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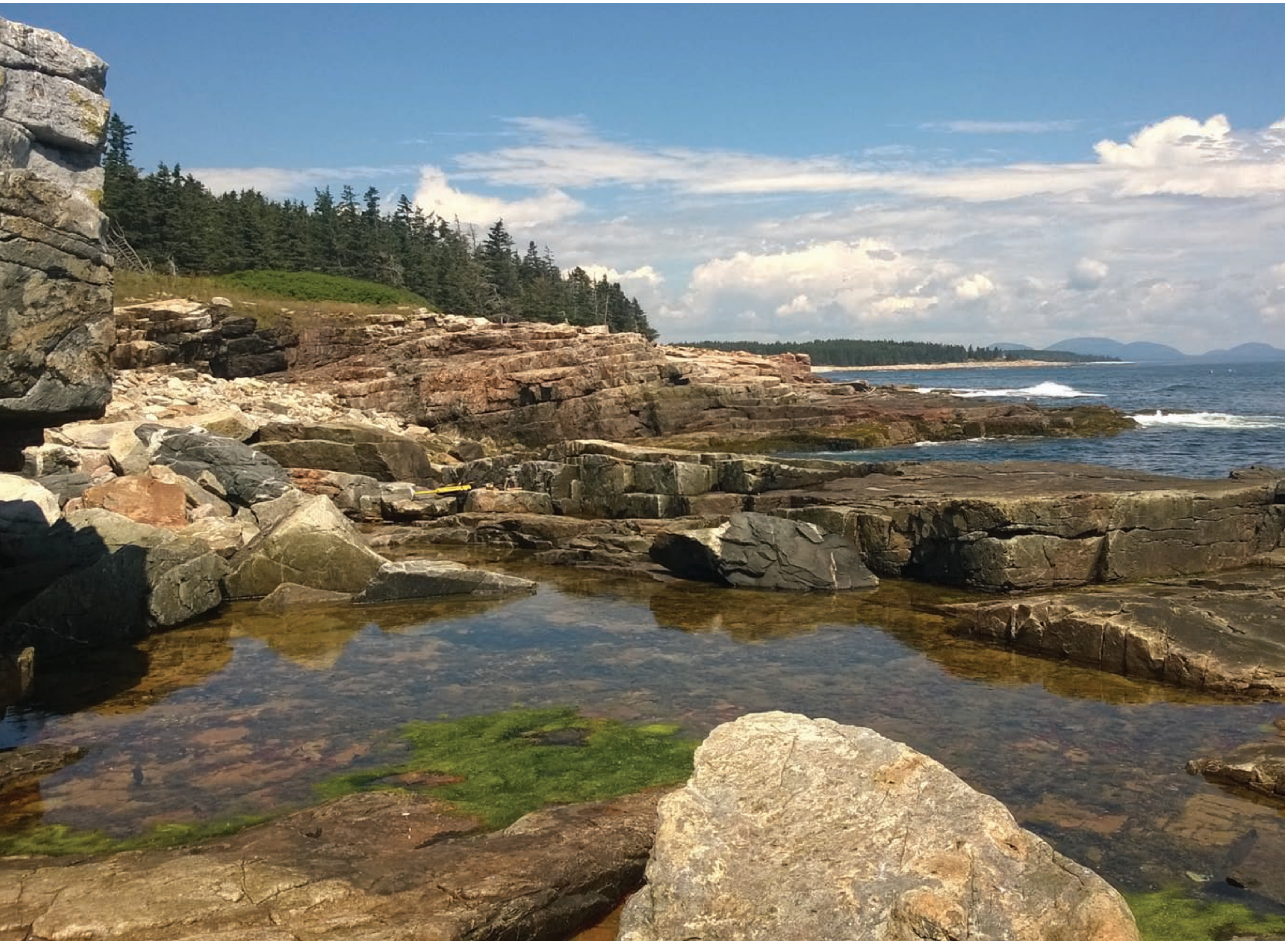

The eastern shore of Great Duck Island looking north towards Mount Desert Island. *Photo courtesy of the author*

The Paleoecology of Great Duck Island

By Gemma Venuti

All landscapes have stories to tell. The towering skyscrapers of New York chatter about the beginning of the Anthropocene. The Long Donegal beaches of Ireland whisper tales of cliffs crushed to sand by ocean waves. Snowy dunes in Maine moan of hard, cold landscapes and ancient volcanoes. New Zealand's hot springs babble about the young, changing land. Of all the marvelous landscapes of the world, small islands have some of the most fascinating stories to tell. This is a story, built on clues from the bedrock and soil, of Great Duck Island, Maine.

Present-day Great Duck Island is a small, coastal island about twenty-five kilometers south of Bar Harbor. It is only one of more than four thousand islands in Maine, but it holds a special place in the hearts of many Mount Desert Island residents. Great Duck Island is a research site cared for by College of the Atlantic, the Nature Conservancy, and private owners. During the summer, the place is home to a small group of students who collect data on the island's seabirds while completing projects on subjects including geology, music, drawing, and human ecology. The island's idyllic landscape of spruce forest, fields of long grass, and pink granite cliffs topped with an old lighthouse make it a popular destination for local cruise tours. Attentive visitors spot eagles soaring over the gull colony, guillemots transporting rock gunnels back to their young, and rafts of eider ducks floating among sea wrack and rocks. As winter approaches, it is easy to imagine the island going to sleep, covered in a blanket of snow and enclosed by the rough Maine ocean. But anyone who has been lucky enough to land safely and explore the island during the colder months will find hundreds of small footprints left in the snow by snowshoe hare. They would also find that the waves crash further up onto the island's shores, making the boulder beaches all but impassable compared to the gently sloping berms of summer. Every now and then, a large chunk of granite will slough down into the sea, perhaps to be carried to Sand Beach or further into the ocean. When this happens, it is easy to imagine Great Duck Island disappearing completely. Global sea level rise is already beginning to engulf the small island's total relief of twenty-one feet, where every inch of sea level rise is noticed. More than a kilometer of ocean separates Great Duck from Little Duck Island, but they're connected by an underwater peninsula. The middle of Great Duck Island becomes flooded during large storms, so island researchers joke that we will eventually have Little Duck, Medium Duck, and Slightly Larger Duck.

Great Duck Island's current population of students, researchers, professors, vacationers, and explorers are the end of a surprisingly long line of island residents.[1] Before the island became a research center for undergraduate students in 1988, it was home to the Coast Guard, which ran the lighthouse. The Coast Guard had taken over lighthouse duties from the original lighthouse families, who began their work in 1890. But records of non-native ownership of the island go back further, to 1792, when the island was bought by Nathan Jones. For generations, the island passed from family to family, including a few who attempted to convert the rocky island landscape into farmland. Multiple grazing animals lived on the island, including sheep, cows, and at least one pony. During that time, families and individuals came and went from the island as needs dictated. In the years leading up to World War I, there were enough children on the island to warrant the construction of a schoolhouse. Like many of the human events on the island, the school was not long-lived, and closed before the end of World War I. Although the population of the island dwindled, Great Duck Island's lighthouse remained operational through two world wars, the ravages of the Great Depression, the atomic bombings of World War II, and continues to stand tall in this era of global oceanic pollution, as microplastics travel through the water and creep their way up to its steps.

As long as humans have lived on the island, seabirds have used it longer. Eider ducks, guillemots, Atlantic Puffins, Leach's storm petrels, herring gulls, and black-backed gulls all nest on Great Duck Island. Currently, the most populous species are the Leach's storm petrel and herring gull. Students researching these petrels have estimated that there are about five thousand nesting pairs on the island. Although there are thousands of petrels on the island during the summer, visitors rarely notice them because they nest underground in burrows. They are only active at night when they fly around the forest, making surreal cackling calls. Gulls are much less numerous on the island than the Leach's storm petrel, but are the first thing anyone hears as they emerge from the shady spruce forest into the southern fields. Gulls also dive bomb anyone that comes close enough, and have a distinctive rotting fishy odor. We do not know when gulls began to nest on Great Duck Island, but there was a well-established herring gull colony by 1901, and six years later the island's gull colony might have been the largest in the United States. Between 1931 and 1943, an unknown cause reduced the gull population by one-third. Then, from 1943 to 1946, officials culled an additional 138 nests and 1,160 eggs. The gull colony has continued to decrease in size since College of the Atlantic researchers first started observing it, but it is unclear whether this decline has been steady or sporadic. It is likely that the colony will continue to decrease in size due to continued predation by eagles and as climate change makes local conditions unpredictable.

The natural world itself is a record of time and events. When objects form or animals and plants grow, they incorporate information about the time of their formation and growth into their physical form and chemistry. The composition and shapes of rocks tell us if a landscape used to be riddled with volcanoes or if it once existed at the bottom of an ocean. Tree rings show the lengths of the winters the tree has lived through. To study Great Duck Island's past, researchers analyzed sediment cores from its wetland. Sediment cores are long cylindrical clumps of soil obtained from pushing a long hollow tube into the ground. We don't typically pay a lot of attention to soil in our everyday lives, but the information it holds is incredibly valuable. Every time something happens at the surface of the earth, the event is recorded in the variety of debris that falls to the ground. Ash from volcanoes and fires, heavy metals associated with mass migration, and nuclear fallout from wars,

Herring and great black-backed gulls take off as an eagle approaches.
Photo courtesy of the author

tests, and accidents are often found in sediment cores. Even small events like the slow growth of plants and the deaths of individual animals are recorded in the soil. Material found at the top of the core represents the most recent events, while material at the bottom of the core represents older events. Researchers date the core's contents using isotopes, noting the ages of especially interesting layers. The cores taken from Great Duck Island have been dated using a lead isotope which indicates that the oldest sediment in the cores is about two thousand years old. The cores contain enough information to occupy years of research. In my year of research, I focused primarily on fire history, microplastics, and human history. Where there was time, I also took samples to study nesting gull history, paleobotany, and storm surge history, but that research is ongoing and will be added to the story by other students.

The first half-inch of material at the very top of the core represents the island's most recent history. One of the recent events that changed the composition of the island's sediment is the fire of 1947, which was so large that the ash reached Great Duck Island. Evidence of the fire is present in the form of charcoal, which is one of the most pervasive materials within the top few centimeters other than bog sediment and spruce needles. The top of the core also contains grass charcoal from a small 2003 fire on the northern end of Great Duck Island. The second most pervasive material, identifiable by microscopy, is microplastic. Microplastics are small and often fibrous, usually only a few millimeters long. They originate from plastic products like water bottles, but also from clothing that incorporates polyester and acrylic textiles. Two cubic centimeters of sediment taken from the top 5 cm of the core contained almost one hundred microplastics. It would be difficult to identify the origin of microplastics on Great Duck Island, but it's safe to say they would have been brought to the island by air and by sea, and also by unsuspecting humans. As remote as the island is, it is not immune to the effects of the Anthropocene — a new epoch defined by humanity's effects on the planet. Our actions have left debris in thin but unmistakable layers that wrap around the entire globe. This thin layer is unmistakably present in the first nine centimeters of the core.

Traveling down the core, the next identifiable zone spans from 20 cm to the 40 cm mark. This zone contains the densest region of charcoal, which was also accumulated during a period of human habitation on the island. The amount of charcoal reflects the use of fire as a tool to stay warm, cook, clean, and possibly clear land for cultivation.

The subsequent zones of charcoal are scattered throughout the 40–145cm zone. They are less dense and accumulated before a written record of humans on the island. These zones probably represent smaller fires caused by lightning strikes or other natural phenomena, or larger fires on nearby islands that produced ash clouds large enough to travel to Great Duck Island. Large fire events start back up again 145cm to 152cm down the core, depths that represent events more than one thousand years old. Great Duck Island would have looked similar then, albeit with some key differences. The island would have been made of the same rock, have the same general shapes with the same dips and slopes, but according to the morphology of the core's charcoal 147–149 cm down the core, the island would have been home to a much larger population of deciduous trees. Charcoal gives less detailed information about vegetation than other materials like pollen, but can be used to identify vegetation type down to grass, conifer, and deciduous trees. Even this general information is important to the story of Great Duck Island, because the forest is currently dominated by spruce trees. Any shift in this domination shows a complete alteration of what we know of the island's story. The large amounts of deciduous tree charcoal existing in the relatively small 2 cm zone suggests a shift not only in forest composition but also climate. Temperate deciduous forests grow in slightly warmer conditions than coniferous forests,[2] which suggests that the climate around Great Duck Island warmed by a few degrees for several hundred years before cooling down again. However, the growth of deciduous trees could also be due to another cause.

The sediment core ends at 147 cm, a point representing about two thousand years ago, but the record of the island's past continues in the bedrock. Great Duck Island's bedrock is igneous, and manifests as large chunks. Because of this, it does not hold the same kind of chronological data as the sediment core. Instead, the dominant story the bedrock holds is of the island's formation. The bedrock is a complex mixture of granite, rhyolite, and basalt hundreds of million years old.[3] The bedrock's igneous nature tells us that Great Duck was born of fire and molten rock. Granite cools slowly under the earth's surface, so its existence on the island suggests that a great tectonic event brought it to the surface. The island is also made of rhyolite, a rock that forms quickly at the surface. The island's rhyolite is pale, with a mixture of black straight and squiggly lines running through it. These black lines are called dykes and formed when lava filled cracks and crevices in the bedrock, solidifying as it cooled. The geologic law of crosscutting relations tells us that rock cutting through other rock must always be younger; it's the same principle as injecting chocolate into a dessert. The intrusion occurred last, because otherwise there would be nothing for it to penetrate. This means the dykes are younger than the surrounding bedrock because they cut through the granite and rhyolite. Although the island formed from fire and lava, its shape is most likely due to ice. Great Duck is long and narrow and its longest axis runs north to south, suggesting that it was shaped by the ice sheets moving south across the Gulf of Maine during the last glacial maximum, twelve to eighteen thousand years ago.[4] The movement of the ice sheets would have scraped and carved the island into the shape we observe today. Some of the island's higher cliffs were sheared and polished by the ice; the rock remains smooth and shiny to this day.

Great Duck Island has gone through many transformations during its long lifetime — and will, of course, continue to change. In time, the seabirds will leave the island, the lighthouse will continue to crumble as its foundation fails, and the rest of the island's pink granite cliffs will slough into the sea. However, even as the island melts back into Maine's dark waters, it will leave behind a legacy of geology, seabirds, hardworking lighthouse keepers, and researchers that will be documented in writing as well as in the sediment of the ocean floor.

Gemma Venuti is a recent graduate from College of the Atlantic, where she focused her studies on Geobiology and Geographic Information Systems (GIS). She spent many months on Great Duck Island and Mount Desert Rock studying Leach's storm petrels, geology, and botany. The research on Great Duck Island's

The Great Duck Island Lighthouse station, circa late nineteenth to early twentieth century. *Courtesy of the United States Department of Commerce, Bureau of Lighthouses* *sediment core was done at the University of Maine, Orono. As a graduate, Venuti worked at the Lane Council of Governments in Eugene, Oregon analyzing environmental data. She is now focusing on creating remote environmental data loggers using Arduino and preparing for the next stage of her career.*

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1. Dr. John Anderson at College of the Atlantic has spent many years tracking down records of the island's human history. John Anderson, "Great Duck Island: A Preliminary Report 1999–2017" (unpublished manuscript).

2. "Coniferous Forest," NASA Earth Observatory accessed September 9, 2019, https://earthobservatory.nasa.gov/experiments/biome/bioconiferous.php

3. Spencer Grey III, Sarah R. Hall, Melanie J. Michalak, and David G. Bailey, "A New Look at the Geological History of Great Duck Island and Mount Desert Rock Through High Resolution Aerial Imagery, Geologic Mapping, Geochemistry, and Geochronology." Poster presented at the Geologic Society of America Conference, Pittsburgh, PA, March 19–21, 2017.

4. Arthur S. Dyke, "An Outline of North American Deglaciation with Emphasis on Central and Northern Canada," *Developments in Quaternary Sciences*, vol. 2b (Amsterdam: Elsevier, 2004), 373–424.