilot can serve as a resource for others who may wish to bring Indigenous and Western ways of knowing into soil health education. Future efforts should adapt these lessons to their own local context, while recognizing the importance of creating time and space for building relationships, clarifying shared goals, and acknowledging what is and is not possible. In our experience, land walks were especially transformative, as was reading *Fresh Banana Leaves* together—both activities helped root this work in relational and cultural contexts.

Project Timeline

Task	Q3 - 24		Q4 - 24		Q1 - 25		Q2 - 25		Q3 - 25		Q4 - 25		Q1 - 26	
1. Establish Curriculum Design and Facilitation Team														
1.1 Recruit students and faculty														
1.2 Hold kick-off meeting to introduce members, define roles														
1.3 Draft background research and monitoring/evaluation process														
2. Conduct background research														
2.1 Conduct an assessment of student interests and needs														
2.2 Build relationships and understanding within the Project Team														
3. Develop curriculum														
3.1 Develop lesson plans, lectures, fieldwork plans, and assignments														
4. Implement curriculum and monitor progress														
4.1 Deliver curriculum														
4.2 Administer pre- and post-evaluations														
4.3 Monitor outcomes														
4.4 Reflect on process														
5. Data analysis and documentation														
5.1 Document successes, challenges, lessons learned, recommendations														
5.2 Write Resource for Implementing the Healthy Soils Voc-Tech Curriculum														

Project Components

The Project Team: Dr. Sarah Cammer (Minuteman), Sarah Saydun (Linnean), Jennifer Albertine (No Loose Braids), Andre StrongBearHeart Gaines, Jr. (No Loose Braids).

Project Partners

This project is the result of collective efforts by the Project Team and Minutemen students. The Project Team included:

No Loose Braids

No Loose Braids is a Nipmuc-led organization working to bring Eastern Woodland Tribal communities together in unity through cultural revitalization of traditional practices to revive community and culture. No Loose Braids aims to teach the original ways and create a space for Indigenous folks to step out of colonization, and the fractured ways of colonized thinking, to reconnect with ancestral knowledge, strengthen bonds of reciprocity, and bring balance back to our People and the Earth. No Loose Braids also works to build opportunities for future generations through changing structures of systemic marginalization and exclusion by advocating for Tribal rights and engaging in dialogue in colonial spaces.

Minuteman Vocational-Technical High School:

Minuteman High School is an award-winning public regional career technical education high school which integrates academic and technical learning. The school has an Environmental Technology vocational program that focuses on fundamental knowledge in ecology, aquatic ecosystems, geosciences, and atmospheric sciences through hands-on field and laboratory work. That knowledge is used to apply technology to reduce our impact on human health and the environment. Students in the Environmental Science & Technology career collaborate with environmental scientists and engineers, community and state officials, and other environmental organizations to investigate real world environmental issues. Minuteman Voc-Tech High School was the host institution and home to the pilot classroom, led by Dr. Sarah Cammer, an environmental science faculty member.

Linnean Solutions

Linnean Solutions served as the project coordinator and facilitator. Linnean is a mission-driven firm based in Cambridge, MA that works with communities, state and local governments, agencies, organizations, and project teams to create a just and regenerative future. A large portion of Linnean's work involves working with community organizations, including Indigenous organizations to develop community-driven and equity-centered climate action. Many of these projects work with state and local governments in the northeast to increase capacity for collaborative governance in a way that enables more voices to shape community decisions and create conditions for more resilient communities.

Project Components

Curriculum Materials

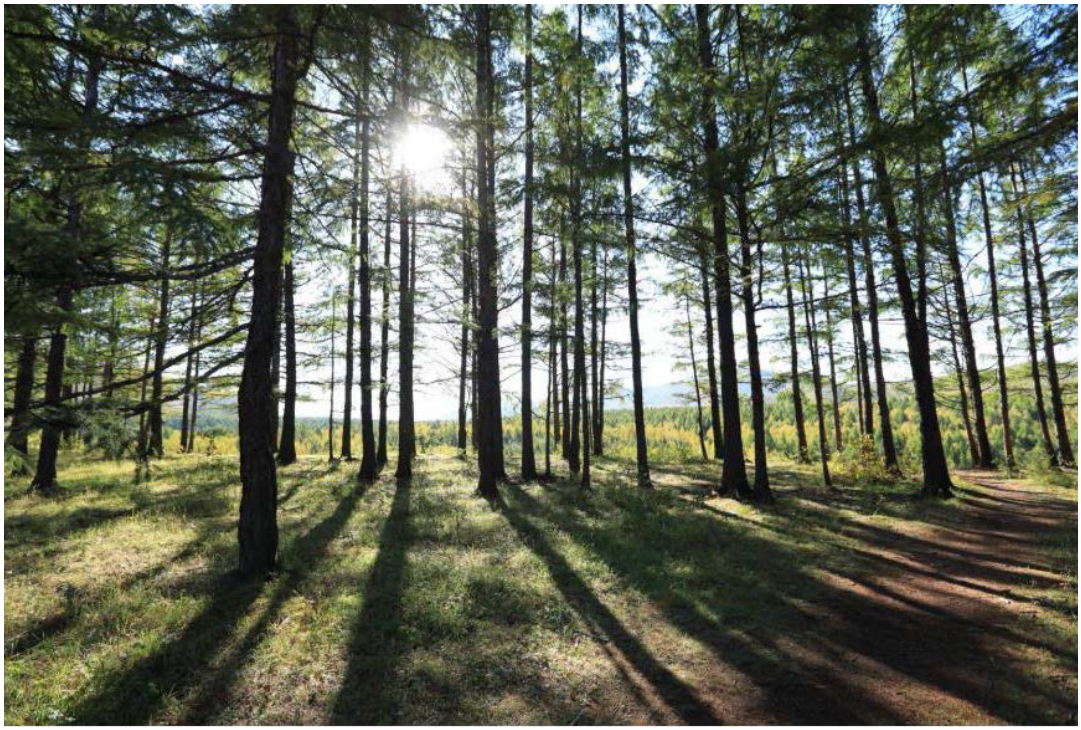
A full list of curriculum materials is included in the "Appendices" section of the report. Primary categories of materials used to build and teach the class include:

Regenerative Soil Health Resources

Soil resources were used by Dr. Cammer to supplement the soil curriculum, to provide foundational education for the project team, and to be supplemental research sources for students.

- **Healthy Soils Action Plan**: The Massachusetts Healthy Soils Action Plan is a plan to protect, restore, and better steward soils across the Commonwealth. The HSAP assesses and makes recommendations for five major land covers of the Commonwealth: Natural and Working Lands includes Forests, Wetlands, and Agriculture, while Developed Landscapes include Recreational/Ornamental and Impervious/Urbanized Lands. The project team sought to understand threats and opportunities to soil health through the three lenses of Land Conversion, Climate Change and Natural Hazards, and Soil Management, and make recommendations consistent with those findings. Additionally, because carbon content is one of the few universally agreed-upon indicators of soil health and can be assessed at a coarse scale, there are findings and recommendations that speak specifically to protecting and enhancing soil organic carbon within the five land covers.

- **Full Forest Guide**: The Nashua River Communities Resilient Lands Management Project was a two-year project supported by the Massachusetts Municipal Vulnerability Preparedness (MVP) Program working with the communities of Clinton and Bolton alongside a team of consultants to understand the potential for land use and land management policies and practices to support climate resilience and regeneration in the region over the coming decades. The tangible outcomes of this process include the guides for forest stewardship and care that you have in front of you, as well as a set of guides focused on turf and "ornamental landscapes" (e.g. parks, gardens), a set of regulatory recommendations and model bylaws that respond to the climate emergency, and a framework for ongoing community participation in decisions that affect the integrity and continued viability of our landscapes.



Forests in New England share a history of similar use patterns over thousands of years. Almost all forests in Massachusetts were cut at least once over the past 300 years.

Project Components

GIS Maps

Map resources were used to understand the land ownership patterns and histories of the area around the Minuteman School and other areas. Historical maps were used as artifacts. Current GIS data was provided to students for their use and manipulation.

The land around the Minuteman High School campus is owned by many different types of landowners, illustrating the fractured nature of ownership and stewardship of land. The land shown as Publicly owned includes ownership by the National Park Service, the towns of Lexington and Lincoln, the City of Cambridge Water Department, and the Massachusetts Department of Conservation and Recreation. Private land includes Utility ownership as well as individual private ownership.

Project Components

Curriculum Resources

The curriculum resources included here were developed by Dr. Cammer, with some assistance from the Project Team on the Curriculum Map.

Soils Curriculum Outline

I. Soils Origin
- Parent Material
- Weathering in Place
- Weathering After Transport

II. Soil Texture
- Organic Soils
- Soil Textural "Ternary" Diagram

III. Soil Structure
- Clods
- Soil Fragments
- Concretions or Nodules

IV. Soil Color – Munsell Color Chart
- Hue – Y R G
- Value
- Chroma

IV. Erosion
- Natural Erosion
- Accelerated Erosion

V. Soil Drainage Classes
- Seven Classes in Order of Increasing Wetness
- Mesophytic vs hydrophytic plants

VI. Soil Horizons
- Organic vs Mineral Content

VII. Soil Quality
- Factors Affecting how Soil can Act as a Water Treatment Plant

Primary Readings for the Classroom

This short reading list was developed by the NoLooseBraids team to help students and faculty to understand Indigenous thinking and experience.

- **Hernandez - Fresh Banana Leaves:** This book speaks to the importance of Indigenous people and their knowledge in our work to save or restore land in the era of climate change.
- **Kapayou et al - Reuniting the Three Sisters:** This reading develops a deeper understanding of the importance of the Three Sisters intercropping, and how reinvigorating the practice can make agricultural techniques more sustainable.
- **Melash et al - Indigeous Agricultural Knowledge:** This research article explores how indigenous farming techniques can reduce the dependency on agricultural inputs and contribute to organically oriented agricultural production.
- **Tuck and Yang - Decolonization is not a Metaphor:** This article prompts readers to move away from the objectives of decolonization and instead use social justice approaches that decenter settler perspectives.

Project Outcomes

The Healthy Soils curriculum sought to bring insights from Massachusetts' Healthy Soils Action Plan (HSAP) and Indigenous stewardship practices and cultural knowledge into the Vocational-technical High School Environmental Science classroom. The aim of the project was to weave these perspectives together and expand students' understanding of what it means to care for land—not only through measurable indicators like carbon storage or soil structure, but also through relational understanding that views land as a living relative. This outcome pointed to the greater goal of the project: to cultivate curiosity, critical thinking, and a sense of responsibility in students toward the land they live on.

Students demonstrated strong curiosity and engagement throughout the process. They asked insightful questions about soil as an ecosystem, about how Indigenous and Western practitioners think differently about stewardship, and about how these perspectives might work together. Their reflections showed a growing awareness that Western soil metrics are only one piece of a much larger picture of ecosystem health, a view that Indigenous knowledge keepers helped us all to see more clearly.

Outcomes across the three core partners:

Building an understanding of how to achieve our curriculum goals:

- Learned firsthand that incorporating this kind of work into a curriculum takes significantly more time and thought than expected. Relationship-building is foundational, not supplementary.
- Affirmed that meaningful work requires intentional processes of interaction and relationship-building before curriculum development can take place. Walking the land together became central to building shared understanding.
- Realized that the timeline required to meaningfully bridge Western soil science with Indigenous frameworks is far longer than initially anticipated—likely a year or more to build understanding, establish relationships, and align perspectives.
- Found that walking the land together was the practice that allowed everyone to co-develop a shared understanding of places, transforming both relationships with each other and with the land. This was the foundation for bringing a richer and more holistic understanding into the classroom.

Through this convergence, it became clear that Western soil science and Indigenous land ethics are not equivalent frameworks. Western approaches—focused on soil chemistry, carbon, and productivity—represent only a small slice of a much broader understanding of ecosystem vitality. With NLB's guidance, the group learned to zoom out, situating soil health within a holistic view of land as kin, emphasizing responsibilities as well as technical measures.

Project and class teams walking the land in the woods on the Minuteman campus to help understand the ecosystem health effects of fractured land ownership.

The Healthy Soils curriculum pilot sought to create a vocational-technical (voc-tech) curriculum for high schoolers that integrated Indigenous perspectives on land stewardship with technical skills for assessing soil and ecosystem health. Evidence from surveys, reflections, and class discussions indicates that students grew along both dimensions and began raising thoughtful questions about the relationship between Western and Indigenous approaches to land care.

Pre- and post-surveys indicated that students left the course with a stronger appreciation for land as a living relative, a clearer sense of how history shapes present-day environmental issues, and a deeper interest in pursuing land-related work with a more holistic view. Several students expressed a desire to visit a Nipmuc home site (Wetu), to learn more about traditional farming practices, and to spend more time outdoors. In this way, student learning reflects the greater goals of the project itself: to cultivate deeper curiosity, critical thinking, and a sense of responsibility toward land as a living relative.

Project Outcomes

A traditional Eastern Woodland Tribe home, or Wetu, built by No Loose Braids. Andre Gaines, Jr. and other members of No Loose Braids are pictured. Students expressed interest in learning more about Nipmuck lifeways and cultural traditions.

Monitoring Student Outcomes

Process for Monitoring and Evaluation

- Administer pre-evaluation
- Administer post-evaluation
- Analyze data from monitoring and evaluation processes, assess program's impact Conduct reflection with the Project Team
- Tracking: gain knowledge in soil health/land management/ etc.; explore new perspectives and beliefs about conservation, environmentalism, etc.; develop skills that prepare for careers in land management.

Perspective Shifts

Many students entered the unit with a more traditional view of conservation as working to separate people from natural landscapes. By the end, their reflections revealed a shift toward recognizing stewardship as a relational responsibility.

One student noted:

"I used to think conservation meant removing people from nature. Now I understand that real stewardship comes from being in relationship with it."

Such comments were common and reflected a trend toward more nuanced perspectives. Post-surveys suggested that students were integrating cultural and relational frameworks into their thinking.

Technical Understanding of Soil Health

Students also demonstrated a stronger grasp of how soil health can be measured and monitored. They engaged with several technical concepts as indicators of ecosystem health such as soil organic matter, soil structure, and biodiversity. Reflections often connect these indicators to bigger ecological processes.

One student observed:

"I didn't know soil could hold carbon. Learning how organic matter works made me realize it's part of the climate system, not just about plants."

Another noted the role of biodiversity:

"Healthy soil isn't just dirt. It's alive. If there are no worms, no bugs, no roots, then it's not really healthy."

Curiosity and Cross-Cultural Connections

Beyond technical knowledge, students expressed genuine curiosity about how different ways of knowing might inform one another. Several reflections asked how Western science and Indigenous practices could be looked at together, revealing students' growing capacity for integrative thinking.

For example:

"I wonder what would happen if scientists and Indigenous knowledge keepers worked together. They might see different parts of the same picture."

"Testing the soil showed us how it stores water and nutrients but the Indigenous teachings made me think about why we need to take care of it in the first place."

Project Outcomes

Moving from Understanding to Application

Students' reflections at the conclusion of the course demonstrated the understanding of the importance of holistic approaches to ecological management and care. Their language shifted from abstract interest to relational responsibility, often expressed with humility and a desire to act.

"Forest health if soil health—and I liked thinking about it that way."

"I want to know more about [Indigenous] songs and spiritual connection to land."

Students described the Indigenous guest teachers as having a big impact on them in the course. Several students expressed a desire to, and an understanding of how to move their learning into action as they prepare to enter the professional world.

"Less talk, more doing. I want to know how to use what I've learned to help."

"I'll definitely support Indigenous cultures when thinking about policy."

These student outcomes from this pilot reflect the purpose of the Healthy Soils project: to bridge Western and Indigenous approaches in ways that generate both technical understanding and relational awareness. Students left the course with a stronger appreciation for soil as the foundation of ecosystem health, a clearer sense of how history informs present-day environmental issues, and a deeper interest in pursuing land-related work through a holistic approach. Their reflections suggest that relationship-centered, place-based learning is both powerful and enduring. Students are eager for more opportunities to engage directly with land and with Indigenous practitioners—evidence that this pilot not only achieved its intended outcomes but also laid the groundwork for continued growth, curiosity, and collaboration.

Student Story Maps

Douglas forest tire tracks

We chose this area for a soil sample to see if there is any comparison between the swamp with very little human interaction, and an area that is not only frequently in human contact but is maintained regularly.

This area, though surrounded by trees, has grass as the only vegetation. There was no leaf cover and, due to the tire tracks, the area we tested had no grass cover.

The ph. was 4.0, the potassium was 40mg/kg, the phosphorous was 8mg/kg, and the nitrogen was 40mg/kg.

This led us to believe that the soil in this area was mediocre at best since it supported minimal plants and animals and had low biodiversity.

https://storymaps.arcgis.com/stories/d1dd74f3ecf049c38353584de68f818e

Outer Cedar Swamp Sample

The results of the tests on the cedar swamp showed that the pH was 4.5, the potassium was 160 mg/kg, phosphorus was 8 mg/kg, and nitrogen was 40 mg/kg.

This soil had an organic layer that was rich in moss debris, and cedar bark. Because of the cedar, the soil has a red color.

https://storymaps.arcgis.com/stories/3880c2215bb347b28f7f4ecbd8c312ac

Project Outcomes

Lessons Learned

One of the strongest lessons from this project is that teaching about soil health cannot be separated from relationships. Soil is not just a medium for growing crops or a set of measurable indicators. "Soil health" came to mean the vitality of the land as a living relative, something that reflects the web of relationships among people, plants, animals, waters, histories, and cultures. Scientific indicators such as soil carbon or nutrient cycling are important, but they represent only one layer of a larger, more holistic picture. Indigenous partners reminded us that land health is as much about memory, reciprocity, and responsibility as it is about chemistry and physics.

We hope that our process can serve as a resource for others who are considering this work. Our intention is not to prescribe a model, but to share reflections that may be useful as you develop your own approach within your local context. Some key themes emerged:

- **Take time to build relationships first.** At the beginning, we underestimated how long it would take to build trust, develop shared language, and create a collective vision. We found that without this foundation, technical lessons risk being disconnected from deeper meaning. In future projects, we would dedicate far more time—months, even a year—to building that shared understanding and language with one another.
- **Develop shared understanding of both goals and limits.** Early conversations about what is possible, what isn't, and what everyone hopes to achieve are essential. We learned the importance of naming boundaries and aligning intentions before jumping into curriculum development.
- **Lead with place-based experiences.** Land walks proved to be among the most transformative practices. Walking the land together created space for everyone—educators, Indigenous practitioners, consultants, and students—to co-develop a story of the land. These experiences deepened relationships with each other and revealed deeper connections between scientific and cultural knowledge.
- **Bring multiple ways of learning into the classroom.** Reading *Fresh Banana Leaves* alongside soil health toolkits helped students and collaborators alike understand that Western science and Indigenous knowledge are not equivalent but complementary. Scientific data represent one piece of the puzzle, while Indigenous frameworks invite us to zoom out to a much larger picture of the health of land and relatives.
- **Expect the process to change you.** Every party involved—students, teachers, consultants, and community partners—came away with a shifted and deepened sense of what it means to care for land. This was not about abandoning one framework for another but about seeing that our initial view was only a fragment of something more expansive and relational.

Our hope is that these lessons can help guide others who wish to explore the intersections of soil health, Indigenous stewardship, and education. Each context will require its own approach, but we believe that prioritizing relationship-building, place-based learning, and humility in the face of multiple ways of knowing will create the conditions for truly transformative work.

Looking Forward

Key takeaway: We began trying to braid two knowledge systems toward a scientifically defined soil-health goal and discovered that simply bringing the worldviews into genuine contact was transformational. Future projects can learn from our experience—placing relationships, humility, and shared leadership at the center of the process, knowing that the most powerful learning happens in the space where expectations and experiences collide.

While this pilot was limited in scope, the potential is expansive. Future iterations could include:

- More field visits to Nipmuc-tended sites. Students expressed desires to visit a Wetu, to learn traditional farming practices, or to spend more time outdoors applying what they had learned.
- A shared resource hub with readings, respectful engagement guidelines, and curriculum templates.
- Stronger evaluation tools that meet school accountability needs while respecting cultural boundaries.
- System-level partnerships that allow Indigenous educators to return annually and shape curriculum across subjects.
- A visual summary—such as a slide deck or short video—designed for schools looking to replicate this effort.

Closing Reflection

"People forgot they can have good influence. I liked realizing that."

This project underscored that cultivating healthy soils is as much about cultivating relationships as it is about measuring ecological indicators. The pilot revealed both the potential and the challenges of bridging Indigenous and Western knowledge systems within a vocational education setting. It showed that true collaboration requires more time, more trust, and more attention to shared processes than initially imagined. At the same time, it highlighted the transformative power of land-based practices like walking the land and reading together, which deepened understanding across partners and students alike.

Our hope is that the lessons learned here can serve as inspiration for others seeking to build similar bridges in their own contexts. This work is not a recipe—it is relational, situated, and evolving. What remains clear is that healthy soils cannot be separated from healthy relationships—with each other, with land, and with the more-than-human world.

The Project Team spent several mornings walking the land and sharing experiences while planning for class work.

Appendices

Healthy Soils Resources

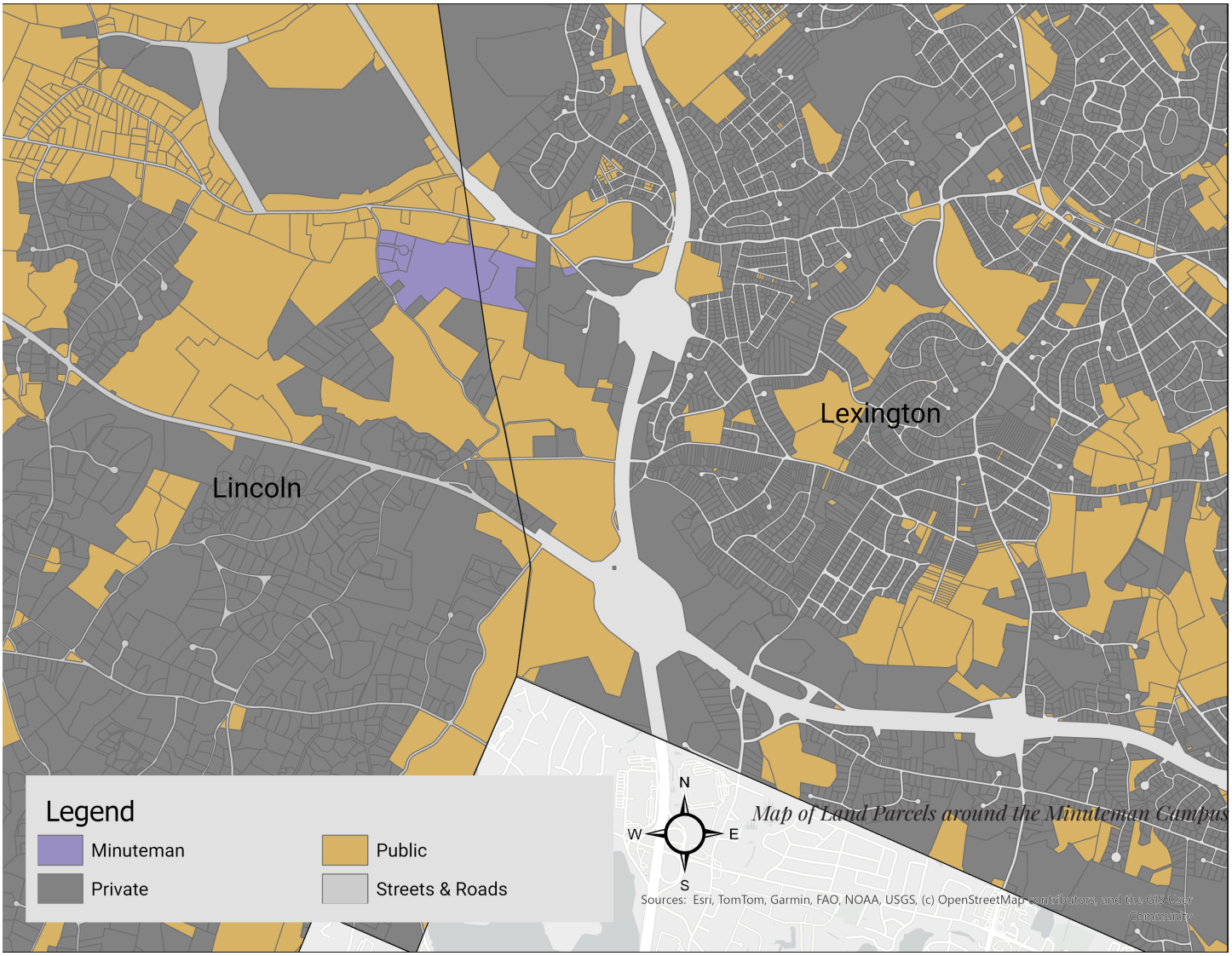
- Executive Office of Energy and Environmental Affairs. (2023). The Massachusetts Healthy Soils Action Plan. Commonwealth of Massachusetts. https://archives.lib.state.ma.us/handle/2452/864846
- Moomaw, W., Stubblefield, B., Kellett, M., & Sinclair, J. (2022, January 29). Use our forests to fight climate change. CommonWealth Magazine. https://commonwealthbeacon.org/opinion/use-our-forests-to-fight-climate-change/
- Neufeld, D. (2022, January 22). Visualizing carbon storage in Earth's ecosystems. Visual Capitalist. https://www.visualcapitalist.com/visualizing-carbon-storage-in-earths-ecosystems/
- Regenerative Design Group. (2023). Forest guide: Nashua River Communities Resilient Lands Project. Nashua River Communities Resilient Lands Project, Municipal Vulnerability Preparedness Program.
- Simard, S. (2021). Finding the Mother Tree: Discovering the wisdom of the forest. Alfred A. Knopf.
- Sudbury, Assabet, and Concord (SuAsCo) Wild and Scenic River Stewardship Council. (2023). Healthy soils report: Hudson, Framingham, and Natick. https://www.suasco.org

Appendices

Maps

GIS Map

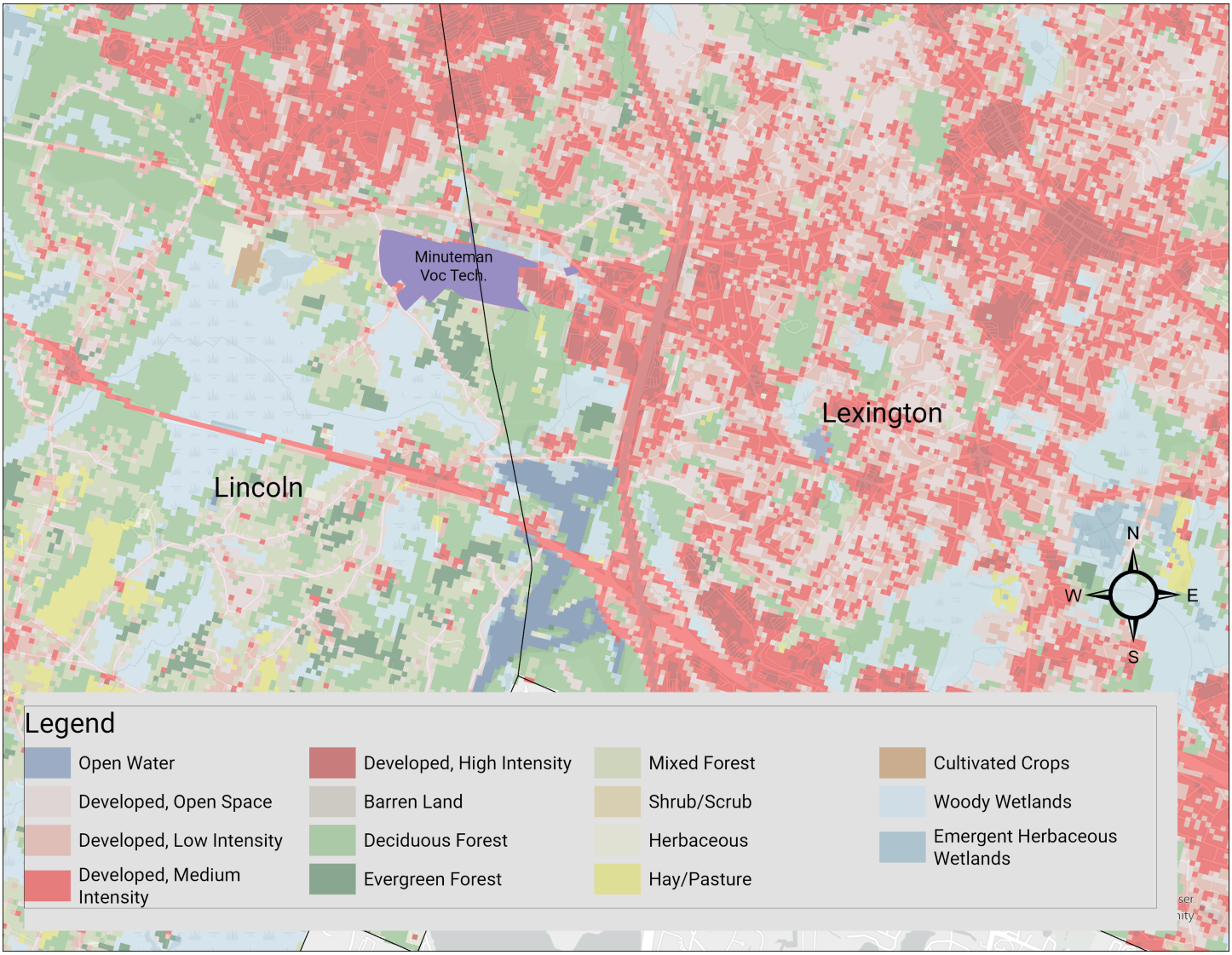
Map resources were used to understand the land ownership patterns and histories of the area around the Minuteman School and other areas. Historical maps were used as artifacts. Current GIS data was provided to students for their use and manipulation.



The land around the Minuteman campus is owned by many different types of landowners, from the Federal Government to individuals. Parcel ownership in this area shows the history of historical uses as well as the effects of modern suburban development.

Appendices

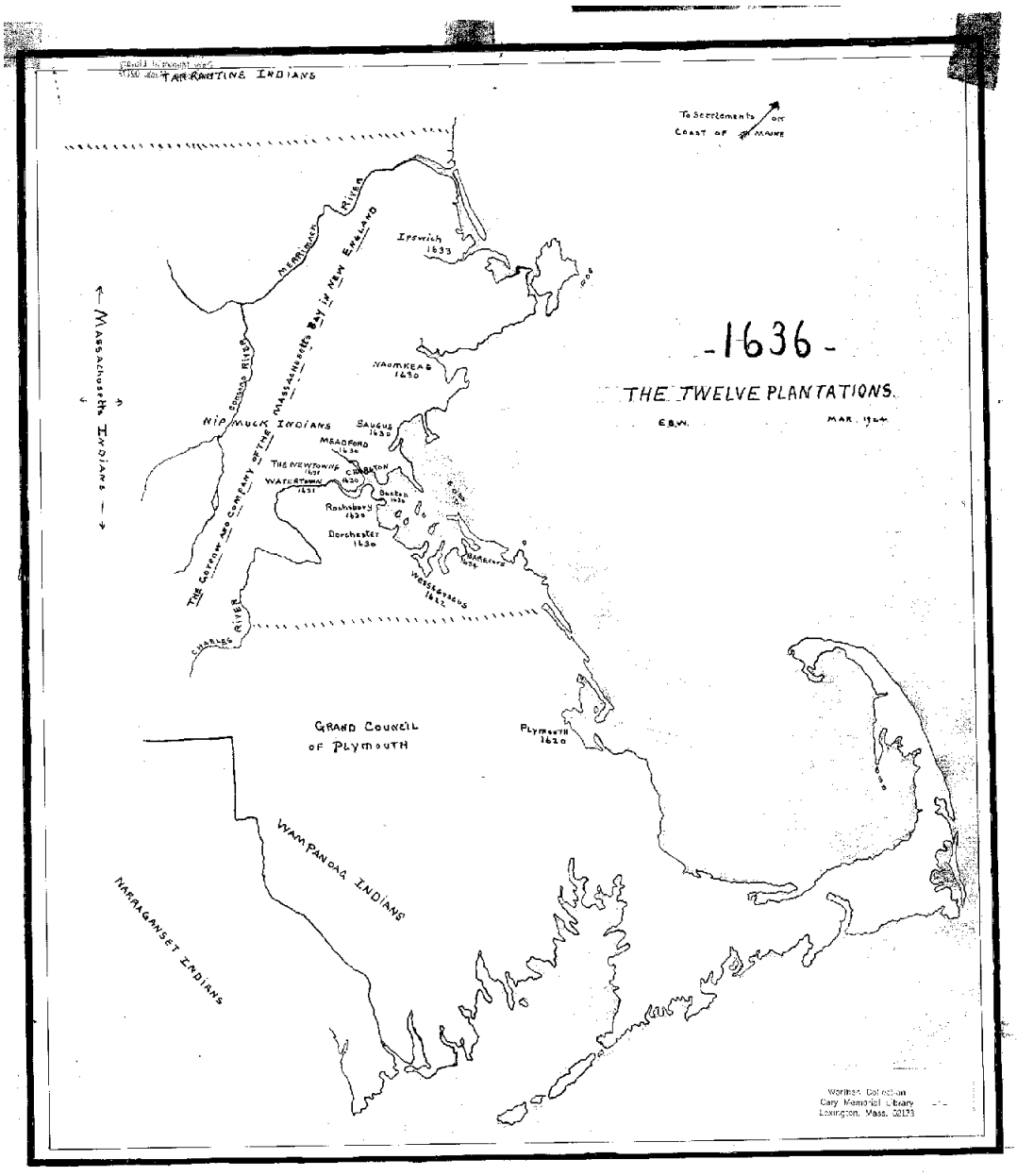
National Land Cover Dataset (NLCD) Map



Map of Land Cover around the Minuteman Campus

Appendices

Map of the Twelve Plantations

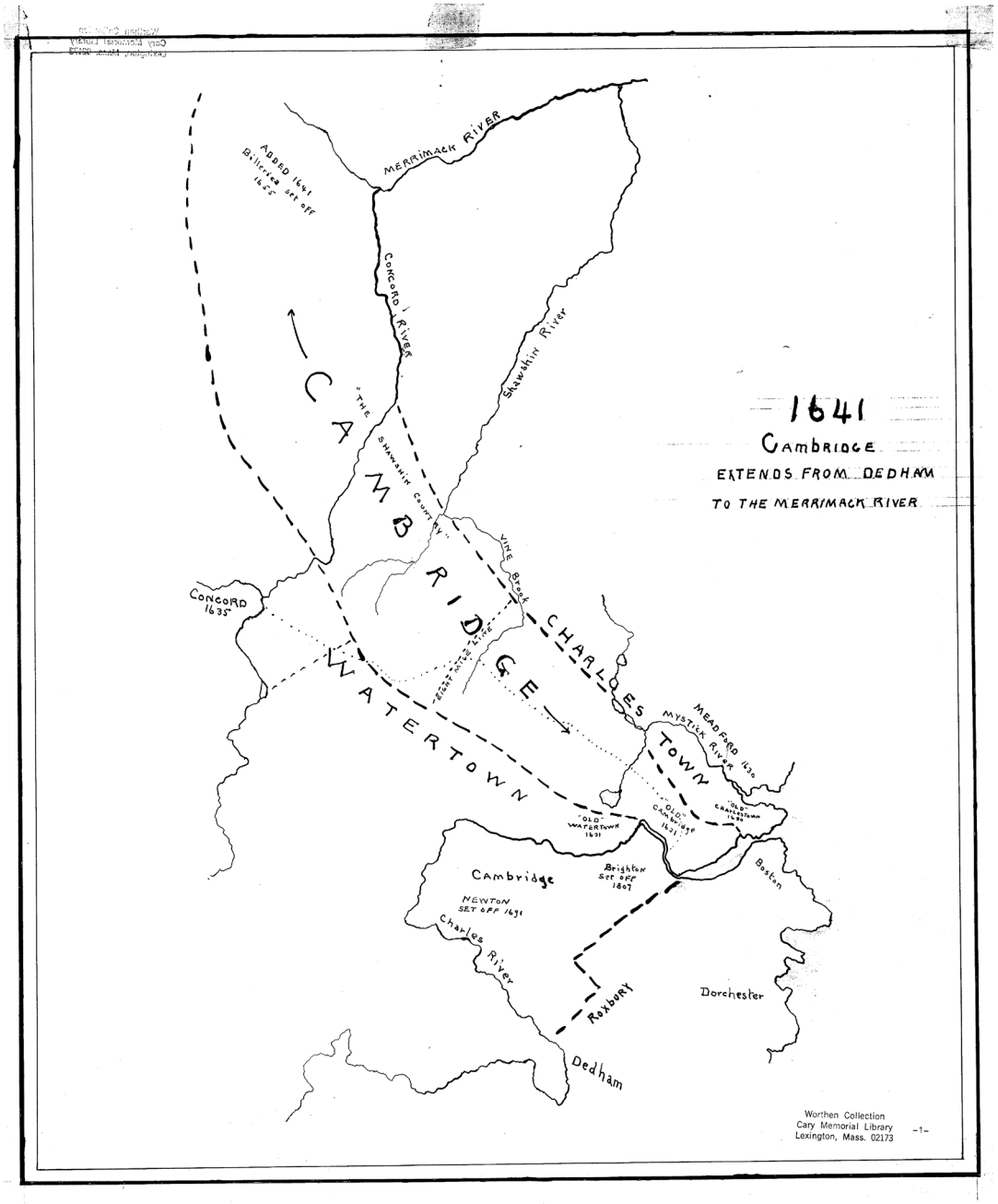


Map of the Twelve Plantations, Massachusetts, 1636, by Edwin B. Worthen

Map of the Twelve Plantations, Massachusetts, 1636. Indicates settlement names and dates, from approximately 1620-1634, as well as general locations of Native Americans.

Appendices

Map of Cambridge, MA



Map, Cambridge MA, 1641, extends from Dedham to the Merrimack River, by Edwin B. Worthen

Appendices

Dr. Cammer's Soil Science Curriculum

Soils Outline

I. Soils Origin
- Parent Material
- Weathering in Place
- Weathering After Transport
  - Transport by Water
    i. Alluvium
    ii. Lacustrine
    iii. Marine
    iv. Beach
  - Transport by Air
    i. Volcanic Ash
    ii. Loess
    iii. Aeolian Sands
  - Transport by Glacier
    i. Glacial Till
    ii. Drumlins
    iii. Stratified Drift
    iv. Glacial Outwash
    v. Glaciofluvial deposits
    vi. Glaciolacustrine deposits
  - Transport by Gravity
    i. Colluvium
    ii. Talus

II. Soil Texture
- Organic Soils
  - Peat
  - Muck
- Soil Textural "Ternary" Diagram
  - Sand
    i. Coarse- Medium- Fine
  - Silt
  - Clay
  - "Loam"

III. Soil Structure
- Clods
- Soil Fragments
- Concretions or Nodules

IV. Soil Color – Munsell Color Chart
- Hue – Y R G
- Value
- Chroma

V. Erosion
- Natural Erosion
- Accelerated Erosion
  - Accelerated Erosion by Water
    i. Sheet Flow, Rills, Gullies

VI. Soil Drainage Classes
- Seven Classes in Order of Increasing Wetness
  1. Excessively Drained
  2. Somewhat Excessively Drained
  3. Well Drained
  4. Moderately Well Drained
  5. Somewhat Poorly Drained
  6. Poorly Drained
  7. Very Poorly Drained
- Mesophytic vs hydrophytic plants

VII. Soil Horizons
- Organic vs Mineral Content
  - O Horizon
  - A Horizon
  - B Horizon
  - C Horizon
  - E Horizon
  - R Horizon

VIII. Soil Quality
- Factors Affecting how Soil can Act as a Water Treatment Plant
  - pH
  - Cation Exchange Capacity
  - Texture
  - Parent Material
  - Soil Depth
  - Slope
  - Soil Drainage

Appendices

Curriculum Map: Healthy Soils

Healthy Soils	2024-2025

Description: The Healthy Soils Voc-Tech Curriculum is an educational program that will challenge students to deepen their understanding of soil health and to critically examine contemporary conservation and restoration practices. The program will start by grounding students in the historical and political context of land management practices over the last several thousand years and outline the impact that colonization has had on landscapes in Massachusetts. Through reading, conversation, hands-on activities (land walks, soil testing, and other technical skill development), students will build technical environmental science skills, as well as wrestle with the implications of different real-world land-management practices. Students will apply these concepts to broader questions of environmental health and resilience. The curriculum is heavily informed by Indigenous ways of knowing and frameworks of right relationship with land and stewardship of the earth. Units include a strong focus on respectful and reciprocal collaborations with the earth, Indigenous stewards, Tribal governments, and community members, toward working together to care for the land. The course will culminate with a project where students apply the Indigenous frameworks and technical skills learned throughout the course to create a set of data and materials that will support land justice efforts led by local Indigenous land stewards.

Course Benchmarks: The curriculum must meet state standards and educational objectives for high school students in Massachusetts. It should encompass learning objectives related to soil health, the historical and political context of land management practices, and environmental science. Additionally, the curriculum should focus on developing students' skills to effectively, respectfully, and ethically collaborate with indigenous partners, and build students' technical research skills. To be successful, this curriculum must highlight that Traditional Ecological Knowledge cannot exist in the absence of indigenous people. All content related to indigenous ways of knowing and specific location-based projects (ex. Cedar Swamp) must directly credit No Loose Braids.

Course Essential Questions

- How has the political history of the land we inhabit in Massachusetts impacted the health of the land and the inhabitants of the land, and how can this history be addressed to improve land stewardship?
- How have different land management practices (perspectives, ways of thinking) impacted soil health and the way we experience our landscapes?
- What unique roles can we play in maintaining the health of our soils, and our earth?
- How can we redefine the goals of land stewardship? How can we work together toward those goals?

Appendices

Course Units/Dates	Major Topics	Course Resources and Activities
Unit 1: Feb 3, 4 ,5 (*half-day*),6 **Goals:** • Provide historical context • Lay foundation for conversations and work that will happen throughout the quarter	• Group agreements • Foundations for developing respectful relationships with the original stewards of land in MA • History of colonization in MA and its impact on the overall health of local landscapes	*Assigned readings to support discussion:* • Fresh Banana Leaves: Chapter 1 No Loose Braids visit on Feb. 6: understanding colonization, sovereignty, stewardship, and respectful relationships from the experience of Nipmuc tribal members *Additional resources to be added, as appropriate:* • *https://www.zinnedproject.org/materials/an-indigenous-peoples-history-of-the-united-states-for-young-people/* • *https://www.zinnedproject.org/materials/teaching-critically-lewis-and-clark* • *https://www.zinnedproject.org/materials/color-line-colonial-laws*
Unit 2: Feb 24, 25, 26, 27 **Goals:** • Students explore the history of land management practices – and corresponding bylaws and regs – in New England • Students connect land management practices with their impacts on the climate and environment **Guiding questions:** • What is the story of this place? How has it changed over time? Why? • Who is the land here? Who are the indigenous stewards? • What are we noticing when we look at the physicality of the land? How has the history of the place shaped and informed that?	• History of colonization in New England • History of conservation and land management practices and the impact of this history on the climate and environment • History of conservation and land management practices and the impact of this history on local Indigenous peoples	*Assigned readings to support discussion:* • Fresh Banana Leaves: Chapter 1 *Additional resources to be added, as appropriate:* • Resources on the history of land management in MA • Data and analysis from 2023 Healthy Soils Action Plan Group agreements

Appendices

Course Units/Dates	Major Topics	Course Resources and Activities
Unit 3: March 10, 11 ,12 (*half-day*), 13 **Goals:** • Introduce students to technical soil heath vocabulary and testing • Students conduct soil sampling and analysis • Students explore the history of land management practices – and corresponding bylaws and regs – in New England • Students connect land management practices with their impacts on the climate and environment **Guiding questions:** • What is the story of this place? How has it changed over time? Why? • Who is the land here? Who are the indigenous stewards? • What are we noticing when we look at the physicality of the land? How has the history of the place shaped and informed that?	• Soil origin, texture, and quality • Defining, assessing, and measuring soil health (HSAP 2023) • Spotlight on soil organic carbon (HSAP 2023) • History of colonization in New England • History of conservation and land management practices and the impact of this history on the climate and environment • History of conservation and land management practices and the impact of this history on local Indigenous peoples	*Technical soils lab:* • Soil sample lab • Soil auger sampling lab *Additional resources to be added, as appropriate:* • Resources on the history of land management in MA • Data and analysis from 2023 Healthy Soils Action Plan No Loose Braids visit on March 10 or 11 (TBD): guided walk around campus with NLB. Discussion of land at Minuteman High School – different land management practices, dynamics between indigenous stewards, conservation bodies, regulations, etc. – examining constructs we are currently operating within and introducing new paradigms through indigenous wisdom Group reflection #1: Journal and/or audio interviews with students and NLB youth reflecting on their learnings and experiences in the class
Unit 4: March 27, 28 **Goal:** • Students conduct soil sampling and analysis		*Technical soils lab:* • Conduct soil sieve analysis, including moisture content analysis. • Compare sieve analysis results to field texture analysis No Loose Braids leads exploratory field trip to Cedar Swamp in Douglas State Forest Group reflection #2: Journal and/or audio interviews with students and NLB youth reflecting on their learnings and experiences in the class

Appendices

Course Units/Dates	Major Topics	Course Resources and Activities
Unit 5: April 7, 8, 9, 10 **Guiding questions:** • How can we weave our resources and skills to carry this work together?		*Students apply their gained knowledge to do a case study of areas near MM or other locations TBD.*
Unit 6: April 28, 29, 30 **Goals:** • Students reflect on learnings • Students work on final projects		*Students apply their gained knowledge to do a case study of areas near MM or other locations TBD.*
Unit 7: May 1 **Goals:** • Students reflect on learnings • Students work on final projects		*Students apply their gained knowledge to do a case study of areas near MM or other locations TBD.* Group reflection #3: Journal and/or audio interviews with students and NLB youth reflecting on their learnings and experiences in the class
Unit 8: May 5, 6, 7, 8 **Goal:** • Students present final projects		*Students apply their gained knowledge to do a case study of areas near MM or other locations TBD.* • NLB and Linnean Soultions to attend presentations

Appendices

Primary Readings for the Classroom

Hernandez, J. (2022). Fresh banana leaves: healing indigenous landscapes through indigenous science. North Atlantic Books.

In this book, Dr. Jessica Hernandez examines the role of displacement — Indigenous peoples like her father, who was displaced by the civil war in El Salvador, and plants like the banana tree, brought from Asia to Central America — in science. Jessica, an environmental scientist, emphasizes how important it is to make sure that Indigenous people and their knowledge are centered as humans work to save or restore land in the era of climate change.

Kapayou, D. G., Herrighty, E. M., Hill, C. G., Camacho, V. C., Nair, A., Winham, D. M., & McDaniel, M. D. (2023). Reuniting the three sisters: Collaborative science with native growers to improve soil and community health. Agriculture and Human Values, 40(1), 65–82. https://doi.org/10.1007/s10460-022-10336-z

This research article explores the importance of many Native American nations practice of intercropping of the "Three Sisters": maize (Zea mays), beans (Phaseolus vulgaris), and squash (Cucurbita pepo). They aim to develop a deeper understanding of Three Sisters intercropping, its cultural importance to Native communities, and how reinvigorating the practice can make agricultural techniques more sustainable for people and the environment.

Melash, A. A., Bogale, A. A., Migbaru, A. T., Chakilu, G. G., Percze, A., Ábrahám, É. B., & Mengistu, D. K. (2023). Indigenous agricultural knowledge: A neglected human based resource for sustainable crop protection and production. Heliyon, 9(1). https://doi.org/10.1016/j.heliyon.2023.e12978

This research article aims to document indigenous farming techniques and pest control, as indigenous agricultural knowledge has not been well documented and is being replaced by modern techniques. The study concluded that implementing indigenous farming techniques can reduce the dependency on expensive and pollutants agricultural inputs, as well as contribute to organically oriented agricultural production.

Tuck, E., & Yang, K. W. (2012). Decolonization is not a metaphor. In Decolonization: Indigeneity, Education & Society (1st ed., Vol. 1, pp. 1–40).

In this article, the authors aim to remind readers what is unsettling about decolonization. Decolonization brings about the repatriation of Indigenous land and life; it is not a metaphor for other things we want to do to improve our societies and schools. The easy adoption of decolonizing discourse by educational advocacy and scholarship turns decolonization into a metaphor. As important as their goals may be, social justice approaches that decenter settler perspectives have objectives that may be distinctly different from decolonization.

Appendices

Detailed Student Responses

Pre- and post-surveys indicated that students left the course with a stronger appreciation for land as a living relative, a clearer sense of how history shapes present-day environmental issues, and a deeper interest in pursuing land-related work through a more holistic lens.

Student reflections showed that Indigenous guest teachers were among the most impactful aspects of the course. Several students expressed a desire to visit a wetu, to learn more about traditional farming practices, and to spend more time outdoors.

Takeaway: Relationship and place-based learning sticks. Students crave real-world experience and holistic perspectives.

Beginning with Curiosity: Shifting Foundations

At the start of the project, many students, along with many members of our project team, brought limited or generalized understandings of Indigenous perspectives on conservation. Since Indigenous stewardship practices are deeply tied to many dimensions of cultural, spiritual, and political life that do not neatly map onto Western paradigms of land conservation and health… with a passive love of nature or aligned it closely with Western environmental science. Few seemed aware of the cultural, political, or historical dimensions that shape Indigenous land relations today.

- "I think Indigenous people support conservation because it helps to restore land their ancestors lived on." (Pre-survey; K-»)

However, even at this early stage, questions emerged that signaled deeper curiosity:

- "I want to know what they think about national parks." (Pre-survey; C+)

Encountering Indigenous Knowledge: Reframing and Reconnecting

The Linnean Solutions site visit and mid-quarter reflections marked a turning point. Students began recognizing that Indigenous conservation practices were not only ecologically effective but culturally embedded, relational, and often in tension with mainstream conservation frameworks.

Key shifts occurred in how students framed Indigenous practices—not as romanticized or historical, but as living, evolving, and intentional:

- "I used to think they just wanted to keep things as they were, but now I understand their practices actively shape sustainable solutions." (Linnean reflection; A-»)

- "I hadn't realized Indigenous people's conservation methods are deeply tied to their cultural values and long-term stewardship." (Post-survey; K-»)

Participants also developed new ethical awareness, expressing respect and concern for collaboration, autonomy, and resistance:

- It was eye-opening to learn that conservation policies can sometimes conflict with Indigenous rights." (Linnean reflection; C+, K-»)

From Understanding to Application: Emotional and Ethical Growth

By the end of the quarter, student responses reflected mature insights, emotional connections, and hunger for action. The most frequent codes in final reflections were C+ (New Curiosity) and E+ (Emotional/Value Change)—indicating that students weren't just intellectually engaged but personally moved.

They described learning that was empowering, relational, and sometimes uncomfortable in productive ways:

- "Forest health is soil health—and I liked thinking about it that way." (End feedback; E+, K-»)

- "I want to know more about their songs and spiritual connection to land." (End feedback; C+, E+)

Many wanted more hands-on, collaborative learning, and several questioned how they could carry these insights into future work or allyship:

- "I'll definitely support Indigenous cultures when thinking about policy." (End feedback; A-», E+)

- "Less talk, more doing. I want to know how to use what I've learned to help." (End feedback; C+, A-»)

Appendices

Key Themes Across the Learning Arc

Theme	Emergence
Corrected Knowledge (K-»)	From stereotyped or simplified views to deeper, relational understanding of land care.
Expanded Knowledge (K+)	Gaining new ecological, historical, and cultural insights—especially around land sovereignty and stewardship.
Attitude Shifts (A-»)	Growing appreciation for Indigenous leadership and practices beyond "preservation"—toward dynamic, sovereign approaches
New Curiosity (C+)	Interest in restoration, spiritual practices, conflict zones (e.g., parks), and meaningful collaboration.
Emotional/Value Change (E+)	Connection to justice, relational learning, and a desire for ethical action.

Reflection Questions

Overall reflection on goals, expectations, and outcomes

- What were your goals and hopes for this project?
- How did your experience of the project align with those expectations?
- How did this project go differently than you expected? If there were moments where you had to pivot or adjust expectations, did that have an impact on how you thought about the project, or your work at large?
- What were the significant and/or meaningful outcomes of this project? For you and your individual goals? For students? For the larger field?

Lessons learned

- What were some of the lessons you learned through this project?
- What went well? What would have done differently knowing what you know now?
- Did you experience any unexpected challenges? If so, how did you move through them?
- What went even better than you originally thought it would?
- What was something that surprised you on this project?
- What is one piece of advice you would give to someone else in your shoes trying to start on a similar type of project?

Working together

- What was it like to work on this team (No Loose Braids, Sarah Cammer, Linnean Solutions)?
- How could our collaboration improve in the future?

Opportunities for furthering this work in the future

- How would you like to see the work and outcomes of this project be carried forward?
- What do you see as the next steps from here?
- What potential does this work have for longer term impact?
- What opportunities exist to collaborate over a longer period of time?

Any other reflections from the project you'd like to share?

Appendices

Specific Process Recommendations

The pilot taught us as much about how to work together as what to teach. We organize the insights into six clusters so future teams can translate them directly into action.

Partnership

a. Exposing students to Traditional Ecological Knowledge requires Indigenous leadership and team collaboration. Traditional Ecological Knowledge is best carried by Indigenous people themselves.

b. Consciously build relationships, not just knowledge. The "content" of the relationship is as important as the technical content, perhaps more important. Time spent building trust, listening, and co-learning is part of the curriculum.

c. It is important for the effective working of the process to pay Indigenous partners fairly and keep asking, "How does this project advance your goals?" The process works best when more than money is exchanged.

2. **Teacher Preparation & Student Readiness**

a. Start curriculum development with extended team learning. Before drafting lessons or beginning to meet with students, teachers, Indigenous partners, and other team members need shared sessions to:

i. Build a common historical lens and vocabulary.

ii. Prepare for difficult conversations about topics like colonization, conservation as a Eurocentric world view, land theft, and other topics that might come up.

iii. Co-design group agreements that protect student safety, Indigenous safety, and student learning.

d. It is important that teachers are prepared to host Indigenous educators respectfully.

e. Students need clear protocols (agreements, respectful language, privacy norms) that are rooted in what Indigenous partners need to participate fully in teaching and learning.

3. **Curriculum Design & Implementation**

a. Map the course with Indigenous partners so what gets taught reflects what they feel is valuable, rather than hiring them for specific presentations.

b. Be prepared to change with the classroom reality. Follow the lead of the teacher's understanding of their students and be ready to slow down, drop units, or change sequence as needs evolve.

c. Be sure to start by grounding faculty and students in historical context. Use readings vetted by Indigenous partners to ground students in context before any technical or scientific work begins.

4. **Mindset & Culture**

a. Humility and curiosity are key characteristics of a successful program. The pilot thrived because the faculty member was openly learning, ready to let others lead, and willing to change their perspective. These traits need to be named and nurtured.

b. Be ready for teaching moments that unsettle students and faculty and upend traditionally taught environmental narratives. Make space for that tension.

c. Starting this kind of process with strong existing relationships is important. Prior trust between Linnean, NLB, and Dr. Cammer shortened the runway and buffered the inevitable misunderstandings.

5. **Field Experience & Embodied Learning**

a. Site walks and land visits deepened student understanding very effectively. Being out in the field also revealed the differing understandings and goals among the team members: when asked how a visit might tie to "soil health," an NLB steward replied, "That's your framing, not ours." Recognizing this gap is, itself, a learning outcome.

b. Respect students' abilities to let multiple worldviews stand. Rather than forcing convergence on a single idea or metric (e.g., soil pH), allow students to hold scientific and relational perspectives side-by-side and wrestle with the tension.

6. **Logistics, Ethics & Documentation**

a. Privacy and safety are always a top priority in school settings. Secure parent/guardian consent for surveys, photos, or videos; respect any limits set by families or administrators.

b. Work collaboratively to determine how to carefully measure what matters. School systems may want tests and surveys; design these with Indigenous partners in ways that respect Indigenous sovereignty and do not misrepresent either Indigenous or scientific ways of knowledge.

c. Realize that every cohort is unique. Accept that a future version of this program—different students, seasons, or partners—will produce a different curriculum, and that variability is the model, not a flaw.

Recommendations & Next Steps

- Deepen hands-on learning: Students consistently asked for more applied experiences with Indigenous-led land care.
- Integrate spiritual and cultural components: Curiosity extended beyond science into cultural relationships and worldviews.
- Facilitate solution-building: Frame future projects around collaboration and responsibility, along with knowledge transfer.
- Use key quotes in presentations/reports: Emphasize shifts in language and tone that reflect deeper ethical growth.