Lessons From the Colchester Bog: Translations of Plant-Environment Interactions

LESSONS FROM THE COLCHESTER BOG:

TRANSLATIONS OF PLANT-ENVIRONMENT INTERACTIONS

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ABSTRACT

How scientific insights and conclusions are communicated to broad audiences is an important consideration. Sharing knowledge about ecosystems and places can help to create greater connection between the human and non-human world. Creative and approachable means of scientific communication can create interest, build curiosity and connection, and encourage further questioning among audience members. This project uses artmaking as a means of ecological storytelling. Information, centered around plant species, and their patterns of distribution, adaptive life strategies, and connections to environmental conditions in bog ecosystems, was established as a background. Attaching ideas from scientific literature to a specific place, the Colchester Bog, helped to contextualize ecological themes and form experiential connections. Regular visits to this place allowed for observational practice. Learning from a specific place allowed for questioning that was guided by curiosity and holistic interactions. To track ideas, and translate processes that were observed at the Colchester Bog into a visual form, tools within drawing and painting were used. Hopefully, sharing this body of work can help to create greater awareness of the function and importance of bog ecosystems, as well as explore human relationships to local ecologies.

TABLE OF CONTENTS

Introduction

Knowledge can come in many different forms. From spoken lessons, to stories, to data driven experimentation, to an awareness of the inherent lessons of the natural world, pursuing underlying connections between humans and nature can happen through many lines of thought. How we attempt to engage with and respond to places and the knowledge that they hold varies greatly.

Holistic observation of environments recognizes different key factors such as light, water, plants, and humans, and focuses on the relationships between them. In a time of human-nature disconnect, this may help to reveal broader connections and strengthen recognition of unity and oneness (Kolan and Poleman, 2009). This project uses observation as a starting point for creating a series of visual art pieces. Connecting with the Colchester Bog in Vermont, serves as a way to practice directly learning *with* a specific place, rather than about a specific place, which Kolan and Poleman (2009), discuss as a foundational step to the study of living systems. Building a visual narrative, through art making, that is informed by the plant ecology of the Colchester Bog, shares ideas about the life that exists there.

The idea of place can encapsulate a wide range of processes. A place has a particular climate, influential physical features, and characteristic flora and fauna that together shape and change the area (Kolan and Poleman, 2009). Organisms interact with each other and environmental factors constantly, and it is these interactions which give life to spaces (Kolan and Poleman, 2009). The result of all of the interactions, from the very subtle to the large and abrupt, reveals something larger than what might come from isolated parts. The larger properties and dynamics of a place arise as a product of all the details.

Through an ecological and scientific lens people aim to question the relationships between living organisms and their physical environments in order to understand the vital connections at play (*What Is Ecology?*, n.d.). Discovering new functions of individual parts, as well as how they interact with surrounding features, helps to build a more complete picture of life processes within an area. In large scale ecological networks, small details and layered interactions can form high functioning cycles of life. An awareness of environmental relationships between inhabitants and features of places such as light, water, and available nutrients is key to understanding the context of survival and impacts of change.

Scientific insights make conclusions about our world based on information that escapes normal human observational capabilities. With certain tools, new perspectives can change our understanding and approach towards complexly structured and dynamic environments. New connections between living organisms and their environments can be formed as the limits of what humans can witness and track expand across scales of time and space. Soil, for instance, hosts countless microscopic interactions that are essential to questions of plant growth. Insights into more precise underlying ecological mechanisms or relationships are useful as questions of larger life can be informed.

Moving forwards in a rapidly changing world, it is essential to integrate scientific insight surrounding ecosystem health, functions, and dynamics into broader attitudes and discussions. For this to happen effectively, the crucial step of communication must be attended to. How ecological information is interacted with determines how insights are interpreted by broader audiences. As scientific inquiry leads to its own data driven conclusions about parts of the world, it is imperative to consider how they inform greater narratives of place and interaction.

Effective visual translations of environments and the underlying processes can aid with communication and decision making surrounding how we value and interact with the places around us on a societal level. Revealing details of a connected world can have powerful impacts on the ways in which we engage with the places around us. As we learn more about what our actions mean for greater life in the surrounding ecologies, we must tell this story in the context of our cultures and our cares.

The relationships that humans form with places are extensive and reciprocal. We interact with surrounding natural systems both directly and indirectly. Resources such as food, water, medicine, and fibers come directly from the features and inhabitants of a place. Jobs, recreation, scientific and spiritual exploration, and aesthetics are also specific to place (Potschin & Haines-Young, 2013). Day to day life relies on these resources, and although we do not always see where they come from, there is a consistent connection to land and the natural communities that our behaviors and needs create. Indirectly, the specific features of a place determine effective nutrient cycling, primary productivity, soil formation, water flow, and other environmental factors (Potschin & Haines-Young, 2013). Vital processes such as these are shaped and influenced by the state of an ecosystem.

The wellbeing of surrounding environments translates to our own well-being. The health of functional natural systems can be thought of as part of our own health. As beings with enormous environmental impacts, it is important to recognize the influential weight that we hold in the global, more-than-human communities that we rely on.

In a time when rapid climatic shifts are changing the world in unfamiliar ways, ecological systems serve as opportunities for learning. Paying attention to how places around us are functioning and responding to change is important because it helps to better understand the context of our current situation. Natural systems hold traces of human behavior, both local and global, and to consider our actions to be separate “reinforces an artificial dichotomy” (Kolan and Poleman, 2009). Parts of our deep histories, current behaviors, and future directions can be informed by understanding the human relationship and role in natural environments (Wilson, 1986) For these reasons, it is important that we connect evolving understandings of the natural world to our experiences, our stories, our lives.

One way that the connection between humans and nature may be strengthened is through the practice of art making. Many types of art making begin with approaching an environment through careful observation. Translating the interconnected parts of a place into a visual language can help to communicate and grow understanding of the world. While choosing what is in view, and how it is represented to audiences comes with inherent danger of misrepresentation (Tufte, 1990), learning how to accurately and responsibly display visualizations can lead to increased connection between information, ideas, and people. Carefully developed visual spaces can represent and contextualize ecological information. When the ecological patterns that are understood through the tools and insight of scientific inquiry are applied to the process of creating visual art, knowledge compiles in unique ways.

The act of creating an image, that includes a diverse set of parts and aims to represent functions or interactions, involves piecing together information often from various disciplines (Goodsell, 2021). The inevitable search for interactions and relationships guides curiosity and searching throughout the process. Spending the time to translate this information and understanding into a new form requires the individual consideration of each part which may lead to strengthened familiarity and insight into holistic relationships.

Tools of science cannot reveal all of what occurs across a dynamic landscape. There is much that is still hidden. What languages can we still not understand or approach? Art is free to approach these unknowns with undefined boundaries. Unknown complexities can still be placed within a context, acknowledging them and encouraging greater questioning.

Art can strengthen curiosity and encourage engagement with natural systems, providing a way of learning from the places around us. Learning about and discussing ecologies should be accessible to everyone because there is such a close connection between human behavior and these systems. Encounters between science and diverse public audiences must be questioned as our impacts on ecologies become more clear. When science is channelized towards specific well-informed audiences, ideas risk becoming smothered by confusion or frustration, and may become isolated or excluded from broader audiences (Davies et al. 2019). Being well informed on the impacts and consequences of actions can help to understand a changing world.

Narratives and stories that are told through art can communicate the facts that science presents with more experiential types of thinking and engagement. Art forms can build interest and spark reflection surrounding scientific ideas by contextualizing them with historical or everyday aspects in a concise way (Richter et al., 2019). When considered in relation to scientific communication, the arts are becoming a beneficial medium, being visually stimulating, encouraging engagement, fostering agency, and inspiring hope (Thompson et al., 2023). The benefits of connecting ideas to an artistic approach grow from artmaking's ability to foster "a collective conversation about environmental concerns, uncertainties and desires" (Thompson et al., 2023). When learning about a topic, art making can boost learning through engagement (Richter et al., 2019) and creative intellectual inquiry (Thompson et al., 2023). This applies well to learning about ecosystems and ecological interactions because of the common threads of precise observation and relational thinking.

Insights into the details of the spaces around us can help grow understanding, but when connections, including our own, are recognized and attended to, ideas of place can flourish. Art can be an effective communicator of the stories that are held within places, and can encourage the sharing of lessons and ideas. Representations of the world through art push the confines of definition and language, providing new lenses for observing the world. This ability can promote care and curiosity for the world around us through questioning the held relationships. In the drawings and sculptures of Guiseppe Penone, details of human touch such as fingerprints or skin, are directly attached to forms of growth such as tree rings, or tree trunks. Penone creates senses of close connection and interaction by revealing how human marks can mimic, reflect, and influence the lines and forms found within trees.

The considerations that we make within art are important for bettering the interactions between scientific communications and society. The societal meaning and significance of environmental information can be built up through art (Davies et al. 2019). This can contextualize the impact of conclusions that are offered by science. Strong connection and communication can grow involvement and input on a societal level. How we choose to tell the stories of places shapes our connections to them.

Literature Review: Bog Ecology

Environments can be described in terms of the plant communities that grow there. Growing in the face of both nourishing and adverse conditions, without being able to relocate as an individual, plants must be in strong correlation with their environments. Adaptive characteristics and lifestyles of plant populations, ways in which plants display a type of creativity to better align with environmental conditions, often hint at features of place. By observing what plants grow where, one can be clued in on soil characteristics, climatic factors, hydrology, and disturbance (Thompson, Sorenson, & Zaino, 2019).

In wetland environments, life aligns with the effects of consistent water. Wetlands include a diverse set of environments including swamps, bogs, fens, marshes, ponds, and pools (Lane et al., 2018). Factors such as inlet sources, mineral availability, and the course of water flow differ between the types of wetlands according to each specific physical setting (Thompson, Sorenson, & Zaino, 2019). Consistently though, wetlands are characterized by the large and impactful presence of water, which leads to hydric soil conditions or non-soil substrates that are covered with shallow water for part of the growing season (Lane et al., 2018). Accordingly, wetland areas host plant communities that are largely hydrophytes adapted to water centric life (Lane et al., 2018).

Overall, wetland ecosystems provide immense benefits. They form diverse habitats which support biodiversity and stabilize interactions between life forms (Xu et al., 2020, Tousignant et al., 2010). Many species of animals, especially waterfowl, rely on wetland areas for habitat structure and food (Nyman, 2011). Unique plant species, which may be outcompeted in surrounding upland communities, find a competitive advantage in these ecosystems and their varied spatial patterns and resource dynamics (Nyman, 2011).

These places of high function are inherently connected to downstream and surrounding systems (Lane et al., 2018). Most directly, wetlands can impact water levels in a watershed through their ability to slow water flows and their high capacity for absorbing and storing water (Thompson, Sorenson, & Zaino, 2019), Tousignant et al., 2010). In the face of large precipitation or snowmelt events, wetlands aid in flood attenuation and reduce downstream water levels (Nyman, 2011). This capacity is largely shaped by the type of soil present, the location of the wetland and its connections to the broader watershed, and the dominant vegetation in the area (Thompson, Sorenson, & Zaino, 2019).

In addition to the level of water coursing through an area, what is carried within the water, the particles and dissolved elements, can have large environmental impacts (Nyman, 2011). Wetlands provide protection and stability by trapping sediments, and removing excess nutrients and dissolved pollutants from water (Lane et al., 2018). High nutrient levels in water and soil, especially nitrogen and phosphorus, are regulated as water seeps through the soil and interacts with the vegetation of wetlands (Xu et al., 2020). Wetland areas safeguard downstream water systems through the retention and transformation of excess nutrients which otherwise have the potential to create eutrophication events in open bodies of water (Nyman, 2011).

On a global scale, wetlands, especially peatlands, are great at sequestering atmospheric carbon (Shi et al., 2015, Tousignant et al., 2010). Plant tissues accumulate in layers and form buried masses known as peat (Nyman, 2011). Peatlands comprise only 3% of Earth's land surface, and yet hold around 30% of global soil carbon (Shi et al., 2015) showing the efficient role that wetlands play in carbon storage.

Greater scientific investigation into the dynamics and mechanisms of wetland functions paired with precise monitoring and data collection can help lead to more widespread recognition and credibility for the important roles of wetlands (Xu et al., 2020). They are recognized as vital to not only human health, but the health of the many interconnected ecosystems (Xu et al., 2020). Despite the diverse services and benefits to human and global health, many wetland ecosystems are greatly threatened by human activity and since 1970, there has been a 35% loss in wetlands globally (Xu et al., 2020). Perhaps overlooked and undervalued amidst human development, these places can have great stabilizing effects and hold partial solutions to many regional and global environmental threats.

A local wetland example exists a few miles Northwest of downtown Burlington, Vermont. The Colchester Bog became the foundation for this project as a way to explore how knowledge develops from specific places. Currently designated as a University of Vermont Natural Area, the 180-acre Colchester Bog rests in a peninsula of Lake Champlain. The Colchester Bog sits where it has since its formation around nine thousand years ago when a former channel of the nearby Winooski River became blocked from the freshwater of lake champlain (Doherty, n.d.).

A bog is a type of wetland ecosystem supplied by rainwater rather than groundwater sources. Poor nutrient levels in bogs like the Colchester Bog define the wetland as ombrotrophic (Gotelli et al., 2008). This general lack of nutrients is partially due to the source of water being relatively low in dissolved minerals as well as the substrates having poor decomposition conditions (Thompson, Sorenson, & Zaino, 2019). Water in this bog rests heavily and impacts the life here in major ways.

Human interaction with this place goes far back in history, beginning with the Abenaki people, who formed the original relationship with the area. Other presences in this area include a French military fort on Colchester Point in the 1700's and a generational farming family's residence during the 1800's which likely involved small scale timber harvesting from the bog edges (Doherty, n.d.). Since 1901, when the railroad was built, developmental pressures have threatened the bog. With the help of the Natural Resources Board, which administers Act 250, Vermont's land use and development law, enacted in 1970 (Natural Resources Board, n.d.), development faced opposition. In 1973, the Colchester Bog was purchased by the Nature Conservancy, before being transferred to the University of Vermont's Natural Areas program a year later (Doherty, n.d.).

Today, the bog is surrounded by modern anthropogenic marks. Rows of houses press against the Southwestern side and Northeastern corner. Airport park, where there exists a sports field complex, scratches into the strip of forest that comprises the Eastern edge of the bog habitat. And the once railroad, now a bike path, cuts directly across the bog, separating a corner of the land in the Southwest from the rest of the bog. This place has become set among the busy happenings of people's lives and the consequences of nearby development. Understanding the framework of the Colchester Bog must now include the effects of a large human presence.

A landscape is shaped and influenced by the entire collection of conditions and inputs. As shown in a study done by Tousignant et al., 2010, vegetation communities in bogs are primarily structured according to abiotic factors such as acidity, nutrient availability, and water table depth, but also to anthropogenic disturbances. This paper shows that the ecological spatial patterns in bogs are not separate from the consequences of human activity, and these must be considered in combination (Tousignant et al., 2010). Certain human behaviors such as logging, drainage, and the creation of artificial rises that change the spatial structure of bogs can alter species composition and richness as many plant species such as sphagnum are very sensitive to changes in light and moisture (Tousignant et al., 2010). Human development can rapidly change environmental conditions. The structures that we build, the changes that we make, can quickly alter characteristics and have layered impacts on the biotic composition of a place. This place, while still retaining characteristics of a bog ecosystem, is pressured and scarred by modern development. The bog reflects the greater space around it and absorbs the consequences of nearby human behaviors.

Paths lead from the nearby park, through the bordering woods, and to a sandy trail that parallels the edge of the bog. It rests under the shade of large Maples and Pines, the established giants of the upland periphery. Water defines an edge at the base of a short but steep downhill coming from the forest. There exists a transitional zone here, where the upland forest and bog ecosystems are colliding into each other. Known as a lagg, this strip, common to the margin of bogs, involves a mixing of water types and soils that give rise to an ecotone with a unique plant community (Howie & van Meerveld, 2016). Ferns and sedges grow in clusters on the bank where past water marks have stained the ground.

Past this margin, the area opens up. The tall forest canopy stops and open light floods a horizon of low crawling growth. Along the Southern portion of the trail, a boardwalk extends into the bog. This narrow wooden path is the only built trail, aside from the former railroad, that enters the bog area. The bog is not a place of convenient travel like the network of nearby roads and bike paths. A small strip that is sacrificed for easy walking into the bog displays a modern lack of direct alignment between human wanderings and this place. As it slants down the bank, the boardwalk is set on solid ground. Then, a step onto the first flat section of boardwalk shifts the large floating blocks that now hold up the path on the bog surface. Water glazes over the dark sunken ground to either side. Not much movement seems to exist in the water.

Plants align with the underlying topographies, water regime, and the resulting conditions of the bog ecosystem. To understand what plants reside here and thrive here, scope of observation must include the underlying structure and dynamics of the bog. The ground surface is the foundation for spatial patterns in bogs (Diamond et al., 2021). The microtopography in a bog, the small scale vertical variations of the soil surface, creates variation in the interactions between space and water (Diamond et al., 2021). Common to many types of wetlands, the patterning of raised areas embedded within a larger basin is known as hummock and hollow topography in bog ecosystems (Shi et al., 2015). The hummocks are often raised above the dynamic water table while the hollows are consistently set within the sunken saturated soils (Diamond et al., 2021).

How does this rise out of the water happen? Structure may take form quickly through the addition of woody debris, nearby trees that fall or branches that break off (Beatty, 1984 as cited by Diamond et al., 2021). At the Colchester Bog, woody debris has a large impact on overall ground structure. Some recent falls rested on top, covering adjacent hummocks and crushing the plants that occupied them. This was especially common along the bog edge where larger trees resided and reached out from the slanted bank. In the bog, some stumps and large pieces sat embedded in the ground, being clawed at and pulled down into the water by Sphagnum mosses. In some places, I could only guess by the elongated shape, that what might rest below the various plants and debris was a branch that had been resting there for a long time. More commonly, hummocks are formed from cycles of plant growth and death (Diamond et al., 2021). Points of preferential sediment deposition that build up banks, as well as preexisting abiotic features like rock forms can give plants a foothold to grow from (Larsen & Harvey, 2010). Early colonizing species of plants stabilize spaces with the growth of lateral roots and upward shoots (Stribling et al., 2007), and this added substance helps to hold sediments and organic matter (Diamond et al., 2021). When plants are able to add structure to pieces of ground, a positive feedback occurs

(Diamond et al., 2021). The increase in vegetation slows water flow in surrounding areas, encouraging more sediment deposition (Larsen & Harvey, 2010), and begins to accumulate organic matter from above as the plants above die (Barry, Garlo, & Wood, 1996). Improving establishment and growth conditions in the raised area bring more and more root and stem structures to further push the process (Stribling et al., 2007).

Small scale landform variations within bogs shape interactions with the frequency and duration of flooding and other hydrological dynamics (Shi et al., 2015). Across the space, hummocks and hollows add complexity and heterogeneity to soil moisture patterns (Diamond et al., 2021). Hummocks, with surfaces that extend above the water table (Diamond et al., 2021), experience reduced flooding and lower soil moisture (Lindholm & Markkula, 1984). Being above the consistent water level also means that these spaces experience a wider range of conditions, as the water levels rise and lower (Lindholm & Markkula, 1984). Hollows, on the other hand, experience longer and more consistent periods of saturation (Diamond et al., 2021).

Hummocks are believed to have a higher nutrient concentration than hollows (Bruland & Richardson, 2005 as cited by Diamond et al., 2021) with up to four times the levels of nitrogen and carbon, and up to five times the levels of phosphorus in the soil (Sullivan et al. 2008 as cited by Diamond et al., 2021). Greater debris and litter accumulation combined with faster turnover and cycling rates contribute to these differences (Sullivan et al. 2008 as cited by Diamond et al., 2021). Lower, more saturated levels are starved for oxygen in the still water, and hold lower redox potential conditions and harshly acidic pH levels (Ahn et al., 2009). Hummocks therefore create refuge for vegetation communities above the stressful conditions of hollows (Araya et al., 2011). Primary production is higher on these raised areas (Strack et al., 2006), where greater chemical cycling takes place and roots respire and are more successful in obtaining nutrients

(Diamond et al., 2021). Conditions in the hummocks are also more favorable for microbiota, which contribute to the turnover of organic matter (Ahn et al. 2009). Finally, mycorrhizal activity is greater in the aerobic conditions of the hummocks, and can be an integral part of nutrient acquisition for plants (Cantelmo Jr. & Ehrenfeld, 1999).

Small vertical variations that span across layers of saturation and soil activity lead to large habitat differences in bog ecosystems (Cantelmo Jr. & Ehrenfeld, 1999). The distribution and community structure of plants within the bog are informed by the water regime and soil conditions (Araya et al., 2011) and the species richness, evenness, and abundance (Diamond et al., 2021) are boosted by the great diversity of stratified habitats. Understanding the life of plants in bog environments requires understanding the topography of the place. The hydraulic dynamics occurring among bog spaces are a central component to where plant species are able to reside and how they survive and compete (Shi et al. 2015). Different species, with diverse means of reproduction, seedling establishment, and growth, have a wide range of conditional needs. Some plants seek out the dry soil conditions that come with being fully raised above the water table, others have basal portions that can tolerate fluctuating water levels, and some establish in fully submerged conditions (Raulings et al., 2010). How long periods of flooding and drying last, as well as the average water depth, are controlling factors in where a plant is able to grow within a bog (Raulings et al., 2010). Each plant community hints at the conditions of the soil and water below by staggering according to the spatial patterns of bogs.

Plant species interact with this space as they establish and grow. There is a reciprocal relationship between the plant species that grow here and the environment. Plant life in the Colchester bog is heavily influenced by the conditions, and the growth processes of plants heavily shape the bog space.

Within this bog ecosystem, the *Sphagnum* mosses have very impactful interactions with their environment. *Sphagnum* mosses are well adapted to bog conditions and are foundational to the structuring of life within these places (Gotellie et al., 2008). Tolerant of extremely low nutrient and mineral levels and harsh acidic conditions, *Sphagnum* finds a place to thrive where the majority of vascular plants cannot, forming expanses from the edge of bog waters (Rydin et al., 2006). These mosses carpet the ground of the Colchester Bog, riding over the hummock mounds in some places and stretching out in vast mats in flatter areas. Communities of *Sphagnum* stretch horizontally, covering as much ground space with small shoots as possible in order to gather sunlight. Unable to compete in a vertical race with vascular plants, these mosses specialize and survive in places where those other plants are not as well equipped, and work to maintain favorable conditions (Rydin et al., 2006).

Mosses in general are water loving, and these species are very closely tied to moisture conditions as they rely on its presence for photosynthetic and growth processes (Rydin et al., 2006). The details of individual parts of *Sphagnum* plants, as well as the structure of moss communities, reflects this relationship with water very directly (Kimmerer, 2003). Surface structures of mosses have a high affinity for holding water at their small scale, and the density of growth within moss communities forms a complex arrangement of sponge-like pores (Kimmerer, 2003). Among the small-scale landscapes of *Sphagnum* mosses, capillary forces within the low lying networks of stems, branches, and leaves are strong, and a microclimate of high water retention forms along the ground (Kimmerer, 2003). This living layer helps to define the bog surface.

The water conditions determine where certain species of *Sphagnum* can reside in the bog. Vertical stratification of habitat conditions affects *Sphagnum* communities through alignment with variation in acidity and moisture (Bengtsson et al., 2016). The position relative to the water table is the largest driving force behind functional traits of species such as shoot density for water retention (Bengtsson et al., 2016). Some species thrive in lower layers that are closer to the water surface and experience more frequent water exposure, while others are able to find a space in the higher, drier, and less acidic layers. Water, which is essential to the mosses' survival, can be wicked upwards through the chains of former cells that have been pushed down and reach wetter conditions (Kimmerer, 2003). Slowed decay may retain capillary networks that reach far down into the hummocks and underlying layers (Rydin et al., 2006). In many ways *Sphagnum* community patterns are integrated with the underlying processes of bogs and their presence represents a reciprocal relationship between land and foundational growth in these places.

Sphagnum shapes bogs. The introduction of its opportunistic growth into a nutrient poor area increases the net primary production (Soudzilovskaia et al., 2010). As it crawls and stretches over available ground spaces, the living top layer of shoots busily constructs dense mats of growth. The thin surface layer, known as the acrotelm, which one can see covering many parts of a bog area is the apparent life of the *Sphagnum* mosses (Lindholm & Markkula, 1984), but this biologically active layer is only the new progress of a slowly accumulating process. As the upper layer cycles new life and death, the organic matter from *Sphagnum* parts and other plant debris begins to descend. Near the top, this collection is porous and air and water can circulate through (Belyea & Clymo, 2001), breathing some life processes into the ground. While some organic breakdown may occur at this point, the biogeochemical components of *Sphagnum* slow rates of decomposition (Soudzilovskaia et al., 2010). The *Sphagnum* itself is resistant to decay as it contains a mixture of phenolic compounds (Rydin et al., 2006) and acid rich cell-wall pectin (Pipes & Yavitt, 2022). Under the weight of past growth, the dead sink, forming an accumulation of dense layers known as peat (Belyea & Clymo, 2001). Weighted down, low layers compress, slowing water flow and restricting air. Because of the anoxic conditions and adverse chemical interactions (Rydin et al., 2006) many microbial decomposers cannot function in this environment (Pipes & Yavitt, 2022), discouraging another component of decomposition. In the dark, the underlying mass rests, with little, if any, decay happening in the saturated, oxygen deprived bog foundation (Belyea & Clymo, 2001). This massive base, is at the heart of a bog's great ability to sequester carbon, locking it in compacted layers where it may sit undisturbed, efficiently storing around a third of the world's soil carbon within peatland environments that cover just two to three percent of Earth's land surface (Bengtsson et al., 2016).

Bogs are known to be acidic environments, and peat formation plays a large role in this. The growth and activity of *Sphagnum* is very closely tied to surrounding waters as it uses the water as a means of altering the environment in which it grows. Living mosses have a high number of active sites of cation exchange as a means to uptake nutrients from the surrounding soils (Soudzilovskaia et al., 2010). In cases where pools of nutrients in the form of cations are available- this is more likely in more nutrient rich systems like fens- *Sphagnum* and other mosses may actively release protons in the form of hydrogen ions and acidify the surrounding waters (Rydin et al., 2006). However, as Soudzilovskaia et al., (2010) point out, cation exchanges may not readily occur if rainwater is the only supply of basic nutrients because levels would be too low. Instead, they offer the explanation that the compiling and slow decay of peat leaks acids into bog environments and greatly lowers the pH. In the deep layers of peat, large amounts of acidic byproducts from dead *Sphagnum* can seep through the base and integrate into surrounding waters, extending the acidifying impacts throughout the bog area.

The physical structure of accumulating peat itself also contributes to the harsh conditions of bogs. With plant material being added to the top layer at a rate much greater than the opposing decomposition rates below, layers of peat accumulate and begin to raise the level of the bog (Belyea & Clymo, 2001). The overall effect of rising surfaces could lift an area above groundwater source tables, creating a barrier between the upper layers of the bog and the nutrient rich groundwater sources below, which would otherwise help to neutralize the acidic water conditions (Soudzilovskaia et al., 2010).

Layered small scale variations in the surface layout of bogs inform the presence of *Sphagnum*, which, in turn, shapes and alters the environment. This living layer clings to the lower levels of the bog at the interface between water and the emerging landforms. *Sphagnum* sets the stage for other plant life, which attempts to enter the conditions of the bog, which cannot be explained without considering the effects of this moss.

The ways in which larger, woody plants establish themselves within bog ecosystems are also very connected to the topographical features. The larger size and increased complexity of root systems of certain species, help to elevate surface spaces above the water level through sediment trapping and added stability (Barry, Garlo, & Wood, 1996). Sheep Laurel (Kalmia angustifolia), for example, can be seen in the Colchester Bog extending from hummocks in clusters. This clonal plant extends laterally through dense networks of rhizomes ((*Kalmia Angustifolia*, n.d.)). This species grows well in acidic peat environments, but favors the more well drained hummock areas of bogs (*Kalmia Angustifolia*, n.d.). It can be seen in the Colchester Bog in large stands in drier areas. Roots run under the moss surface and seem to physically support the accumulation of organic material and further moss growth. Shrub species, which are tolerant of acidic environments, are able to establish within the upper layer of the bog soil and improve the network of stability.

Establishing and reinforcing vertical layering of conditions and diverse topographical features are important for further plant growth as the spatial relationship with the water affects seed germination and seedling establishment, growth, and survival (Raulings et al., 2010). Tree seedlings find greater success in raised areas with greater relief from the stress of saturated soils and anaerobic conditions (Diamond et al., 2021). The varying conditions along the ground surface may be a determining factor in the location of tree establishment. In the Colchester Bog, many hummocks feature a central individual tree or group of trees. One overstory character found connected to the relatively dry hummock areas is the Tamarack (*Larix laricina*). This deciduous conifer is very tolerant of acidic conditions and is often found in bog ecosystems (*Tamarack | American Larch | Larix Laricina*, n.d.) where it can find relief in harsh bog environments to avoid being outcompeted by other species. Shallow root systems search in the nutrient poor conditions. The low nutrient conditions lead to very slow growth rates, and the shallow soil layer in places prevents these individuals and other trees from growing too tall as there is little support against toppling.

Speckled or Gray Alder (*Alnus incana*) can be seen stabilizing ground spaces in the Colchester Bog with roots that interlace patches of Sphagnum moss. As a nitrogen fixing species, these trees have a large impact in very nutrient poor ecosystems such as bogs because they add essential nutrients as they go through their growth cycles (*Alnus Incana*, n.d.). It has been observed that as stands of these trees establish in bogs, vegetation cover shifts towards more nutrients requiring species and successional ecological steps may follow (*Alnus Incana*, n.d.).

Many plant species must be adapted to the acidic conditions of the bog. Within the mats of *Sphagnum*, the Purple Pitcher Plant (*Sarracenia purpurea)* finds a place to grow and survive in bog edge habitats. Here, the acidic and nutrient deficient characteristics of the bog discourage the growth of many species, but *Sarracenia purpurea* is equipped with another strategy for acquiring nutrients. The bright yellow green to purple evergreen leaves of this species are modified to form a vertical pitcher which fills with rainwater. When an insect, lured in by coloration and scent (Lenihan & Schultz, 2014), slips into the pitcher, small, hair-like projections on the inside surface of the leaf prevent easy escape for an insect (*Sarracenia Purpurea*, n.d.). Digestive enzymes and accumulated bacterial communities in the water begin to break down the prey. Through carnivory the plant is able to source alternative forms of nutrients and trace elements that are necessary for growth. The ability to gain nutrients through an above ground leaf system and the lack of root contributions may shift the allocation of resources towards growth of the basal leaf portion of the plant (Lenihan & Schultz, 2014).

Common Dodder (*Cuscuta gronovii)* is another example of a plant that looks to alternative strategies to acquire the necessary resources for growth. This plant, found along the edge of the Colchester Bog, may initially have a root system to acquire nutrients from the soil, but as it rapidly sprawls out above the bog surface it shifts its focus to other nearby plants. Dodders are parasitic and are able to extract water and nutrients directly from the stems of host plants (Hettenhausen et al., 2017). Communities of this plant can form dense networks over parts of the landscape as they link between other individuals, all while not relying on a direct connection to the poor soil conditions.

These examples are a few of many instances that display how the topography and nonliving features of this bog are deeply connected to the makeup and distribution of plant species. Plants layer and grow according to the microclimatic differences in nutrient availability, sunlight, and varying interactions with hydraulic processes. The effects of microtopography and the resulting patterns of soil saturation are a factor in the cycling of nutrients and elements between the living and non-living environment (Diamond et al., 2021). The growth and cycling of plant organic material, in turn, influence the constantly developing structure of the bog from which it grew.

In combination across an entire bog, the rows of mounds and trench like dips create a vast array of vertical surfaces (Dettman & Bechtold, 2016 as cited by Diamond et al., 2021). Varied interactions between plant communities and the environment occur constantly across the complex Colchester Bog environment.

Literature Review: Observation and Artmaking

Humans cannot directly see many of these processes as they happen. Underground layers of peat, for example, are constantly accumulating, but may be hidden because of physical separation from the observer. Many important interactions within bogs are happening on spatial scales that are difficult to observe normally. Chemical exchanges between the environment and plant roots, for example, require special equipment and preparation to observe.

Scientific insight advances the understanding of ecological happenings by viewing processes through tedious examinations, specific lenses or tools, and in controlled conditions. In one study done in the Colchester Bog area, Weeks (Weeks, 1987), used a core sample of peat and underlying sediments to determine the succession of plant communities over time. The bog layers, being highly acidic and anaerobic, provide a unique space for excellent preservation. This inquiry led to predictions about what the bog communities might have looked like during different time periods. Information, layered underground and over vast periods of time, required direct attentiveness and thoughtful design to be better understood. Efforts such as this, expand our thinking to include time scales that extend beyond our normal frames of reference and push the limits of both spatial and temporal observation.

Following the collection of information, the process of visualization can lead to sharing an understanding more broadly and communicating ideas more clearly. Effective visual representations can come from an artistic toolset. By summarizing information visually in a way that connects to data, represents known properties of the subject, and is consistent in portraying details of a subject, art can be a tool for science (Goodsell, 2021). Evidenced by diagramming within botany or other fields of science, images have great power to record observations, display relationships, and communicate lines of thinking.

Representational visualizations, developed through artmaking, have room to incorporate many different features of a place simultaneously. Well defined art can effectively communicate scientific information (Goodsell, 2021), as it can layer visual information and orient individual pieces and steps of greater processes within larger systems. Depictions of ecological happenings can contextualize collections of knowledge and ideas that may have been studied in isolated experimentation. Done effectively, the process of going from information to visualization can uncover underlying relationships and insights based on structure, function, and positioning. With careful considerations and intentionality, the insights, knowledge, and observations behind a visualization can exist together in a way that is visually streamlined (Goodsell, 2021) and widely approachable.

Historically, the diagraming of individual parts of biological systems through art making has been an important and useful form of communication. Certain representations aim to be accurate and record the shapes, colors, lines, and positioning of a certain subject as they appear. This detail oriented process attempts to transfer observation directly onto material so that it holds characteristics and may be easily recognizable.

Botanical drawings have long been used to diagram various species of plants in detail. These recordings often highlight many aspects of plant forms including seed types and even root forms. Products that are visually accurate in this way can function as a resource for visual learning. Individual moments of witness can be shared with audiences elsewhere.

Diagraming within science can be very valuable learning tools. In the medical field, the neuroanatomist Santiago Ramón y Cajal translated observations made using microscopes into hand drawn figures. His discoveries surrounding brain structures, connectivity, and maturation over time found a common resting place within his drawings which were often successful in building larger conclusions by combining information from multiple observation techniques (*The Beautiful Brain*, 2016). Still today, the drawings of Santiago Ramon y Cajal are an important resource for the study of human neurological networks (*The Beautiful Brain*, 2016).

With the toolkit of art making, there is space to represent what was observed in diverse ways. In much of the artwork of Rackstraw Downes, he paints with exactness in an attempt to form realistic scenes that are recognizable without prior introduction (Schwartz et al., 2005). Every visual detail of the surrounding environment is accounted for and the resulting picture contains everything that is in plain view. This care forms a very full world that allows viewers to explore far into the horizons (Schwartz et al., 2005). Even though his viewpoints often contain very complex happenings, like city streets, or vegetated hills, Downes builds a convincing representation that is constructed through collected pieces. A complete and layered visualization is achieved by considering all foundational parts, from broad atmospheric features, to detailed individual objects. This level of detail draws viewers in towards the scene, and encourages attentive exploration. His process has been described as being hyper alert to a maelstrom of data (Schwartz et al., 2005), the data being what enters his view. The understanding that each visual piece is a mark that was organized according to his experience, encourages the viewer to notice details and grow curious about their placement.

The subjects of Rackstraw Downes' paintings, city blocks, park spaces, highway overpasses, or bridges over water, are often not extraordinary sights, and could even be labeled as unremarkable, yet he displays a great character within his scenes. There is a character that is held in these environments, even human built ones, from the inherent interaction between forms and the emergent properties that arise from those interactions. Through attentively translating the interaction of parts from a scene to a piece of art, awareness of interconnectedness in scenes can be encouraged within audiences.

Relationships between parts of an environment are a common consideration for both art making and ecological thinking. Decisions about the layout of a piece of visual art can be informed by ecological patterns, which provide insight and familiarity into spatial and temporal relationships. In works of Rackstraw Downes, paths of water, steep slopes, and human built structures are attended to with detail. The presence of these factors together influences vegetation placement and influences the appearance of the scenes especially in regards to vegetation colors. Bright yellow green grasses emerge from the streambanks or from between piles of concrete pipes. These occurrences form feelings of connection and influence.

Incorporating ecological patterns into a visual art piece can build on standard artmaking tools. An important visual consideration within two-dimensional artmaking such as painting or drawing are lines. Lines build to create spaces and shapes and the appearance of forms within those spaces. When connected to ecological thinking, lines may translate spatial patterns and relationships into a drawing or painting. The buildup of marks can represent patterns of growth or change over time. In the Colchester Bog the topographical forms and shapes of vegetation growth are dense and organic. The marks of life in the Colchester Bog, the complex branching of shrubs from uneven ground or the precise textures of moss layers, require a wide range of mark making techniques to represent them effectively.

A second important visual consideration is color. In observation, the color humans may perceive in environments is a product of light interacting with the spatial environment (Lee, 2007). The plants of an environment host a wide range of apparent colors, and this is a consequence of their interaction with light as an environmental factor. For plants, the radiant energy of the sun is a guiding force for life. Seed germination, stimulation of organ growth, spatial and temporal orientation, and photosynthesis all are centered around the reception, transduction and responses to light energy (Hart, 1988).

Color within plants, which humans may perceive, is a result of what intercepted light wavelengths are reflected and not absorbed by the plant pigments (Lee, 2007). Pigments in plants can result in a wide range of perceived colors from the interaction of the chlorophyll, carotenoid, and flavonoid chemical classes (Hart, 1988). Chlorophyll a and b are the most abundant pigment molecules on Earth and originated as the first oxygen-producing photosynthetic organisms began absorbing light for energy over three billion years ago (Lee, 2007). These pigments are the internal greens that are displayed in dense stands of vegetation in the bog. Carotenoids are often accessory pigments in photosynthetic complexes and result in a wide range of oranges and yellows (Lee, 2007). Flavonoid and anthocyanin pigments give rise to the pinks, purples, and reds that are produced in fruits, flowers, and leaves, and they play important roles in protection against ultraviolet light damage (Lee, 2007).

Color in environments is not standardized and is impure as it is full of different properties such as shine, texture, and transparency (Batchelor, 2000). Color may be treated as an independent part of an environment that is highly dependent on materials and surfaces (Batchelor, 2000). There are many features of plant surfaces that affect color. Surface structures, such as particles of wax, hairs or trichomes, or scales all influence light scattering and absorption (Lee, 2007). Other factors such as the lens effects of epidermal cell curvature, scattering effects of air spaces in intercellular spaces, and the positioning of pigments within cells may also influence plant color (Lee, 2007).

Colors are all around us, and yet, color in general is not well understood. When confronted with the immense range of hues and their infinite interactions, our human language proves to be an insufficient attempt at comprehension due to our mistranslations and misunderstandings of the language of color (Batchelor, 2000). Our names for colors that often come from collective past experiences with plants, only cover a small percentage of the vast range of perceivable colors (Lee, 2007). There is much to learn still about color perception and the roles of color in the world (Lee, 2007).

We may look to plant pigments for a place where color is valued for its role in growth, development, and survival. Being familiar with the subtle color changes that plants signal to the observer can provide insight into the function of plants in their landscapes (Lee, 2007). When the colors of a bog come together to form a landscape, they may hint at underlying patterns, processes, and interconnectedness.

Methods

Visiting the Colchester Bog created experiential connections, which contextualized my growing understanding of wetland functions from literature readings. Engaging with a local example helped to solidify my understanding of ecological dynamics within bog ecosystems and strengthen my curiosity and questioning about these places.

Engaging with the Colchester Bog environment through observation was the foundational step in making this body of art. Different areas of the bog were visited. While limited by the physical difficulty of walking through the bog and threat of ecological damage due to trampling, viewing occurred along the trail that is the former train track in the Southwest section of the bog, the trail that parallels the bog edge on the Eastern side, the boardwalk that extends into the bog from the Southeastern section, and a crossing to the pine island in the center of the Southern part of the bog when the water was frozen over. Some visits consisted of covering a large range of locations and observing in a broader sense. Other visits were more centered around sitting in one place and making more precise observations. The boardwalk was the most frequented spot, as it covered a range of bog sections extending from the edge, and allowed for access into an area of open bog.

While at the bog, the area became a context and space for questioning. Some topics paralleled a class assignment, Nature Observations, where weekly visits to a place led to contemplation and written reflections about natural processes. Topics of contemplation included: energy sources of the ecosystem, nutrient cycling, decomposition, and future thinking about how this place may change over the course of extended periods of time. These guiding questions were a starting point for thinking about and interacting with the Colchester Bog in a recurring way.

This form of questioning often approached the environment as a whole. Broad ideas about environmental factors such as water, sunlight, and soil were considered as well as large scale processes such as decomposition and growth. Sometimes, when in this environment, direct questioning yielded to practices in awareness and attentiveness. Rather than searching for answers, features of the place were noted based on what arose from listening to the soundscape, feeling the surrounding atmosphere, and sensing what it meant to be in this physical context.

Surrounding these experiences and place-based inquiries, ideas could be expanded on and explored further through literature research. Scientific studies informed views on the underlying ecological patterns of bog ecosystems such as soil conditions, hydrology, and topography. A constantly growing knowledge base made it so that every new visit to the bog included new insights and curiosities. Much of what is going on biologically at the Colchester Bog is unavailable to directly view because of spatial or temporal barriers. But having scientific insight available to build descriptions of microscopic, hidden, or invisibly slow processes added to what could be 'seen' when in this place.

From this starting point of broad environmental-scale inquiry, topics became more specific and focussed. Areas of focussed research included: hummock and hollow topography within bog ecosystems and the resulting microclimatic arrays, the specific formation and history of the Colchester Bog area, water dynamics including the acidification of bogs, soil conditions and decomposition, and impacts of development and human behavior on bogs.

A common line of further questioning were the individual plant species that were present. The plant species are what are directly interacting with these broad environmental forces such as sunlight or water. Therefore, by paying attention to the lifestyles of plants here, more insights about survival in bog ecosystems could be made. After identifying and learning the name of a plant, research could add information about adaptive traits, or mechanisms of survival. The biological information of a plant species was combined with the experiential knowledge of seeing the species grow in this specific place. This added aspects such as spatial relationships with other plants and the environment, unique individual growth forms, and change over the seasons.

The layout of the bog was full of interactions between plants and the underlying abiotic forces such as the hydrology, topography, and light conditions. The ways in which plants interacted with the characteristic environmental forces acted as the central idea of this place-based inquiry. New information was presented by how plant growth displayed a connection between life and the harsh environmental conditions of the bog. Adaptive lifestyles, precise spatial alignment, and influential shaping abilities were demonstrated by the different plant species.

Throughout the process of engaging with this place, ideas were noted in a variety of forms. Pieces of writing reflected on individual visits, encounters with plant species, conditions, and other noteworthy aspects. Photographs formed a visual reference base of plant species, topographical features, and specific moments to return to later on. Sketches using graphite and colored pencils were a way to visually note spatial patterns, light interactions, and ideas for further artmaking. Paintings were made at the bog to note color, and create a collection of color over the seasons.

The knowledge base that grew over the two semesters was tracked through the artmaking process. Following observation and inquiry, aspects of the environment and plant growth were translated into a visual language through the mediums of drawing, gouache painting, and watercolor painting. An artistic toolset was used to record specific occurrences from the Colchester Bog.

Line and form recorded spatial elements of the environment. Patterns involved with topography and vertical organization could be represented within drawings and paintings. The many diverse forms of the bog, from the low lying water surface, to the raised hummocks supported by underlying root systems, to the dense plant growth, created a complex scene. Artmaking allowed for different aspects of the underlying spatial context to be explored and contemplated from a variety of viewpoints.

Using a section of the bog as a visual reference, I would draw a group of hummocks. From the water, which was often represented through the remaining white space of the page, lines would track how the landform rose from the water surface. Darker marks were used to represent shaded and lower sections.

Sometimes, the hummocks were drawn without the plant cover. Other times, the plants were included. Old stumps and emerging branches from shrubs would be drawn. The space where these forms emerged from the hummock would be marked with precise lines. Interacting lines showed the close connection between structures and what was underlying them.

Often, the art making process would use sketches and photographs made at the Colchester bog as reference, then expand on these through more detailed drawing and painting in the Williams Hall independent study studio.

Interactions between light and plant growth were noted and represented through color. Color was also used to mark and represent the presence of environmental forces such as sunlight and water within this bog ecosystem. Variations in surface texture details or material differences between different plant species were an important consideration for color choice. Bright colors were used to represent organic material that was still growing, or more recently settled. These initially bright colors were dulled with the dark colors of the water or with browns to represent the process of decay over time. Some colors within the paintings, such as bright reds or yellows were not meant to be a direct translation of what colors were observed, but rather stand in for understood ideas of acidity, or growth. Layering colors helped to embed leaves within the water surface or roots within the substrate.

Using water was an important aspect of painting. Sometimes paints were used with lots of water involved. The natural dispersal, collection, and trailing of the water took some decision making away from myself and led to organic patterns and random occurrences in the marks and shapes. Other times, paints were used with very little water and the brushstrokes were more precise. Marks like these were used to add details.

The scale of observation would change from looking at an individual stalk of moss, to looking at an individual hummock, to looking across the landscape as far as I could see. Perspectives also varied from representing the view of standing on the edge of the bog, to looking down on the water from above, to imagined views of underground spaces.

Drawings were made with graphite and on a range of paper sizes from small sketchbook pages to large sheets from a roll of paper. Paintings were done initially using gouache paints, and then with watercolor paints. Paintings also varied greatly in sizes ranging from small pads that were easier to take to the bog area to large individual sheets in the studio space. Some paintings were done on cardboard sheets. These large horizontal panels were first covered in a layer of gesso to prevent warping from the water used with the paints.

The final series of paintings can be displayed together to allow for the viewing of visual representations of the Colchester Bog. The scale represented in the paintings ranges from a zoomed in view of the moss layer to a broad landscape view.

Paying close attention to visual signs and processing them through an artmaking procedure encouraged questioning and informed about the underlying spatial and temporal relationships of this specific place. The diverse parts of a place and the events or changes that occur there, are marked by visual information. Artmaking acted as a means of recording the lessons, curiosity, and ideas that were presented by this place. Many different elements of this ecosystem, from the topography, to the water dynamics, to the plant growth, to what it means to physically be in this ecosystem as a human being, are combined into a single body of work.

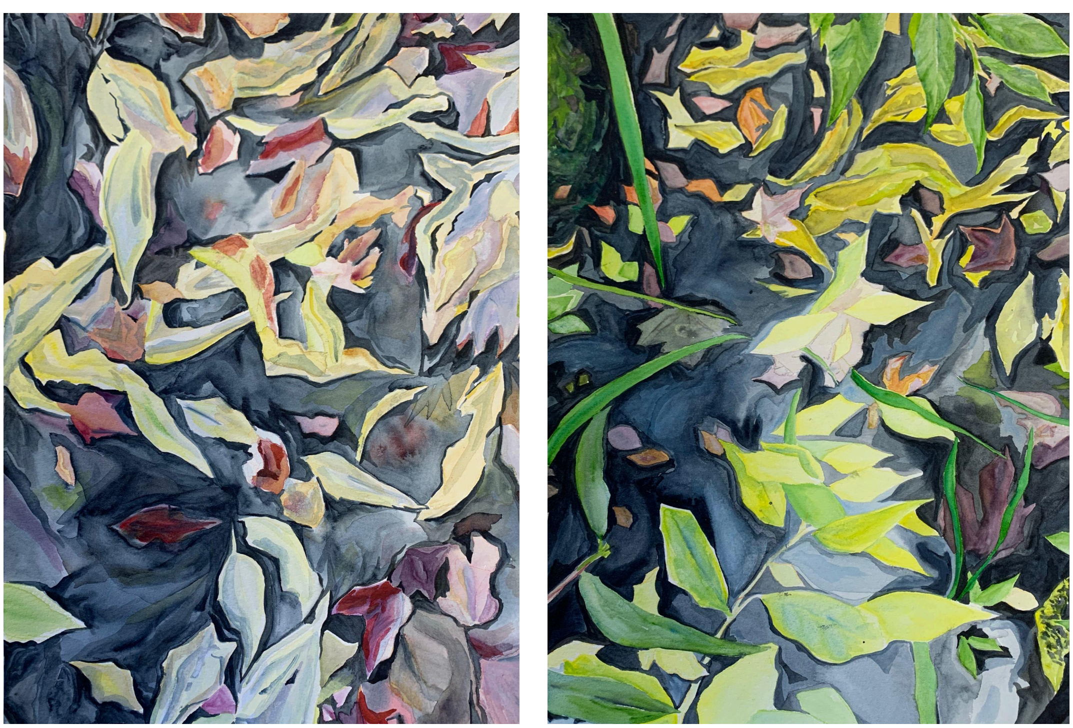
Results

Features of the Colchester Bog were translated into a visual form through art making. Broader ecological patterns across space and time added a framework for artistic questioning and exploration in this project.

One of the most impactful environmental factors in the bog was water. The water throughout the bog is less of a flowing entity, and more of an embedded part of this place. It accumulates from precipitation events, and rests very still between the hummock and hollow forms. In some places, only a couple inches of clear water rest on top before becoming intermixed with sunken pieces. Under the still surface, the water holds layers of dark leaves and debris. Brighter leaves from the most recent fall rest towards the top, shifting to darker layers below. Stirring it disrupts the sediment and causes a swirl of browns, oranges, and purples while releasing a heavy, rich scent of decomposing leaves. The water is thick with slow decay and organic matter. In places, not much solid ground exists, and even a long stick won't find the bottom of the sludge. Information about the high acidity, low oxygen, and source isolation in this water moves through my head while engaging with the quiet water.

Water is what underlies the growth in this area, and the connection through water is central to the setting, so it needed to have a central place in the artworks. Within the art works, water was painted with the heaviness and congested layers in mind. Color layering helps to form the impact that the water has on this place (Fig. 1). It holds color gradients of decomposition and conditions such as acidity or low oxygen (Fig. 1). Leaves would transition from bright greens and yellows to deep browns and blues as they sunk and became embedded in the layers.

Fig 1. *Water Surface,* Fertik, 2024, watercolor, 18" x 24"



Water as a substance hosts shaping characteristics of the bog environment. It is life giving, but also low in nutrients and requires that life survives according to its conditions. It is the medium where reciprocal interactions between chemical characteristics, soil, and plant growth occur in the bog. The water is in close contact with landforms, and the plants that grow on them. Motion in the brushstrokes of water settles, seeps, and wicks, between plant and landforms, representing the way in which water is often closely held within the saturated land or plant forms (Fig. 2). In some places moss communities would grow right up to the water edge and, some parts would even grow under a thin layer of water. This led to a visual where the greens of the moss were embedded within the water itself.

Fig 2 *Hummock in Winter,* Fertik, 2024, watercolor, 18” x 24”

The interactions between water, land, and plant life were very visually connected. There is room within an artistic toolkit to add details of the interactions by closely considering spatial context and adding marks and colors to represent the water characteristics. Layers of paint washes were used to embed the colors of slowly decomposing organic material and underlying plants into the colors of the bog water.

Using water as an integral part of the gouache and watercolor painting helped to embed the physical characteristics of water into the artworks. Water, in this way, could guide the layout and behavior of the paints. Sometimes the water would collect or drip, displaying the colors in very organic ways that mimicked the flow of the bog water. The surface material used in the paintings influenced these details as well. Paintings on paper resulted in smooth washes and predictable flow of water. The paintings that were done on cardboard were more responsive to the properties of the material itself. The underlying rectangular spaces in the cardboard layers were revealed in the paintings.

Some of the works include imagined below surface spaces (Fig. 3), where the vastness of the layers of organic matter can be felt. This recognizes that what we are able to see from above is not the whole story. There are countless microscopic interactions occurring throughout a large area that give rise to the above ground plant communities. In these imagined spaces, the complexity of interactions was shown through dense layers of colors, busy movements, and fluid marks.

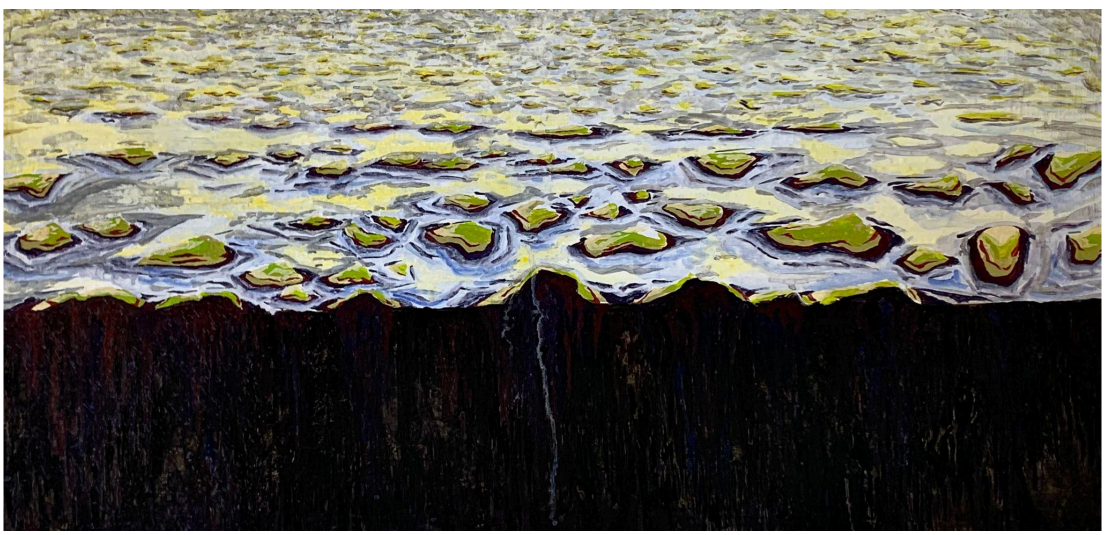


Fig 3, *Under the Bog Surface,* Fertik, 2024, Gouache on cardboard, 18” x 36”

The emergence of land forms and the resulting topography of the bog was another visual theme. Sediment deposition may slowly give rise to new ground spaces, or tree fall may more rapidly supply relief from the water. Using line work in drawings, these formations can be represented as something that builds up across the landscape over time. Built up layers of lines can show periods of growth, like in the growth rings of a tree. Or they can translate into vertical space, like in a topographical map. Drawings used interacting lines to translate the topography of the Colchester Bog in a layered and dynamic way (Fig. 4). A diverse range of hummock shapes, sizes, and heights occur in this place. Organic forms build from deposition and the input of organic matter. The many lines used in the drawings show the constant motion and formation which may escape our notice during a single observation.

Fig 4 *Emerging Ground*, Fertik, 2024, Graphite, 12" x 16"

The hummock and hollow topography of the bog spreads across the horizons in a complexity that is hard to follow visually. It is vast, organic, and covered with dense shrub and tree growth. For this reason, some works focus only on the land forms, and not the plants themselves. When the shapes of hummocks rising from hollows are isolated, patterns in spatial changes can be seen looking out across the bog surface (Fig. 5).

This practice helps to contextualize the plant life by focussing on the bog surface underlying the plant growth.

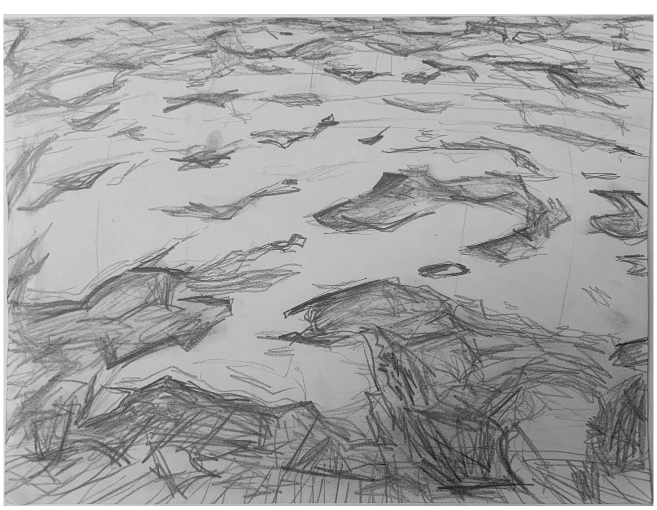


Fig 5 *Topography*, Fertik, 2024, Graphite, 12" x 16"

The topography of the bog is an important structural aspect for plant life here. A range of microclimates climbs up along the growing ground spaces as raised areas slowly build up away from the conditions of the water. These are patterns that the plants are very attentive to. Sharp line edges in drawings and paintings mark the transition from the water's edge. The spatial scale here is very precise and small differences of topography can lead to large scale differences in productivity, biodiversity, and resilience (Diamond et al., 2021). One space may be the right growing conditions for a particular species of plant, while another close by space may have largely different conditions that make it unsuitable.

The stratification of conditions informed another layer of visually displaying the hummocks and hollows. The changes of conditions across small spatial scales were a foundational thought for colors and line placement within the topographical art pieces (Fig. 6). Specific areas in the bog, as small as one individual hummock, host a range of colors and textures due to the soil conditions and the subsequent alignment of different plant species. Mosses rising from the dark water overlap each other. Higher up seedlings and woody species grow, making for a gradient of life along the conditional changes. Patterns of growth align with vertical spaces because of their relationship to the water and other abiotic factors.

Fig 6 Detail of *Topography Colors*, Fertik, 2024, Gouache, 18” x 24”

Organizing the visual pieces of an observation into an artwork was like mapping conditions through mark making. In one area, there might exist a tall, dry, sunlit hummock that is structured around an old broken tree stump, and next to this, there could be a low shaded hummock that is low enough to be saturated with water. Data across a space such as this would reveal variation in acidity and moisture that drive the spatial distribution of plants (Bengtsson et al., 2016). These two spaces take a wide range of colors and light conditions within a painting to hold all of the variation in conditions and subsequent plant life.

The plants of the bog were an important inspiration to the artworks. The variety of growth forms here, from the low sphagnum layers, to the complexly branching shrub layers, to the trees, was inspiration for mark making. Plant forms differ as a result of diverse adaptive lifestyles. Translating the differences of growth between these layers meant experimenting with different types of lines. How do you represent a tree trunk emerging from a hummock, covered in moss with only lines and colors? The differences between growth habit, location, textures, and any other distinguishing factors have to be carefully considered. The resulting physical structure of these plants and their interactions with the topography was a great practice in spatial organization within drawings.

Color making with the watercolors and gouache was also informed by the plants in the bog. During observation, the colors are witnessed within their biological context. There are many different greens filling the bog space. Slight variations in color exist due to various morphological features of different plants. Internal leaf pigments, patterning, or small scale structural components of leaves all lead to unique appearances. Paying close attention to what colors were present in the bog, helped to realize the diversity of adaptations and growth forms that were present.

The thick leaf surfaces of Sheep Laurel (*Kalmia angustifolia*) display a tough and waxy bluish green. The vase structures of Northern Pitcher Plants (*Sarracenia purpurea)* are patterned with veins of red and purple on their modified basal leaves. This patterning is thought to help to attract insects (Lee, 2007). The dense mats of various Sphagnum moss species ranged from pale green to reds and purples. The intricacy of the dense mats of small scale branches and leaves made these colors visually complex and very textured. As seasons changed, the greens of chlorophyll faded to reveal other underlying pigments in some plants. The Red Maples (*Acer rubrum*) transitioned to the bright reds of underlying carotenoid and anthocyanin pigment layers. The needles of the Tamaracks (*Larix laricina*) went from a blurry green to a golden yellow as fall came.

As plant surfaces interact with the environmental factor of sunlight, the resulting display of colors can clue us in to the broad range of life forms and survival mechanisms going on in a place. At the Colchester bog, there is no common “green” of plant growth. Close consideration reveals a range of colors as diverse and intricately layered as the life here.

Being inspired by the endless range of colors within biology that can be influenced by factors as precise as leaf intercell spaces, microsurface structures such as hairs, and pigmentation chemicals, creates a palette that changes fluidly. When painting, the making of colors was very flexible. Paints would sometimes be added to the pallet in clusters, but not mixed. In this way they were near each other and could be combined in unique ways without being standardized. Continuous subtle additions of yellows and blues to paints on the pallet, rather than premixed combinations, creates tiny variations in colors across the images.

Whenever I would approach the bog from the forested side, the changes in sunlight would always be very noticeable. In the forest I would be in a deep shade under the tall canopy layer, while out away from this forest edge, sunlight flooded into the basin among the smaller trees of the bog. This was a reminder of the impact of light as an environmental factor on plant life in an area. Washes of colors were used to create feelings of light entering the environment as a force of growth.

The plants on the bog surface are set to receive the solar radiation. Vertically, the bog is densely layered. Sunlight is absorbed by the canopy, through the shrubs, to the ground layer of mosses and embedded plants. Biological colors could be seen across scales of size and vertical layers, in a way that felt like the plants were catching the light. A couple landscape watercolor images were oriented on a slightly tilted axis in order to represent this idea of collecting light. If the paintings are oriented so that the lines representing the bog trees are positioned vertically, straight up and down, then the edges of the paper will point to the angle that the sunlight was entering the bog.

Translating observations from this place into artistic representations grew my own art making practice in many ways. My observational skills were strengthened throughout the process of returning to the same place and being attentive to what was going on around me when at the Colchester Bog. Creating images while being at the bog was a practice in making art outdoors and in the elements. Making visual notes through sketches was helpful in recording certain spaces and incidents. Doing this accurately formed a visual reference source. My technical skills and style both evolved from representing the ecology of the bog into visual works. Decisions about how to represent topographical features and dense layers of vegetation cover led to great experimentation with line and form. The immense range of colors that were experienced over the time spent here helped to grow my understanding of color as a representational tool.

Towards the end of this project, a large selection of works was selected and displayed at the University of Vermont Student Research Conference. Around twenty art works were set up at a table and on display stands. Written notes were displayed alongside the art works. Many students, faculty, and members of the public approached the work over the course of the day. Discussions about the process, the bog, and many other topics were had.

Discussion and Conclusions

The Colchester Bog was a successful place to observe many characteristic processes of bog and wetland environments. This project steps away from the standard scientific procedure model to focus on holistic observations in an effort to better understand how the bog functions as an interacting system. By attaching this project to a specific place, the interaction with the scientific background changed. Rather than having predetermined lines of questioning, the body of research evolved as new ideas were presented. Approaching an ecological system as a whole led to a wandering path of questioning that was directed by experiences and curiosity. Knowledge was flexible to grow and change as I spent time there, and new ideas and connections developed. Encounters with the plant communities and the ecological interactions that they are a part of strengthened understandings through contextualization. This is an important part of creating meaning around scientific concepts (Davies et al. 2019). Over time, as seasons changed, as water levels swelled and retreated, as I became familiar with new species of plants, the learnings had space to evolve, but were still connected to a specific place.

Normal observation is only presented with the surface of what is happening. It is not easily approachable to know how processes are fully behaving and acting in the environment, or interacting complexly with surroundings.

Learning about biological processes and patterns through science can alter perception when looking into the world because science proves what occurs constantly, yet goes unnoticed through common perspectives. The complexities, interactions, and unknowns of ecological systems are understood to be there even if we may not be able to directly view them.

The effects of bog microtopography and water interactions on plant community distribution and growth was seen at the Colchester Bog as it developed over the course of nine months. Literature surrounding bog topography and microclimates discusses the precision involved with vertical scale variations (Newman et al., 2019). The topographical context of diverse shapes and forms of the hummock and hollow patterning reinforced this idea (Raulings et al., 2010). Many unique occurrences involving the water, the land, and the plants occupying specific places were noted and considered while at the bog. Nested ecological units and structural heterogeneity (Newman et al., 2019) existed in the bog. Singular hummocks hosted a range of conditions, and as you change to a landscape scale, these patterns grow and become more broad, creating a landscape with a wide range of environmental conditions.

Being in this place revealed the dynamic and changing nature of the landscape. Ground spaces shifted as new leaf material, sediment layers, and tree fall accumulated (Raulings et al., 2010). Water's impactful presence was obvious in the Colchester Bog. The ground was always saturated and often unstable due to underlying water. Plants were often seen growing in very close contact with the water surface. The effect that water had on species distribution (Shi et al., 2015) was obvious as some plants such as the sphagnum occupied spaces close to the water layer whereas others such as Sheep Laurel resided on the dry hummock tops. Precipitation events and freeze-thaw cycles changed the water level between visits. Plants species must tolerate these natural fluctuations (Raulings et al., 2010) and the spaces that they occupy do not have consistent conditions.

Observations and learnings that developed over the course of two semesters were translated into a visual representation through art making. Translating observations of the bog topography into drawings and paintings helped me to familiarize with the precise relationship between soil conditions and plant distribution vertical spatial patterns of bogs. These art making practices reflected the precision of spatial organization within the bog. Marks represent the unique landform shapes of the hummocks and the placement of colors was attended to with great consideration based on what was seen at the bog. This precision, can draw viewers into a two dimensional scene and encourage exploration.

A limitation to observation of the bog topography was the dense growth of shrub species in the Colchester Bog. When looking across the landscape, the view was filled with complex branching lines and I could not easily see horizon lines. To highlight the underlying topography, many of the art pieces filtered out the layer of plant growth, and instead focussed portrayal on the hummocks and hollows. This ability to apply visual filters comes from a flexible artistic representation. Forming spaces through art making begins with a unique perspective. Although coming from a viewpoint that exists in the real world, each visualization is created by an individual observer. This means that there is great interpretive range based on factors of decision making. Where to look, what to notice, how to retell the story of that experience is all coming from undefined beginnings. From here, unique connections between the underlying observations can form, highlighting specific ideas within sets of visual information.

Color within the artworks was informed by color within diverse plant structures and surfaces. To inform the ongoing discussion on color theory and the human relationship with color (Batchelor, 2000), this project considered the interface between plant surfaces and sunlight, using the range of colors found within the Colchester Bog as an example of how color and biological happenings are interconnected. Leaf surfaces of various plants displayed an immense range of colors, and being acutely aware of differences between these colors helped with identification and recognition of adaptive differences between plants (Lee, 2007). While color within painting may be superficial or ornamental (Batchelor, 2000) the colors of the Colchester Bog show that it is a very important and embedded feature of plant life.

Plants, ranging from groundlayer mosses, to herbaceous species, to trees and shrubs displayed their understood mechanisms of survival in the harsh bog ecosystem. Experiencing these species within the context of their bog habitat revealed the broader contexts of their growth. Vertical layering and competition to find light resources, created a very full display of plant-light interfaces and a resulting flush of biological color.

While paintings can collect a large number of colors in a space, they do not hold the same visual effect as the internal colors of plants. They are far less complex in their appearance and roles. The applied pigments coat the canvas fibers evenly while the internal pigments of plants are essential for life and compartmentalize according to function (Lee, 2007). It is still useful to consider how color may act as an ecological detail and for it to inspire painting techniques.

Using the observation and exploration of plant color as a questioning guide may lead to further questioning about specific plant structures and adaptations. The botanist David Lee explores light environments, structural colors, and the ecological function of leaf colors in tropical forests (Lee, 2007). Connections can continue to be made, in the future, that link visual appearances of plant colors to the interactions between plants and their environments.

Understanding where to take a closer look in a landscape can come from observing and contemplating the complexity of interactions occurring in a place. Observations can provide a surface level entry for forming ecological questions. Color may be a good starting point for refined questioning because it signals structure, process, and change in plants.

Greater questioning also benefits from the sharing of ideas. When informed by scientific inquiry and understanding, art can be a place where ideas compile. Combining art and science can boost learning by attaching emotional responses and engaging the imagination (Thompson et al., 2023). Scientific communication may benefit from aspects of engagement that art often considers heavily. Art has an ability to draw people in and it may have a role in increasing the flow of information between people, leading to greater communication about environmental knowledge and concerns (Richter et al., 2019).

As this body of work has been made accessible to audiences, it has sparked conversations and questioning. When presenting the art at the UVM Student Research Conference, people would sometimes just pass by and quickly glance at the visual works, but this moment of curiosity sometimes was the beginning of a greater interaction. Initial engagement often led to a conversation, a telling of the story of the Colchester Bog based on my experiences with this project, and lots of questions about the place and the art making. The art has been commented on as approachable, leading to lots of casual engagement with a variety of people and interests.

When the entire body of work is presented together, conversations take place, and it feels like a story forms about the Colchester Bog. By translating observations of this environment into expressive forms, a narrative developed around a specific place. Discussing broader wetland ecological themes and specific aspects of the Colchester Bog hopefully nourishes greater interest, encourages reflection, and contextualizes scientific ideas (Richter et al., 2019). It is important to strengthen the connections that humans hold with surrounding ecologies, and art making is one way of doing this.

Greater awareness of the functioning and importance of bogs, wetlands, and all environments is important for the connections that humans hold with the world. Healthy and diverse ecological systems can host many functions that are important for a wide range of life forms. Being acutely aware of the details of ecological systems can inform how negative impacts from human behaviors may be reduced and ways of living can become more harmonious.

When the connections between biological components are healthy, ecological systems can be stable, self-regulating, and resilient. Healthy ecosystems thrive with diverse parts carrying out varied roles and occupying various spaces. Alternatively, close attachments can echo harmful effects throughout a place and amplify the negative impacts. The health and function of the spaces that we occupy benefits from knowledge that extends beyond our human communities and integrates a better understanding of the places around us. Living in accordance with natural systems requires recognizing the connections that exist between the many living and nonliving parts within a setting. We are positioned in the middle of exchange, attached to sites, and associated with the nonhuman individuals. We belong to the ecologies around us.

Currently there is much disconnect between humans and life-sustaining processes (Kolan and Poleman, 2009). “The manifold ways by which human beings are tied to the remainder of life are very poorly understood, crying for new scientific inquiry and a boldness of aesthetic interpretation.” (Wilson, 1984). Better alignment with greater life during a changing climate requires acknowledging our connections and impact to the ecologies around us. Careful and meaningful observation and the openness to learn from functional ecological systems can help guide societal decision making about resource use and behavior. Applying the lessons that come from careful observations of natural systems can help to find innovative approaches to societal problems that benefit human well being and general biodiversity (Cohen-Shacham et al., 2019).

Artmaking may reveal connections between human presence and places that may not be broadly considered otherwise. As the world continues to change, and ecologies reflect collective human behavior, art takes into account what it means to be there as an observer.

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