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Holocene in Fragments: A Critical Landscape Ecology of Phosphorus in Florida

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HOLOCENE IN FRAGMENTS: A CRITICAL LANDSCAPE ECOLOGY OF PHOSPHORUS IN FLORIDA

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by

Zachary A. Caple

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Abstract

Zachary A. Caple

Holocene in Fragments:
A Critical Landscape Ecology of Phosphorus in Florida

This dissertation is a study of the landscape ecologies made by the phosphate fertilizer industry in Florida. Chemical fertilizers are one of the big stories of our times, rivaling fossil fuels in terms of Earth-altering effects. I use the Florida phosphate industry and the human-altered phosphorus cycle as a lens to understand the emergence of what earth scientists call the Anthropocene. Unlike most Anthropocene scholars, I argue that we are not “in” the Anthropocene so much as we are living through the Holocene/Anthropocene transition. Studying the Holocene/Anthropocene transition, I assert, requires arts of noticing patchy multispecies landscapes with both Holocene and Anthropocene parts. It also requires anthropological elucidation of industrial capitalism. Understanding how industrialization drives the Holocene/Anthropocene transition is at the core of a new discipline I call *critical landscape ecology.*

At the heart of my critical landscape ecology of Florida is a structural critique of the human-altered phosphorus cycle and the industrial food system it fertilizes. In the Anthropocene, phosphorus forms a broken biogeochemical cycle, feeding the capitalist world-system in a one-way flow from mine to farm to fork and to water body. By learning to convert phosphate rock into an overabundance of cheap food, humans have created the biogeochemical foundations for economic, human population, and (sub)urban growth.

Located within Central Florida is one of the world's largest and oldest phosphate-rock-producing regions, known as Bone Valley. Central Florida is also an agricultural region with lakes, rivers, and estuaries that have been polluted by phosphate fertilizers. Lastly, it is a region transformed by suburban sprawl and the politics of growth. I examine how phosphate mining, the eutrophication of agricultural watersheds, and suburban development have fractured the regional Holocene and generated an Anthropocene. As Holocene natures are destroyed and polluted, Floridians invest in restoration and conservation. I document how environmental managers attempt to stave off the ecological entropy unleashed by phosphorus industrialization. Attending to the natural history of this mosaic Holocene/Anthropocene region reveals a strange and surprising mix of invasive weeds, native remnants, restored habitats, and the ghosts of extirpated species.

Acknowledgements

A dissertation is a living document. And like an organism, it belongs to and emerges from a mosaic of ecosystems. The project got its start in a freshwater ecology course at the University of Michigan Biological Station on the shores of Douglas Lake. It is there that I learned about the pollution and restoration of Lake Apopka in Central Florida. The seeds for the project were planted in Northern Michigan, but the dissertation underwent metamorphosis on the campus of the University of California Santa Cruz amidst the redwoods, chaparral, and views of the Pacific Ocean.

My debts to the University of California Santa Cruz and its circle of multispecies thinkers are deep. I am grateful for the mentorship of my dissertation committee: Anna Tsing, Andrew Mathews, Lisa Rofel, Laura Ogden, and Heather Swanson. Donna Haraway, Nancy Chen, Mark Anderson, Don Brenneis, Margaret Fitzsimmons, Susan Harding, Danilyn Rutherford, and John Thompson helped me think through aspects of my approach. I am thankful to friends whose intellectual camaraderie has made all the difference: Katrina Schwartz, Jude Todd, Colin Hoag, Jerry Zee, Kirsten Rudestam, Tim Johnson, Gregory Cushman, Christoph Rosol, Daniel Muenster, Ursula Muenster, Richard Bargielski, Rachel Cypher, Xóchitl Chavez, John Moran, and the participants of the Planetary Transitions graduate seminar. A special shout-out to the members of the Ecological History group organized by Stevan Harrell and Peter Perdue through the Social Science Research Council DPDF. I also extend gratitude to the Haus der Kulturen der Welt and the Rachel Carson Center for their sponsorship of the Phosphorus Apparatus collaboration.

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This dissertation is dedicated to Thylias Moss and Fred Bookstein.

Introduction

A Story, an Apparatus, an Approach

The Wood Storks of Lake Somerset

During my fieldwork, I would regularly visit a small neighborhood park in a subdivision of Lakeland, Florida. Lakeland is a sprawling suburban city located between Orlando and Tampa along the I-4 corridor. Sandwiched between khaki-colored condominiums, the park is furnished with a tidy lawn, a few trees, and a bench that looks out on Lake Somerset. Fifty feet from the lake's shore is a long, linear island that is teeming with birds. The island belongs to an archipelago of similar islands arranged in long parallel strips. Nestled in the islands' vegetation are

Figure 1. Wood storks in the boughs of Brazilian Pepper

egrets, herons, roseate spoonbills, and — most abundant of all — the Everglades wood stork. Wood storks have made a rookery on these islands (Figure 1).

Lake Somerset is a man-made lake created by phosphate mining in a region known as Bone Valley. Spanning an area three-quarters the size of Rhode Island, Bone Valley is one of the oldest and most productive phosphate mining areas in the world. The islands are made of overburden: the top layer of earth that a large mechanical excavator removes and sets aside to access the phosphate rock. The parallel arrangement of the islands inscribes the path of the excavator, called a dragline, as it roved up and down the landscape mining in successive strips (Figure 2). Growing on the overburden islands is Brazilian pepper, an invasive shrubby tree introduced to Florida through the ornamental plant trade. It covers the islands and gives them a blobby, bristly character. Wood storks are a federally threatened species endemic to the mangroves of the coastal Everglades. In the 1970s, storks fled the Everglades in droves as drainage and flood control projects fractured the hydrology of this iconic wetland ecosystem. Some of these storks set up shop in Bone Valley. Here they can be seen squawking, preening, repairing nests, and tending their young.

Lake Somerset's wood storks are the poster bird of my dissertation, *Holocene in Fragments: A Critical Landscape Ecology of Phosphorus in Florida*. In this dissertation, I explore how the phosphate fertilizer industry has transformed the ecological landscapes of Florida and generated what earth scientists call the Anthropocene — a new earth epoch in which humans have become a geological force (Crutzen and Stroermer 2000). I am interested in Florida as a ground zero of the

Figure 2. Lake Somerset and its islands. A dragline operator mines phosphate in strips, much like Americans mow a lawn. The dragline mines a row, removing the top layer of overburden to one side, pivots, and begins mining a new row parallel to the last.

Anthropocene but also as a space in which Holocene ecologies and species can still be found, albeit in fragments. Wood storks are one such fragment. Chipped off the Everglades, forced into diaspora, and made to live in degraded urban-industrial environments, wood storks are finding a foothold in the Anthropocene, however precariously. In 2014 the wood stork's conservation status was downgraded from endangered to threatened under the Endangered Species Act. Bone Valley's islands represent one strand of their partial recovery.

If you were to visit Lake Somerset in 1900, you would have encountered a very different scene: where today there is a lake and condos there was once a mosaic of pine flatwoods and cypress domes. Beginning in the early 1920s, this area was strip mined for phosphate rock by the Southern Phosphate Company as part of the Pauway Mine (Figure 3).

Figure 3. Southern Phosphate Company dragline at Pauway Mine.

Phosphate is a critical ingredient in chemical fertilizers, an industrial material — like fossil fuels — that has helped make a human-dominated Earth. The mining process is destructive in many regards, but in the hands of real estate developers it is also creative. As mining pits fill with water and bulldozers regrade the land: an industrial black eye becomes lakefront property. If you were to take a stork's-eye-view of Lakeland, you would see a number of subdivisions snaking around the shores of former phosphate pits, some of which have been "reclaimed" by having their slopes smoothed and their islands flattened. The Lake Somerset subdivision is largely occupied by white, retired East Coasters and Midwesterners who flocked to Florida for the sunshine and its lack of an income tax.

Along with the snowbirds, Lake Somerset has become the habitat of Brazilian pepper. Brazilian pepper is native to Brazil, Argentina, and Paraguay. It has shiny, compound leaves with white flowers that ripen into attractive sprays of red berries. A few meters in height, pepper trees form dense, impenetrable stands that block the growth of other plants through shading and the release of allelopathic chemicals. Pepper is a prolific seeder and is dispersed by passerine birds like robins and waxwings. Brazilian pepper is one of the most invasive plants in Florida, covering more than 700,000 acres. Millions of dollars have been spent on its eradication. In 1898, Walter T. Swingle, a U.S. Department of Agriculture horticulturalist, obtained a shipment of seeds from Algeria, derived from an unknown locale, that were propagated at the Plant Introduction Station in Miami. A second introduction occurred in 1926 when Dr. George Stone received pepper seeds from "somewhere in Brazil" and planted them in his garden in Punta Gorda on Florida's southwest coast. "[Stone] distributed these seedlings freely among his friends and plant lovers, and many were planted out along the city streets" (Williams et al. 2005). Later genetic analysis would reveal that Swindle and Stone's pepper seeds came from two different parts of Brazil, the north and southeast respectively. These two pepper stocks represent two distinct genetic types or haplotypes that were separated by an 800-km distance in their native range. For several decades, birds and human gardeners slowly spread the Miami haplotype west and the Punta Gorda type east. In the 1960s, the haplotypes met for the first time in Central Florida. The plants hybridized and pepper underwent rapid evolution. The Florida hybrid exploded across the peninsula, exhibiting higher survival and growth rates and greater biomass than its parents (Mukherjee et al. 2012). A superweed was born.

Given the histories of strip mining, suburbanization, and Brazilian pepper invasion, it is surprising to find a federally threatened bird at Lake Somerset, especially one indigenous to the tropical tip of the peninsula. Why would an Everglades bird immigrate to an industrial environment that has been degraded in so many ways?

In the Holocene, the mangrove fringe of the coastal Everglades supported the largest wood stork rookery in Florida. In the late nineteenth century, hunters stalked storks to the brink of extinction supplying feathers to milliners in northern cities. As political pressure against the plume trade mounted and fashions changed, the rookeries recovered. But it wasn’t too long before humans struck again, this time through a series of drainage schemes intended to “improve” the Everglades for flood control and agricultural development. The Everglades is a complex wetland environment that, in its pre-European condition, overflowed Lake Okeechobee to form the distinctive “River of Grass.” The Everglades is a slow-moving wetland of sawgrass, tree islands, and sloughs that grades into mangroves in Florida Bay. Wood storks foraged across many parts of the Everglades, but in the breeding season storks relied on special sloughs as a foraging ground. During the winter dry season, water levels in the sloughs dropped and created isolated pools with high concentrations of fish. Storks feasted in these pools, building up the caloric and nutrient stores for laying eggs and feeding hatchlings (Ogden 1994).

Like many Everglades critters, the wood stork's social biology was attuned to the wetland's rhythm of winter drought and summer flood. Agricultural drainage, beginning in the late nineteenth century, disrupted this rhythm. But it wasn't until the implementation of the Central & Southern Florida Flood Control Project, or C&SF, that the Everglades irreversibly entered the Anthropocene. In 1948, a hurricane swept through South Florida, causing considerable damage to property. Rather than expose the folly of Everglades drainage, the storm prompted the federal government to double down on flood control. The high-modernist C&SF was born. Backed by the engineering and financial muscle of the Army Corps of Engineers, the dike around Lake Okeechobee was strengthened, the large canals that diverted floodwater to the Gulf of Mexico and Atlantic Ocean were deepened, and the lake's floodplain was converted to a massive sugarcane production zone — a zone, incidentally, that required Florida-mined phosphates to flourish.[1] These changes fundamentally altered the hydrology of the Everglades, spurring widespread drought and raging fires. As Everglades floodwater was flushed to the sea, fish populations plummeted and wood storks starved (Ogden 1994).

Most wood storks fled South Florida. The storks dispersed across Florida and into Georgia and South Carolina adapting their Everglades lifeways to new

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[1] This is a simplification. The history of Everglades drainage and the C&SF is layered and complex and includes the construction of large reservoirs and the channelization of the Kissimmee River, among other bold terraformations.

landscapes. Attracted to its island environments, storks established several colonies in Bone Valley. Spoil-pile islands share several of the architectural features of their native mangrove that make useful breeding habitat: Alligators guard against egg-hungry raccoons, and the flexible branches of Brazilian pepper hold nests together in the tumult of summer storms. Despite these advantages, the pit affords little in the way of food. Unlike ordinary lakes that support rich marshes on their fringe, mining pits have a steep drop off that occludes wetland development. Surrounded by subdivisions and strip malls, the birds must fly several miles across a busy toll road to forage in a recently restored marsh.

Although wood storks have been removed from the Endangered Species List, to suggest that wood storks are thriving in Bone Valley would be misleading. Storks are fledging offspring, but the possibilities for colony expansion are eclipsed by suburban sprawl. At best, these wood storks may be said to be “living in ruins” (Tsing 2015). To live in ruins is to live in tolerable, potentially damaging but nonetheless good enough conditions for ongoingness. Wood storks are doing okay, Brazilian pepper is doing better. Living in ruins is the story for many creatures of the Holocene who find themselves immersed in a sea of anthropogenic landscape change. But the Holocene is more than individual species; the epoch comprises a vast array of landscape symbioses that have emerged within the last 11,000 years and beyond.

In this dissertation, the Holocene signifies a multispecies planetary inheritance that is ancient, diverse, and enduringly livable. My use of the term is intended to evoke an image of a pre-industrial Earth enveloped by a baroque tapestry of rainforests, temperate grasslands and deciduous forests, deep and shallow marine ecologies, coral reefs, tide pools, tundra, taiga, bush, desert, steppe, savanna, chaparral, dunes, caves, lakes, rivers, marshes, swamps, estuaries, and lagoons. The Holocene is a planet of landscape symbioses. Landscape symbioses are webs of multispecies relations that have evolved over geological time into deeply attuned, life-perpetuating assemblages. For promoters of the Anthropocene hypothesis, the Holocene has come to a close. My evocation of the Holocene is distinctly present tense: the Holocene is alive, however precariously.

It is with an eye to this precariousness that I introduce the notion of the fragmented Holocene. The fragmented Holocene refers to those elements of a more-than-human social landscape that have not yet been erased in the onrushing geography of industrial capitalism. Holocene fragments are all around us. They exist as individual species like the wood stork that have learned to live in heavily modified environments, as degraded ecological patches hemmed in by roads and urban developments, as marine ecosystems confronting a growing drift of plastic, and as large protected wilderness zones that are managed for tourists. In all its terrestrial, marine, and atmospheric permutations, the Holocene is under threat. It is the job of multispecies anthropologists, shapeshifting to become better naturalists, to map how the Holocene is faring now.

If we are to speak of a fragmenting Holocene, we might also speak of an encroaching Anthropocene. The Anthropocene is a world of mines, monoculture plantations, exurbs, suburbs, cities, megacities; it is a planet of fragmenting road networks and cargo ships with invasive-species-laden ballast water; it is an Earth of airports, cars, canals, factories, confined feeding operations, manure lagoons, clear-cut mountainsides, depleted and contaminated aquifers, dams, landfills, toxic pollution, endocrine-disrupting chemicals, extinction cascades, and climate-busting CO_2 emissions. The Anthropocene is the habitat of the industrial human and a terrifying list of world-breaking injuries.

Rather than treat the two epochs as well-demarcated time zones, this dissertation examines how the Anthropocene and Holocene come together to form a complex, interdigitated timescape with distinct temporalities and entwined multispecies trajectories. Holocene and Anthropocene worlds coexist, overlap, and entangle. They do not come together in a balance of forces or a manichean struggle but in a lopsided dynamic of extinction and feral emergence. The Holocene — in all its eclecticism — is dying a patchy death as the Anthropocene — in all of its eclecticism — encroaches with increasing momentum. Gaia has not reached a critical tipping point that ejects Holocene lifeways once and for all… at least not yet. It is the incompleteness of Anthropocene erasures and the increasing islanding of sometimes-resilient Holocene patches that compel me to tell stories of Holocene/Anthropocene (H/A) natures in all their jumbled heterogeneity and tragic temporality. As Holocene and Anthropocene worlds collide, we need geographical methods and storytelling arts that plot unbearable histories and awkward frictions that make capitalist landscapes evermore empty and feral. At the same time, we must chart the patchiness and partiality of capitalist world-making. Capitalism is not everywhere, not uniformly. And even in landscapes where its effects and erasures are most acute, Holocene forms and forces, like the wood stork, may continue to persist.

This dissertation is a study of the Holocene/Anthropocene landscape ecologies made by the phosphate fertilizer industry in Florida. Chemical fertilizers are one of the big stories of our times, rivaling fossil fuels in terms of Anthropocene-conjuring effects. The industrialization of phosphate rock and fertilizer materials has spawned big changes to the Earth's biogeochemistry and spatial ecology. A complete chemical fertilizer is composed of three elemental ingredients: nitrogen (N), phosphorus (P), and potassium (K). The raw materials for these elements are sourced from around the world and assembled in fertilizer plants. The sourcing of NPK materials constitutes a geopolitical saga with roots in guano-plundered islands, the agricultural chemistry of Justus von Liebig, the formation of international cartels, the professionalization of economic geology, and the development of fertilizer materials into bombs and munitions during the First and Second World Wars. It is a saga that exceeds the narrative scope of this dissertation. This dissertation focuses on but one element in the fertilizer trinity: phosphorus. And it does so through the lens of Florida landscapes: the geography that best exemplifies all of industrial phosphorus' Holocene-breaking/Anthropocene-making effects.

The Phosphorus Apparatus

Phosphorus is the fifteenth element of the periodic table of elements. It was discovered by the sixteenth-century German alchemist Hennig Brandt in 1669. Brandt was searching for the philosopher's stone, an alchemical substance believed to turn base metals into gold. Piqued by the gold color of urine, Brandt heated vats of urine to distill a material that emitted a faint green glow. Brandt had produced elemental phosphorus (Ashley et al. 2011). Phosphorus is Greek for light-bearing (*phōs* 'light' + *-phoros* '-bringing') which denotes the luminescence of phosphorus when it reacts with oxygen.

Forged by an improbable sequence of nuclear reactions in exploding stars, phosphorus is the most cosmically rare of the six biogenic elements needed in large quantities to produce life (Cummins 2014).[2] Phosphorus is essential to the biochemistry of living beings. Because of its high reactivity, elemental phosphorus is rarely found in nature. In its biochemical form, phosphorus occurs as phosphate — a tetrahedral molecule composed of one phosphorus and four oxygen molecules, PO_4^{3-}. In this dissertation, I use the terms phosphorus and phosphate interchangeably. Phosphorus is an essential component of bone, DNA, RNA, and the energy-transfer molecule ATP. Like the oxygen we breathe, phosphorus makes us up in the flesh. And like oxygen, without it we perish. Unlike oxygen, however, environmental phosphorus is relatively rare. This makes phosphorus life-limiting and, arguably, the most precious of all mineral resources.

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[2] Carbon, hydrogen, nitrogen, oxygen, and sulfur are the others.

In the social sciences and humanities, we take power seriously, but we do not typically understand power as a concatenation of the most basic elements of fertility. What does the history of the world look like through the lens of human-phosphorus relations? I offer a quick and dirty history.

The invention of agriculture in the Neolithic 8-10,000 years ago was, among other things, a revolution in soil phosphorus and human fertility. Early horticulturalists were able to concentrate phosphorus into their bodies and communities by farming the fertile silts of river floodplains. Pastoralists concentrated phosphorus with the help of livestock that scoured the landscape and converted indigestible grasses into milk and meat. Human populations expanded. By learning to engineer phosphorus hotspots into the landscape, our agricultural ancestors created surpluses in the form of grain that gave life to the agrarian state with its priests, slaves, tax collectors, and child-bearing women (Scott 2011).

European colonialism represents a second pivotal phase in human-phosphorus relations. Sanctioned by the church and compelled by divine right, European men exerted great force and ingenuity appropriating the fertility of other people's lands. Europeans combined enslaved African people, exotic crops, and disciplined landscapes into a fertility-extracting machine: the plantation (Casid 2005). The plantation converted the fertility of local ecosystems into agricultural commodities shipped long distances to satisfy the appetites and desires of Europeans. Phosphorus — embodied in the biomass of cotton, tobacco, sugar, and indigo — flowed from colony to metropole. This invisible traffic in soil nutrients marked the entwined beginning of a global crisis of soil exhaustion and the rise of European empires. When a plantation had worn out its soils, Europeans expropriated new lands in a centuries-long march of manifest destiny.

Fast forward to the Green Revolution of the twentieth century. The frontier has closed and the cults of fertility have taken new form. Lithospheric rather than biospheric phosphorus is harvested at an accelerating pace. The mining of phosphate rock and the production of nitrogen through the Haber-Bosch process track one another in overlapping j-curves. The Great Acceleration is on. Human population soars. In the United States, suburbia, the cult of the nuclear family, and TV microwave dinners proliferate as supermarkets become an everyday technology of phosphorus acquisition. In the Green Revolution, phosphorus materializes as a fetish of the capitalist sciences: how to find and mine it, how to refine it, how to price it, ship it, mix it, spread it, market it, and — let us not forget — flush it. Phosphorus in the Anthropocene gets flushed down the toilet. Phosphorus is human excrement.

This history of phosphorus is quick and dirty, but it helps us appreciate that soil fertility, technological culture, social organization, and the landscape are always entangled. Phosphorus is a life-binding force that threads and holds together sociobiogeochemical worlds. It is not just a molecule. As an ingredient in chemical fertilizers, phosphorus makes possible industrial society and its seemingly endless supply of cheap food. Human life and capitalist civilization depend on its industrial circulation. This circulation is achieved by a large technological system that mines phosphate rock, turns it into fertilizer, applies it to farm fields, feeds it to livestock, processes it into food, sells it human consumers, and deals with it as human and nonhuman shit. I will refer to this fertility pipeline as the *phosphorus apparatus.*

The phosphorus apparatus is both a human-amplified biogeochemical cycle and global capitalist assemblage (Ogden et al. 2013). The first thing to know about phosphorus as biogeochemical cycle is that it has no atmospheric component. Unlike the carbon or nitrogen cycles that can cycle quickly between the soil, biota, water, and the atmosphere, phosphorus lacks a gaseous phase. Consequently, it moves in the landscape as a one-way transfer from the lithosphere to the ocean. The phosphorus cycle begins with erosion and weathering of rock and the assimilation of soil phosphorus by plants. In plants, phosphorus promotes root growth, flowering, fruiting, and seed development in young tissues (Smil 2000). Phosphorus circulates between plants, animals, fungi, and the soil in cycles of life and death, assimilation, and excretion. Through erosion and runoff, storm events pulse phosphorus into watersheds. Slowly and surely, phosphorus is conveyed down streams and rivers and into the sea. Terrestrial phosphorus becomes marine phosphorus, nourishing oceanic food webs and accumulating on the ocean floor as particulate matter.

The second thing to know about phosphorus is that it takes millions of years for the element to complete its biogeochemical cycle. Sedimented marine phosphorus is returned to land over geological timescales. “Recycling of [marine] sediments depends on the slow reshaping of the Earth’s surface…. [T]he P cycle piggybacks on tectonic uplift, and the circulation closes after 10^7 to 10^8 years as the P-containing rocks are re-exposed to denudation" (Smil 2000). Along with its cosmic rarity, this unimaginably slow cycle contributes to phosphorus' biological scarcity. Most of Earth's ecosystems have evolved under conditions of phosphorus limitation, rendering them susceptible to dramatic transformations when confronted with unusually large pulses of phosphorus.

The third thing to know about the cycle is that phosphorus inputs into the biosphere have been massively amplified by humans and the phosphate fertilizer industry. From a relatively small number of large deposits, phosphate rock is mined, converted to fertilizer, and shipped around the world as a global commodity. This rock is used to replenish the fertility of agricultural landscapes, making it possible for agribusiness to generate ever-increasing yields of food, fiber, and fodder. Approximately 15 million tons of phosphorus in fertilizer is applied to agricultural lands per year. This massive pulse of phosphorus inflates the carrying capacity of those lands, unleashing food surpluses that support exponential human population growth. Once phosphate fertilizers are applied to agricultural fields, the path of phosphorus bifurcates: phosphorus taken up by crops is harvested, processed, stocked in supermarkets, and consumed by humans. Vaclav Smil estimates the global anthromass of phosphorus (the quantity of P embodied in human bodies) to be 2.5 million tons (2000). Yet humans consume considerably more: 98% of phosphorus consumed is excreted by the human body. Phosphorus that remains in the fields runs off into local watersheds or is retained in the soil. Phosphorus from both fertilizer runoff and the excrement of humans and their livestock contribute to the degradation of aquatic ecosystems by fertilizing the growth of harmful algae. The anthropogenic enrichment of aquatic ecosystems is known as cultural eutrophication. Phosphorus discharges from agricultural lands in the United States represent more than 80% of the nutrient release into lakes, rivers, and estuaries (Smil 2000). Just as the industrialization of the carbon cycle has produced global warming, the engineering of the phosphorus cycle has produced a crisis of too much fertility. These effects are felt most acutely in the world's fresh and ocean ecosystems. In sum:

> No other element used in large quantities by modern civilization has such a peculiar fate as P: Millions of tonnes of P are taken every year from just a score of places in the Earth's crust in order to be processed and distributed thinly over an area exceeding one billion hectares of the world's cultivated land. Roughly half of the applied nutrient is assimilated by crops and most of the rest is fixed in soils and stored in sediments; although only a small amount of the lost nutrient is dissolved in water, it is the dominant cause of undesirable eutrophication (Smil 2000).

The Phosphorus Apparatus in Florida

The phosphorus apparatus is a biogeochemical force. It is also big business. This is perhaps more evident in Florida than any other world region. Since the 1880s, the Florida phosphate industry, with its epicenter in Bone Valley, has lead the world in the production of phosphate rock. Formed by Miocene seas that once submerged the peninsula, Bone Valley is one of Earth's big caches of fossil phosphorus. Because of the immense size of the Bone Valley deposit, phosphorus became the backbone of the U.S. mixed fertilizer industries. Large NPK fertilizer producers like the former American Agricultural Chemical Company, the Virginia-Carolina Chemical Company, and International Minerals & Chemical Corporation owned mineral rights and mined in Bone Valley. After a century of mergers and acquisitions, these and other firms have incorporated into the Mosaic company, the largest landowner and sole mine operator in Bone Valley. Mosaic is a producer of phosphate and potash crop nutrients. In addition to its phosphate mines in Florida, the multinational corporation owns potash mines in New Mexico and Saskatchewan. In 2016, it produced 14.2 million tons of phosphate rock at four mines: Four Corners, South Fort Meade, Wingate, and South Pasture. At the close of the twentieth century, 70% of the domestic phosphate rock supply and 30% of international stock came from Bone Valley producers. Since 1880, over a billion tons of phosphate rock have been mined from Bone Valley, leaving behind a ravaged landscape ecology of pits, tailings ponds, chemical plants, and depleted aquifers. Because of its importance to the human-altered phosphorus cycle and its fascinating landscape ecology, four of the five chapters in this dissertation are devoted to the history and multispecies ecologies of Bone Valley.

Freight costs of transporting phosphate fertilizer materials add considerably to their cost. For this reason, Florida farmers had unprecedented access to cheap phosphate fertilizer. And because of its low price, Florida farmers used more of it. According to a U.S. Department of Agriculture study, in 1949 Florida farmers used phosphate fertilizers to elevate the soil-phosphorus levels 1057% of the amount removed by crops (Markham 1958). This is more than any other state: for Texas and Virginia the percentage was 45 and 382, respectively. During this same period, a large shallow lake in Central Florida, Lake Apopka, was undergoing a catastrophic shift from a clear water lake to a turbid algal lake. Beginning in the early 1940s, Lake Apopka's floodplain was diked, ditched, and converted into an industrial vegetable plantation. Phosphate fertilizer-laden runoff was discharged directly into the lake, inciting the abrupt ecological transformation. In chapter 5, I explore the agricultural and environmental history of Lake Apopka as a window into the eutrophication impacts of Florida agriculture. Like citrus growers, cattle ranchers, and sugarcane producers, the winter vegetable farmers around Lake Apopka used phosphate fertilizers at extravagant levels. These fertilizers translated into big profits, but also into a neon green lake of toxic algae and trash fish.

Across the state, Florida's lake, rivers, wetlands, and estuaries are suffering from a crisis of too much phosphorus. In the Everglades, point and non-source pollution from sugarcane fields and cattle operations have created a crisis of eutrophication on numerous fronts: cattails have begun invading the oligotrophic sawgrass marshes of the Everglades; Lake Okeechobee has blooms of toxic algae and periodic fish kills; and the drainage from the eutrophic Lake (that historically flowed south) is diverted to both coasts, creating algae blooms that impair estuarine wildlife and close beaches to human recreation. Although Florida sits on top of one the world's great caches of fossil phosphorus, its ecosystems — especially its aquatic ecosystems — have evolved and adapted to oligotrophic (nutrient scarce) conditions. This makes the eutrophication of Florida's watery places both tragic and ironic. By unearthing the fossil phosphorus in Bone Valley, humans have unleashed insurgent ecologies of algal waterbodies and nutrient-loving weeds around the world. In this way, the global crisis of eutrophication is akin to global warming and the industrialization of the carbon cycle. The Anthropocene is a warming and overly fertile Earth. Because agriculture is exempt from the Clean Water Act and Florida farmers have a powerful lobby in Tallahassee, we should not expect serious regulation of nutrient runoff in Florida anytime soon.

In 2014, Florida surpassed New York to become the third most populous U.S. state. Twenty million people live in Florida, a ten-fold increased from its 1940 population. Florida is a pro-growth state. The state's tax structure and lax development regulations are designed to lure bodies to the sunshine state. Florida's economy is predicated on the income-generating presence of tourists, snowbirds, and new permanent residents: more people means more money. This influx of outsiders creates tension between so-called "Florida natives" and new residents who come to Florida for a piece of cheap paradise. At the core of this tension is a widespread concern that Florida is growing out of control. Florida is a landscape of rampant suburbanization: new subdivisions and strip malls — like those surrounding Lake Somerset — are continuously expanding at the fringe of Florida cities and along its once-rural highways. The sprawling growth, driven by boom-and-bust speculation, has generated the sentiment that Florida's built environment is a "geography of nowhere" (Kunstler 1994).

In Florida, population growth, economic growth, and suburban growth are entangled phenomena. Cheap paradise is predicated on cheap real estate, cheap fuel, and free sunshine, but also cheap food. Enter the phosphorus apparatus. The biology of all organisms requires phosphorus, including tourists. Sprawl has been tied to the rise of the automobile and fossil fuels (Wells 2012), but no attention has been paid to the complex embodiments of fertilizer. The phosphorus apparatus circulates into and out of the bodies of suburban humans by way of two technologies: supermarkets and sanitation systems. Industrial civilization requires an uninterrupted and ever-expanding circulation of phosphorus. Rather that retrieve phosphorus from the local ecosystems as our ancestors once did, industrial humans obtain their phosphorus from food systems organized around long-distance commodity chains and supermarkets. As noted earlier, once consumed, 2% is incorporated into human biochemistry and the rest is flushed down the toilet. Within city limits, sewage is funneled through sewers to a wastewater treatment facility. In exurban and rural areas, human waste is disposed in septic tanks. Both improperly treated wastewater and leaky septic tanks can be a source of ambient phosphorus that causes eutrophication.

Human sewage is an Anthropocene material, but the force of the phosphorus apparatus as a suburban form lies in supermarkets, sanitation systems, automobiles, and gas stations as articulated infrastructures. Sprawl could not survive as a human settlement pattern without supermarkets to deliver massive quantities of phosphorus, automobiles to transport that phosphorus to consumers' single-family homes, and flush toilets to relieve residents of the responsibility of dealing with their own shit. By yoking the phosphorus apparatus to the combustion engine, Florida is able to support the metabolism of 20 million people and their sprawling, near-instant habitat. As destructive as phosphate mining and industrial agriculture are to Florida's Holocene ecologies, the sprawling niche construction of 20 million people is the phosphorus apparatus' most insidious manifestation.

In the next phase of my research, I will be looking more closely at the phosphorus apparatus and its relationship to sprawl. I will also be pursuing a multi-basin analysis of eutrophication in the Everglades. In this dissertation, the Everglades and Florida sprawl are an important backdrop to the stories to come.

Critical Landscape Ecology

How do we study multispecies interactions in heterogeneous landscapes transformed by powerful humans?

Beginning in Bone Valley and following the phosphorus apparatus out into the world, I aim to develop a complicated portrait of multispecies death and life in Central Florida. This portrait foregrounds multispecies interactions, but it also examines the cultural and political histories unique to Florida and its industries. In this, I lay the groundwork for an approach to the study of more-than-geographies that I call *critical landscape ecology.* This critical landscape ecology takes inspiration from the science of landscape ecology and its attention to spatial pattern and process, but it inflects its object — land mosaics — through the critical methods of the humanities and social sciences.

Landscape ecology was formalized as a discipline in the 1980s but has roots in geography, ecosystem ecology, plant community ecology, biogeography, and conservation biology.[3] Landscape ecologists are interested in ecological process across a heterogeneous patchwork of ecosystems and human land uses that becomes visible from an airplane and satellite images (Forman 1995). These heterogeneous geographies are called mosaics. Florida's mosaic landscapes are forged in the heterogeneity of its Holocene ecologies and the uneven development of capitalist industries. Patchy landscapes with both Holocene and Anthropocene characteristics are the result.

Mosaic landscapes are composed of three kinds of elements: patches, corridors, and matrices. Patches are relatively discrete units of land that differ from their surrounding environment (Forman 1995). This dissertation opened with a story of a patch: the wood stork island of Lake Somerset. Landscape ecologists are keen on measuring the size, shape, and distribution of patches in a landscape region and correlating those metrics to an array of ecological processes. A patch is also a unique assemblage of more-than-human elements with particular spatial qualities and histories.

"Matrix" refers to the background ecosystem or land use type in which patches and other landscape elements are embedded. Forman (1995) describes a landscape matrix as having "extensive cover, high connectivity, and/or major control over dynamics." In the Holocene, pine flatwoods constituted the matrix ecosystem for Central Florida. Pine flatwoods are fire-adapted ecosystems. Because of their

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[3] *Foundation Papers in Landscape Ecology* (Weins et al. 2007*)* provides a useful introduction to the landscape ecology's history and key interventions.

extensive distribution and high connectivity, they spread fire across the landscape, contributing to its blotchy mosaic character. In Anthropocene Florida, low-density suburban development is rapidly becoming the landscape matrix of Central Florida.

A corridor is a linear element in a landscape, like a river or highway, that serves as a conduit or barrier to human and nonhuman flows. The Bone Valley phosphate mining region is demarcated by a heavily trafficked section of Interstate-4 between Orlando and Tampa. North of I-4 is the Green Swamp — a modified but relatively intact Holocene mosaic of pine flatwoods and cypress swamps. I-4 is an important transportation corridor at the same time that it creates a formidable barrier to species movements. Radio-collared bears in the Green Swamp have been tracked roving back and forth along I-4 looking for (and failing) to find a pass in the freeway to continue their southern migration.

Using the patch-matrix-corridor model, landscape ecologists investigate species movements and interactions, material flows, and extinction and evolution dynamics within a mosaic. For example, a landscape ecologist might study how animals living in an agriculturally fragmented landscape use hedgerows to move between isolated woodlots; model how patch size of a rare plant's habitat correlates to inbreeding depression; or correlate water quality data along the length of a stream with changes in urban land uses. To a landscape scientist, patches, corridors, and matrices are elements with quantifiable features. Once quantified, these data can be incorporated into geo-statistical, experimental, and model-based analyses.

Landscape ecology works within the methods and tropes of prevailing scientism. Scientific conventions are indispensable to validity and seriousness of landscape ecologists' knowledge production. But an unreflexive adherence to quantitative orientation also imposes certain limitations regarding the kinds of analyses and narrative genres into which the insights of landscape ecology may figure. Mosaic landscapes have quantifiable aspects, but they are also flush with histories and relations that cannot be captured through a quantitative approach. The science of landscape ecology needs a qualitative counterpart — one that can grapple with space, culture, power, and history on both human and more-than-human terms.

Exploration

Cultivating curiosity about a particular patch of Earth is an important first step in critical landscape ecology. Consider the following patch (Figure 4). The patch is a plantation of slash pine. It has a regular geometry; its size and distance from other ecological elements can be measured; and the number and diversity of species it supports can be inventoried. Along with its quantifiable features, the patch has a cultural history unique to Central Florida. The patch is a "Hidden Mickey." Hidden Mickeys are representations of the iconic Disney Corporation logo that have been subtly embedded in theme-park architecture, animated films, and the landscape. As you drive along the I-4 from Orlando to Lakeland, there is a Hidden Mickey incorporated in the design of a transmission tower. This pine-plantation Mickey was designed to be observed from airplanes as they make their descent into the Orlando International Airport.

Figure 4. Hidden Mickey pine plantation in Central Florida.

According to Wikipedia, Hidden Mickeys were dreamed up by imagineers in the late 1970s and early 80s during the construction of Epcot.[4] Originally conceived as a theme park for adults, part of the Epcot vision included the selling of alcohol. Epcot imagineers were instructed to avoid using Disney iconography in its plans as "alcohol and Disney characters were deemed an improper combination." Imagineers took this as a challenge and began subversively incorporating the iconic mouse head and ears into the park design in ways that were not readily apparent. Although Epcot has long abandoned its prohibition on character-themed designs, the tradition of

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[4] https://en.wikipedia.org/wiki/Hidden_Mickey (Accessed 15 December 2017)

Hidden Mickeys persists as a scavenger hunt and cult phenomenon. Hidden Mickeys excite the passions of diehard Disney fans, but they also speak to ways that Disney has infected and transformed Central Florida. Disney, like the phosphate industry, is an Anthropocene-making force in Central Florida. There is no escaping the sprawling imprint emanating from The Mouse.

As I pan across the Central Florida in Google Earth, I wonder about what critters (mice?) live in this Mickey Mouse-shaped patch and how the histories of pine plantation development and Disney imagineering became entangled in this particular design. Curiosity becomes an incitement to explore the patch, its biography, and its position within the wider natural-cultural mosaic region.

Exploration is an open-ended, movement-dependent method through which one comes to know a landscape region in its situated details and broad contours. Exploration is a process of noticing and mapping the event structure of a mosaic. Noticing is a process of using one's senses to grasp the heterogeneity of human-altered landscapes at various temporal and spatial scales. Different patches, landmarks, or species assemblages draw us in. To know a landscape is to see it, hear it, feel it and, in some cases, smell and taste it. Paying attention to a landscape over time, under different conditions, and with different instruments of observation (e.g. binoculars, a hand lens, maps, etc.) attunes us to its rhythms and ongoing historical processes. Noticing is a scale-jumping process: in one moment, we can attend to the mosaic worlds of insects on the forest floor and, in the next, the construction of an encroaching subdivision.

Noticing many parts of landscape together and puzzling out their relations is what I call *mapping*. Mapping is a way of piecing together sometimes disparate forms of geographical and historical information to uncover connections across scales and between many landscape elements. Mapping does not necessarily involve counterposing landscape observations and features on a map, although that can and often should be done. To map the historical transformation of a drainage basin may mean walking the landscape to follow the flow of water through ditches and culverts, while using historical aerial photographs or consulting interviews with a long-time resident who has familiarity with past drainage patterns. Noticing and mapping is best carried out in conjunction with a guide or local expert who knows a landscape best. Getting trained to see a landscape helps us notice what is important, reveal invisible histories, interpret the stakes of impending events, and interpret form and function. While landscape ecologists might not admit it as a formal method, exploration serves as common ground for both critical and scientific approaches.

In critical landscape ecology, noticing and mapping are pursued recursively from new angles and with knowledge gleaned from diverse ethnographic, historical, and natural history methods. Once I establish research sites, I explore them repeatedly while learning more about them from interviews, textbooks, and archival sources. When I explore a site, I do so with an openness to unplanned encounters and new sights and sounds, but also with specific goals. For instance, there are two patches in an abandoned phosphate region that I would frequently visit. One of these patches was mined, the other was not; both supported a goldenrod called euthamia. I visited these patches to assess their botanical structure, but my primary aim was to see what pollinators were visiting the euthamia. This little natural history experiment afforded me an informal way to compare the insect diversity of the mined and non-mined patches. From my comparison-driven explorations, I observed greater pollinator diversity and more frequent visits in the non-mined patch. Although there is much to be learned about the plant-pollinator worlds in both patches, I was drawn to notice this interesting pattern through systematic exploration, but only after spending significant time in unstructured wandering.

Qualitative methods, like their quantitative counterpart, have their limitations. Critical landscape ecology depends on a range of earth sciences to ground its interpretations and analyses. Anna Tsing (2015) and Andrew Mathews (2017) have discussed the need to revitalize natural history methods for the study of the Anthropocene. During its heyday in the eighteenth and nineteenth centuries, natural historians investigated the natural world and its people through exploration, observation, description, comparison, and collecting. Although a thoroughly colonial science, it sparked the development of contemporary anthropology, geology, and geography, the Darwinian synthesis, and field biology. Fractured by disciplinary specialization and eclipsed by the quantitative approaches in ecology and evolutionary biology, natural history today is cast as antiquated and less than serious. Crutzen and Stoermer's naming of the Anthropocene jolts us to look anew at the Earth that is being made and rapidly erased (Crutzen and Stoermer 2000). Tsing's and Mathew’s campaign to revitalize natural history is a call to be woke to the more-than-human configurations of this new planet. Their anachronistic rethreading of natural history into the Anthropocene affords a methodological openness that privileges noticing and description over esoteric theory or computer modeling.

Critical landscape ecology joins Tsing's and Mathew's call for openness and curiosity, while directing our observations to more-than-human social life in human-dominated mosaics. In so doing, critical landscape ecology invites an analysis across scales: from the human scale of natural history observation to the civilizational scale in which landscapes are transformed by human land uses and infrastructure. Looping between these scales of analysis, we can synthesize coarse- and fine-grain interpretations of multispecies landscape change in relation to industrial capitalism and its mosaic impacts.

Patch Stories

Critical landscape ecology traffics in patch stories. A patch is a species of space that helps us notice uneven natural-cultural histories of place. Stories of patches are crucial in mapping landscape ecologies. Patches, corridors, and matrices fit together like pieces in a jigsaw puzzle, but their stories do not. Patch stories veer off course, multiply plot lines and subplots, and entangle phenomena across diverse scales.[5] They explode the fetish of a landscape as a visually integrated scene by

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[5] In critical landscape ecology, the distinctions between patches, corridors, and matrices instruct us how to see the landscape, but they are not ontologically primary. What can count as a patch is open-ended and made in relation to situated perspectives. Narrations of corridors and matrices are simply patch stories with a

tracing its more-than-human biographical threads into the dynamics shaping the present. Compared with the science of landscape ecology, critical landscape ecology is better equipped to absorb culture, history, and power into its analytic fold.

Critical landscape ecology grants new permissions to study the cultural formation of mosaic landscapes by tracing human social relations wherever they may lead; culture, history, and power deserve flatfooted tracing in the same way that the movements of a focal species deserve flatfooted tracking. Landscape ecologists recognize that landscapes are sites of culture and history, however they tend to treat cultural history as a source of design or background information, rather than of ongoing process. Culture and history are part of the landscape ecologist's wheelhouse. Incorporating analyses of power into mosaic landscapes might prove less comfortable to a landscape ecologist.

The "critical" in critical landscape ecology signals an alliance with marxist, feminist, and postcolonial scholars and their exegeses of power. Gathered under the umbrella of "critical theory," these scholars explore how power is generated and distributed across colonial, capitalist, and state networks, within heterogeneous cultural encounters, and along divisions of race, class, gender, and indigeneity. Like culture, power is immanent in social life. No analysis of Anthropocene geographies is complete without attention to powerful institutions, their people, and their landscape-transforming projects. In my research in Florida, I develop a critical analysis of the

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different landscape geometry. The I-4 is a long concrete patch that supports the movement of automobile traffic. Flatwoods matrix was the master patch during the Holocene. Etc.

power invested in and emanating from the phosphorus apparatus. As such, I am interested in the power of the phosphate fertilizer industry to transform landscapes, but also the authority and wealth conferred to corporate elites who oversee the conversion of fossil life into a fertile form of capital.

Critical theory has primarily focused on humans and their cultural difference, but in recent decades it has drawn nonhuman entities into its empirical and analytical orbit. Multispecies anthropology is one of its satellites. Like landscape ecology, multispecies anthropology is its own motley assemblage, cobbled together out of critical approaches of science and technology studies (STS), animal studies, environmental anthropology, political ecology, environmental history, and cultural geography. A multispecies approach to anthropology explores how humans and other species come together in transformative encounters in different times and places. Recent developments associated with the Anthropocene and the "geological turn" challenge the critical humanities and social scientists to expand their analysis to deep time and the planet (See Latour 2017, Palmer 2015, and Stern 2017 as examples of anthropology in a "geological" mode). Anthropocene scholarship is provoking anthropology and cognate disciplines to rethink the human in terms of Earth systems and geological time scales but also to understand how humans have transformed the planet through various incarnations of empire (See Stoler 2016) . Critical landscape ecology emerges against this multiplex field of influences.

Outline of the Dissertation

This dissertation, based on 18 months of fieldwork, explores the natural-cultural histories of the phosphate fertilizer industry and the mosaic Holocene/Anthropocene landscapes it has made in Florida. Building on commodity chain analysis (Marcus 1995; Friedberg 2004), I trace the sociotechnical life of phosphate fertilizers from mine to farm but depart from these approaches in charting human and nonhuman interactions in industry-disturbed patches.

The dissertation's organization takes a cue from the fertilizer industry's metabolic relationship with phosphate rock. Chapter 1 explores the historical emergence of the Florida phosphate industry and the processes by which Bone Valley geology is sorted into commodity and waste. Chapters 2-5 examine the landscape ecologies created by these different waste products, including fertilizer runoff in agricultural watersheds. Chapter outlines are provided below.

Chapter 1. Unearthing Leviathan: A Geo-History of Bone Valley. The dissertation begins by tracing the formation of phosphate deposits in shallow Miocene seas into the period of settler colonialism when phosphates are first discovered and mined. Over the course of the twentieth century, I track the co-emergence of corporate political culture, mining and processing technologies, and the metabolization of rock into a heterogeneous waste landscape. In linking these geo-stories, I show how an Anthropocene is generated (and the Holocene is fragmented) through an industrial process of unearthing a fossil ocean to unleash human population growth.

Chapter 2. Island Scrub: Endurance and Extinction at the

Holocene/Anthropocene Boundary. This chapter explores what it means for Holocene and Anthropocene ecologies to coexist in the same time and space. I provide a natural history description of neighboring landscapes: a remnant patch of ancient scrub and a feral-industrial grassland. In contrasting these landscapes, I reframe contemporary debates surrounding human-altered ecosystems, encouraging anthropologists to rethink their critiques of nature and embrace of novel ecosystems.

Chapter 3. Tegu Trouble: Corporate Landscape Ecology and the Unravelling of a Chelonian World. Bone Valley is a corporate landscape ecology owned and operated by Mosaic. Reclaimed phosphate mines are notoriously feral, weedy places. Nonetheless, they are home to a host of imperiled gopher tortoises that have escaped the annihilations of the dragline and relocated. This chapter examines the contest between Mosaic and a state wildlife agency over the management of tegus — a newly introduced lizard in Florida that imperils the company's gopher tortoise population. I illustrate how Mosaic's performance of property enacts a landscape ecology of tegu expansion that may spell extinction for the gopher tortoise and its symbionts.

Chapter 4. Life in Clay: On the Reclamation and Carrying Power of Wounded Space. In Bone Valley, large aboveground ponds of liquid clay waste tile the landscape. I chart how these ponds give rise to novel willow swamps and fragment the larger watershed. I argue that an anthropological and multispecies attention to waste clay ponds exposes how negative value relations — both economic and ecological — erupt in capitalist zones of abandonment.

Chapter 5: Lake Apopka and the Trophic-Dynamic Aspects of the

Plantationocene. Over the course of the twentieth century, corporate vegetable farmers spread thousands of tons of phosphate onto Lake Apopka farm fields. This phosphorus ushered in a controversial era of fish kills, algae blooms, and mysterious wildlife deaths. Under the guidance of a state water management district, the lake is being restored by Vietnamese families who are fishing the lake back to health. This chapter approaches Lake Apopka's collapse and restoration as a profound restructuring of more-than-human social relations in the crisis-times of late industrialism.

Chapter One

Unearthing Leviathan: A Geo-History of Bone Valley

All progress in capitalist agriculture is a progress in the art, not only of robbing the worker, but of robbing the soil; all progress in increasing the fertility of the soil for a given time is a progress towards ruining the more long-lasting sources of that fertility. The more a country proceeds from large-scale industry as the background of its development, as in the case of the United States, the more rapid is this process of destruction. — *Karl Marx*

The capitalist world-system has an insatiable appetite for phosphorus. Phosphate fertilizers form a biochemical foundation of capitalist society, inflating the carrying capacity of agricultural lands through geotechnical means. Unlike nitrogen, which can be endlessly harvested from the atmosphere, phosphorus must be mined from relatively rare mineral deposits. Whole islands in Oceania and the Caribbean and large tracts in North Africa, Russia, and China have been mined for phosphate rock to meet the fertilizer demands of capitalist agriculture. Perhaps more than any single deposit, the Bone Valley deposit of Central Florida has laid the foundations of the phosphate fertilizer industry and nourished a form of human bigness that is toppling Holocene stabilities and diversities. Since mining began in the 1880s, well over a billion tons of phosphate rock have been mined in Central Florida — the great majority of it used as fertilizer.

In this chapter I offer a history of the Bone Valley phosphate deposit and the large technological systems that metabolized it into fertilizer. At the center of my narrative is the matrix of phosphate pebble, sand, and clays that form the Bone Valley stratigraphic unit. The chapter begins with a journey deep into the Miocene (5-24 million years ago), when an unusual configuration of marine geology created massive upwellings of phosphorus into shallow seas covering much of Florida and the southeastern continental margin. This upwelling nourished incredibly productive ecosystems the detritus of which sunk to the ocean floor and, over time, became sedimented into phosphate rock.

Exiting the Miocene, the chapter jumps track to the nineteenth century when phosphate rock is first discovered in South Carolina and, later, Florida. The history of the U.S. phosphate fertile industry is both technical and politically dense. For this reason, I have chosen to focus on three conjunctures in which phosphate technologies, corporate social relations, and surface geology change together. I refer to each of these conjunctures as geo-stories (Latour 2017). These geo-stories recalibrate our attention to capitalism as a metabolic force, one that parasitizes fossil histories and lifeworlds to fuel its unsustainable growth.

In the first of these geo-stories, I argue that slavery created the conditions for the phosphate industry by precipitating a crisis of soil exhaustion in the U.S. cotton belt and by amassing an exploitable labor pool that, upon emancipation, would be yoked into the postbellum phosphate economy. In the aftermath of the Civil War, ex-slaves and their decedents mined phosphate in Charleston using a combination of land- and river-mining techniques. Phosphate work was carried out with picks, axes, and mule-drawn carts but also crude steam machines. I refer to this social and technological moment as the “mule and steam regime.” In the 1880’s the industry expanded into Florida with the discovery of phosphate rock in Bone Valley and the north Florida hard-rock district. South Carolina and Florida phosphates were sold internationally and to northern farmers, but the great majority were used to restore the fertility to the South’s depleted cotton fields. Cotton production soared as Bone Valley’s Holocene ecologies were sacrificed to mining.

In the first decade of the new century, electrification came to Bone Valley and brought an end to the mule and steam regime. In the 1920s, companies introduced draglines and Bone Valley entered an era of bigger and more efficient technologies. In my second geo-story, I focus on one of these new technologies: flotation. Flotation revolutionized the efficiency of beneficiation plants. In the beneficiation or “washing” process, phosphate rock is sorted from the waste sands and clays. Flotation enabled firms to capture the sand-sized phosphate particles that were previously discarded. Flotation technologies created new economies of scale. They were also used to build an international cartel. Flotation’s gains in efficiency were such that any firm operating in Bone Valley needed to incorporate the technology to stay competitive. A phosphate export association used discriminating licensing of the flotation patent to block new competitors from entering the field. Flotation helped conjure a new era of big machines and monopoly capital. It also generated a new waste landform: mountains of sand tailings. Sand tailings piles, along with the waste clay ponds, began to radically alter the physiography of the region.

The conclusion of World War II brought radical changes to Bone Valley's phosphate producers and its landscape. Awakened fertilizer markets in the Midwest, new competition from Western rock producers, and farm modernization programs of the Tennessee Valley Authority spurred a reorganization of the industry. The reorganization was centered around the production of a concentrated fertilizer called triple superphosphate (TSP). Shifting the industry over to TSP entailed a complete overhaul of the fertilizer production and distribution geography. The economics of TSP production favored siting chemical plants closer to the source of phosphate rock in Bone Valley. But the industry, at this time, was organized around the production of ordinary superphosphates. Ordinary superphosphates privileged siting fertilizer plants close to the agricultural consumer. With the transition to TSP, fertilizer plants closed across the eastern United States and new chemical plants were erected in Bone Valley. With these new chemical facilities came new wastes: toxic fluorine gas and radioactive phosphogypsum. The emissions of fluorine gas sparked the first serious wave of environmental protest in Bone Valley that culminated in the passage of the 1975 mandatory reclamation laws.

The mechanical and chemical sorting of Bone Valley phosphate deposits has generated a heterogeneous waste landscape. A view from an airplane or Google Earth reveals the toll the phosphate industry has taken on Bone Valley. Once a splotchy mosaic of pine flatwoods and cypress swamps, today Bone Valley is an otherworldly tessellation of 1) pit-lakes and overburden piles generated by strip mining; 2) sand tailings piles and clay settling ponds generated by beneficiation operations; and 3) radioactive phosphogypsum stacks generated by fertilizer manufacture.

These waste landforms comprise the tiles of a new Anthropocene mosaic ecology. In subsequent chapters, I explore the more-than-human ecologies that develop in these waste landforms. Here, I offer stories of the historical relations and the industrial metabolism that produced them. As the industry evolved, corporations exercised greater control over local geology, parsing commodity from waste with increasing efficiency and precision. To this end, I offer a story of the co-production of capital and corporate power, on the one hand, and mining wounds and waste on the other.

In my aspirations for this chapter, I had hoped to chronicle the histories of mergers and acquisitions that began in the Great Merger Movement of the 1890s and culminated in the formation of the Mosaic Company in the twenty-first century. But the chapter became too thick with stories, so this narrative thread was crowded out. Suffice it to say, in each of these geo-stories the industry becomes more concentrated into the hands of a few powerful agrochemical firms. At the turn of the twentieth century, upwards of 100 companies owned land and operated in Florida. However, the industry was quickly dominated by larger fertilizer firms with roots in the South Carolina industry. Today the industry is dominated by Mosaic — a multinational, vertically integrated fertilizer firm and the last remaining mining operation in Bone Valley. A genealogical analysis of Mosaic exposes an institutional chimera, over the long twentieth century, has absorbed all of Bone Valley's major phosphate producers.

Technology is never innocently applied to nature. Nor can it be hived off from the social forces that produce it. In Bone Valley, it is impossible to disentangle capital and technics, but is also impossible to disentangle geology and ecology from the relational mix. Keeping in mind these entanglements, this chapter may be read as the intertwining biographies of two behemoths: a giant mineral deposit and the industry that consumed it.

LEVIATHAN'S OCEAN

> Polk County. Black men laughing and singing. They go down in the phosphate mines and bring up the wet dust of the bones of pre-historic monsters, to make rich land in far places, so that people can eat. But, all of it is not dust. Huge ribs, twenty feet from belly to back bone. Some old-time sea monster caught in the shallows in that morning when God said, "Let's make some more dry land. Stay there, great Leviathan! Stay there as a memory and a monument to Time." — Zora Neale Hurston, *Dust Tracks on a Road*

Bone Valley is one of the best places in the world to hunt for fossils. In the late twentieth century mining companies opened their pits to amateur fossil hunters and paleontologists to search for the skeletal remains of manatees, giant sloths, rhinoceroses, saber-tooth cats, and alligators. Bone Valley gets its name from this rich cache of marine and terrestrial fossils. One of the most coveted fossils is the large, triangular tooth of the great shark, *Carcharodon megalodon.* In the 1920s, Zora Neale Hurston went to southeast Polk County, the epicenter of Bone Valley, to collect folk tales from black men and women living in the phosphate towns (Patterson 2015). The “twenty feet ribs” Hurston described did not belong to megalodon[6] but, most likely, to an extinct species of dugong — a large marine mammal (3-3.5 meters long) related to the manatee. Dugong ribs are one of the most common fossil in Florida, although they are nowhere near twenty feet long! But when Hurston described “shark teeth as wide as the hand of a working man” (1942) she was not being hyperbolic: she was writing about megalodon,

Weighing in at 18,000 kg, megalodon sharks were among the largest predators in history. In a television interview for the Discovery Channel program *Shark Week*, the paleontologist Chuck Ciampaglio opined that megalodon "was probably the apex predator of all time. People think T-rex or something like that. It's dwarfed by megalodon. Megalodon is huge. Maybe 70 feet long. T-rex wouldn’t have a chance against this thing. T-rex’s head would fit in this guy’s mouth.” These awesome leviathans patrolled the broad seas that inundated the U.S. southeastern continental margin during the Miocene. These seas were warm, shallow, and episodic — waxing and waning with swings in the Earth’s climate.

Buried along with megalodon are the fossilized teeth of smaller sharks. These sharks were contemporaries of megalodons but also their prey. Megalodons dined on smaller sharks, whales, and other large prey. To maintain their gargantuan metabolism, megalodons consumed 2 percent of their body weight a day — an enormous quantity of food.

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[6] Shark skeletons are made of cartilage and rarely fossilize.

Albert Hine is my guide to megalodon's ocean. In his textbook *Geologic History of Florida,* he raises the question: "what environmental conditions existed to sustain so many predators?"

The answer lies with phosphorus. Lots and lots of phosphorus. Hine devotes an entire chapter to the marine origins and industrial significance of Florida phosphates. It is here that we are introduced to megalodon.

During the Miocene, upwelling streams of nutrients sparked intense growth of phytoplankton — microscopic plants that drift along in the ocean's currents. Phytoplankton assimilate these nutrients, via photosynthesis, into biomass that forms the foundation of marine food webs, just as land plants do in terrestrial systems. Lots and lots of phytoplankton mean lots and lots of zooplankton — microscopic animals that feed on phytoplankton. Zooplankton feed small fish that feed bigger fish onward and upward until we arrive, at last, with megalodon. Although this food-chain model is simplistic (the reality was a much messier food web), it captures the general relationship between nutrient abundance and the productivity and trophic complexity of an ecosystem. Nutrient-rich worlds support ecologies of big predators (Hine 2013).[7]

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[7] Megalodon's size is impressive, but as Hine points out "the organic mass of [phytoplankton] is far greater than the sum of the mass of big fish in the ocean" (2013). These ancient seas were governed by infinitesimal floating plants just as much as giant sharks.

Hine, a geological oceanographer, explains how these fertilizing upwelling events formed in a unique interaction between ocean currents and the bathymetric highs of the Florida peninsula:

> One of the most important physical components of the modern Gulf of Mexico is a filament of moving water called the Loop Current. This is a component of… the well-known Gulf Stream that flows along the east side of northern South America and North America and heads toward Europe from Cape Hatteras, North Carolina.… Geologists hypothesize that when sea level rose ~50-100 m higher in the Middle Miocene, the Loop Current moved eastward up onto peninsular Florida, flowed across the platform and directly into the northern Straights of Florida, following a much more northernly path than today.… This paleo Loop Current had to flow around the topographic high posed by central peninsular Florida, forming a bend or dogleg in its flow pattern.…This bend in the current produced persistent upwelling, which brought nutrients closer to the sea surface, thus stimulating primary productivity. As the current was deflected by bathymetry, water from below replaced the water that was removed by the deflection. This is called *topographic steering* and results from the interaction of oceanographic currents with bathymetric high areas of the seafloor.…When topographic steering was at a maximum, upwelling was not only persistent but enhanced. The result was a proliferation of food (organic matter) in the surface waters, producing a very fertile ocean, which, in turn, supported a robust food web including large numbers of fish. This enhanced the number of predators: the great sharks (Hine 2013).

According to Hine, Florida's phosphate deposits were formed by three upwelling phosphatization events in the Miocene, the most significant occurring mid epoch. He also explains that similar phosphatization events were happening along the southeastern continental margin from Georgia to North Carolina, creating a phosphate belt that stretches across the low-lying Southeast coast. This phosphatic province contains an estimated 10 billion tons of economic phosphate rock and is considered one of the world's giant deposits (Compton 1997). Within this expansive province, Bone Valley represents the greatest economic concentration of that phosphate wealth. However, it is in South Carolina's lowcountry that phosphate rock was first discovered and mined on a commercial scale.

In most ecosystems, phosphorus is relatively rare and what phosphorus there is efficiently recycled between lifeforms. In most ocean environments, phosphorus embodied in excreta and dead organisms is rapidly taken up by living organisms. As a consequence, phosphorus rarely accumulates in sediments in high concentrations. But in these eutrophic seas, upwelling events supplied more phosphorus than the ecology could absorb: phosphorus settled out of the water column and became buried in sediments. Bacterial activity decomposed this matter, mineralizing phosphate in the low-oxygen seafloor conditions. The process by which sediments turn into sedimentary rock is known as *diagenesis*.

The diagenesis of phosphate rock takes place within a complex biological and chemical milieu. Inside the shells of foraminifera and gastropods, mineralized phosphate crystallized into fluorapatite. The fluorapatite crystals "are concentrated into fecal pellets by burrowing worms and other organisms, form crusts, and fill interstitial voids between other sedimentary particles" (Hine 2013). These fluorapatite crystals form a phosphatic cement that, over time, are broken up and smoothed into pebbles. These pebbles constitute 50% of Bone Valley phosphate, also known as the Florida land-pebble district. The other 50% takes the form of sand-sized particles. These phosphatic sands are fecal pellets of burrowing organisms that ingested the phosphatic muds. It is these sand-sized fecal pellets that are captured with the flotation process (Hine 2013).

Fluorapatite has the chemical formula $Ca_{10}F_2(PO_4)_6$. The fluorine and calcium are common elements in seawater. Fluorine is introduced to sea water through underground volcanos. When fluorine binds with the phosphate (PO_4), strong chemical bonds make an insoluble new molecule. To make a soluble form of phosphate that can be taken up by plants, fertilizer manufactures react phosphate rock with sulfuric or phosphoric acids. The acids break those bonds and release a highly toxic fluorine gas. Since the 1970s, fluorine gas has been captured as a pollutant and sold as a fluoridation product for public water supplies. The reaction of phosphoric acid with phosphate rock in the manufacture of concentrated superphosphate (see geo-story III below) creates another hazardous waste: radioactive phosphogypsum. In addition to fluorine, Bone Valley fluorapatite has trace amounts of uranium that substitute for calcium. Yellowcake has been recovered from Bone Valley phosphates since the 1950s. The decay of uranium generates radium and radon, the source of radioactivity in phosphogypsum (Hine 2013).

Fluctuating sea levels submerged and exposed the Florida peninsula numerous times from the Miocene to the present. These episodes of flood and exposure meant that the mineralized fluorapatite was re-sedimented again and again. When the fluorapatite was exposed to the terrestrial environment, residual organic matter was decomposed; rivers concentrated the phosphate by washing out fine-grain sediment, jumbling it with quartz sands and clays of various ages. In the beneficiation process, these sands and clays are sorted from the phosphate rock and are disposed in mining cuts as sand tailings and clay slimes. It was also during these terrestrial periods of sea-level lowstand that mastodons and other land animals joined megalodon in the fossil record (Hine 2013).

During the Pliocene and Pleistocene, a great wave of sand from the eroding Appalachian Mountains slowly pulsed down the Florida peninsula and buried this great cache of fertility. Across this emergent, sandy landscape, an array of Holocene ecosystem — pine flatwoods, cypress swamps, marshlands, and scrub — spread out across the peninsula, adapting and adjusting to the phosphorus-poor conditions of the sand. In order to carry out mining, these Holocene ecosystems must be razed and the Plio-Pleistocene sands must be removed as overburden.

GEO-STORY I: SLAVERY AND FERTILITY

In the nineteenth century, cotton was king. The American South was the leading producer of cotton, spurring “the first great phase of capitalist industrialization” in the West (Beckert 2016). Planters assembled African slaves, European capital, and the fertility of local soils to grow the cotton that supplied textile mills in New England and western Europe. Cotton invigorated and re-sculpted the capitalist world system, but it also rewired the phosphorus cycle. Cotton exports created a one-way flow of phosphorus from the former forests and grasslands of the South to the northern cities and to Europe. This created nutrient deficits in the South that precipitated a western march of cotton. Plantation lands were utilized for a generation or two and then abandoned for new lands in the west. Decades of soil-depleting agricultural practices rooted in the slave system had robbed the soil of nutrients and precipitated the much-discussed crisis of soil exhaustion. In this context, the discovery of South Carolina phosphates gains relevance.

The South Carolina industry was the first site in the United States to mine phosphate rock on a commercial scale. Focused around the city of Charleston, the phosphate industry was launched by gentlemen-scientists, lowcountry elites, and northern capitalists in the aftermath of the Civil War. At the end of the war the South's plantation economy was at its nadir: planters experienced sharp capital and labor losses associated with emancipation, but they also confronted the slow-motion disaster of soil exhaustion. Manure from livestock was in short supply and most plantations were too rural and remote to justify importing urban wastes or expensive guano (Wines 1985). Planters' capital and managerial investments were in managing slaves, not land (Wright 1985). Cotton and tobacco are nutrient-demanding crops, and planters paid little heed to replenishing the soil's fertility through crop rotation, green manuring, or other soil-building practices. Most plantations were too remote to justify importing urban wastes. Only the wealthiest planters in Maryland and Virginia experimented with fertilizers, but even in elite circles there were doubts about fertilizers' efficacy. Purity was also a concern. Before fertilizer inspection became widespread, fertilizers were often adulterated with dirt and fillers (Wines 1985). Even if a planter had money to invest in fertilizers, he was unlikely to purchase sufficient quantities to make up the nutrient debt across his large landholdings. Agriculture in the South was extensive rather than intensive, so much so that many growers "considered moving to the Southwest a better alternative than improving their 'old' soils" (McKinley2014).

In the north, family-owned farms clustered around urban centers. By the 1840s, these farmers recognized the symptoms of soil exhaustion and began importing waste from cities to improve the fertility of their fields. These wastes included manure from carriage houses, local dairies, and feral hogs that roved city streets; fish scrap and slaughterhouse refuse; and organic ash. In this early fertilizer economy nutrients were recycled between the city and countryside (Wines 1985).

Rather than deepening a "recycling mentality" among farmers, this early fertilizer economy created consumption patterns that were its own undoing (Wines 1985). Northern farmers, seeing the fertilizing benefits of urban wastes, were primed to experiment with seabird guano imported from Peru, the Caribbean, and Pacific Islands (Cushman 2013). Guano was the first fertilizer to achieve wide distribution in the United States. Guano-importing fertilizer companies sprung up in Baltimore, New York, and Philadelphia and began marketing to farmers. Compared with urban wastes, guano was nutrient dense and less bulky to transport, although the freight costs added considerably to their price.

By the end of the Civil War, guano's demise was in sight. Foreign governments began exerting greater control over the dwindling resource. Fertilizer manufacturers, scrambling to find a replacement, began to develop superphosphates, the first chemically manufactured fertilizer. Superphosphates were created by reacting raw bone, bone black (a bone-based charcoal), and phosphatic guano with sulphuric acid. Bone had been used as a fertilizer for centuries, but in the mid 1800s it took on a new importance. Advances in agricultural chemistry demonstrated that bone reacted with sulfuric acid produces a “super” soluble source of phosphate that is more readily taken up by plants. In the late 1840s, the English chemist John Bennet Lawes substituted phosphatic rocks for bones in the manufacture of superphosphates. Lawes’ advances — underpinned by Justus von Liebig's mineral theory of plant nutrition — had been taken up by fertilizer entrepreneurs across the Atlantic, as evidenced in the market substitution of superphosphates for guano in the Northeast.

By 1865 it was becoming clear that phosphorus was the limiting nutrient in the worn-out soils of the U.S.; it was also evident that the phosphorus supply chain was bottlenecked. Superphosphates made headway into southern states before the war due to their cheaper price, but there was not enough bone in the Southeast to remedy the ails of worn-out soils. After emancipation, southern farmers — reeling from the loss of their labor force — were primed to experiment with cheap fertilizers and intensive agriculture.

In the aftermath of the war when Charleston planters and gentlemen-scientists discovered phosphate, they “marveled that the rocks had appeared as if by holy design to offer ‘their’ state and section ‘redemption’ during their most dire hour of need, Reconstruction” (McKinley 2014). Stones that were considered a nuisance and removed from the fields became, almost overnight, some of the most valuable mineral on the continent. With this new cache of phosphorus, the "backwards" South became the vanguard of agricultural modernization (Johnson 2016).

The phosphate fields around Charleston rapidly industrialized, supplying much-needed phosphorus to the South's worn-out cotton fields. The first company to step on the scene was the Charleston Mining and Manufacturing Company (CMMC) in 1867 (McKinley 2014). CMMC was organized by Dr. Nathaniel A. Pratt and Francis S. Holmes and capitalized by two wealthy fertilizer entrepreneurs from Philadelphia. Pratt was a chemist who bears the distinction of being the first person to assay the high phosphate content of lowcountry rock and to identify the epicenter of the state’s land deposits in Charleston. CMMC would become the biggest and most powerful land-mining corporation in Charleston, shipping most of their rock to fertilizer manufacturers in the cities in the north, where the fertilizer industry was based. The phosphate discovery sparked numerous start-ups. Most firms specialized in mining, but some new firms, like the Wando Company, sought vertical integration by producing their own rock and manufacturing it into fertilizer using their own acidulation plants. The Charleston phosphate industry took off, building on the same commercial networks that made it a cotton-factoring hub. Cotton factors became phosphate dealers, selling fertilizer to growers in the South but also to buyers in Liverpool and other western European cities (McKinley 2014).

Mining was carried out on plantations and underutilized lands by ex-slaves, many of whom had worked these same lands sowing and picking rice. Freedmen were paid by the task and hired and supervised by contractors. Freedmen used picks and shovels to excavate the phosphate and wheelbarrows and mules to haul it to the washer works. As the industry evolved, black men worked alongside a steam shovel and hauled the ore to a tram that conveyed the rock to the washer and dryer works. The historian Shepherd McKinley (2014) argues that phosphate work in South Carolina was relatively unalienated, at least compared with the other kinds of black labor during Reconstruction. Although subject to the worst jobs and standards of living, black men and women insulated themselves from the "inhospitable white economy" by cultivating what McKinley calls a *quiet economy*. In the quiet economy, cash generated from mining or fertilizer manufacture was supplemented with hunting, fishing, and sharecropping. Freedmen were able to exercise control over their time and labor by translating the subtle forms of power leveraged in the task system — a regionally distinctive form of slavery used in rice cultivation — to phosphate work. The task system was distinct from the gang-labor system of cotton and tobacco plantations. In the task system, white overseers avoided the malaria swamps of the lowland rice fields and, consequentially, assigned tasks to slaves who worked in pairs or family groups to be completed before the end of the day.

A few years after the land mining industry was established, the industry diversified into river mining. River rock was first collected by poor men, mostly black, who gathered stones using oyster tongs at low tide or dove to reach small boulders in deeper waters (McKinley 2014). A commentator from the 1930s described the origins of the South Carolina industry in this way: "The original technique was simplicity itself, requiring a rowboat or bateau, a length of rope, and two colored boys, one of which, and preferably both, able to dive. While one boy stayed on the boat, the other dove to the river bottom, groped for a small phosphate boulder, whereupon return to the surface was insured by the rope, one end of which had been fastened about his middle" (U.S. Congress 1939).

Hand mining of river deposits was quickly replaced by dredges. Dredges were equipped with washing equipment and a digging apparatus. Dipper dredges, like the kind used in ordinary navigational dredging were equipped with a bucket shovel; other barges were equipped with "grapplers" that dislodged and loosened hardened sediments. A third kind was the suction dredge. The suction dredge was specifically invented for vacuuming phosphatic pebble from the bottoms of the Ashley, Cooper, and Coosaw Rivers. Driven by a centrifugal pump, the suction dredge became the dominant technology in the short-lived Florida river-pebble industry and, as we will see, a pivotal machine in land-pebble operations too (Wines 1985).

The 1880s represent the peak of the South Carolina industry. It was also during the 1880s that phosphate was discovered in both central and north Florida. In 1881, Captain Francis LeBaron, a chief engineer with the Army Corp of Engineers, was surveying the Peace River as a potential route for a cross-Florida canal when he became curious about water-worn pebbles, bone fragments, and fossils in the river's sand bars. Suspecting that these rocks were nodules of phosphate, LeBaron sent a sample to a Smithsonian chemist who confirmed the rock's high bone phosphate of lime content and urged him to undertake a geological survey. The survey never took place, but LeBaron, galvanized by his find, took a leave of absence the following year to court capital in northern cities, encouraging potential financiers to “buy or bond the entire Peace River Valley” (Blakey 1973). Unsuccessful, LeBaron took a position in Nicaragua to oversee the survey and construction of a proposed canal. In 1889, phosphate was again discovered in Florida, this time around the northern town of Dunnellon. While cleaning out the bottom of a spring, Albertus Vogt encountered rocks scattered among bones, tusks, and teeth that he suspected might be phosphatic. Vogt had them analyzed by a St. Louis firm that revealed high-grade phosphate, calling Vogt’s find “the most valuable rock in the world” (Blakey 1973). These two discoveries led to the opening of the Bone Valley land-pebble field and the North Florida hard-rock district.

The exuberance surrounding South Carolina rock spawned curiosity and a lust for fortune on the Florida frontier. News of Vogt’s discovery in north Florida spread quickly, sparking a land boom reminiscent of the California Gold Rush, albeit on a smaller scale. Thousands of prospectors and investors descended on the northern phosphate district, bought and sold land, and formed companies at a frenzied pace. Prospecting parties swarmed North Florida but knew nothing of the physical qualities of the local phosphate rock. To these would-be prospectors "anything more cohesive than sand and more resistant than putty was phosphate. [The rock] was true petrified bone when it was hard, and very valuable. When exceedingly soft it was decomposed bone and therefore more valuable. If unusually light-colored, it was amazingly rich, though if uncommonly dark-colored, it was richer" (Blakey 1973). Strange theories mutated out of ignorance: some prospectors mistook patches of certain grasses or oddly shaped trees as a clue to a rich deposit. Prospectors inexperienced with phosphate geology failed to translate their exuberance into mineral wealth. Perhaps it is unsurprising, then, that those who made the swiftest and most enduring entry into the Florida phosphate fields were those who knew phosphate best: the leaders of the South Carolina industry.

In 1886, under the guise of a hunting trip, a group of southern and northern entrepreneurs with ties to the Charleston industry embarked on a phosphate expedition along the Peace River. The phosphateers included Dr. Nathaniel D. Pratt— the son of Dr. Nathaniel A. Pratt, the geologist who founded the Charleston Mining and Manufacture Company — and George W. Scott a New York businessmen who owned Oak Point, a land- and river-mining outfit out of Charleston. Pratt performed chemical tests on the rock in the privacy of a hunting tent. After discovery of the 61 percent phosphate content, the men vowed to keep this discovery a “graveyard secret” to avoid sparking a land rush (Blakey 1973). Among locals, the hunting party’s disguise wore thin. One resident remarked, “It is surmised that they are out for something else beyond pleasure and will combine it with business, judging from the instruments they carried” (Brown1991). In order to purchase all the land they desired, the team concocted the ruse that they were planning to open a tannic acid plant that would utilize the area’s great stock of palmetto roots, and “as soon as they had grubbed out all the roots they…would sell them back to the owners for a mere song” (Blakey 1973). Soon they possessed deeds for long stretches of land along the Peace

River. In 1889, these adventurers formed the Peace River Phosphate Company and began exporting river pebble rock to Scott's fertilizer plant in Atlanta.

These cunning industrialists represent the first trickle of chemists, engineers, and investors from South Carolina's phosphate fields into Bone Valley. These entrepreneurs, very often the sons or male relatives of industry leaders, would shift the phosphate fertilizer industry's center of gravity from the "Old South" to the southernmost state.

Into the Piney Woods

Our story now shifts to west central Florida in the late nineteenth century when Bone Valley land pebble was first prospected and mined. Phosphateers used the South Carolina land- and riving-mining technologies experimentally, adapting them to the social and geological particularities of the frontier. The remoteness of the deposits made long distance transport of industrial equipment and fossil fuels difficult. Consequently, black labor and local forests became an indispensable source of power. Black miners, drawn from the Jim Crow cotton belt, muscled phosphate out of the earth by hand and carried out the dangerous work of operating steam-powered equipment in more mechanized operations. Local slash and longleaf pine forests were razed to power steam engines. These engines transformed the chemical energy of the wood into the mechanical action of suction pumps, dipper dredges, and steam shovels.

At the time of LeBaron’s discovery, Bone Valley was a sparsely populated backwater of “impossible sand banks and uninhabitable tropical swamps” (Blakey 1973). The first towns and settlements were formed from military posts from which the bloody campaigns of the Second Seminole War were waged. This war transformed the Peace River Valley from a safe haven for Seminoles and marooned blacks into space of racial violence and intimidation (Brown 1991). The majority of residents were cracker pioneers who made a living from the land by raising cattle on the open range. In the wake of the Civil War settlements gained population, but the region saw a steep decline among black residents. This population decline stemmed from violent campaigns of a group of white vigilantes who called themselves the Regulators (Brown 1991). The region began developing roads, churches, and schools, but it remained in many ways a rugged and isolated wilderness, lacking railroads, communication lines, and industry.

Phosphate fever brought change to the Peace River Valley. Streams of wildcat prospectors, mining equipment, new railroads, and European and Northern capital flowed into central Florida. Black men, fleeing the social and economic chaos brought on by the Civil War and Reconstruction's failure, flocked to Polk County to work in orange groves, turpentine camps, lumber mills, railroad construction, and phosphate mines. In the early period, 1890-1920, black men constituted approximately 95% of the common labor force (Blakey 1973). They cleared vegetation, stripped overburden, mined rock, washed it, dried it, and prepared it for shipment. The mining boom also brought white migrants to Florida to work as mechanics and foremen. Local crackers were considered an unreliable labor source. As one contemporary disdained:

> Though naturally intelligent, the "crackers" have grown accustomed through their indolent life to taking things easily; they are most independent in their views, and as most of them own a homestead and cattle of their own, they like a holiday after a week's work. The consequence is that they are rarely employed for anything but cutting cord wood by contract (quoted in Blakey 1973).

The first mining was conducted in an outcropping of Bone Valley phosphate deposit in the Peace River beginning in 1888. River pebble was excavated with suction dredges invented in the South Carolina river-mining industry (Wines). The suction machine was driven by steam-powered centrifugal pumps. Operating in tandem was a separate barge equipped with a crude system of screens that filtered sands and clays back into the river. The phosphate gravel was then loaded onto a scow and conveyed to the mill where it was sorted a final time and dried. The pebble was then shipped to fertilizer plants in southeastern cities where the rock was turned into ordinary superphosphate. Given its access to water transport, the river pebble industry was the first phosphate operation to obtain profitability. River mining concluded in 1908.

In Bone Valley and the North Florida hard-rock district, mining was carried out by hand and by crude steam machine. Hand mining represented some of the most grueling and oppressive labor conditions. Miners excavated pebble with shovels, picks, and wheelbarrows. Wooden planks zigzagged throughout the pit. Pits were a hive of activity. Men worked in tandem with draft animals. Mules and horses were equipped with scrapers to drag off overburden and carts to haut phosphate to the washers. In more mechanized mining operations, black men tended steam engines and the mining and beneficiation equipment they powered. The engines and the pipes that conveyed steam needed to be continuously relocated to keep pace with the advancing pit. The first form of mechanized mining in Bone Valley and the hard-rock district employed the dipper dredge, a technology used in the rivers around Charleston. In the hard-rock district, these dredges were used to mine land deposits with a high-water table. But in the land pebble district, where labor shortages and the pressure to mechanize were more acute, water was brought in by ditches from nearby ponds and streams to float the digging machines.

Work in the mines was dangerous. Uncovered steam pipes sprung leaks, injuring and scalding workers; a malfunctioning boiler created lethal explosions; cave-ins buried miners alive. In the hard rock district, dynamite was used to excavate large phosphate boulders, a practice that resulted in loss of life and limb. Workers lived in camps and, as the industry matured, segregated company towns like Pierce, Brewster, and Phosphoria. Camps were squalid and consisted of unpaved streets and shoddy wooden shacks. Sanitation was poor. Laborers were paid in company scrip and often found themselves in debt that restricted their movement. Most children did not go to school and women's labor was confined to domestic duties. Corn bread, salt pork, sweet potatoes, rice, beans, and cane syrup were staples of the miner's diets. Segregated phosphate towns offered better living conditions for black family men recruited to work in the land-pebble district. These towns included houses, gardens, and recreational grounds, but workers were still dependent on the commissary for basic goods.

In the 1920s, Zora Neale Hurston came to Polk County to record folk tales from “Negroes from all over the south” who shuffled between timber, railroad, citrus, and phosphate work (Patterson 2005). She encountered a vibrant social world in the camp’s jook joint where workers found reprieve from the day’s toil. Blues music, gambling, liquor, dancing, and “promiscuous love” came together at these speakeasies. Passions ran high and Hurston found her life in danger on several occasions, incurring jealousy from local women. “Some little word, look or gesture can move them either to love or to sticking a knife between your ribs. You just have to sense the delicate balance and maintain it” (Hurston 1935).

From Hurston’s perspective life at the camps was lively but rough. “All of these places have plenty of men and women who are fugitives from justice. The management asks no questions. They need help and they can’t be bothered looking for a bug under a chip…The wheels of industry must move, and if these men don’t do the work, who is going to do it?” (Hurston 1935). Although Hurston does not foreground violence, her novels and ethnographies show us how the upheaval and racial violence of Jim Crow percolated through the everyday geography of the Florida migrant. For Hurston, the violence of the New South was insidious but not a totalizing force. New forms of mobility, wealth, love, art, and pleasure were being improvised on the Florida frontier. Yet this was no quiet economy. Emergent freedoms were negotiated alongside emergent dangers.

From 1890 to 1930, Florida had the highest rate of lynching anywhere in the South (Mormino 1996). Within the mining towns there were numerous cases of black men “hanged, burned at the stake, or even drawn and quartered (Blakey 1976).” Vigilante justice was not new to the Peace River frontier but it grew in intensity with the influx of black laborers. In the town of Mulberry — the business of hub of Bone Valley — local miners imparted the following tale to the Works Progress Administration’s Federal Writer’s Project:

> A legend of a different kind, fraught with realistic dread, was the renewal of life years ago in a mulberry tree, which is said to have taken place in the town of Mulberry. Negroes there say the place received its name from this particular tree. It was the custom of lynch mobs, the story goes, to hang the victims from this tree and then riddle their bodies with bullets. This gunfire finally killed the tree. For many years it stood bare and apparently dead, until one spring it again sprouted leaves. The news spread rapidly among Negroes, who saw in it an omen of more lynchings, and many of them fled to other sections. In 1938, the hollow and battered trunk still supported a live bough, but further lynchings had not yet occurred (Melillo n.d.).

The most systematic form of racial violence took form in Florida’s convict lease program, 1877-1924. The vast majority of convict laborers were black men in their teens and twenties who were incarcerated on petty charges of vagrancy, gambling, and theft. In 1877, Florida lacked a penitentiary system and the Republican government was reluctant to spend tax money on prisons (Drobney 1994). Convict leasing programs generated income and relieved the state of the financial costs of a prison system. Convicts were leased to the highest bidder. Businesses who leased convicts assumed responsibility for their housing, food, clothing, and health care. Convict leasing represented an insidious revival of slavery, albeit with new masters.

Work was carried out under the watchful eye of guards armed with guns, whips, and dogs. Beatings were a common form of punishment; instances of torture and killings were numerous. Convict leasing was ubiquitous in the South and underwrote Jim Crow capitalism (Drobney 1994).

> Southern entrepreneurs were short of both capital and labor to fulfill the prophecy of the New South. Convict labor bridged the gap between an agricultural slave economy and a society in the earliest stages of industrial development…. The establishment of the convict lease offered an acceptable solution to the dilemma of creating a sufficient pool of industrial workers without disrupting the labor supply available for agriculture (Drobney 1994).

The prophecy of the New South was coming true in Florida: new extractive industries, tourism, and large farms were diversifying and expanding the reach of capital. Practices like convict leasing and debt peonage arose from a "white consensus that the economic expansion of Florida depended on the subjugation of black labor" (Ortiz 2005). Cheap labor made new industries like phosphate mining profitable and demonstrated that Florida deposits were worthy of greater capital and technological investment.

Forests as Fuelwood

To foreground the coercion of labor alone can only go so far in explaining how mining emerged on a remote frontier. Early mining was carried out without electricity or fossil fuels. Motive power was derived from black laborers and draft animals, but also local forests. The steam engine was a prime mover, and in the absence of oil or coal, local forests became an indispensable fuel. Extensive areas of slash and longleaf pine forests were clear-cut to power digging and beneficiation machines. Although local timber was used to dry phosphate and to build housing and washer plants, the greatest use of forests was as fuelwood for steam engines.

Large steam engines were imported from the north to power dredges, pumps, steam shovels, and washers. In an average mine running four steam boilers, 36-40 cords of wood were consumed daily. A cord is a wood pile 4 feet high, 8 feet long, and 4 feet deep. A cord probably consisted of anywhere between 3-10 trees, depending on their diameter. There are no historical records that detail the logging industry or forest acreage that catered to phosphate mines. But given these basic figures we can infer that a single mine likely consumed 200-300 trees per day. Consuming this large number of trees would have deforested a considerable area, especially given the sparse architecture of southern pine forests.

Early naturalists described these forests as "unusually open" and often commented on their uninterrupted views (Walker 2000). Given the savanna-like quality of these forests, supplying the fuelwood required by the mines entailed extensive deforestation, but perhaps minimal impact to the understory. Although there are few records, phosphate mining turned cordwood production into a minor industry. The first companies undoubtedly deforested an area considerably larger than their property holdings. Deforestation followed paths laid down by the railroads. Spurs built off the main line gave lumberjacks access to forest patches. "Trees were felled by axe or reciprocating saw and logs were chained to high-wheeled carts, and then pulled, dragging on end, by teams of mules to the rail spur" (Walker 2000). It is unclear how much of the labor was supplied by local crackers or black migrants.

West central Florida's pine forests were of the flatwoods variety and represented the longleaf pine's southernmost range. Flatwoods are characterized by level, poorly drained, sandy soils, uneven age structure, and a palmetto understory with high plant diversity. Flatwoods were the ubiquitous ecosystem type in this region and grew in a range of soil conditions. Scrubby flatwoods were found on drier, higher elevation soils and often intergraded with sandhill and high scrub. Still others were found in wetter mesic conditions with a greater proportion of slash pine. These were fire-adapted ecosystems that supported high populations of animals, including gopher tortoise, cockaded woodpecker, white-tailed deer, but also the feral cows and pigs unleashed by Spanish colonists (Walker 2000). In the language of landscape ecology, flatwoods was the matrix ecosystem in a wider ecological mosaic of cypress swamps, wet prairies, high scrub, and numerous lakes and rivers. For an ecosystem or land use to have the property of the matrix, it must cover an extensive area, be highly connected, and strongly influence regional dynamics (Forman 1995).

Mining etched new patterns into the landscape ecology. Hand- and steam-machine mining in Bone Valley left behind a pockmarked and denuded landscape. Many of these cutover lands were mined. Vast areas of forests beyond the mining zone were clear-cut for fuelwood. Overburden was left in piles or washed into streams by hydraulic giants, forming the first source of pollution. Although the destruction paled in comparison to the mining to come, early mining operations were an assault to the region's Holocene ecological mosaics. Geographical descriptions from the period are lacking, but gauging from old photographs and production statistics the footprint of the early mining companies was extensive. Archaeological records of this mining era are paltry to nonexistent. Innovations in mining and recovery technology (discussed in the next geo-story) made it possible to re-mine these landscapes. The physical record of this early landscape destruction has, quite literally, been cannibalized.

Finally, we should revisit the question of cotton. The South produced more cotton after the Civil War than before. This expansion is strongly linked to the industrialization of South Carolina and Florida phosphates and their use by southern farmers. Cotton thrived to such a degree that in some areas it reversed its western course and began moving east! “Parts of the Piedmont that were among the oldest cotton-growing areas and had long been considered ‘exhausted,’ enjoyed a new revival in cotton growing” (Wright 1985). The fertility of fossil oceans reanimated the cotton economy. The growing price of cotton squeezed out other land uses, subsistence food crops in particular. Southerners began large-scale imports of corn and hogs from the Midwest, thus contributing to a crisis of soil exhaustion in the Midwest that would not be remedied until after WWII.

Transition to Hydraulic Mining

In the first decades of phosphate mining in Florida, hand mining and experimental steam-machine operations coexisted. Firms negotiated the costs of recruiting and maintaining a labor force against the costs of importing large, expensive equipment. As the industry matured, the economics favored mechanization.

Rock mined by hand cost $3.50 per ton, whereas mining carried out by steam-powered excavators was a dollar cheaper (Blakey 1973). At the turn of the century, land-pebble companies developed an excavation method that utilized the suction dredge that reproduced elements of river mining on land. This technique served as an important transition between South Carolina-derived technologies and the hydraulic methods that prevail today. It merits description.

The technique made use of a new piece of technology: the hydraulic giant. A hydraulic giant is a pressurized water gun, developed in the California Gold Rush. In Bone Valley, hydraulic giants were used to remove overburden, dig holes, and slurry the phosphate matrix. Today, they are still in use but only to slurry the phosphate rock. In the early period, hydraulic giants were used to excavate long, linear holes. Miners filled these holes with water and floated suction dredges. Here’s how the mining process worked: First, miners used the hydraulic giant to blast a sump into the bedrock. The suction apparatus from the dredge was inserted into the sump. The dredge was floating in a neighboring pit filled with water and separated by an earthen bank. In the first pit, the miners sprayed pebble into the sump. Once the pit was excavated, the hydraulic giants were removed and the bank separating the pits was breached. Water spilled into the freshly excavated pit and the dredge was floated onwards. The miners then dug a new hole and sump and the process was repeated. In this way, the miners created a “river” which they used to barge phosphate to the mill (Blakey 1973).

In the first decades of the twentieth century, phosphate mining companies built electrical stations. Electrification created a more powerful and reliable energy source that precipitated numerous changes in the industry. As electricity replaced human muscle and forest power, this terrestrial "river-mining" method was considerably abbreviated. In the electrified configuration, the dredge was dropped from the apparatus and its suction device elongated. Using multiple electrically powered pumps, the suction tool became a pipeline. These pipelines extended several miles long and directly connected the mine to the washer plant. This innovation simplified mining operations and reduced the number of laborers.

Electrification triggered dramatic reorganization of the industry. Yet there were no hard breaks with the past. The suction dredge developed in the Charleston river-mining regime was bootstrapped into new industrial and geographical configurations, simultaneous as some of its features (the dredge) were rendered obsolete. For the next twenty years, this electrified mode of hydraulic mining was the dominant method in the land-pebble industry.

In the early 1920's, phosphate companies added draglines to the assemblage after observing their successful use in building the Panama Canal. In Bone Valley, draglines were first used to excavate the phosphate rock and later to remove the overburden, leaving the hydraulic giants the job of slurrying the phosphate matrix. Draglines considerably expanded the capacity of mining companies to unearth matrix. But to avoid processing bottlenecks, companies built bigger plants and more durable washers. From 1900 to 1938, output per washer-hour increased from fifteen tons to eighty tons (Blakey 1973). The slurrying process and long-distance piping of the matrix helped prepare the materials by breaking up clay balls and thoroughly churning the sand, clays, and pebble.

GEO-STORY II: AN EFFICIENT MONOPOLY

By the 1920s, Bone Valley was entering an era of big machines. Electricity, hydraulic giants, and draglines scaled up the mining process and increased the industry's command over the local geology. Simultaneously as the machines were growing big, mining companies experimented with processes like flotation and hydraulic classification that enabled them to pry into the rock's fine-grain associations. Fertilizer companies, with their teams of engineers, became masters of the large and the small simultaneously, giving them greater control over the volume, concentration, and quality of phosphates they produced. As the industry grew and its relationship with the deposit became more intricate and alienating, the gangue became more refined, voluminous, and cumbersome to dispose. In this story, I tell the story of the flotation process, the forms of power and geo-metabolism it enabled, and the new waste landform it created: the sand tailings pile.

In 1951, athletes from Norway, Belgium, France, Holland, Denmark, and Switzerland assembled in Bone Valley to compete in the International Sand Ski Tournament. The race was organized by Dick Pope, a local waterski enthusiast who had dreams of making Polk County a global center of the new sport. The tournament was arranged on the highest point of land in Florida, a 200-foot dune known as Sand Mountain. Located a few miles south of the town of Fort Meade, Sand Mountain was a popular attraction and landmark among locals who would scale up and tumble down its fine sand slopes. "Skiers found that metal skis on sand performed very similarly to traditional snow skis, allowing them to race downhill or slalom" (Bair 2010). Women clad in bikinis and men in tank tops zoomed down the powdery slope to a parking area crowded with spectators. Although Polk County hosts naturally occurring dunes (see next chapter), Sand Mountain was not one of them. Sand Mountain was made of sand tailings generated by Swift and Company's phosphate beneficiation plant.

Sand piles began dotting the Bone Valley landscape in the 1930s with the widespread adoption of the flotation process. Flotation is a hydraulic and chemical technology used to sort phosphate and sand particles of the same size and specific gravity. The development of the flotation process is widely hailed as the most important innovation in the industry's history. Before the development of the flotation process, phosphate particles smaller than .033 inch were discarded as waste. These particles (the excretion of ancient worms that burrowed in the phosphate seafloor) constitute approximately 50% of the phosphate ore. The implementation of flotation greatly expanded the life of the deposits and the geographic area that could be economically mined. Flotation also created cost-saving efficiencies in labor and energy by reducing the volume of overburden and matrix handled per unit of phosphate.

Industry historian Arch Blakey (1973) illustrated the significance of flotation technology by describing how one company used the process to recover phosphate from old washer debris that had been discarded in its mine cut. When the site was originally mined it yield 1,000,000 tons of phosphate pebble. Some years later, when the company re-mined its old washer debris with the flotation process it recovered 1,250,000 tons of phosphate! Across the industry, flotation doubled output. And as the industry matured the process became more and more refined. So much so that in 1964, Swift and Company used its improved flotation technology to re-mine Sand Mountain, thus destroying the local landmark.

Here is how flotation works: phosphate and quartz sands are immersed in a bath of water and chemical reagents. The reagents form an oily or soapy film around the phosphate particles, but not the quartz sand. A hydraulic force is then applied to the bath and the coated phosphate particles float to the surface. The particles are skimmed off the top, leaving the quartz sand behind.

Flotation technology had been employed in the refining of zinc and lead since 1906, but it was not successfully applied to nonmetallic minerals, like phosphate, until the late 1920s. Research on phosphate flotation began in the United States Bureau of Mines as well as in the private laboratories of the Phosphate Recovery Corporation, a joint subsidiary of the International Agricultural Company and the Minerals Separation North American Corporation. This flotation process, also known as the Crago process (named after the engineer Arthur Crago), was patented by the Phosphate Recovery Company in 1929. With the basics of flotation in place, engineers experimented with the process. Companies experimented with an array of reagents, including “fuel oil, pine oil, caustic soda, soap or soap-forming material such as fatty acids or their derivatives” (Blakey 1973). Some companies agitated the baths with air bubbles that clung to the phosphate particles helping them float; others deployed a process called tabling that shunted phosphates and sand down a ribbed, vibrating table that sorted the sand and phosphate into different collectors. No matter how flotation was implemented, it unleashed revolutionary efficiencies in the industry that allowed companies to produce more phosphate with fewer fixed costs (Blakey 1973).

To appreciate the significance of flotation, we must peer into its technological guts but also embed it in its social, economic, and technological webs of relation. Three conditions — increased labor volatility, a powerful international rival, and depressed markets — placed pressure on the industry to research, develop, and invest in new technologies (like flotation) that greatly expanded mining capacity and reduced production costs, especially labor. Bone Valley experienced labor unrest rooted in the industry’s exploitive history. Black and white strikers fulminated against low wages, the length of the workday, and the use of company scrip. In 1919, three thousand workers instituted a strike with the support of the International Union of Mine, Mill, and Smelter Workers. The strike ended in concessions but the strikes exposed the industry's vulnerability to unionization and the willingness of black workers, in particular, to fight for better working conditions. In 1917, the discovery of high quality phosphate rocks in North Africa jeopardized Florida producers’ share of the European market, “the most lucrative market they had until World War I interrupted international trade” (Markham 1958). Finally, a depression in agricultural markets beginning in the 1921 and lasting throughout the Great Depression created a slump in the demand for fertilizer products.

In the early 1920s, the industry developed a method of phosphate concentration called hydraulic classification. Although less powerful than flotation, it enabled mining companies to capture smaller-sized fraction of phosphate rock. Hydraulic-classification took advantage of the differential settling rates of variously sized particles. By adjusting the current of a flowing bath of water, engineers could sort larger particles of phosphate from sand and clays. The current was strong enough to float away the smaller clays and sands, leaving behind the heavy phosphate pebbles. By adjusting the strength of the current, the hydraulic classification enabled mining companies to sort out various size classes of phosphate, including the sand and clay fractions. Sand-sized phosphates and quartz were sent on to flotation. Clay slimes were discarded in tailings ponds.

The sand-sized output of the hydraulic-classification apparatus forms the input for flotation. As interlinked phases of the beneficiation process, hydraulic classification and flotation’s waste are, in a sense, co-generated. Clays and sands are a relatively inert waste product of the phosphate industry, yet their landscape impacts and post-mining affordances couldn’t be more different. Clay settling areas occupy approximately 40% of the post-mining landscapes and reflect one of the most intractable reclamation challenges. The slurrying of the phosphate matrix causes the clays to absorb water and expand, forcing mining companies to build aboveground impoundments for clay storage. It takes several decades for the clays to evaporate the original slurry water and to settle. Once settled, the lands can never support buildings without costly engineering. These clay ponds support wetlands communities with low habitat value, and they interrupt recharge of aquifers. In chapter 4, I describe the ecological and watershed impacts of clay settling ponds in detail. Although sand tailings piled up in Bone Valley for much of the twentieth century, they have also been used to build levees for clay settling ponds. Since the passage of the 1975 mandatory reclamation laws, sand tailings have become a valued material for repairing the post-mining landscape.

Flotation and hydraulic-classification reconfigured the waste geography of Bone Valley and laid the groundwork for a new economy of scale. Efficiencies conferred by flotation came to the aid of a foundering industry, but they did not automatically translate into greater market share or corporate power. In what follows I show how the flotation technology was used as a political fulcrum that helped turn a domestic fertilizer oligopoly into an internatiorenal cartel.

In 1919, Florida phosphate producers banded together to form two export associations: the Phosphate Export Association (PEA) and the Florida Hard Rock Phosphate Export Association, Hardphos. PEA catered to big pebble-mining companies and Hardphos to the northern hard-rock producers. These export associations functioned as legal cartels, sanctioned by the Webb-Pomerene Act of 1918, a regulation that exempted industries from certain anti-trust laws as a reward for aiding the war effort. These associations worked in close collaboration to control all sales of domestic rock outside the United States to the advantage of their members. The PEA and Hardphos fixed minimum export prices and developed a quota system that participating firms had to abide. These measures were taken to inflate the price of phosphate and reduce competition among domestic producers in the lucrative European market (Markham 1958).

The formation of these export associations is largely attributed to an emerging rivalry between Florida firms and French North Africans producers, the latter having a distinct freight advantage in Europe. As early as 1920, PEA and Hardphos negotiated with French miners to form an international cartel. Although the Americans were cordially received, prices on the European market remained stable and the North Africans, flush with business, maintained their independence. The 1929 stock market and global depression, however, cut significantly into demand. From 1930-1932, the French North Africans exports declined from five million to three million tons and the PEA's exports declined by half. These declines prompted the North Africans to help organize the proposed cartel. In December 1933, the International Phosphate Cartel was formed (Markham 1958).

Just as the domestic export association imposed quotas, the International Phosphate Cartel imposed quotas on its members, which included firms from phosphate-producing regions around the globe, except Russia. In this arrangement, exports from all U.S. producers were applied against the quota of the PEA and Hardphos. Any U.S. exports stemming from outside the cartel would cut into the quota allotted to PEA and Hardphos. This rule created a strong incentive to limit domestic producers who might participate in foreign trade. The PEA restricted entry into phosphate mining through strategic, short-term price suppression and, more importantly, through discriminating licensing of the flotation patent (Markham 1958).

Prior to the 1933 cartel, all land pebble companies that applied for a license for the Phosphate Recovery Company's flotation patent received one on a royalty basis. After the cartel was formed, patents were issued to PEA members only. In the hard rock district where the phosphate occurred as boulders, flotation technology was not applicable. Consequently, Hardphos attempted to deny the entry of new producers by restricting competitors' access to the Fernandina terminal facilities north of Jacksonville — the sole facility where hard-rock phosphate was crushed, dried, and stored (Markham 1958).

To appreciate the significance of the PEA's exclusive patent arrangement, it is important to remember that flotation's momentous efficiency altered the competitive landscape of phosphate mining: a company that did not adopt flotation could not compete with those that did. The Federal Trade Commission documents at least two instances of the firms being denied licensing agreements for flotation. International Agricultural Company, the parent company of the Phosphate Recovery Company, refused licenses to Armour Fertilizer Works and the Virginia-Carolina Chemical Company. Although it is impossible to calculate its significance, we know that the cartel was moderately successful in raising export prices of Florida rock. "In 1933 the export price of Florida pebble rock was $2.81 per ton, or only 1.4 per cent higher than the domestic price of $2.77. By 1937 the export price had increased to $4.45 per ton, or to over twice the domestic price of $2.14" (Markham 1958).

In 1944, the Federal Trade Commission established that the PEA and Hardphos were in violation of the Webb-Pomerene Act and federal anti-trust laws. While Hardphos amended its business practices to be in compliance, the PEA voluntarily dissolved the association in 1945. This dissolution of PEA and the international cartel's oligopoly would pave the way for the next technological revolution discussed in the next geo-story.

In conclusion, the flotation process ramped up the scalability of phosphate operations, generated a new waste landform, and was strategically deployed to forge a quasi-monopoly in domestic and international fertilizer markets. As such, flotation must be understood as an obligatory passage point (Latour 1993) through which corporate social relations and phosphate materials were channeled. Just as the early mining carried out with hand tools, draught animals, and crude steam machines transformed the Bone Valley from a Holocene mosaic into a pockmarked, deforested landscape, the adoption of large draglines, hydraulic-classification, and flotation technology transformed the geological landscape yet again. Draglines expanded the strip-mining footprint, creating the characteristic pit-lakes and spoil pile islands. Hydraulic classification created aboveground slime ponds in 40% of the post-mining landscape. Before dam engineering specifications were legislated in the 1970s, these tailings ponds would occasionally breech and spill mustard-colored clays into the Peace and Alafia Rivers. Sand tailings generated by flotation created another alien presence: manmade sand dunes. These sand and clay landscapes formed the physiography substructure of Bone Valley's feral upland and wetland ecosystems.

GEO-STORY III: CHEMICALIZING BONE VALLEY

At the end of the Second World War, the phosphate fertilizer industry experienced explosive growth and dramatic transformations. With the opening of new phosphate fields in the West, increased demand in the Midwest, and the rise of state-sponsored agricultural modernization programs, Florida producers experienced new competition and new pressures to innovate. These changes triggered a new economic geography in which production, distribution, and consumption were reconfigured to deliver concentrated or high-analysis fertilizer products to farmers. They also triggered a revolution in Bone Valley's waste geography. Whereas previously, the economics of fertilizer manufacture privileged the export of raw materials to fertilizer plants sited in agricultural consumption zones across the eastern U.S., the economics of high-analysis fertilizers necessitated that chemical plants be built as close as possible to the source of phosphate rock. The late 1940s and early 1950s saw a rash of new chemical facilities in Bone Valley. These chemical plants generated phosphoric acid, ordinary superphosphate, triple superphosphate, ammoniated phosphates, and a range of mixed fertilizers (Blakey 1973 and Markham 1958). They also unleashed new toxic wastes and extractive economies of scale. The most consequential of the new wastes were immense volumes of phosphogypsum, a radioactive byproduct of phosphoric-acid production, and fluorine gas emitted in the acidulation of phosphate rock. These new wastes represent the most intimate corporate penetration into Bone Valley geology: into the molecular relations of the mineral itself.

Let us begin with the geography of consumption. In 1945, farmers across the United States were primed to spend money on fertilizers. Agricultural price-support programs instated in the Great Depression by the Agricultural Adjustment Administration created a new wealthier class of farmer, one that was being educated to embrace Green Revolution technologies and practices. Fertilizer demand was especially high in the Midwest where, historically, soil nutrients had been extracted faster than they were replaced. Midwestern farmers' lag in phosphate fertilizer consumption was largely a function of distribution. Prior to WWII, the Midwest represented the periphery of Florida's phosphate markets. The freight cost of phosphate rock and elemental sulfur (the raw materials of fertilizer manufacture) added considerably to the price of superphosphates. In Georgia and Alabama, the rail-freight charge of phosphate rock transportation exceeded the price of the rock. In Michigan, freight costs were nearly two times the price of rock. Consequentially, Midwestern farmers, supplying meat and cereals to much of the nation, consumed fewer fertilizers and developed soil-nutrient deficits. In the flush times following the war, these deficits would make the Midwest one of the most important fertilizer markets in the postwar era (Markham 1958).

New demand but also new competition precipitated the industry shift to high-analysis fertilizers. Western phosphate fields in Idaho, Wyoming, Utah, and Montana, prophesied to overtake U.S. production, were beginning to come online and challenge the hegemony of Florida producers, especially in the Midwest. Western rock producers could not compete with Florida producers in the South, but they could successfully compete in the nation's Corn Belt, which lies at the outer margins of both mining centers' freight-advantage area. 1945 saw the conclusion of the war but also saw the end of the Phosphate Export Association. After the Federal Trade Commission broke up the cartel, Florida firms' monopolistic grip over phosphate rock prices diminished. Florida producers were forced to compete with Western producers and, at last, each other. Soon it became apparent that capturing Midwestern market share would mean a dramatic overhaul in the geography of production so as to transport more nutrients longer distances at a cheaper price. Concentrated fertilizer products were the future (Markham 1958).

The postwar era of high-analysis fertilizers was launched with the production and sale of triple superphosphates (TSP). Triple superphosphate has the highest analysis of any straight phosphate fertilizer. TSP refers to fertilizers with phosphate concentrations around 45% and are distinct from ordinary or single superphosphates with historic concentrations between 12-20% (Nelson 1990). The technology for making TSP is old, developed in Germany in the 1870s; a handful of commercial TSP plants have existed in Europe and North American since the turn of the century. But widespread adoption of TSP was delayed due to the high profitability of ordinary superphosphates. Ordinary superphosphates have been the industry standard since the opening of South Carolina fields. Fertilizer companies "had large capital investments in ordinary superphosphate and fertilizers plants that took a high proportion of their domestic rock sales” (Markham 1958). Production and distribution infrastructure had congealed around ordinary superphosphates. Switching the industry over to concentrated superphosphates would dramatically reconfigure the geography of production, requiring the closing of fertilizer plants across the country and the construction of new chemical plants in Bone Valley. "With the industry thus organized it is not surprising that the larger entrenched producers were slow to introduce new phosphatic fertilizers” (Markham 1958). Moreover, under the monopolistic organization of the PEA, there was little economic incentive to incur the high capital costs of revolutionizing production: ordinary superphosphates were already a highly profitable commodity. And as the lion’s share of consumption centered in the South, there was little incentive to cater to the market's periphery. This was especially true as Western firms, many of which were still in the prospecting stage, were slow to introduce TSP (Markham 1958).

Inertia against TSP was compounded on the consumption side of the equation. Farmers maintained a preference for ordinary superphosphates. By weight, ordinary superphosphates were cheaper than concentrated phosphates, although the latter offered more nutrient bang for the buck. To buy more concentrated fertilizers presupposed that farmers knew how to use them effectively. Figuring out the optimum combination of N, P, and K is a complicated task that depends on a number of factors (a farmer’s soils, crop type, amount of rainfall, crop and fertilizer prices, etc.) and is usually carried out in consultation with an agronomist (Markham 1958).

Confronting this bewildering complexity, it is unsurprising that farmers' fertilizer decisions were informed more by brand loyalty and customary practices than the agronomic avant-garde. How was this inertia overcome?

The answer lies with agricultural modernization programs promoted by the state, specifically the Tennessee Valley Authority. Since its inception in the 1930s, the TVA's fertilizer program was involved in designing, testing, and manufacturing new fertilizer products and distributing them to farmers. The TVA began distributing high-analysis fertilizer materials to farmers as an outgrowth of its test-demonstration program. Test-demonstration farms were model farms scattered across rural communities in eleven states. These farms were designed to educate farmers in modern commercial methods and soil conservation. Efficient use of fertilizers was an important aspect of managing the "whole" farm. Farmers participating in this program received high-analysis fertilizers developed at the TVA's Muscle Shoals fertilizer plant for free; farmers only had to pay the shipping costs. Beginning in 1937, this fertilizer-giveaway program was greatly expanded. By 1950, the agency had distributed 1.2 million tons of concentrated fertilizer products to cooperating farmers (Markham 1958).

Unsurprisingly, the TVA fertilizer program was popular with farmers and unpopular with manufactures. However, fertilizer companies were also the direct beneficiary of the TVA. TVA freely shared the patents to its fertilizer-production technologies, including the 1945 invention of the cone mixer (hailed as a masterpiece of design simplicity) used to create triple superphosphate (Nelson 1990). As fertilizer companies delved into more sophisticated chemical operations, the TVA helped train industry employees and sent TVA consultants to help design fertilizer plants and implement TVA processes. But perhaps the TVA's most enduring gift to the fertilizer industry was the creation of a new brand of farmer and fertilizer consumer, one that could appreciate and utilize high-analysis fertilizers.

The confluence of these events — new competition from Western producers, new fertilizer consumers, the dissolution of the PEA — compelled Florida producers to overhaul production and distribution infrastructure organized around ordinary superphosphates and build chemical plants in Bone Valley. To appreciate these changes and their implications for new waste generation, we must delve into the economics and chemistry of the ordinary and triple superphosphate production. Let us start with the economics.

In the ordinary superphosphate regime, phosphate rock and elemental sulfur were transported to fertilizer plants near the source of consumption. This is because the manufacture of ordinary superphosphate is a bulk-gaining process. To produce a ton of superphosphate requires 1,200 pounds of high-quality phosphate rock and 230 pounds of elemental sulfur. At the fertilizer plant, the sulfur is combined with water to create sulfuric acid: 230 pounds of sulfur generates 1,110 pounds of sulfuric acid. This sulfuric acid is then reacted with the rock to produce a ton of ordinary superphosphate. The final product weighs 560 pounds more than its raw materials (excluding water). Shipping the raw materials is more economical than shipping the finished product. For this reason, the fertilizer plants were located in agricultural landscapes close to consumers. By contrast, the production of a ton of triple superphosphate requires 3,105 pounds of high-grade rock and 595 pounds of sulfur. As the market shifted toward high-analysis fertilizers, the advantage of siting chemical plants near the rock supply became economically advantageous (Markham 1958).

Now let us look at the chemistry behind ordinary and triple superphosphate production as a window onto the industry’s new wastes. Ordinary superphosphate is manufactured by reacting phosphate rock (fluorapatite) and sulfuric acid. The reaction is as follows (Nelson 1990):

$$\underset{\text{Fluorapatite}}{Ca_{10}F_2(PO_4)_6} + \underset{\substack{\text{Sulfuric}\\\text{Acid}}}{7H_2SO_4} + \underset{\text{Water}}{3H_20} \rightarrow \underset{\substack{\text{Monocalcium}\\\text{Phosphate}}}{3Ca(H_2PO_4)_2 \cdot H_2O} + \underset{\substack{\text{Calcium}\\\text{Sulfate}}}{7CaSO_4} + \underset{\substack{\text{Hydrofluoric}\\\text{Acid}}}{2HF}$$

The rock and acid mix to form a plastic-like material of monocalcium phosphate and calcium sulfate (gypsum). The material is hardened and then milled. The gypsum byproduct remains in the finished material. The acid breaks the molecular bonds that made the phosphate rock insoluble and releases the toxic fluorine gas. Under the ordinary superphosphate regime and during the first decade of the triple superphosphate regime, this fluorine gas was released to the atmosphere.

The manufacture of triple superphosphates follows a similar formula, but instead of sulfuric acid the phosphate rock is reacted with phosphoric acid, thus magnifying the phosphate content of the fertilizer. The production of the phosphoric acid generates the nuisance phosphogypsum (Calcium sulfate dihydrate). The chemical reaction for phosphoric acid is (Nelson 1990):

$$\underset{\text{Fluorapatite}}{Ca_{10}F_2(PO_4)_6} + \underset{\text{Sulfuric Acid}}{10H_2SO_4} + \underset{\text{Water}}{20H_20} \rightarrow \underset{\text{Calcium Sulfate Dihydrate}}{10CaSO_4 \cdot H_2O} + \underset{\text{Hydrofluoric Acid}}{2HF} + \underset{\text{Phosphoric Acid}}{6H_3PO_4}$$

The reaction is carefully controlled to form large crystals of phosphogypsum that are filtered from the phosphoric acid (Nelson 1990). For every ton of phosphoric acid five tons of radioactive phosphogypsum are produced. The phosphogypsum contains small amounts of radium that prevent it from being repurposed (e.g. as dry-wall ingredient, soil amendment, or road filler). Radium is a daughter isotope of uranium. Federal regulations require that it be disposed of in stacks. The gypsum leaves the fertilizer plant in a slurry form and is pumped into ponds. As the material settles, new phosphogypsum is added and the impoundment dikes are raised. Over time, the gypsum accumulates into a large ziggurat structure. Each year, the Florida phosphate industry generates 32 million metric tons of new gypsum. The average stack "occupies 135 acres (100 football fields), and many reach 60 m in elevation" (Hine 2013). In 1994 and again in 2016, a phosphogypsum stack collapsed into a sinkhole, spilling radioactive waste into the Floridan aquifer.

The production of triple superphosphate, like ordinary superphosphate and phosphoric acid, generates fluorine gas. In the prewar era of regional fertilizer plants, fluorine gas emissions were distributed around the country. In the postwar era, domestic and international phosphoric acid production became concentrated in one place: Bone Valley. Today fluorine gas is scrubbed from chemical plants and sold to municipalities that use it to fluorinate drinking water supplies. But throughout the

1950s and 60s the toxic gas was released into the atmosphere where it poisoned cattle, damaged citrus groves, and took the paint off cars.

> Local farmers and ranchers saw citrus yields fall markedly and cattle sicken. Citrus leaves began to yellow around the edges and fall off prematurely, and generally stunted growth patterns were observed on fruit and fruit trees. At the same time local cattle ranchers began to note in their animals stiff leg joints, strange knobs on ribs and leg bones, inexplicable starvation, and prematurely rotted teeth (Dewey 1999).

The air quality crisis created by fluorine emissions precipitated the first wave of environmental protest against the phosphate fertilizer industry. In the mid 1950s, ranchers, citrus growers, and other concerned local residents amassed evidence of fluorine damage and reported their findings to local officials. During this period, industrial pollution was largely unregulated at both the federal and state level. A local citizens group was successful in goading the Florida legislature to create the Florida Air Pollution Control Commission, yet the commission proved feckless in the face of an industry with a powerful influence over state and local politics (Dewey 1999). In 1960, sales of phosphate rock (65 million tons) supplied 22% of Polk County's tax income (Blakey 1973).

Despite the chorus of complaints and weighty evidence that fluorine emissions were poisoning the region, the federal and state governments were reluctant to confront the industry. Emissions were gradually halted in the late 1960s, as ranchers and citrus growers began to win lawsuits against phosphate companies. The state air-control officials encouraged the phosphate companies to "purchase the land of their angry neighbors in order to quell local protest" (Dewey 1999). The cost of these land purchases and the shadow of impending federal air quality legislation compelled phosphate firms slowly and voluntarily to install the expensive air-pollution abating equipment.

This episode branded the phosphate fertilizer industry as environmentally destructive, but it is important to keep mind that it was the destruction of agricultural capital rather than Holocene ecologies that compelled the industry to reform. In 1975, the Florida legislature implemented a set of laws mandating the reclamation of all new phosphate mines. This important legislation forced the industry to re-contour the landscape, restore wetlands on an acre-for-acre, type-for-type basis, and pay a severance tax that helped fund the Florida Institute for Phosphate – a research agency that has conducted important studies on the reclamation of phosphate lands. Despite the considerable environmental improvements that came from this legislation, it is important to note that it stemmed from protests by local leadership from the City of Lakeland. Like all Florida cities in postwar period, Lakeland was rapidly sprawling outside of its historic boundaries. As the city sprawled it encountered a limit to growth: unreclaimed phosphate lands. The mandatory reclamation legislation, infused with the environmental spirit of the 1970s, was first and foremost designed to mitigate the landscape for future real estate development.

CONCLUSION

In this chapter I described a century-long metabolic encounter between Bone Valley's phosphate geology and the U.S. phosphate fertilizer industry. In *Consuming Ocean Island,* Katerina Teaiwa (2015) examines a similar encounter that took place on Banaba Island in the Pacific Ocean. Only two-and-half square miles in area, the small island of Banaba, along with its neighboring island Nauru, was pillaged for its phosphate rock by the British Phosphate Company from 1900-1980 and sold to agricultural interests in Australia, New Zealand, and Japan. Teaiwa, of Banaban descent, describes how mining fractured the landscape, displaced native Banabans, and torqued their cultural identity. Ghostly coral pinnacles haunt the landscape, a stark emblem of the irreversibility of imperial landscape transformations.

In her book, Teaiea offers a provocative reworking of the standard chemical reactions that are strewn through the literature on fertilizer, including this chapter:

land/people + rock + technology + empire $\leftrightarrow Ca(H_2PO_4)_2$ **+ food + profit**

In Teaiwa's hands, the chemical reaction becomes a trope to convey the imperial transformation of an indigenous world into an agro-industrial resource. Building on Teaiwa's creative intervention, I have revised her equation to reflect this chapter's central argument:

geology + labor/technology + capital $\rightarrow Ca(H_2PO_4)_2$ **+ food/fiber + profit + heterogeneous waste + human population growth**

I point to a few differences in our equations:

Mining impacts are irreversible. I substitute Teaiwa's two-way arrow with a one-way arrow. These "reactions" are not reversible. In Bone Valley and in Banaba, there is no going back to a pre-mining world no matter how many resources are allocated to ecological restoration or reparations to displaced Banabans.

The phosphorus apparatus grows food and fiber. Today, 66% of phosphates are used to grow cereals, 60% of which is fed to livestock (Smil 2000). It is important to remember that the cotton world economy created the fertility deficits that were foundational to the phosphate industry. In the postbellum period, chemical fertilizers substituted for slave labor. During slavery, planters managed fertility through the coercion of labor on large landholdings that could be abandoned if necessary. Chemical fertilizers held plantations in place and allowed planters to grow crops with less labor, shifting the structural dependencies that organized black-white relations under slavery. This structural shift coincided with emancipation, which unlocked a wave of migrant laborers who came to Florida to find work.

Increases in southern fertilizer use put more land in cotton and took less land out of food production. During the late nineteenth century, the South became reliant on the Midwest to produce much of its food. As fertility flowed out of the South as cotton, the Midwest's fertility flowed into the South to feed people. This flow of phosphorus from the central plains and prairies would create nutrient deficits that, over time, helped spur the postwar triple-superphosphate market.

Mining, beneficiation, and fertilizer manufacture create a heterogeneous waste landscape. I have chronicled the phosphate industry's evolution from a simple frontier operation to a large technological system. At different phases in the industry's evolution, new technologies afforded fertilizer firms new powers over Bone Valley geology. With every innovation, phosphate mining companies insinuated themselves more deeply into the geological association. New technical intimacies begat expansions in industrial capacity: bigger excavators, more throughput, expanded distribution networks, more consumer demand, etc. Fertilizer companies, with their teams of engineers, became masters of the small and the large, giving them greater control over the volume, concentration, and quality of phosphates they produced. As the industry grew and its relationship with the deposit became more intricate and alienating, the gangue became more refined, toxic, and voluminous. Each revolution of the industry's power over the small enacted new forms of institutional bigness and economies of scale. The Mosaic Company is a manifestation of that history.

Population matters. Adding human population growth as a byproduct of the phosphorus apparatus turns this equation into a runaway chain reaction. Fertilizers created surpluses that create population, which creates more demand for fertilizer, etc. Chemical reactions in which the byproduct of a reaction is a catalyst of that reaction receive a special name: explosions. The explosive population growth of the Great Acceleration is directly tied to the industrialization of the phosphorus cycle.

We are megalodon incarnate.

Chapter Two

Island Scrub: Endurance and Extinction at the Holocene/Anthropocene Boundary

Scrub is an ancient, fire-dependent ecosystem found on a range of remnant dunes in Central Florida. Naturally rare and biogeographically scattered, scrub has become even more rare and scattered in the Anthropocene. Land clearing associated with citrus growing and suburban sprawl has decimated Florida scrub, leaving behind an archipelago of fragments. Since the early nineteenth century, 83% of Florida scrub habitat has been lost to development, making it the eighth most imperiled ecosystem in North America (Noss 1995).

In this chapter, I chart scrub's historical emergence from its Miocene origins in the Sierra Mountains in Northern Mexico to its fragmentation by twentieth-century development. I focus my analysis on the ecosocial world of one of those fragments: the Lakeland Highlands Scrub. The Lakeland Highlands Scrub is the last remaining patch of Florida scrub on the Lakeland Ridge. The northern and central section of the Lakeland Ridge was converted to citrus groves and subdivisions; the southern third has been completely consumed by phosphate mining. On three sides of the remnant scrub parcel are old phosphate lands; on its fourth is a new subdivision. The chapter offers a natural history description of the Lakeland Highlands Scrub; it also describes the feral-industrial ecosystem created by mining. These two descriptions come together in a fence that partitions the Lakeland Highlands Scrub from the former Bonny Lake Mine. Across this fence I contrast Holocene and Anthropocene worlds. In making this contrast, I argue that the Holocene scrub and the Anthropocene vegetative assemblages of the mine have opposing and incompatible essences. Scrub exhibits the properties of multispecies endurance. This endurance is formed in the interpenetrating lifeways of diverse organisms that have evolved over geological time into a landscape symbiosis. The landscape symbiosis, I argue, is a hallmark of the Holocene. For millions of years, scrub organisms evolved complementary life history strategies that allow them to survive in the xeric, nutrient-poor dunes that form the peninsula's spine.

On the opposite side of the fence is the historically novel cogongrass savanna. Cogongrass is an invasive plant from Southeast Asia. Cogon grasslands are a dominant ecological formation in Bone Valley and arise in the creative destruction of phosphate mining and the careless human practices the resulted in the grass's introduction and spread. I argue that learning to value cogon grasslands as an "emergent" ecosystem carries the danger of downplaying or erasing the violence of strip mining and the anti-social behavior of the grass.

By exploring the sharp spatial contrast between scrub and cogon grasslands I seek to understand how Holocene/Anthropocene landscapes are a jumble of enduring entanglements, feral proliferations, and vanquished forms. Learning to see this intermixture of elements is a challenge of natural history vision. One of the best ways to cultivate this natural history vision is to take a walk with those who have learned to see the landscape.

Let me be your guide through a lonely piece of scrub.

A Walk in Island Scrub

As you enter the Lakeland Highlands Scrub, you are greeted by an informational kiosk. “You are standing on beachfront property!” Set against a colorful topographic map of the county, the kiosk explains: “You are standing atop what is left of the Lakeland Ridge, one in a series of elevated ridges, each uniquely formed when ocean currents brought sandy soils and marine deposits to old shorelines that existed in the middle of our state long ago.”

The Lakeland Highland Scrub is a 550-acre nature park in Polk County and the last remaining patch of Florida scrub habitat on the Lakeland Ridge. The Lakeland Ridge is one of several sandy ridges that are part of the Central Florida Ridge System — a relic dune system that runs along a north-south axis in the interior of the peninsula. Purchased by the county in 2001, the park attracts joggers, dog walkers, and nature lovers from the sprawling suburbs of Lakeland. Like many remnant nature areas, Lakeland Highlands Scrub is understood as an important asset in the county park system. Local people use it to jog, walk dogs, enjoy nature, and, increasingly, operate remote control toys. In addition to hosting a number of human users, the Lakeland Highlands Scrub is home to an increasingly imperiled assemblage of xeric flora and fauna.

Walking in the heart of the scrub, I am struck by the color and texture of this ancient environment. Charred, twisting boles of oaks jut out of the low-lying assemblage of wiregrass, palmetto, and showy tarflower. Patches of white sand crusted with lichens interrupt the groundcover. Pipewort flowers, looking like pins stuck in a cushion, line the trail. Due to lack of fire, large patches of dwarf scrub oak — a hallmark of the ecosystem — have become bushy and overgrown. But there is evidence of fire, too: Polk County burn crews teamed with the Florida Forest Service have been conducting prescribed burns in the remnant scrub, using hiking trails as firebreaks. Tidy blocks of scorched vegetation are a sign of stewardship.

Anthropologists, in some way, are very much at home in the Anthropocene — the timescape in which it is impossible to ignore humans' influence over the Earth. For decades, we have played the role of intellectual Cassandra, insisting that what the West call's *nature* is socially constructed and anthropogenic. We argued that nature is a category of the Enlightenment wrought in a fantasy of mastery and progress; we showed that pristine nature is a fiction that inspired wilderness movements that resulted in the forced removal of native peoples from their lands; and we argued that humans are always part of ecosystem processes, never removed. To make this latter point, we cited Native American prairie-burning practices and we gestured to the lone beer can at the bottom of the deepest oceanic trench: no surface of the Earth, we argued, was untouched. But in our desire to see our discipline's very real relevance to world, we may have overstated our case. Or at least we did not reckon with the way the oceanic trench — let alone the lone beer can — is saturated with entanglements that exceed the human. Humans are movers and shakers to be sure, but the world exceeds and precedes us. Even in the Anthropocene, nature is not fully anthropogenic. The social history of Florida scrub can help us see this.

Thinking with scrub's natural history deepens our understanding of the Holocene as an other-than-human social universe. Hunter gatherers, swidden agriculturalists, and pastoralists make a living and shape landscapes without creating an Anthropocene. Although the question of how humans fit into the Holocene is an important one, I am mostly interested in the epoch as a thickly imbricated multispecies world that is independent of human designs. Florida scrub is one environment whose historical genesis has little to with our species. Its sociality and its fires preceded the Paleo-Indians and Archaic peoples who preferentially settled Florida's coasts to take advantage of its bountiful estuaries. The peninsula's harsh interior was not a space of permanent dwelling. Although aboriginal people may have foraged in scrub for gopher tortoises and other useful species, this foraging did not turn scrub into an Anthropocene, nor did it make it particularly anthropogenic. How can anthropologists — so thickly committed to the human — learn to see and think about multispecies worlds that are beyond us? This question is not being asked within current conversations about the Anthropocene, but it becomes relevant when we shift frames from the Anthropocene (where anthropologists feel affirmed to talk about nature) to Holocene worlds (where anthropologists must contend with nonhuman histories that precede and exceed us).

October is my favorite time of the year to visit the Lakeland Highlands Scrub: the scrub is loaded with blueberries, and the polygonella is in bloom, garlanding the scraggly scrubland with white, powdery inflorescences. Amidst the pompon lichens are thin-leaved milkweeds, St. John’s Wort, and ant colonies that make unbelievable labyrinths below ground. Sand toads and grasshoppers blend in with the sand exactly. One gets the sense that these plants and animals belong to this harsh environment; that they are attuned to its fire, drought, and nutrient-poor sand soils; that there are invisible lines of collaborative survival holding this world together.

Wander off the main trail, wading through palmetto and scrub oaks, and you will encounter a chain-link fence. This fence marks the property boundary between the county park and Bonny Lake Mine. Bonny Lake was mined from the late 1940s to the early 1980s, first by the Davison Chemical Corporation and, later, by the W.R. Grace and Co. Today the property is part of Mosaic Company’s immense landholdings and is utilized as cattle pasture. Peering through the chain link a panorama of reclaimed phosphate lands unfolds before you. In the distance is a large fertilizer plant and a ziggurat of phosphogypsum, a radioactive byproduct of the phosphate mining process. In the foreground are a few cows and the weedy assemblage of plants characteristic of reclaimed mining lands: natalgrass, Brazilian pepper, hairy indigo, bahiagrass pasture. A lush, bright green grass forms a sprawling patch. This is a cogongrass savanna. Cogongrass is one of the world’s worst weeds, found on every continent except Antartica. In Bone Valley, cogongrass is a nasty infection that creates biological deserts in its invasive grip.

Despite the adjacency of phosphate lands and ancient scrub, there is little commingling of vegetation. There are pines on the mining side of the fence, but they are planted from nursery stock as part of the mandated reclamation of the mine: they bear no direct relation to the slash and longleaf pines next door. There are, however, a few sprigs of exotic cogongrass creeping up at the scrub's edge, but it has not achieved the hegemonic grip that it does on the mining side of the fence. The scrub soils are nutrient poor, and its niches are already filled by plants that are attuned to the scrub's poverty. On the mining side, earth-moving equipment has created a devastating disturbance that has allowed weedy species like cogongrass to establish and saturate the soil with their propagules. Because the substance being mined is phosphate, the jumbled sand and overburden soils are enriched with phosphorus, fertilizing weed growth. Scrub plants fail to compete in this rigged ecology.

During my fieldwork in Florida, I traversed this chain-link fence numerous times reflecting on the stark contrast in the landscape ecology. Gradually, I began to think about this fence as an embodiment of the " / " that indexes a calamitous break in the Holocene/Anthropocene timeline: an ancient landscape symbiosis and a feral industrial landscape, side-by-side, parsed by chain link. In one imagining, the fence becomes a zero point that slices Earth history in two. The Holocene half extends backwards, deep in time, gathering the biocomplexity of bygone ages into the tapestried present. The Anthropocene segment launches forward, cannon-ball like, ignited in the original sin of laying down property lines and propelled into new trajectories by the nullifications of strip mining. Both temporal horizons are expansive, although in opposite directions, and become compressed in this fence: a fence that marks the boundary of an expansive death zone and the impoverished starting line of a new evolutionary epoch.

In a linearizing abstraction of time, the fence is a zero point. But in the fleshed-out world of historical landscape ecologies, the fence wraps. It wraps at right angles inscribing a plot of land and a patch of ecological difference forged in industrial violence. In ecology, the concept of "ecotone" describes the biodiverse zone where two ecosystems come together. The fence is not an ecotone; it is an exclosure erected by Mosaic to keep people off of its land. The plants seem to obey too, except for cogongrass with its tentacular rhizomes. The fence inscribes a Holocene ecology all but lost. Curated with prescribed fire and informational kiosks, the Lakeland Highlands Scrub is a museum piece. On its south, east, and west sides phosphate mines surround the Lakeland Highlands Scrub. To the north, a new subdivision is under construction. I walk the circumference of the fence, wavering between political ecologies of romance and horror.

In the Anthropocene, entire ecological regions can become ghosts. Industrial society's appetite for phosphate rock has obliterated native ecologies in Bone Valley. This eating — and the geological upheaval that it necessitates — has diminished the region's Holocene natures to fragments. Fractured from its generative tapestry of relations, the Lakeland Highland Scrub is a Holocene island in a sea of Anthropocene land uses and weedy ecologies. As such, it is an icon of the Eremocene, E.O. Wilson's proposed term for the new Earth epoch — the age of loneliness (Wilson 2016). I return to the message from the kiosk: "You are standing atop what is left of the Lakeland Ridge."

In the Lakeland Highlands Scrub, nature and culture come together in a sharp divide: on one side of the fence is a Holocene ecology that pre-exists humans; on the opposite side is an extractive capitalist apparatus that has, quite literally, overturned the Holocene order of things. The scrub's severed edge carries the memory of industrial rupture and the alienation of land into a resource. If we transpose this sharp divide onto a timeline with the fence as the zero-point, we can contrast past and future, Holocene and Anthropocene ecological modes.

In what follows, I use the fence line as an iconic structure to partition two different types of multispecies time. On the Lakeland Highlands Scrub side we encounter the bumptious rhythms of the *landscape symbiosis*; it is characterized by multispecies endurance and deep-time becoming with. On Mosaic's side of the fence we confront the *feral-industrial* landscape; it is characterized by irreversible rupture caused by earth-moving machines and the invasive species that entangle with the machine-wrought disturbance.

In forging this distinction between landscape symbiosis and the feral-industrial, I gesture to a synecdochical linkage of the landscape symbiosis with the Holocene and the feral-industrial with the Anthropocene. In creating these scale-jumping associations, I seek to show what is at stake in the Holocene/Anthropocene transition currently underway. If the Holocene — the most biodiverse period in Earth history (Wilson 2016) — is the timespace of the landscape symbiosis and the Anthropocene is its violent negation, we must find a way to exit the Anthropocene as quickly as possible. In making this strong claim, I contend that the Holocene landscape symbiosis, strongly exemplified in Florida scrub, is a very different type of assemblage than the "novel" or "emergent" ecosystems of the Anthropocene.

Scrub as Landscape Symbiosis

Scrub is the oldest ecological community in Florida, located on ancient sandy ridges. These ridges, collectively called the Central Florida Ridge System. These ridges are relic dunes formed by outwash from the erosion of the southern Appalachian Mountains that began 260 million years ago. "Rivers carried the quartz sand to the sea, and coastal currents transported the sand south, creating dune islands…. Whenever the oceans receded, new coastal sand dunes formed, resulting in a series of parallel ridges, running north to south" (Swain and Martin 2014). This watery history of erosion and dune formation is critical to understanding the physiography and biogeography of scrub, but the biotic origins of scrub must be told with another deep-time story.

In the cold and dry climates of the late Tertiary, glaciers descended on North America binding up vast quantities of Earth's water in their sluggish expansion. Sea levels dropped and exposed a long band of coastal shelf — stretching across Texas, Louisiana, and west Florida — called the Gulf Coast Corridor. Across this emergent terrestrial zone spread an array of oak-pine woodlands, savanna, and thorny scrub that had evolved in the Sierra Madre Mountain Range of Northern Mexico in the early Miocene. This complex of environments, called the Madro-Tertiary Geoflora, included the evolutionary precursor to the scrub that now occupies Florida's central ridges. Scrub was extensive throughout the Gulf Coast Corridor and a much wider peninsular Florida, but as the planet's climate warmed and sea levels rose, this xeric habitat was cut off from its center of origin, leaving behind a disjunct island of Western ecology in the American Southeast. Longleaf pine woodlands expanded into Florida's coastal plain, displacing scrub. As the climate warmed, scrub retreated to xeric refugia in the dunes. For many species, the terrestrial "sea" between dune-islands acted as a barrier to dispersal, allowing species differences to accumulate over evolutionary time (Noss 2013).

Scrub is an open environment dominated by shrubby, evergreen oaks with tough, thick leaves to prevent water loss. In 1931 the ecologist Maurice Mulvania described scrub this way: "The vegetation is mostly dwarfed, gnarled and crooked, and presents a tangled scraggly aspect. It…display[s] the misery through which it has passed and is passing in its solution of life's grim riddle. Here live the rosemary, spruce-pine, poor grub, and their associates rooted in a bed of silica, to which the term soil is but remotely applicable. Here the sun sheds its glare and takes a toll of the unfit" (quoted in Swain and Martin 2014). Life on the ridge is harsh. Despite our picture of Florida as a watery paradise, Florida exists at desert latitudes and has two distinct seasons: a subtropical wet season in the summer and a parching winter dry season. Perched on well-drained ridges, scrub organisms have learned to live with drought, nutrient-poor sand soils, and lightning strikes that spread wildfires across the peninsula.

Florida scrub's age, island biogeography, and extreme environmental conditions have created the evolutionary ingredients for a landscape symbiosis with exceptionally high rates of endemism. Forty-sixty percent of scrub organisms are endemic to the ridge ecosystems. Some species' ranges are so specialized that they are found on individual ridges and nowhere else!

Florida scrub typifies a *landscape symbiosis*. A landscape symbiosis is a well-rehearsed system of co-living in which organisms and their relations become attuned to the life puzzles of particular environments over evolutionary time. Landscape symbioses are not just ecosystems. An ecosystem can refer to any assemblage of species and their abiotic-biotic interactions. The components of an ecosystem need not share a history. Deep-time histories, by contrast, are a critical ingredient in the sociobiophysical ties of the landscape symbiosis. If we liken the landscape symbiosis to a dance, it is one in which the dancers are old acquaintances and have learned the choreography by heart. The choreography is palpably of the flesh and intergenerational in its rehearsal. Symbiosis forms an ontological foundation: the complex sociality of the landscape emerges from mutual aid at many scales, including the primordial scale of endosymbiogenesis (Margulis 1998). In the language of Lynn

Margulis, the dancers are bionts: co-constitutive units of living matter. Landscapes support many types of interaction among bionts — e.g. competition, predation, parasitism, and commensalism — but symbiosis is primary, lest the dance turn into a war and the actors outcompete and eat each other into oblivion. Mutual aid is obligatory but a landscape symbiosis' essential feature is the ritualized attunement of many species in eclectic interaction. The longer the evolutionary rehearsal of these relations, the more *carefully calibrated* the attunement of loosely or tightly woven parts. These attunements are constitutive of a kind of knowledge — a repertoire of sensitivities, techniques, and plasticities — that synchronize and weave organisms into enduring assemblages. This knowledge is not of the neck-up Enlightenment variety but of a morphological and phenological kind that fosters collaborative survival (Tsing 2015).

The Holocene is flush with morpho-phenological knowledge. Knowledge, in one sense, is a good term to describe how critters get on: organisms come to grips with the world through social interaction and learning. For example, living with catastrophic fires requires scrub plants to germinate from underground tubers and stems or to have seeds that regenerate after a burn. Surviving on well-drained sand soils requires tough, evergreen leaves and extensive shallow roots for capturing precipitation. But the idea of plants having knowledge is misleading inasmuch as it supposes that the ground of learning and social interaction is that of the individual organism. The knowledge that I am describing is not accreted in the life course of an individual, but in the lives lived across intergenerational time. "Knowledge," in this sense, is too thin a term: *biological memory* or *ancestral form* is better. A scrub organism's physiological, behavioral, and sensorial form is a complex inheritance that enables it (to *know* how) to survive the scrub's harsh conditions in relation with other scrub species. Across cycles of life and death, fire and regrowth, organisms continuously regenerate environments that would have been familiar to their ancestors. That is to say, each generation is a *re*generation, the members of which prehend or "grasp" ancestral form into the living present.

Let us think of this chain of prehensions that cuts across the individual organism as a kind of memory or intergenerational endurance within a landscape. How do these chains hold? To answer this question, I think of the repeating form of an organism over intergenerational time as a kind of line. "A species must be understood as something like a 'line of movement' through evolutionary time" (van Dooren 2014). The organismal line is joined end to end by its ancestors and its progeny. Different species lines weave together in the landscape symbiosis:

> Lives [as lines] are open-ended processes whose most outstanding characteristic is that they carry on. And in carrying on, they wrap around one another, like the many strands of a rope… [T]he rope is always weaving, always in process and – like social life itself – never finished. Its parts are not elementary components but ever-extending lines, and its harmonies reside in the way each strand, as it issues forth, coils around the others and is coiled in its turn, in a counter-valence of equal and opposite twists which hold it together and prevent it from unravelling (2015).

The landscape symbiosis as an interweaving of lines that forms a durable mesh of relations. In the landscape symbiosis, organisms are developmental and ecological resources to one another; in this co-resourcing, species lines knot and entwine. Scrub species are able to endure the harshness of the scrub environment because they endure it together as lines in a tapestry.

"To tapestry" is a very different verb from "to entangle." Entanglements can be improvisational, spontaneous, and easily formed in the present. Step into a hunter’s trap and you are entangled. A landscape symbiosis as tapestry, by contrast, is patterned and finely wrought; its lines of dependent creativity are bound in relations forged in an intergenerational dance subject to natural selection. Its patterns are baroque, least in part because of the many players in the game. The landscape symbiosis is not a return to the “balance of nature” but it is a recognition that our planet is a symbiotic one (Margulis 1998) and that the stability of the Holocene is is forged in the intergenerational work of learning to be response-able (Haraway 2008). Whether the landscape symbiosis is a romanticization or not, it sure looks like a tapestry when compared to the landfill — a jumble of so much recent, non-living, non-biodegradable history.

Phosphate mining, like other types of industrial land conversion, destroys these tapestried relations. The force of the mining disturbance obliterates the landscape symbiosis, creates new soil conditions, and unleashes exotic species, all of which set in motion new historical trajectories. As the Holocene confronts the lethal novelty of the Anthropocene, the embodied, deep-time knowledge of the landscape symbiosis is too often inadequate to ensure survival. How could we expect any suite of organisms to adapt to the earth-tearing devastations of the dragline?

Algal Crusts, Scrub Jays, and Fire: Figures of Scrub Symbiogenesis

To give the concept of landscape symbiogenesis precision, let us take a brief look at a few critters whose relations tapestry the scrub: a crusty soil ensemble, a cooperative bird, and stand-destroying fires.

Soil crusts are a common feature of soils in many arid environments. In a soil crust, microalgae, cynanobacteria, fungi, lichens, and mosses come together in a symbiotic binding with sand particles. Collectively they form a thin, horizontal, living layer of soil that captures moisture, fixes nitrogen, and encourages seedling germination (Hawkes and Fletchner 2002). In the Florida scrub, soil crusts provide an important food source to a strange class of insects: the flightless pygmy mole cricket. This curious insect group spends its entire life history underground. Its migrations are vertical and short: in the winter dry season, it burrows down into the soil and becomes dormant; during the rainy season it burrows up to feast on filamentous algae in the crust. These crusts, in microcosm, help me understand a landscape symbiosis. The multispecies ensemble of the soil crust come together in a pattern of mutual aid, forming a foundational food base for the pygmy mole cricket. The insect predates on the crust, attuned to the signaling presence of increased soil water that nourishes its algal garden (Deyrup 2005).

Florida scrub jays are obligate scrub dwellers and the flagship species of scrub conservation. Glen Woolfenden and John Fitzpatrick, Archbold scientists and the authors of the seminal long-term study on scrub jay social biology (1984), argue that the birds are confined to scrub due to an avoidance relationship with aggressive blue jays that occupy full-statured oak hammocks. In the blue-jay compressed range of the scrub island, scrub jays — dependent on the acorns of fire-groomed scrub oaks — have evolved to live in close-quarters by developing a cooperative breeding strategy in which multiple "helpers" assist the parents in feeding and protecting the young. In this arrangement, fledged offspring "queue up" for breeding space, a limiting element in the scrub-jay niche. As the young birds await an opening in the breeding hierarchy, they join the nest of a close relative and learn the arts of being a cooperatively breeding jay. It is worth noting that the blue jay's aggressive territoriality shapes and entrains the cooperative social pattern. Thus, this antagonistic relation, which gives rise to mutual aid, is part of the broader matrix of relations that configure the landscape symbiosis — a symbiosis that extends to the oaks, which the scrub jay helps propagate through caching and to specialized parasites that live exclusively on the jays (Fitzgerald and Woolfenden 1984).

Scrub jays are conspicuously absent from the Lakeland Highlands Scrub. When the park was first founded in 2001, there were four breeding families of scrub jays in the park. Today, there are none. Either those families were extirpated or they abandoned the remnant scrub in search of better habitat. Given the extensive destruction of their habitat, Florida scrub jays are listed as federally endangered. It may be that the 128-acre portion of scrub in the park was just too small to support these remaining birds, and the families observed at the park's christening were fated to decline.

One way fragmentation creates endangerment is by impeding the ecological movements between ever smaller and more distant patches. This is true for the scrub jays, but it is also true for one of scrub's keystone species: fire. Frequent lightning strikes in primeval times and, later, Native American burning practices spread fire throughout Florida. In the Holocene, pine flatwoods, longleaf pine savannas, dry prairie, and scrub formed a mosaic of flammable environments that evolved with and regenerate from fire. Just as water flows across a watershed, fire travelled across this mosaic in uneven blazes, following the path of fuel. In the Anthropocene, roads, real estate development, and fire-prevention programs fractured Holocene fire regimes, depriving uplands of their regenerative disturbance. Unlike longleaf pine savannas that burned every two to three years in low-temperature understory fires, scrub burns every 20-50 years. Scrub has a high heat ignition, but when it burns it forms stand-replacing conflagrations. With the demise of these fires, pyrogenic uplands transition into oak woodlands (called hammocks) that support an altogether different and less diverse species assemblage. Not only does scrub ignite at high temperature, but it is often bordered by wetlands that block traveling fires. These wetlands are formed by drainage from scrub soils and contribute to the scrub's ecological diversity, hosting distinctive species like the gopher frog that utilize both wetland and scrub habitats (Ewel and Myers 1990). Vestigial scrub patches now rely on prescribed burning carried out by state agencies, NGOs, and volunteers to maintain their fire-climax assemblage structure.

As fire is extirpated from the landscape, prescribed-burn teams have become ecological surrogates carrying fire to patch fragments. Fragmentation necessitates that humans bring fire to scrub remnants, but it also multiplies the number of scrub patches in need of burning. As scrub patches become smaller and more numerous, the burdens of prescribed burning become more onerous. For patches located near freeways or expensive developments, burning may be ruled out altogether. Of the 17% of scrub remaining, a significant percentage is deprived of fire and succeeds into hardwood hammocks. When scrub oaks become overgrown, scrub jays abandon their territories. This is a fraying of the landscape symbiosis. Fire exclusion, arising from habitat fragmentation, pushes scrub jays and other scrub species toward extinction.

The Cogongrass Savanna

In the last chapter, I detailed how phosphate mining destroyed a Holocene mosaic of flatwoods, cypress swamps, and scrub and replaced it with an Anthropocene mosaic of pits, tailings piles, and phosphogypsum stacks. Despite the violence and alienation that generated these forms, they are not without life. Weedy plants, both native and exotic, colonize these landforms and form novel ecological assemblages in the midst of extinction. In chapter 4, I explore the novel willow swamps that grow up in clay settling ponds. Here, I am interested in cogongrass savannas. In Bone Valley, cogongrass is like a fungal infection or cancer. It sprawls across the dikes of clay ponds, along roadsides, and into restoration areas and takes roots in every mining soil except the wettest clays.

Cogongrass (*Imperata cylindrica*) forms “mega-grasslands” in Southeast Asia where it co-occurs with fire-wielding humans who clear the land for livestock and plantation crops (Tsing, personal conversation). Cogon is the most problematic weed among many nuisance plants in Bone Valley. It first reached the American Southeast as packaging material in a box of satsuma oranges from Japan. The Bone Valley infestation, however, arose from a cattle-forage experiment gone awry. Ranked by ecologists in the top ten of the world’s worst weeds, cogon forms a monospecies grassland that outcompetes other vegetation and has little to no habitat value to native species (MacDonald 2004). In my many excursions into cogongrass thickets, often on an ATV, I encountered only grasshoppers and an occasional rabbit: a stark contrast from the bustling diversity of the scrub.

Cogongrass achieves its dominance by developing a thick mat of underground rhizomes and a dense meadow of bright green leaves. The rhizomes possess sharp tips that inhibit seed germination and root development in other plants; the leaves shade and smother plants that might otherwise find a toehold. Cogongrass absorbs silica from the soil and concentrates it into a sharp leaf edge, rendering it unpalatable to herbivores. Cogongrass has another invasive property: it responds quickly and aggressively to fire. Cogon thickets burn incredibly hot, earning it the nickname “green gasoline.” Cogon fires sterilize the soil seed banks and kill Florida trees that are otherwise adapted to fire. After the fire, the grass quickly replenishes from its rhizomes and spreads out into new territory, outcompeting what came before.

In Bone Valley, cogongrass has become a powerful invader because of its anti-social morphology but also because of an entangling relationship with mining companies' earth-moving equipment. Unlike other plants that are dispersed by animals or wind, cogongrass is dispersed by bulldozers! What does it mean for a plant to be dispersed by bulldozers? Cogongrass in Bone Valley does not reproduce sexually: it flowers but its seeds are sterile. Instead, it reproduces vegetatively: new cogongrass plants grow from rhizome pieces. The scattered cogongrass patches around Bone Valley region are clones of the original cattle-forage-experiment stock. On its own, a single cogongrass patch can grow larger and larger, but without viable air-born seeds it would not spread to new locations. Fortunately for cogongrass, it has industrial humans to spread its propagules. In earth-moving activities like mining and reclamation, cogon mats get broken up and bits of rhizome get stuck in the tire treads and miscellaneous vehicle parts; from there, they get transported to new mining-disturbed sites. Cogon, like most weeds, thrives in soil disturbance and quickly takes over the landscape.

Industrial humans may be the dispersal agents for cogongrass, but they also try to combat its spread, primarily through herbicide spraying. Mosaic spends hundreds of thousands of dollars fighting cogongrass with chemicals like imazapyr and glyphosate. Mosaic outsources much of this herbicide spraying to local environmental engineering contractors. Mostly, this work is carried out by undocumented Latino men, drawn from the agricultural labor pool, who wade through reclamation sites with backpacks full of chemicals and little botanical training. Increasingly, Mosaic works to prevent the unintentional spread of cogongrass by washing down and inspecting its vehicles before they are moved to a new site. While this method has shown to be effective, it has impracticalities. Mining and reclamation often take place in far-flung places that lack a reliable water source for spraying down vehicles. In restoration zones, herbicide crews contracted by Mosaic wage chemical warfare against the exotic pest. But in Streamsong, a luxury golf course that Mosaic built on reclaimed land, cogongrass is encouraged and grows into a picturesque grassland covering craggy dunes of sand tailings. This uneven approach to cogon's management — desired plant in one zone, enemy in another — is part of the grass's patchy political ecology.

Creative Niche Destruction

Cogongrass savannas and other weedy ecologies in Bone Valley come into being through a process of creative niche destruction. Creative niche destruction bridges the domains of political economy and theoretical biology, splicing the conceptual concerns of *creative destruction* and *niche construction*. Creative niche destruction is a hybrid term that foregrounds the generativity of capitalist projects — their ability to make commodities and proliferate cultures of innovation— and the landscape destruction upon which capital formation rests.

The political economist Joseph Schumpeter developed the concept of *creative destruction* to describe the ways capitalism destructively parasitizes socioeconomic orders in the fashioning of new economic systems. A good example comes from the last chapter. In order to establish the phosphate industry on the Florida frontier, firms employed black laborers who mined rock with mules, simple tools, and crude steam machines. The mule and steam regime laid the groundwork for the electrified hydraulic form of mining that would ultimately render it obsolete. Schumpeter did not develop the term as a critique of capitalism, however the terms has been taken up marxist scholars to describe the violence of capitalist projects and the unequal distribution of its goods.

Biologists have developed the term *niche construction* to describe how organisms modify environments and, in so doing, transform the ecology and selection pressures of neighboring species. Animals modify their environments by building nests, dams, burrows, and mounds. Plants transform ecological relations by casting shade, blocking wind, and releasing chemicals into the surrounding soil. The soil crusts described above provide a good example of niche destruction. The algae, fungi, and bacteria assemble into a mat that captures rainwater which alters the ecological and evolutionary dynamics of a host of organisms, including the pygmy mole cricket. Niche construction has opened a new branch of research in biology and has sparked a dialogue between the natural and social sciences about the roles humans play in engineering nonhuman niche-space. Such a dialogue will necessarily have to grapple with the niche-altering effects of industrial capitalism (Odling-Smee et al. 2003)

In the last chapter, I explored how histories and political culture of the phosphate fertilizer industry co-generated capital and a heterogeneous waste landscape. In this, I went some distance in developing an analysis of creative niche destruction. I described the manufacture of fertilizer, the destruction of Holocene ecologies, the production of sand tailings piles, clay ponds, and mining pits. But I did not take the essential next step of describing what lives in those waste landforms and why. Creative niche destruction foregrounds capital's ability to destroy the niche structure of a landscape and, in the process, create it anew. Strip mining creates a niche for cogongrass by voiding the niches that came before. Cogon is able to colonize areas quickly and without the competing claims of other plants. This new niche is one saturated with the disturbance-making movements of large equipment. Cogon — unlike scrub species — thrive in empty, phosphorus-enriched, machine-disturbed soils. The biology of cogongrass and the industrial environment are aligned in the realization of this niche. This is a historically contingent alignment. If the cattle-forage experiment that introduced the invasive grass had not occurred, an altogether different niche-space would have actualized. Before the introduction of exotic invasive plants, Holocene species colonized Bone Valley's disturbance zone.

Creative niche destruction places industrial humans as the focal ecosystem engineer, but the remaking of niche-space a multispecies affair. Cogon creates/destroys niche too. As a more-than-human dynamic, creative niche destruction has strong ties to Alfred Crosby's concept of ecological imperialism. Ecological imperialism is a theory of European colonialism in which livestock, weeds, vermin, and microbes collaborated with European colonists in their conquest of the New World (Crosby 1986). Many of these species proliferated to the detriment of New World ecologies. Rather than see creative niche destruction and ecological imperialism as analogues from different periods, I locate the contemporary crisis of exotic species invasion as an historical extension and intensification of the Columbian Exchange.

Anna Tsing uses the term *feral ecologies* to describe the weedy landscapes that colonial and capitalist histories build into the world. In feral biologies, weeds, pests, and plagues emerge out of histories of plantations, industrial transport systems, international plant nursery trade, and ecosystem degradation. These industrial projects spread weedy lifeforms around the world and create the disturbances that allow them to flourish. Tsing also shows how industrial landscape-making creates the co-evolutionary environments that turn otherwise benign species into virulent invaders. By entangling feral ecologies with political, economic, and technological histories, Tsing provides an important alternative to the novel ecosystems paradigm.

The novel ecosystem — also referred to as emergent or no-analogue ecosystems — is a new ecological category used to describe ecosystems that have been modified by human action. According to Hobbs et al. (2006), novel ecosystems constitute “either the degradation or invasion of native or ‘wild’ ecosystems or the abandonment of intensively managed systems.” What political affects should be brought to bear on novel ecosystems is a matter of controversy. A key point of controversy is whether invasive species are ecologically harmful or whether the alarm concerning exotic species invasions is merely a xenophobic projection onto ecosystems that were never “native” to begin with. As an anthropologist, I have tracked how my discipline — more interested in ecological discourse than actually ecologies — has aligned itself with the xenophobia critique. I have also observed ecologists who are proponents of the novel ecosystem concept draw on anthropological critiques of nature to lend legitimacy to their concept. In the strong form, novel ecosystem enthusiasts have argued that we might embrace invasion ecologies as part of the project of forging a "Good" Anthropocene (Revkin 2016). In such reconsideration of the "goodness" of invasive species, novel ecosystems have been likened to "rambunctious gardens" (Maris 2013) that deserve love, curiosity, and cultivation.

This dissertation does not adopt this perspective, although I am sympathetic to the concern that the histories that produce novel ecosystems cannot be reversed: novel-ecosystem proponents are keen to point out that novel ecosystems are here to stay. Novel ecosystems, in my view, are less "novel" or "emergent" than they are damaged and dangerous. In making this claim, I seek to understand Bone Valley's novel and feral ecologies as emergent outcomes of intersecting histories of capitalism: the creative niche destruction of phosphate mining and the traffic in experimental cattle forages come together in the cogongrass savanna. The morphology of Bone Valley is threaded through multiple histories of capital. To understand these ecologies as capitalist entanglements moves us out of a normative debate around whether exotic species are good or bad and re-centers our focus on the practices and projects that make novel ecosystems in the first place.

Florida environmentalists, as a general rule, consider invasive species a deleterious force that should be eliminated. Yet there is a great deal of anxiety about what can be done and how one should feel about the irrepressible tide of invasive species. Increasingly, there is talk about embracing invaded ecologies as novel ecosystems. In professional workshops, Mosaic ecologists have pointed to the practical limitations of managing cogongrass with herbicide treatments and vehicle spraying and have argued for more realistic expectations about what ecological reclamation can accomplish. On two occasions, I have heard Mosaic ecologies evoke the concept of novel ecosystems and, in so doing, subtly question the restoration ideology that underwrites the state's reclamation standards.

For example, I attended a local invasive species council meeting that included a presentation from a Mosaic ecologist. The employee invited the audience to a game of *Native or Not?* Here is how the game worked: The Mosaic employee presented images of plants found in Florida and queried the audience about the plants' endemic or exotic status. The exotic and native species she chose were neither common nor were they invasive. As hands went up, it was clear that most of the trained ecologists in the room did not know if the plant under consideration was indigenous or not. The point of the game was not educational. The Mosaic ecologist used the game to argue that state environmental agencies are unreasonable when they expect Mosaic to reclaim its land to an "exotics-free" standard. *Native or Not?* exposed the ignorance of the experts in the audience and challenged them to relax their ideological stance against exotic species. If local experts can't discern the difference between an exotic or native plant, why should Mosaic be expected to?

The *Native or Not?* game made a pragmatic appeal for a looser approach to restoration, but it also betrayed a dangerous political affect that lurks in the novel ecosystem discourse. Just as novel ecosystems defenders can embrace invasive species in the making of a "Good" Anthropocene, Mosaic can use the novel ecosystem discourse to legitimate the feral industrial ecologies it unleashes. This is where anthropology can do better. In this time of rapid extinction, the "social construction of nature" argument left unqualified can become a tool for powerful industries to valorize creative niche destruction. Humans are involved in discursive and practical invention of nature, but that doesn't give us license to commit ecocide. Worlds made in industrial violence are not "rambunctious gardens." Might multispecies anthropologists learn to defend native ecologies like they have learned to defend native peoples? Such a move brings us closer to a much-needed politics of Holocene survival.

Cogongrass is an anti-social organism. It behaves as "a law unto itself," weaving a fabric of self-sameness that is colonial in its spread and domination of Earth others. Cogongrass savannas are a feral ecology born of industrial trauma; their historical becoming is bound up with that of the Mosaic Company and its earth-moving practices. Like European colonists with their livestock, weeds, and pathogens, Mosaic and cogongrass work together as portmanteau invaders (Crosby 1986). If strip mining generates wounds, cogongrass savannas are those wounds' post-injury infections. Their joint colonization of the landscape fractures the Holocene and places its remnants under duress.

Conclusion

"[T]he world 'holds' the memory of all traces; or rather, the world *is* its memory"

— Karen Barad

In this chapter, I juxtaposed Florida scrub and mining-created cogongrass savanna in an effort to contrast Holocene and Anthropocene worlds and to politicize the patchy H/A transition. In making this argument I described the situated ecologies on either side of the fence, but I have also made them stand for something bigger than themselves. I have rendered the stories of scrub and cogongrass savannas into parables of the Holocene and Anthropocene. This is a lot of work for two ecosystems to do. The fence that separates the properties is a useful site from which to observe the Holocene/Anthropocene divide, but the multispecies essence of the respective epochs deserves straightforward characterization. To this end, I have produced the following table designed to provoke a reassessment of our planetary timespace coordinates:

Holocene	**Anthropocene**
landscape symbiosis	feral/industrially disturbed
slow emergence and evolution	creative niche destruction
most biodiverse period in Earth history	extinction
rich in world	poor in world
Humans make a living from local landscapes	Humans live within large technological systems and are dependent on large inputs of fossil resources
pre- and non-industrial	industrial
agroecology	plantations and feedlots
human as one among many	human exceptionalism
integration of ecosocial relations	alienation of ecosocial relations
episodic disturbances	landscape devastation
oligotrophic	hypereutrophic
stable/semi-stable climate	climate change
safe planetary operating space	unsafe planetary operating space
low entropy	high entropy

The goal of this table is not to render the world in black and white terms, but to offer guidelines to see the ecological assemblages generated in Holocene-Anthropocene collisions. We are living through a planetary inflection point.

Straddling time zones, we are able to peer into the ecological past and the future simultaneously. Exploring and describing the Holocene/Anthropocene rupture demands that we learn to see landscapes and sort out what's old, what's new, and what has been injured and lost, perhaps irrevocably so. Learning to discern old and new ecological elements can be difficult, but can be achieved through guided and discerning attention to what's present in a landscape. Absence, and the effects absences have in the landscape, are harder to see.

In drawing our attention to Holocene/Anthropocene ruptures, we must be alert to remaindered life and feral emergence but also to the proliferation of ghosts. Ghosts are ecological figure that once occupied a landscape but were somehow extinguished or extirpated. Ghosts do not appear on their own. We must train to look for them and seek evidence of their past presence in records that themselves may be at risk of vanishing. Learning to see ghosts alongside the vestigial and feral-emergent requires a forensic sensibility: we must learn to map Anthropocene crime scenes and follow chains of evidence to understand who and what has been wounded or killed. This chapter, among other things, is a gesture toward a forensic ecology of Holocene injury and loss.

Ghosts multiply in the Anthropocene. Mosaic's phosphate mining lands and the Lakeland Highlands Scrub do not come together in a generative interplay of forms, but in uneven landscape destruction. As scrub patches grow smaller and further apart, as diminished patches become more numerous and overgrown through lack of fire, extinction will prevail. In the spirit of the Barad quote above, the

Holocene landscape symbiosis ‘holds’ the memory of all traces; or rather, the world *is* its memory. But this memory — material and immaterial — can be extinguished by the more-than-human invasions of the Anthropocene. As anthropologists come to grips with the violence of the Holocene/Anthropocene transition, we would do well to remember the hauntings of the Eremocene and the ghostly patches of Florida scrub.

Chapter Three

Tegu Trouble: Corporate Landscape Ecology and the Unraveling of a Chelonian World

In Bone Valley, a socioecological drama is unfolding around a newly introduced lizard: the Argentine black and white tegu. Similar to monitor lizards in form, the tegu is indigenous to South American and was introduced to the peninsula in the exotic pet trade. Tegus have voracious appetites and are extraordinarily agile in avoiding human captors. Because they are large, reproduce quickly, and tolerate cool temperatures, tegus pose a serious threat to Florida's Holocene wildlife. Egg-laying species like the gopher tortoise are particularly vulnerable.

Gopher tortoises are long-lived chelonians that have dwelled in Florida's longleaf pine forests and ancient scrub ecosystem for the past two million years. Gopher tortoises build extensive burrows in sandy, well-drained soils with their shovel-like forelimbs. Burrows are critical to the life history of tortoises but they also act as refugia for over 350 commensal species, offering protection from fire, temperature extremes, and predators. One theory for the high rates of diversity in these subterranean environments is that gopher tortoises initiate a "burrowing cascade" in which other fossorial species, like the Florida mouse and camel cricket, build sub-chambers off the tortoise's central artery (Kinlaw and Grasmueck 2012). The interspecies burrowing collective generates a quasi-fractal environment in which the burrow-form repeats on multiple scales and across species difference. The result is a landscape with a diversified niche-space that, over evolutionary time, has gathered a complex faunal assemblage, many species of which are obligate burrow users.

In 2006, the first feral tegu in Florida was spotted in Bone Valley on lands owned by Mosaic. Mosaic is a vertically integrated producer of phosphate and potash fertilizers. Incorporated in 2004 through the merger of IMC Global Inc. and the Cargill Crop Nutrition subsidiary of Cargill Inc., Mosaic dominates the global phosphate industry. Mosaic is also the largest landholder in the region. In 2014, Mosaic acquired CF Industries' phosphate mining operations, the last remaining phosphate-producing competitor in the region. The CF Industries acquisition represents the apotheosis of a long history of mergers and acquisitions that transformed this region from a backwater frontier into a consolidated corporate territory.

Mosaic's landholdings consist of unmined lands, active mining operations, and post-mining disturbance zones in various states of reclamation. Reclamation is a broad term that at once encompasses wetland mitigation under the Clean Water Act and the construction of hazardous waste incinerators and luxury golf courses. Despite a public relations campaign that depicts Mosaic lands as an eco-paradise, reclaimed phosphate mines are notoriously feral, weedy places. Alongside a smorgasbord of invasive plants and animals, these reclaimed lands are home to a handful of protected, indigenous species that have been spared the annihilations of the dragline. One of these protected species is the gopher tortoise.

Over the next 30 years, Mosaic, under state mandate, is estimated to relocate 18,000 tortoises, the majority of which will be released into habitats made of sand tailings, a waste product of the beneficiation process. The ultimate cost of gopher tortoise relocation and conservation will certainly be in the tens of millions. In limited contexts, Mosaic agents will relocate commensal species they unearth while excavating for tortoises, but overwhelmingly commensal species are left behind. This single-species approach to conservation, while effective in preserving tortoises as populations, fractures the burrow symbiosis. Once relocated, it is unknown if tortoises form new commensal assemblages on mined land, but it seems unlikely given the dispersal barriers and distances that commensals would have to overcome to reach reconstructed habitats. Life in these new burrows may be lonely and, with the rise of the tegu, dangerous.

The story of tegus and gopher tortoises is a story of extinction-by-predation — or at least it promises to be. Since 2006, there have been over 150 confirmed tegu sightings in a concentrated area just west of Mosaic's Four Corners Mine. The Four Corners Mine is relevant to this drama as a possible hotspot for the tegu invasion and as the location of Mosaic's primary gopher tortoise relocation site. The tegu invasion is relatively new and thus localized; unlike the Burmese python that has likely become a permanent fixture of the Everglades, wildlife biologists hope the tegu invasion might still be contained. Nipping incipient populations in the bud is key. Corporate obstruction of the state's tegu monitoring and eradication program may not only be lethal to the tortoises for whom Mosaic is legally responsible, but it may also imperil the species as a whole and its commensal companions. Left to reproduce in Mosaic's 300,000-acre property, a land area three-quarters the size of Rhode Island, tegus could become so numerous as to be unmanageable, in which case they too will become a permanent fixture of Anthropocene Florida, endangering gopher tortoise across their range in the southeastern U.S. While the political landscape ecology is certainly more complex, Mosaic's landholdings form a keystone patch in the long-term struggle for tortoise ongoingness.

Despite the very real possibility of a tegu infestation, Mosaic refuses to grant access to state wildlife biologists who want to monitor for tegus and set up traps on company land. This stunning turn of events forms the ethnographic basis for the analysis to come.

This chapter explores Mosaic's spatial and economic hegemony over Bone Valley and its implications for tegu-tortoise futures. It does so through the lens of private property. Property is a Euro-American cultural formation that legitimates Man's dominion over Nature and a concrete legal arrangement that specifies the rights bundled in things. Although property is at times powerfully fixed, the fluid nature of social reality demands that property relations be continually shored up through everyday social performance. For a large corporation like Mosaic, shifting public attitudes surrounding the firm's environmental practices threaten to weaken its property rights. In 2007, the State of Florida upgraded the gopher tortoise's conservation status to Threatened. Under its prior designation as a Species of Special

Concern, landowners could purchase incidental take permits that allowed them to kill or entomb gopher tortoises — a more economical alternative to relocation. Under the new threatened status, however, gopher tortoise relocation is mandatory. For a firm like Mosaic, this change in policy represents an enormous shift in the gopher tortoise ontology. From the 1880s to the 1970s, mining companies' property rights were unencumbered by environmental concerns; gopher tortoises were company property that could be trashed along with the rest of the landscape. The threatened-species designation reverses this relation by converting "Mosaic's" gopher tortoises into the *de facto* property of the state. Corporations are still allowed to mine but are forced to care for the state's gopher tortoises, along with other protected upland species like the burrowing owl, caracara, and scrub jay. This arrangement creates a tension between Mosaic, the state, and environmental advocates — one that is negotiated through contested enactments of property as a geographical, cultural, and legal form. During my fieldwork, I was struck by the state's power to mandate tortoise relocation and its inability to monitor for tegus on Mosaic land. This contradiction prompted me to explore how property and its performance generate force fields that shape multispecies dynamics on the ground.

In this chapter's ethnographic section, I investigate how Mosaic performs property as a defensive posture against state wildlife officials who wish to monitor for tegus on Mosaic land. Mosaic's relations with the public, environmental organizations, and state agencies are varied, but, as a general rule, the company is suspicious of outsiders and is increasingly reluctant to cooperate with their requests.

In developing this analysis of corporate knowledge politics, I use my own experience as an ethnographer, eager to gain access to Mosaic lands and staff, as an affective and narrative window into Mosaic's property performance and policing. As you will see, I made repeated requests to study Mosaic's reclaimed properties and translocation experiments and was repeatedly barred access.

In the second empirical section, I set aside questions of tegu-tortoise politics to examine one of Mosaic's public relations campaigns. These campaigns are designed to craft a sympathetic public that is less likely to challenge its property rights. I analyze two commercials that appeal to two different Florida publics: coastal liberals and heartland conservatives. I claim that Mosaic's deceptive claims to ecological and community stewardship in these commercials strengthen the property form that propagates extinction.

I begin by staking out a theoretical conception of property and corporate personhood and describing the neoliberal structure of environmental protection in the U.S. and Bone Valley.

The Corporate Geo-Body, Republic of Property, Scrap-And-Salvage Conservation

What does it mean for a landscape to be corporately owned? How does Mosaic exert control over ecological space? To answer these questions, I turn to Thongchai Winichakul's analysis of the geo-body of the nation. For Thongchai, the geo-body is a set of territorial forms and technologies that discursively enact the nation as a spatial object and a source of identity. Thongchai's case study is the colonial mapping project that turned Siam into the nation of Thailand. "[T]he geo-body of the nation is a man-made territorial definition which creates effects — by classifying, communicating, and enforcement — on people, things, and relationships.… It appears to be concrete to the eyes as if its existence does not depend on any act of imagining. That, of course, is not the case" (1994).

Thongchai anticipated my argument when he asserted "that multinational corporations, not a single government, increasingly predominate" the political economic order. "Nations and nationalism," he declares, "will sooner or later be obsolete." In the rush of neoliberalization that has characterized the last 35 years, we have indeed seen the strengthening of multinational corporations, the weakening of states, and the privatization of state functions and lands. Since the formation of the Dutch East India Company, corporations have always been critical to colonial and capitalist world orders; however, their concentrated influence over social life is increasingly impossible to ignore — for humans and nonhumans alike.

The corporate geo-body partakes in many of the key tropes of territoriality that characterize the national geo-body. Concerns of sovereignty, border control, and the imagined threat of external invasion extend to the corporation as much as they do the nation, albeit at a different political register and with different tactical imaginations. Consider the following set of analogies: Corporations have a headquarters as a nation has a capitol; CEOs have many of the symbolic and functional responsibilities of sovereigns; companies often display flags that bear the corporate logo, often alongside or just below the American flag; employees are part of a corporate culture that distinguishes insiders from outsiders; companies with extensive landholdings police and surveil those boundaries as a nation would its borders. These similarities are, of course, not coincidental. The corporate geo-body emerges from and takes as its model the geo-body of the nation, despite the fact that the corporation is discursively constructed as its logical opposite. Understanding structural similarities between corporations and states is inadequate: the geo-bodies of corporations are nested within the geo-body of the state, even as they expand beyond national boundaries and conglomerate into multinational forms. The corporation, in a sense, is *a state in miniature* whose sovereignty is both curtailed and enlivened by the nation-state.

Following the work of Susan Gal, I will refer to this nested similarity as a *fractal recursion*. Gal writes:

> “Fractal recursions” involve the projection of an opposite, salient at one level of relationship onto some other level. To be fractal, a distinction must be co-constitutive, so that the terms — like *right* and *left* or *east* and *west* — define each other. Such co-constitutive contrasts can be used to organize virtually any kind of social fact: spaces, institutions, bodies, groups, activities, interactions, and relations. Furthermore, whatever the local, historically specific cultural prototypes or images that motivate oppositions like public and private, the distinction can be reproduced repeatedly by projecting it onto narrower and broader comparisons (2005).

Gal uses the example of a house to illustrate the fractal recursion of the private/public duality. “From one perspective the major division of public and private is between the house and the street…; however, if we take a closer perspective, looking only at the house itself, the public/private division can once again be reapplied. Focusing only on the rooms inside the house, the living room is public whereas the bedrooms are private."

From the perspective of the fractal recursion, the national and corporate geo-bodies are not two separate kinds, but iterative and entangled projections of a patriarchal, rule-based system that organizes social collectives. The state and the corporation (and, at a smaller scale, the family) partake in the same cultural logic organized around the primacy of property, land as sovereign territory, an orientation to boundaries that sort a We-self from Others, and a right to defend that territory through conflict. Following the work of Michael Hardt and Antonio Negri, I will refer to this shared cultural logic and the imperial spatial formulations that arise from it as the *Republic of Property* (2009). The Republic of Property saturates the Euro-American species being, underwrites colonial land and power grabs, and sanctions destructive extractivist projects like phosphate rock mining.

Within the Republic of Property states and corporations collude in the production of the capitalist world-system. They may have their conflicts but they are essentially aligned in defending the rightness of the property form and capitalist growth. Despite functional differences and occasional tensions, corporate and state structures and governance forms mirror one another, not only as a matter of practical intelligibility but also as a matter of shared genealogy and ricocheting interpenetrations (of high-level employees, for instance).

What interests me is not the fractal recursions between states and corporations (and households) per se, but the ways in which the corporate geo-body, enacted in this most advanced phase of neoliberalism, shapes landscape ecologies. Anthropologists have analyzed property as a potent fiction that organizes social life, however they have not heretofore examined how property regimes carve up landscape ecologies and poke holes in life's tapestry. What kinds of creative niche destruction do corporations impose on the world?

To answer this question, we cannot think the corporation in isolation but must nest it within the regulatory environment of the state that, in its non-unity, is both sympathetic and antagonistic to the telos of capital. The state is antagonistic to the intentions of capital in as much as it is adamantly committed to environmental protection. But if, as this dissertation claims, capital and Holocene natures are essentially incompatible, then the capitalist state cannot be an adamant protector of the environment: it can only be *partially committed* to environmental protection. The modern state is in the impossible position of encouraging growth at all costs and mounting formidable pushback to capital's environmental violence. How does the state resolve this contradiction? One way it does so is by creating environmental protections at home and exporting capitalist destruction to resource frontiers abroad, most typically in the Global South. This is NIMBYism at a geopolitical scale. When the extraction frontier is in the geo-body of a first-world nation like the U.S., another technique prevails. I call this technique *scrap and salvage.*

The scrap-and-salvage model of conservation has two parts: the first part — *scrap* — capital prevails and ecological places are sacrificed for accumulation. The second part — *salvage* — the state mandates the repair of sacrificed landscapes through a number of means, including: in situ remediation, ecological transplantation, ex situ conservation banking, or some compromise involving land sparing. In the scrap-and-salvage model, capitalist firms destructively extract value while aspects or elements of the native ecology are allowed to endure, albeit in an altered or entirely reconstructed form. As neoliberal scrap-and-salvage schemes mature, they grow more sophisticated in their legal, practical, and scientific enactment. But suffice it to say, no matter how sophisticated these schemes become, capital trumps ecology. This becomes especially evident as we extend our analysis to zones where capitalist projects layer and generate geographies that have been scrapped and salvaged on more than one occasion. (I explore this phenomenon in the next chapter.) Needless to say, with each successive round of scrap-and-salvage, the ecological entropy of the landscape increases and corporations can point to projects of partial ecological repair as evidence of their stewardship.

Scrap and salvage comes in two varieties: the salvaging of individual species and the salvaging of larger ecological units, like wetlands. How does scrap and salvage work in Bone Valley? In 1975, the State of Florida instituted mandatory reclamation for all new phosphate mines. Wetlands are required to be reclaimed on an acre-for-acre, type-for-type basis. Indeed, the industry has many fine examples of wetland restoration. (Although some types of wetlands, especially forested wetlands like bayheads prove more difficult to engineer.) Uplands, the sacrificial lambs of development, do not have the protections of wetlands at either a state or federal level. In Bone Valley, however, 10% percent of the post-mining landscape must be reclaimed as uplands. Unfortunately, this mandate carries no ecological specificity and, by and large, this quota is met through the creation of monocultural pine plantations for mulch and pulpwood production. There are a few examples of reclaimed scrub and other upland ecosystems, but these reconstructions are shoddy simulacra of what came before. This shoddiness has a political economic and biophysical explanation. Because uplands have none of the umbrella protections of wetlands, there are fewer firms that specialize in upland restoration and creation. Environmental policy has not spurred a market for upland restoration like it has for wetlands under the Clean Water Act. This means that there are few upland species cultivated in nurseries and less research and development of upland-cultivation techniques. The second challenge is biophysical: uplands grow much slower than wetlands. Herbaceous wetlands are easy to establish because they grow quickly in environments with plenty of water, nutrients, and sunlight. Get the hydrology right (a challenge to the industry before the early 2000s when computers and hydrologic modeling entered the reclamation toolkit), plug in your grasses and forbs, and your marsh will thrive — although without the symbiogenic inertias of the Holocene wetland that was scrapped. Because upland soils are well-drained sands, it takes longer to establish upland trees and groundcover. In the time it takes for planted ecosystems to grow and mature, weeds invade and shade out the planting, requiring more vigilant monitoring, herbicide spraying, and site preparation.

Within both upland and wetland reclamation, a new technique called topsoiling has shown considerable promise. Here’s how it works: before a parcel is mined, Mosaic clears the trees and major obstacles from the land, scrapes off the top layer of the soil, and transplants that soil to another mining site, spreading it across land that has been reclaimed with sand tailings and overburden. Topsoiling is like a hair transplant but instead of individual hair follicles Mosaic transplants bumptious worlds of soil organisms, fungi, and plant propagules. While Mosaic celebrates the success of the topsoiling technique, it is not a zero-sum game. For topsoiling to work, it requires the destruction of an ecological place to repair another destruction zone; and much is lost in translation. No matter how you crunch the numbers, there is a sharp decline in upland acreage and quality from pre-mining to post-mining worlds.

The second type of the scrap-and-salvage project concerns single-species populations. Gopher tortoise relocation falls in this category. In the state of Florida in 2007, the conservation status of gopher tortoises was upgraded from "Species of Special Concern" to a "Threatened" species. Under the old designation, developers could pay to relocate tortoises or purchase an "incidental take" permit that would allow developers to entomb tortoises (and commensals) in their burrows. Incidental take permits were banned with the 2007 upgrade and gopher tortoise relocation became the dominant method for disposing of tortoises in development zones. Gopher tortoises are captured from "donor" sites by authorized agents who either set bucket traps or, more commonly, use a backhoe to excavate the burrow. The chelonians are then transported to an authorized "recipient" site where they establish new social relations with the landscape. As a large landholder, Mosaic carries out its own gopher tortoise relocations through a special legal arrangement with the Florida Fish and

Wildlife Commission (FWC) that administers the gopher tortoise permitting program. Unlike topsoiling, which hauls an entangled mass of the landscape symbiosis from one site to the next, gopher tortoise transplantation traffics in tortoises *as populations.* While FWC is attuned to the plight of tortoise's commensals, the practical arts of burrow excavation are not refined enough to capture and retrieve the specialized frogs, mice, snakes, beetles, and flies. The translocated gopher tortoise is an alienated form. In the context of Bone Valley, alienated tortoises are relocated into recreated upland environments that are themselves products of industrial alienation. Add to this the third insult of a tegu infestation and we begin to see that Mosaic's gopher tortoises are in trouble.

Performing Property Amidst Invasion

On February 26, 2015, I attended an invasive species workshop hosted by the Heartland Cooperative Invasive Species Management Area (CISMA) chapter that services Central Florida. CISMAs are alliances of stakeholders comprised of state agencies, NGOs, and private firms that address invasive species management issues in various parts of Florida. After a morning of presentations, the group split up into breakout sessions. After a tour through the "Garden of Evil" — a curated showcase of invasive plants — I attended a breakout session on tegus lead by Erin Manzer, Florida Fish and Wildlife Commission's Early Detection Rapid Response coordinator for tegu eradication. During the session, we learned how to operate a wildlife camera, set up a live trap, and identify tegu tracks in the sand. We even had the chance to pet a living breathing tegu. After moving through the different learning stations, we gathered for Q&A. After a few polite questions about tegu biology, I raised my hand and asked about the possibility of tegus on Mosaic land. This question, it turned out, was a trigger to both Erin and the group. Erin explained that she had sent numerous requests to Mosaic but had been repeatedly denied permission to perform surveys. Erin then proceeded to pull out her smartphone and read an email from a Mosaic biologist. I later obtained a copy of that correspondence.

Tegus have been documented on Mosaic land and, furthermore, have been observed raiding burrows for eggs, hatchlings, and commensals. In her email, Erin outlined the trouble. She inquired about Mosaic's gopher tortoise population and requested permission to monitor on their land. In his reply, a Mosaic's biologist stated that he had heard there were tegus in a nearby nature park, but he ignored her inquiry about the company's tortoise population. He concluded his short email: "Unfortunately we don't allow independent surveys due to safety liability." Of course, the company's performance of property has less to do with asserting possession and more to do with policing the corporate geo-body from outside intrusion.

As an anthropologist working in Bone Valley, Mosaic has never granted me access to its lands or staff. The majority of my contact with phosphate lands comes from research on state-owned lands like Tenoroc (see next chapter). Mosaic's refusal to provide outsiders with knowledge of its operations and landscape is increasingly common, even in its relationship with government agencies. This airtight performance of property is new to the phosphate fertilizer industry where, historically, local people hunted for fossils and companies gave tours and granted access to researchers. This shift in corporate culture is designed to protect Mosaic from negative publicity, environmental litigation, and in the case of tegu eradication, another layer of costly environmental management. At the same time that Mosaic works to guard itself against outsiders, it projects an image of ecological stewardship into the public mediascape, an unsurprising strategy in the era of the BP oil spill where news coverage of environmental disaster can interrupt the machinery of accumulation.

Another Story of Denied Access

During my fieldwork, I conducted participant observation at a semi-annual meeting of the Gopher Tortoise Technical Assistance Group, or GTTAG. The meetings were held in the Department of Agriculture's Plant Industry auditorium in Gainesville. GTTAG is maintained by the Florida Fish and Wildlife Conservation Commission (FWC), the state wildlife agency tasked with gopher tortoise management and tegu eradication. The group's steering committee is composed of public and private sector stakeholders: conservation organizations, large landowners, animal welfare advocates, primary industry, and state and county governments are represented at the table. This eclectic group of tortoise spokespersons are involved in evaluating gopher tortoise management policies, guidelines, and science, especially in relation to relocation.

The conversations at these meetings are hard to jump into: they are, as the name of the group suggests, technical discussions. At one meeting, the group heard a short presentation from Arthur Goffman, an ecological consultant with Cardno ENTRIX, an engineering and environmental consulting firm. Arthur has been heading up research on tortoise minimum viable populations. Minimum viable populations (MVPs) refers to the "smallest isolated population size that can persist without facing extinction from natural disasters or demographic, environmental, or genetic stochasticity." Utilizing variables of demography, predation rates, and habitat requirements, MVPs are calculations of how much duress a population, as a single-species assemblage, can withstand without confronting long-term collapse. How much development-forced habitat loss, fragmentation, and degradation can the gopher tortoise endure? While such a question only makes sense within the scrap-and-salvage logic of a neoliberal state, the calculation and Goffman's findings are critical to designing habitat conservation areas that can absorb displaced tortoises without leading to an extinction spiral in the long term.

At this meeting, I re-introduced myself to Margaret Gilbert, a lead ecologist for Mosaic. Mosaic has a seat on the steering committee representing one of two slots for large landholders. Large landholders are an important contingent at these meetings. Big tracts of private land with tortoise habitat are eligible to become recipient sites. For Lykes Brothers, a big cattle-ranching and citrus magnate and the other large landholder representative, gopher tortoise relocation can be a revenue generator, but it also means accepting state oversight and regulation. At the previous meeting, I had introduced myself to Ms. Gilbert and requested a tour of Mosaic's restoration sites as part of my research. Unlike any of the other steering committee representatives, Margaret attends these meetings with a lawyer who sometimes joins Margaret at the U-shaped table reserved for committee members. The lawyer provides technical assistance to Margaret who, though a committed ecologist, is a spokesperson for Mosaic before she is a spokesperson for tortoises.

After the morning session, I joined the corporate contingent for lunch. Mexican food. At this lunch, I learned about Mosaic's scrub jay relocation program from Arthur Goffman. Mosaic is breeding the federally endangered birds like chickens, he says. They feed them cat and dog food and cut down sand pines to prevent hawks from perching and picking off transplants. Mosaic is not able to create xeric scrub capable of supporting jays, so the birds are relocated to a small, unmined parcel of Mosaic land situated next to the Duette Preserve, which according to my maps will one day be surrounded by phosphate mining.

I hung on every word of Arthur's presentation delivered quickly between bites of enchiladas. I had asked Arthur for an interview about the project but he told me he needed permission from Margaret. I could tell she was leery of me. So, I listened closely as this might be my one shot to hear the story.

In the parking lot on the way back into the building I asked Margaret about the plausibility that Mosaic might would open its doors to my research. In a moment of candor, she said that the odds were not in my favor. She explained that Mosaic is hesitant to work with outsiders: the staff have been burned by researchers in the past, and they worry that they —and she knows this sounds bad— have no way to control the message. In a gesture of honest consolation, she broke frame to share a revealing fact: she, a high-level ecologist, had been transferred to Mosaic's public relations wing. The company's ecological programs, she intimated, are deployed strategically to give Mosaic an environmentally friendly face.

After the meeting, I stopped Margaret one last time to implore her to grant me access. I want to study your most successful project, I say, your scrub jay relocation program, for example. But she is still not clear on who I am and what the science of anthropology entails. It is like journalism, I explain. We write stories and work with the material we get (scraps, in this case). I explain that I care about having a good relationship with Mosaic and, despite my interest in all facets of phosphate mining, I am content gaining access to remediation sites with positive stories to tell. We continue talking and I begin to get the inkling that we are involved in a subtle bargain and that she might grant me access provided I defer to company messaging. This worries me, and to avoid any confusion in the future I politely assert that Mosaic might be coordinating the scrub jay project but it does not own the story surrounding the project. To my surprise, she counters: No, Mosaic owns the story of its scrub jay restoration.

Stories are ownable; so is electronic speech. This is interesting. After Margaret and me part ways, I am left in the hallway of the Plant Industry's auditorium in Gainesville wondering: What are the involuted depths of Mosaic's property culture?

My interaction with Margaret and Erin's email correspondence with the Mosaic biologist are two stories that shed light on the everyday enactment of the corporation as a territorial form. As with any discursive-material construction of property, space is powerfully present (Blomley 2003). Worlds lurk behind words. In these exchanges, a symbolic barrier is erected between the outsider and the geo-body of the corporation. This barrier is akin to the chain-link fence that partitioned Mosaic lands from the Lakeland Highlands Scrub in chapter one. Unlike the fence, however, Mosaic employees must construct this property boundary over and over again in encounters with outsiders who are concerned about mining's environmental impacts.

Property is a potent fiction that saturates American culture. Through vigilant enactments in courtrooms, boardrooms, statehouses, but also everyday encounters like the kind described above, property fictions are turned into facts. As powerful as the property fiction is to American identity and institutions, it is nonetheless a fiction that requires purchase from the multitude. Of course, the multitude cannot just simply renounce the property as fiction and find itself in a post-capitalist society: the legal, material, and cultural inertias of property arrangements are too thickly imbricated to be jettisoned. But various publics operating through NGOs and the state can and do contest the bundling of rights that organize property regimes. Consider gopher tortoise relocation. By gaining environmental protections, tortoises status as private property was revoked. Tortoises are no longer killable features of private property; they have become a special class of objects that carry the protections of the sovereign.

They are now the state’s things. Of course, for free-roaming wildlife the property fiction has no purchase whatsoever. A "No trespassing" sign will deter a nosy anthropologist from scrambling under a gap in a fence but it won't dissuade a tegu from entering the Lakeland Highlands Scrub. The "/" that hives Holocene and Anthropocene worlds is a permeable border.

The Geo-Body Has a Face

In the preceding ethnographic section, I portrayed Mosaic ecologists as actors who play the role of sentinel, defending the company from state wildlife officials and an unwelcomed anthropologist. In assuming this defensive posture these employees are helping guard Mosaic from negative public attention. Among environmentalists and large swaths of Floridians, Mosaic has a public relations problem. (This PR problem has only gotten worse with the recent crisis in which a radioactive phosphogypsum stack collapsed into the Florida aquifer.) Given the depth of the phosphate fertilizer industry's trauma to Bone Valley's landscape ecology, this PR problem is well deserved. To combat these negative associations, Mosaic has undertaken a concerted, well-financed television and radio campaign to green and convivialize its image.

There is one conspicuous feature that runs through Mosaic's television and radio commercials: they make no reference to phosphate mining or fertilizer production. As one retired mine regulator from the Department of Environmental

Protection complained, “You see their ads on the television, but you have no idea that Mosaic is in the phosphate business!”

In this final section, I interrogate the discursive and filmic construction of Mosaic's corporate face through an analysis of two of its commercials: “Our Job — Coastal Education” and “Our Job — Tomorrow's Farmers.” Inspired by Elana Shever's work on the Shell oil (2010), I argue that to understand the construction of the corporate geo-body we must understand how firms construct their public face and, from time to time, give them a facelift. In crafting its face, Mosaic works to redirect public consciousness away from the wounding of the land by cementing a positive brand identity that links Mosaic with vibrant ecologies and thriving agricultural traditions. Mosaic’s media campaign works to erase memories of its destructive past and avert attention from its destructive future.

In her article “Engendering the Company: Corporate Personhood and the ‘Face’ of an Oil Company in Metropolitan Buenos Aires,” Shever (2010) points to the ways that international extractive firms “reconfigure the ‘legal fiction’ of corporate personhood” through strategic reconstructions of their public face. Writing in the context of Buenos Aires shanty towns, Shever documents how the Shell updates its public relations materials to reflect changes in its stewardship model: from corporate philanthropy to corporate social responsibility (CSR). In this shift — precipitated by the political-economic collapse of 2001 — Shell’s stewardship audience pivots from “middle-class consumers, investors, and employees in Europe, North American, and Argentina” to shanty-town residents who live in the shadow of a refinery. Defending itself against critiques that Shell failed to defend human rights and protect the environment, Shell underwent a "makeover" in which:

> sympathetic images of dark-skinned women and children in CSR reports supplemented the stiff portraits of mostly white male executives and action shots of workers found in financial reports. CSR facialized Shell in a new way by deploying particular human visages with socially coded features to portray the company as an upstanding citizen and caring neighbor, thereby enabling it to continue what many regard as unethical, if not also illegal, business practices (2010).

Just as Shell drew on dark-skinned women and children in its attempt to brand itself as socially legitimate, so too does Mosaic. Consider the transcripts from the two commercials, arranged in a column for comparison. Produced as a pair, the commercials follow the same format and utilize the same introductory footage and dialogue, but depart in their narrative focus at the 10-second mark. I have indicated the significant changes between the scripts with numbers; I have also highlighted in bold each commercial's portrayal of race and gender. In each commercial, a core narrative figure emerges: In "Coastal Education" that figure is the white female employee who helps the urban girl of color interpret the coastal ecotone; in "Tomorrow's Farmers" it is the white male rancher who is raising his son to inherit the ranch. Although rendered in 31 seconds, these ads conjure stories with complex cultural, political, and affective themes.

The commercials can be viewed here:

https://www.youtube.com/watch?v=NIVGUSJwgCk&list=PLD1743294D325D9C6&index=1

https://www.youtube.com/watch?v=OFJotBly494&list=PLD1743294D325D9C6&index=2

Our Job - Coastal Education

Pan over a lush wetland and forest zone; sun glinting in the water. Brief shot of white male employee collecting a water sample in a naturalistic swamp.
1) ***Female*** *voiceover:*
> "At Mosaic, knowing more about nature makes
> us better at our job."

White female ecologist unloading pine saplings from pick-up truck:
> "Our job: plant millions of trees." *[Pan to*
> *forest]*

Asian female employee in hard hat. Technical infrastructure and trees in the background:
> "Our job: conserve and recycle water…"

2) White male employee with glasses in a high-tech computer lab:
> "… and make clean, renewable energy…"

3) ***White female ecologist at the Gulf of Mexico shore****:*
> "…and what we've learned, we also teach." *[Close up of the same ecologist bending over, in the water, inspecting an aquatic critter that a* ***young black girl*** *has collected in a net.]*

Female voiceover:
> "The Mosaic Coastal Education Center teaches local students the importance of the environment…" *[Flash to shot of the young black girl facing the camera and images of a* ***multiracial group of girls*** *playing on the naturalistic shore line.]*

White male ecologist kneeling in the mangroves, young girl running by:
> "and how to protect it."

Same white female employee at Gulf of Mexico (Coastal Education Center):
> "Mosaic: workplace for today's ecologists…"

Young white or Hispanic girl *holding a horseshoe crab with binoculars draped from her neck, next to white female ecologist:*
> "classroom of tomorrow's!"

Close: Company logo and slogan:
> Text: "We help the world grow the food it needs."

Our Job - Tomorrow's Farmers

Pan over a lush wetland and forest zone; sun glinting in the water. Brief shot of white male employee collecting a water sample in a naturalistic swamp.

1) ***Male*** *voiceover:*

> "At Mosaic, knowing more about nature makes
> us better at our job."

White female ecologist unloading pine saplings from pick-up truck:

> "Our job: plant millions of trees." *[Pan to forest]*

Asian female employee in hard hat. Technical infrastructure and trees in the background:

> "Our job: conserve and recycle water…"

2) White male with southern accent in an orange grove:

> "… and help farmers grow more food on less
> land." *[Employee instructively shows an
> older, white male grower something on the tree.]*

3) White, male employee on a ranch*:*

> *"*What we've learned, we also help
> teach." *[Horses in stable in the background]*

Male voiceover:

> "Mosaic proudly helps organizations that teach modern farming and ranching practices, so local students can continue the proud tradition that feeds us all." *[Pan to white pick-up truck pulling up to a ranch; white Mosaic employee helping* ***blond boy and girl*** *load bales of hay onto the truck; flash to quick images of a saddle being placed on the horse (sounds of straps being tightened) and cowboy boot entering stirrup; white male rancher leading a horse with his daughter on the saddle; flash to image of white male employee interacting with students and rancher interacting with* ***son and daughter****.]*

White male rancher *leaning on fence, cattle in the background:*

> "Mosaic: helping today's farmers…"

Son, popping out from behind the farmer/father:

> "and tomorrow's!"

Close: Company logo and slogan:

> Text: "We help the world grow the food it needs."

First, I point to the obvious: “Coastal Education” — with a female voiceover actor — is gendered female, cosmopolitan, and multiracial. It is designed to appeal to diverse and culturally liberal coastal cities like Tampa, where Mosaic's Coastal Education Center is located. “Tomorrow's Farmers” is targeted to the white agricultural interior of Florida and has a male voiceover actor. It is is gendered male, rural, and southern white. How do these twin stories play out, and what do their narrative resolutions reveal about Mosaic's complexion?

In “Coastal Education,” Mosaic is rendered as a white mother, nurturing the land and future generations. Mosaic’s children are white and brown girls. The brown girls are urban and likely suffer from nature deficit disorder. Mosaic takes these girls into nature for the first time and shows them how to care for it. Mosaic pays special attention to girls of color because they are the most in need of an environmental education.

In “Tomorrow’s Farmers,” Mosaic is a white company man who provides technical assistance to the white father/farmer who cares for his family. The father works the land and is raising his son to follow in his footsteps; he is proudly white and southern. In this story, we see the father and his son, but we also meet the grandfather, the citrus grower, who is receiving cutting-edge agronomic advice from a Mosaic specialist. Mosaic maintains the patriline and its claims to the agricultural heartland. Importantly, he is not the father but an aid to the farmer. In "Coastal Education" Mosaic becomes a surrogate mother to young girls whose parents (especially the fathers) may be out of the picture or fail to take them into nature. The gaping absence of any black men in these diversely cast commercials bears this last point out. The absence of any black boys suggest that the future of Florida will not belong to black men. In both stories, Mosaic is cast as the maker of a future that is ecologically whole and inherited in the right way, by the right people. These commercials construct an image of a corporate person who alternately care for Mother Earth and bolster white southern patriarchy, thus appealing to divergent cultural demographics. More than its omission of black men, it is Mosaic's omission of phosphate mining and fertilizer production that speaks volume. Only in this lacuna can Mosaic construct an image of a "good Florida."

Conclusion

In this chapter, I have shown how everyday performances of property enact the corporation as a territorial form. The corporate geo-body enacted by Mosaic's biologists is one that reifies the boundaries of corporate landholdings, unravels the already frayed multispecies world of the gopher tortoise, and seeds the possibility of tegu invasions beyond corporate borders. In short, it helps produce the Anthropocene as a timescape of voids, ghosts, and feral dangers. Of course, this story is complicated by Mosaic's very real efforts to create habitat and relocate tortoises. It should be remembered, however, that the conservation apparatus that infiltrates the gopher tortoise's world— while powerful, well financed, and well intentioned — exists as a work-around for capitalist development. Scrap-and-salvage programs like wetland banking and gopher tortoise translocation mitigate the entropy created by mining, but they will not — in the long term — be able to buttress the Holocene Earth against the Republic of Property.

Anthropologists appreciate how important the construction of territory is to the nation-state. However, we often fail to see how the tropes of territoriality — sovereignty, border control, external invasion — shape the corporation and the more-than-human spatialities it makes. If we are to diagnosis Gaia with the illness of human property regimes, we ought to better understand how corporate geo-bodies relate to, but also mirror, the geo-body of the state. Is the making of a geo-body a form of niche construction that is reproduced on multiple scales, across diverse human actors like the fractal tortoise burrow? If so what kinds of niches are being created and for whom? One critter that is finding a niche in capitalist worlds is the tegu. But what are tegus? In the Florida context, tegus are property unleashed — literally. "Scientists and officials suspect that [tegus] were released by reptile breeders on the theory that capturing them in the wild was cheaper than breeding them in captivity" (Nuwer 2014). The logic of accumulation appears yet again, albeit at a different scale.

Getting inside the enactment of corporate property and the nation-state is key to charting conservation challenges in the Anthropocene. It is equally important to recognize that such regimes and the powerful rights discourses that go into making them exist to protect corporations' access to "Cheap Nature" (Moore 2015). In his chapter on "The Life and Times of Cheap Food," Jason Moore argues that Green Revolution agriculture increasingly faces a situation of diminishing returns: the unpaid costs of depletion, waste, and toxicity are meeting up with agribusinesses' incapacity to revolutionize production. Moore calls this the rise of negative-value. In the dramatic tale of gopher tortoises and tegus, we see how negative-value takes a predictable form in the planned destruction of phosphate mining and waste generation, but we also see the countervailing influence of the state. By mandating the conservation of tortoises and the reclamation of mined lands, the state forces Mosaic to capture and recuperate residual value from an otherwise devastated landscape. As deficient as these conservation measures may be, they are better than nothing. Tortoise relocation eats into Mosaic's ledger. And tegus eat tortoises. From the standpoint of corporate profits, tegus — despite the real ecological harm they cause — may be the solution to the imposed financial burden of tortoise mitigation. For Mosaic, a tegu-infested future may spin pure gold.

Chapter Four

Life in Clay:
On the Reclamation and Carrying Power of Wound Space

In Bone Valley, large aboveground ponds of clay waste tile the landscape. Held together by immense earthen dikes, these ponds are used to store the liquid clay waste from phosphate beneficiation operations. Clay settling areas — or “slime ponds” as they used to be called — have a big presence in Bone Valley. Forty percent of the post-mining landscape is built in clay settling areas that range in size from several hundred to over a thousand acres. Clay settling areas are problematic in a number of regards: they are hydrologically isolated from the larger watershed, are vulnerable to catastrophic spills, and make poor habitat.

When waste clays are first discharged from the beneficiation plant into the earthen impoundments, they take a liquid form. These liquid clays slowly develop a hard crust and consolidate after a period of decades. This consolidation process coincides with a process of ecological succession. The clay settling area begins as a lake of liquid clays; as it dries out it sorts into a mix of wetland and upland environments, depending on the underlying topography. Clay ponds are built atop the pits and spoil piles of the post-mining landscape. In this chapter, I focus on the novel swamp assemblage formed by a low-diversity mix of native and exotic weeds. I also explore how clay areas are used by humans. Given the low weight-bearing capacity of clay settling areas, they have limited potential for development and are often reclaimed as cattle pasture. However, as development pressure in the region increases, the potential value of clay settling areas as real estate is being reevaluated.

This chapter offer a multispecies account of one of these clay ponds, located within the Saddle Creek basin of the Peace River. The Peace River is a major river system in Central Florida that has been negatively impacted by the phosphate industry. Two types of impacts have transformed the Peace River: excessive pumping of the Floridan aquifer and the construction of clay settling ponds. The former depletes groundwater reserves, and the latter halts surface- and groundwater recharge. The outcome is a fractured hydrogeology in which the Peace is starved of flow, its springs die, and sinkholes open up in its floodplain.

Saddle Creek is the northernmost drainage in the Peace watershed. The Saddle Creek basin contains clay ponds that have been neglected by humans and taken on feral complexity; it also contains clay ponds that have been reengineered and revegetated within the context of the Saddle Creek Restoration Project. The Saddle Creek Restoration is a 9.3-million-dollar initiative designed to improve hydrologic connectivity within the mining-altered basin and increase water deliveries to the Peace. The centerpiece of the restoration are numerous culverts and water control structures engineered into the landscape to create hydrologic connections between pit lakes, clay settling ponds, and the remnants of Saddle Creek. The Saddle Creek Restoration was implemented in the 2000s and financed with mitigation monies associated with the construction of the Polk Parkway, a 24-mile toll road that encircles the City of Lakeland and connects to Interstate-4.

During the 1960s and 70s, the Saddle Creek basin was the site of three different phosphate mining operations: the Borden Chemical Company's Tenoroc Mine, American Cyanamid's Orange Park Mine, and Agrico's Saddle Creek Mine. Today, these former mines are aggregated into two large landholdings: the Tenoroc Fish Management Area and the Williams Company property. Tenoroc is an 8,000-acre public fishing area and nature area co-managed by the Florida Fish and Wildlife Conservation Commission and the Florida Department of Environmental Protection (DEP). Tenoroc has 24 pit lakes that are stocked with game fish and managed for recreational fishing. The Tenoroc Mine was established by the Coronet Phosphate Company in the early 1950s. (Tenoroc is Coronet spelled backwards.) The majority of mining at Tenoroc, however, was carried out by the Borden Chemical Company after it acquired Coronet. In the 1980s, Borden donated the mine to the state in order to avoid the financial costs and hassle of reclamation.

The Williams Company is an oil and gas firm based in Tulsa, Oklahoma. In the mid-1970s, the company entered the phosphate business with the purchase of Agrico. The Williams Company property encompasses several thousand acres and is contiguous with Tenoroc to the north. The property is also the site of a planned development associated with Florida Polytechnic University. In 2004, the Williams Company donated a 530-acre unmined portion of the property to the state for the construction of Florida Polytechnic University, the twelfth and newest school in the State University System of Florida, situated at the interchange between Interstate-4 and the Polk Parkway.

In this chapter, I examine the more-than-human social life of a 760-acre clay settling area that straddles these two properties. The clay settling area is AGR-SC-010, so named by the DEP, the state agency that regulates mining and reclamation. This first part of the name, AGR, refers to the company that mined the parcel, in this case Agrico; the second set of letters refers to the name of the mine, in this case the Saddle Creek Mine; the terminal number is used to identify different parcels within the mine.

AGR-SC-010 is a clunky name, so I have decided to give it a new one. In keeping with the tradition of naming clay settling areas at Tenoroc with the suffix -wood, I will refer to this site as Polywood. Polywood joins Boogerwood and Myrtlewood as noteworthy clay settling areas at Tenoroc. I have named this parcel Polywood to signify its relationship with Florida Polytechnic but also to foreground the polygenetic histories and forces that give this landscape its distinctive morphology.

The human history of Polywood, as with most of the mining landforms in Bone Valley, is complicated. Polywood was mined in the 1950s by Borden and was subsequently used for clay waste disposal in the 1960s, 70s, and early 80s. In 1978, it was purchased by the Williams Company for clay storage. Polywood was never filled to capacity and, as a consequence, has greater topographic and landscape diversity than clay settling areas that are filled to capacity. Because it is interlaced with terrestrial environments, it afforded me greater opportunities for natural history exploration. A decade after the Williams Company purchased Polywood, it closed the Saddle Creek Mine. During the 1980s, the Williams Company reclaimed the Saddle

Creek Mine, including Polywood. During this time, the Williams Company began leasing the land to Dell Bolin as pasture. Dell Bolin is a part-time rancher and retired chemist with the Minute Maid division of Coca-Cola Company.

In 2010, the Williams Company donated three-quarters of Polywood to the Tenoroc Fish Management Area. The donation was accepted by Tenoroc managers as mitigation for wetland impacts incurred during the construction of an access road to Florida Polytechnic. As part of the mitigation package, the Williams Company installed two water control structures at Polywood. The first is an intake structure that moves stormwater from the Williams Company property into Polywood. The second is an outfall structure that drains Polywood's water into the engineered network of pit lakes and clay ponds at Tenoroc. The Williams Company donation and the water control structures expanded the drainage area of the Saddle Creek Restoration by several thousand acres.

Three-quarters of Polywood now belongs to Tenoroc. The northeast quarter of the parcel was retained by the Williams Company. This 200-acre parcel is slated to become a golf course. I interpret the Williams Company's land donation to Florida Polytechnic as a strategy to increase the property value of its reclaimed mine land. As Florida Polytechnic takes off (it matriculated its first class of students in 2014), the real estate value of the Williams Company's property will increase. Rather than simply sell the land, the Williams company is selling the property as an already-blueprinted, mixed-used development called Village Center. Village Center is a new urbanist community designed to meet the residential and recreation needs of Florida

Polytechnic as it grows and expands. The proposed golf course on Polywood is part of the Village Center plan.

Polywood, once existing at the boundary of the two mines, today exists at the boundaries of two divergent visions of reclamation. The first vision is that of restoration ecology. The second vision is that of real estate development. Later, I will discuss the political economic relationship between these paradigms and their implication for the landscape region.

Just as state ecologists and real estate developers make claim to the landscape, so too do an array of nonhuman species. Nonhuman species also reclaim the landscape and imprint them with new designs. Feral pigs, browsing cattle, willow trees, exotic tallow trees, and soils formed of waste clay transform Polywood in ways that defy human schemes and ideals. These elements form assemblages that exceed ecological classification. Given the layered histories of mining, waste disposal, and reclamation, how do we interpret Polywood's multispecies social form? What conceptual resources come to our aid as we struggle to notice and describe reclamation ecologies born of industrial trauma?

In my effort to decipher the life of clay, I analyze Polywood as a form of wounded space. Deborah Bird Rose defines wounded space as a geography "that has been torn and fractured by violence and exile, and that is pitted with sites where life has been irretrievably killed" (Rose 2004). By calling attention to the wounded space of settler societies, Rose invites anthropologists to pay attention to indigenous ecosystems, not just indigenous people, arguing that genocide and ecocide go hand in hand. For Rose, wounded space may not always remain wounded: injured landscapes can be “brought back to life.” She calls this capacity for renewal and repair *resilience.* Resilience is a neoliberal buzzword (see next chapter), but in Rose’s hands it is an urgent program of recuperating human-nonhuman connection in a world of relentless violence. Rose calls us to consider resilience, but she also clearly perceives that some wounds are so total and thick with infection that a landscape is unable to spring back to life. She calls this failure to spring back to life *anti-resilience*. The story of clay settling areas — and the Anthropocene — may be a story of anti-resilience.

Clay settling areas are anti-resilient landforms, but they are not devoid of biological capacity. The phosphorus unearthed through mining makes them surprisingly fertile zones. But fertility is not identical to resilience, especially when we take the pre-mining Holocene assemblage as a benchmark for assessing recovery. How should we think about the life possibilities of a damaged landscape? Why are clay settling areas livable for some species and lethal to others? This is a question that has vexed me since I have begun this project, and I am still in the process of developing a response. In this chapter, I will share some initial thoughts. The resilience or anti-resilience of a landscape is bound to what I call its *carrying power:* the multiplex powers of a landscape to breathe life into a multispecies ensemble.

Carrying power is akin to the concept of carrying capacity and might be understood as its qualitative counterpart. To understand what I mean by carrying power, let’s start with a simple example. Consider a lump of clay. The clay is soft and malleable and has a volume of water bound between the fine clay particles and distributed within the lump. Now take this lump of clay, mold it into the form of a bowl, and fire it in a kiln. The water that was bound between the particles has been baked out and you are left with a hard clay bowl. Take this bowl and fill it up with water.

Let's consider the transformation we have wrought. I want to draw attention to two things. First, notice that the lump and the bowl hold different quantities of water. Although we didn't measure it, it is evident that the bowl we created holds more than the lump of clay. Let us think about this quantity of water for both the lump and the bowl as their respective carrying capacities. Second, notice that the same mass of clay has a very different mode or method of holding water and, furthermore, that this mode of holding water bears directly on the way the clay is patterned. The relationship between what the patterned mass of clay holds and how it holds it is its *carrying power*.

Landscapes have both carrying capacity and carrying power. Carrying capacity is a measure of the biological productivity of a unit of land. The concept has been applied in many contexts: from the number of cattle that can be grazed on a range, to the population density of fruit flies in a test-tube environment, to the number of human lives that a finite planet can support (Sayre 2008). Carrying capacity is a quantitative, mathematical concept forged in a neo-Malthusian, production-oriented view of life focused on yields, populations, and limits to growth. Rather than reject the notion of carrying capacity as so many social scientists have done, I choose to reframe the debate in terms of carrying power.

As a descriptive ecologist, I approach the landscape as an interplay of form and pattern that generates and eliminates niche. Carrying power emanates out from the Earth. In this, it is similar to *infra*structure, structuring relations above from below. An analysis of carrying power begins with a particular construction of ground. Ground is foundational to the life architecture of a landscape. My conception of ground is closely akin to what ecologists call physiography: the complex patterning of geology, topography, soils, and water that make up a landscape and landscape region. As a term, physiography focuses attention on the non-living components of landscape, yet our challenge is to understand how physiography forms the base or *infra*structure of ecological events. This requires that we attend to the relationship between physiography as a multiplex pattern and the constellation of ecological niches it makes available to local lifeforms. As physiographic ground changes in time, niches open up and close down. As niches open and close, organisms enter and exit the pattern, further diversifying and transforming the carrying power of the landscape. Physiography and multispecies ecologies are in a process of co-becoming. To understand this co-becoming we must look closely at both the patterning of ground and the patterning of organisms. In this interaction of pattern, we get a landscape's carrying power — its actual and potential niches.

Let's return to our lump of clay and the bowl of water. If we placed a seed on the moist clay lump, it might sprout and survive as a seedling, utilizing the water and nutrients in the clay. If we place the same seed in the hardened bowl, with or without water, it won't germinate. The lump and the bowl have different affordances relative to the life history traits of the seedling. Now let’s take a goldfish. We place it on the lump of clay and it dies; we place it in the bowl of water and it lives. The same unit of clay, differently patterned, produces two very different niches. For both the lump of clay with its germinating seed and the bowl of water with its goldfish, the organisms add to the carrying power of the ensemble. As we add the organisms to the patterned water and clay, what can be gathered together that couldn’t be gathered before? The notion of carrying power, in short, provokes a way of noticing the interplay of forms and pattern that magnifies or shrinks the who, what, when, where, and how of ecological places.

The phosphate fertilizer industry has radically diminished the carrying power of the Bone Valley region to support Holocene lifeways, including the lifeways of water. Strip-mining and clay-waste disposal eradicate Holocene physiographies and ecologies at large spatial scales and replace them with geographies with alien carrying power. This alien carrying power supports alien ecologies — assemblages of organisms that have never existed in combination before. Furthermore, the carrying power of the post-mining landscape is not only alien but alienating. Holocene landscape symbioses that once occupied this landscape, such as pine flatwood and cypress swamp, do not reassemble in the post-mining aftermath, even with the assistance of humans. Reading the post-mining landscape for its carrying power is a problem of discerning not only what lives in a clay settling pond but what cannot live in a clay settling pond. What features of the post-mining landscape’s carrying power make it inhospitable to the critters that once dwelled there?

What is the difference between carrying capacity and carrying power in clay setting areas? Clay ponds, as I mentioned, are rich in phosphorus and have high water retention properties, so much so that reclamation ecologists have experimented with reclaiming clay ponds for agricultural production. In terms of sheer biomass production, clay settling areas might be more productive than the native ecosystems they replaced. Despite their high carrying capacity, however, the carrying power of clay ponds is deeply impoverished: clay ponds cannot support the ecological relations of a cypress swamp. The "how" and "how much" of ecosystem formation are very different questions. Both, however, hinge on the construction of ground.

The chapter is divided into four sections. Section one briefly details the construction and physiography of clay settling areas. In section two, I take the reader on a natural history expedition through Polywood and its anthropogenic and feral becoming. Section three examines the wayfinding and forest-making powers of willow trees in clay settling areas. Willow is a native species that thrives in wetland portions of clay settling areas. I am interested in what traits make willow a successful invader in relation to the unusual carrying power of the clay ponds. Section four examines the competing infrastructure projects and connectivity imaginaries of Tenoroc managers and Florida Polytechnic boosters. Together, these stories help us notice the shifting patterns of life in the wounded, waste-ridden timescapes of late industrialism.

Morphogenesis of a Clay Pond

A clay settling area is both a giant lump of clay and an enormous bowl that sits upon the landscape.

When fertilizer companies mine phosphate rock, they excavate large volumes of sand and clay along with the phosphate ore. Mining companies use large electric draglines to excavate the matrix of phosphate, sand, and clay and dump it into a pit. In this pit, workers slurry the matrix with pressurized water guns and pipe it to the processing plant for beneficiation. During beneficiation, the slurried matrix passes through a series of mechanical screens that sort phosphate pebble from the sand and clays. The sands and clays then undergo a water-intensive, cycloning process that sorts the clays from the sand-sized particles of quartz and phosphate. At this juncture, the liquid clays become waste and are pumped to settling ponds; the sand fraction moves on to the flotation process.

Clay disposal is no simple feat. During slurrying and cycloning, the clay particles, with their large surface areas, adsorb enormous quantities of water. These clays expand to ten times their original volume, creating a waste product that greatly exceeds the volume of the void created by mining! Companies dispose of clay in the void but must build large earthen dams around the pits to accommodate the swollen clays. When mining companies make the earthen architecture of settling ponds, they leave often leave the geography of pits and spoil piles unmodified. The resulting landform is a colossal, elevated pond of clay with a highly irregular bathymetry. As the clays consolidate and lose water, the settling area transitions from a deep clayey lake into a patchy landscape of wetlands and uplands. As we develop our analysis of the clay settling area's carrying power, it is useful to consider how the basement topography of the pits and spoil piles transforms the surface topography and its ecologies. Wetlands emerge in the troughs (underlaid by pits) and the uplands emerge in peaks (underlaid by spoil piles). Here we can see how niche is made in the emanation of form from the ground up.

It takes over 40 years for a clay settling area to fully consolidate. Mining companies, prompted by state regulators, speed up the consolidation process by carving drainage channels in the clay and disposing of excess water through an outfall structure. This process is known as "de-watering." De-watering is one of many reclamation activities carried out by phosphate mining companies. Unlike other mining landforms, there are fewer opportunities to restore clay areas with native ecosystems. Because of the premium on restoring wetlands, the phosphate industry has dreamed of creating wetlands in clay soils since the early 1980s. However, studies in clay settling ponds conducted by H.T. Odum and others demonstrated that the soil and hydrological properties of clay areas are too variable for Florida wetland communities to successfully establish. For this reason, clay settling areas are primarily reclaimed as cattle pasture, and wetland communities take on spontaneous, feral designs.

Because a clay settling area is like a big bowl, rainfall enters the basin but has nowhere to go. Prior to phosphate mining and the urban and agricultural drainage campaigns of the last century, stormwater moved across Central Florida in gentle sheets of water. During the summer rainy season, this sheetflow turned flatwoods into ephemeral, slow-moving wetlands. This stormwater would charge the aquifer or flow horizontally into swamps, rivers, and streams.

Because stormwater is impounded in settling areas and mining pits, its only exit from these landforms is through evaporation and transpiration by plants. Water that would normally flow downstream is returned to the atmosphere or retained in the mine, depriving the Peace River and its tributaries of its historic flows. In the winter months, large sections of the karst-threaded Peace River go dry. Karst is a geological formation characterized by limestone rock with underground rivers and pockets. Water dissolves the limestone, but also provides the hydrostatic pressure to keep the Swiss-cheese-like structures from collapsing. In a region with overdrawn aquifers and impoverished surface waters, these Swiss-cheese structures often collapse, creating sinkholes. The Peace River, more than any other river in Florida, has had its hydrology transformed by mining. Mining companies have withdrawn so much water from the Floridan aquifer that hydrologists tag this region as the “Big Red Hole” on groundwater maps. In an effort to restore flow to the Peace River, a number of restoration projects have been implemented. The Saddle Creek restoration is the most ambitious of the plans. As we think about the altered carrying power of the landscape region, we must consider how mining alters the way water is conveyed across the landscape and what implications it has for multispecies life, both upstream and down. The patterning of ground, the patterning of water, and the patterning of life are all entangled and at stake.

Descent into Clay: A Not-So-Natural History Foray

to be on the lookout

for evil (swamp rattlers) is a form of paying
attention, and to pay attention is to behold the

wonder, and the rights, of things

— A.R. Ammons, "Garbage"

March 2014. It's 9:15 a.m. and already hot. I have prepared for a day of exploration in Polywood. I drive through Tenoroc and park at the base of Polywood's southern dike. Although the land has been deeded to the state, Tenoroc managers allow Dell Bolin's cows to rove within the Tenoroc donation. Tenoroc's managers like the cows because they keep the weeds down. I configure my GPS app to record my journey. I slide through the barbed wire fence and ascend the dike of the clay settling area. At top of the berm, I am hit with the stench of death. A gang of vultures are hard at work devouring a large tawny cow. Flaps of leather hang on its skeleton. I stomp through the browned-out tufts of invasive smut grass that have grown up among the closely grazed pasture grasses. I startle a pair of quail nestled in the clumps of exotic grass. In the distance, I hear the song of a meadowlark.

From the top of the clay settling dike, I look down into a basin of trees. I am at canopy level and peer out over a sea of bright green: a swamp of Carolina willow and invasive Chinese tallow. A momma cow and her calf are resting on the berm. Unsettled by a human on foot, they scamper away. I walk down the cattle-groomed dike toward the swamp. Where the dike meets the clay is a strange ecotone. Threaded throughout the clayey margins are a series of trails worn into the earth by cattle and feral pigs. I walk these trails with an eye and ear for swine: I am on their turf and I have been warned they can be aggressive, especially when they have piglets. The trails lead into a damp clearing that extends into the willow swamp. The clearing appears to be made by the selective grazing of cattle—a clearing that looks and feels lived in, a room of sorts. Hoof prints, both cattle and swine, have churned the clay surface. Munched and trampled weeds proliferate as groundcover. My sneakers (I've worn my crummiest pair) clump with clay. The animals have scraped the clay surface into divots and flaps. Fire ant colonies mound out of the clay amidst dung piles and a diverse mixture of plants, both grazed and diminutive, that sort themselves out in this uneven microworld. I stare into two hoofprints full of water: one clear, one bright green with algae (I infer the latter has a bit of shit in it).

It is a mostly open clearing but it is furnished by plants that the cattle won't eat. A ten-feet-tall thistle is the room's centerpiece. Its rosette of spiny leaves whorl along the bristly stem that culminates in a droopy apotheosis of pink-purple flowers. I look around: a half-eaten tussock of cogongrass, tropical soda apple, and blackberry. The ungrazed plants in this area have a prickly demeanor. The soda apple's prickles are particularly interesting. An exotic escapee from South America, the toxic soda apple has become a nuisance plant in pasturelands across the southeast. Long yellow-green spines emanate from the surface of its leaves. It communicates, in no uncertain terms, "don't touch me." Plants are not stupid. Having co-evolved among herbivores, they have learned to interpret the animals' toothy touch and have responded in kind. "The rose has teeth in the mouth of the beast" (Wittgenstein 1969). Cogongrass, lacking prickles, pulls silica from the soils and engineers it into a lacerating leaf edge. Plants have all manner of defenses. In a landscape stocked with cattle, it is no wonder that physically and chemically unpalatable plants abound. I walk away from the berm, through the cow-munched room, toward the willow swamp. The trees are 15-20 feet tall. Black water beetles skim the surface in a frenzy; frogs make a squeak before they plunge into the water upon my approach.

Along the water's edge, the clays are mottled with the bioturbation of worms. I dig in and pull out a handful of red, wriggling threads. Local catfish fishermen call these organisms "red worms" and tell me they are important part of the food chain. The swamp water is surprisingly clear, but the water surface is covered in duckweed so I am unsure what lurks below the surface. My curiosity leans out over the water, but my body stays firmly on the bank. Plunging into the swamp is a mucky proposition. Cattle are known to get stuck and die in the semi-solid clays.

Today the swamp is serene, even beautiful. The willow canopy is backlit by the sun, and the tree's cottony fruit drifts, like snow, through the understory. The famed ecologist H.T. Odum from the University of Florida was the first to study clay settling ponds. Funded by the then newly founded Florida Institute for Phosphate Research, or FIPR (pronounced "Fipper"), Odum set to work mapping the circulation of materials, energy, and organisms in clay settling areas. In Odum's publications, clay settling area ecologies are rendered in his modernist cybernetic diagrams. (For more on Odum's conceptual approach, see next chapter.) Betty Rushton, Odum's student, took up the challenge of studying succession in clay wetlands for her PhD research. Surveying multiple clay settling areas of different ages, Rushton saw a clear pattern: willows were never replaced by slow-growing species like cypress. In floodplain ecosystems, willows are a pioneer species that are succeeded by trees like cypress, but in clay settling areas, willows are both pioneer and climax species. As the climax species, willows grow larger and more mature than they would in their native webs of relations. Rushton and Odum theorized these swamps as monospecies ecosystems in an arrested state of succession (Rushton n.d.).

Mixed in with the willows at Polywood are Chinese tallows. When Betty Ruston studied willow swamps in the 1980s, tallows were not part of the ecosystem. Chinese tallow is an invasive tree that spread into Florida from Texas, where it was introduced as an ornamental plant. Tallow has a rich history with humans. For the last fourteen centuries, Chinese people used tallow as a seed crop for the manufacture of oils, soap, and candles. The tallow tree's fruit is a white fleshy capsule that looks like popcorn. In the American South, people call it popcorn tree. In the restoration community, Chinese tallow is looked upon with scorn — it is an aggressive invader. The managers of Tenoroc joke, half-seriously, that they need two million dollars and a helicopter stocked with herbicide to effectively manage the tallow problem.

Central Florida has been in a drought for the last six years, and the water levels in Polywood are low. A dark brown ring circles the trees, indicating a past high-water mark. Below the ring, adventitious roots dangle out of the water. Adventitious rooting in wetland trees — the ability to create roots in unusual places — is an adaptation to flooding. Clay settling areas flood. Within clay settling areas, low-permeability clays set up an unusual hydrology: stormwater entering the impoundment moves quickly down the soil surface into ponds and swamps. The thick mass of clays has little pore space for downward seepage: consequently, stormwater rapidly piles up and inundates zones at lower elevation. This “flashy” hydrology creates unnatural rhythms of flooding that inhibit seed germination and seedling survival in most native trees. Willows, adapted to floods and the disturbances they make, thrive in these conditions.

The flashy hydrology of clay settling areas was key to Odum and Rushton’s theory of willow swamps as monospecies systems in an arrested state of succession. Other wetland trees do not have a tolerance for flashiness. To test this, Betty Ruston planted common wetland trees as both seeds and seedlings in experimental plots in clay areas. The results from her study showed that the seedlings were big enough to withstand some flooding, but they did not thrive. The seeds did not germinate at all. She concluded that Florida wetland trees, with the exception of willow, could not survive in clay ponds because frequent, high-volume flood events inhibited seed germination.

Odum and Ruston identified another factor that created willow swamps: the biogeography of the mining disturbance and the dispersal barriers created by settling area dikes. Clay settling areas are often surrounded by bare-mined soils and ongoing mining operations. Few native wetland plants are able to disperse from Holocene remnants across this vast disturbance zone into the clays. Fewer still are able to disperse over the dikes. The dike walls, anywhere from 20-50 feet above grade, act as barriers to species movements. As water does not run up hill, wetland trees like cypress and gum that disperse their seeds in floodwaters are uniquely occluded (Rushton 1988). With its cottony, air-born seeds, willow is one of the few native species that can disperse across long distances and over the dikes to establish in the clays. Tallow, with its fleshy popcorn-like seeds, is bird-dispersed.

I leave the clearing and return to the cattle trail. I wind along the bank of the dike until I reach a large concrete culvert jutting out of the berm. This is one of two water control structures added to Polywood as part of the Williams Company's donation to Tenoroc. Water flows into the culvert over an adjustable set of interlocking boards. By adding or removing boards, Tenoroc managers control how much water enters and leaves Polywood. This structure is the outfall; in the northeast corner of Polywood is the inflow structure that receives drainage from the Williams Property. By removing a plank, Tenoroc managers can increase the amount of water released into the network of pit lakes and clay ponds that form the Saddle Creek Restoration project. What path does Polywood's water take? First, the ponded water at the mouth of the outfall structure passes through the culvert buried into the dike. The water moves through the dike and flows into its first mining pit: Picnic Lake. From Picnic Lake it flows through a series of culverts to Lake 5, Boy Scout Lake, Lake 2, Lake 3, two clay pits that have been revegetated with native plants, Lake 10, and finally the remnant Saddle Creek.

I leave the culvert and ascend the dike overlooking Polywood once again. The cows are leery of me. As I approach, they begin to herd and funnel into the interior of settling pond. The cows enter the interior by way of a ridge (a spoil pile below the surface asserts its form). From either side of the ridge, I look down into swamp. In the 1970s, Polywood was a clayey lake with cattail wetlands. In the intervening 40 years, Polywood has consolidated considerably. What was once soupy clays has congealed into a mosaic of pasture and willow-tallow wetlands. I follow the ridge. It leads me to a rolling landscape of neatly cropped grasses and oak trees. Water pools here and there, but it is a mostly dry site. I am in the northeast corner of Polywood where the Williams Company has proposed to build a golf course.

Within this rolling pastoral landscape is a rickety pen used for capturing calves. It is crowded with perching vultures. If the Williams Company finds a buyer for the Village Center complex, Dell Bolin, the owner of these cattle, will have to sell or relocate his herds.

Dell's operation is typical of calf-cow operations. In Florida, ranchers raise cows to make and sell calves; they do not raise cows for slaughter. Calves are grazed in Florida's subtropical pasturelands and then shipped to feedlots and confined feeding operations in the Corn Belt and Texas where they are fed to maturity and slaughtered. In this commodity chain, the social worlds of Florida pastures consist of "mommas" and "babies" (as Dell calls them) and a few hand-selected bulls. Dell Bolin relayed the following story:

In 2004, a series of tropical storms swept across Central Florida and flooded the Williams Company property. Dell could not access his cattle for a considerable period. When it came time to round up the calves, large areas of the property were too wet to access by truck. Dell was busy at Minute Maid and missed a few calves. The male calves matured, began to breed, and developed a harem. Normally, male calves are sold at auction before they reach sexual maturity. When male calves escape the cowman's grip and become sexual adults, they are nicknamed "hairy dicks." Dell works hard to maintain the angus breed and has no patience for hairy dicks and the threat of feralization that they pose.

Floridians have a rich history of engagement with feral cows. During the period of settler colonialism, poor whites of Celtic origin, so-called crackers, migrated from the Carolinas to Florida to hunt cows descended from strays of early Spanish ranches. These feral or "cracker" cattle were small-statured, stringy-fleshed cows that became rapidly adapted to Florida's harsh climate and terrain (Mealor and Prunty 1976). Cracker cattle were the staple of the Central Florida economy well into the twentieth century, before fence laws, pasture improvements, new breeds (with fattier marbled meat), and tourism reached Florida. Dell's cattle, left to their own devices, would likely evolve into a form similar to the cracker cow.

Angus cattle are not the only creatures of empire in this scene (Anderson 2004). Feral pigs, too, have been a fixture of the Florida landscape since Spanish colonization. Pigs, however, were never hunted and bred out of their feral form like the cracker cows. Pigs are considered an invasive species by environmentalists. At Tenoroc, pigs are a nuisance: they tear up roads and restoration plantings looking for tubers and worms, compete with native animals for acorns, and prey on herpetiles and the eggs and chicks of ground-nesting birds. Tenoroc's lead manager, Danon Moxley, along with other male managers at Tenoroc, carries a gun in his truck. Killing pigs is a form of masculine prowess. It's also real work. Danon has hired a professional trapper and his three sons to hunt pigs with their dogs. Danon has a theory: as the hunting pressure on pigs increase, the sows make more piglets to replace their numbers. They are not stupid, he tells me. I have a theory of my own: pigs retreat to clay settling areas as a refuge from hunters. The trapper and his sons do not trek out into the clay mud and bramble. For feral pigs, clay settling areas are a space of freedom.

Casey, a female manager at Tenoroc, claims that Tenoroc's pigs no longer flee on the approach of her white truck. She does not carry a gun. Perhaps, she jokes, they've pegged her as a pacifist. Pigs, of course, are notoriously smart and, in Florida, have become attuned to humans that hunt them. Hog catchers must be careful to avoid introducing human scent into live traps—a telltale sign of danger.

Cattle and pig live in two separate but overlapping disciplinary regimes: one driven by agricultural capitalism and the other by restoration ecology. The beasts do not live in fear so much as they live in the knowledge of how these disciplinary regimes works. Cows on Williams Company land have come to associate men's trucks with hay and pelleted feed. This feeding relationship is essential for making cooperative cows that enter pens and, unwittingly, give up their calves.

For cattle, men with trucks come bearing food. For pigs, men with trucks carry guns. Food and guns, lures and sticks. The animals, like their human overseers, are paying attention. The prickly plants seem to be paying attention too. This choreography of interspecies attention matters to the ecological structure of clay settling areas.

Also important to the ecological structure of the clay ponds are the grazing habits of the cattle. Cows are an important shaper of Polywood's carrying power. The lands recently donated by the Williams Company are the only parts of Tenoroc where cows are allowed. (Pigs go wherever they please.) The division created by barbed wire fencing creates an interesting natural-history comparison between grazed and non-grazed clay settling ponds. Within Tenoroc is a clay setting area called Boogerwood. Boogerwood, as its name suggests, is a slimy mess. Unlike other areas in Tenoroc, it has not been reengineered or revegetated as part of the Saddle Creek Restoration. It has feral design without cows. The vegetative structure of Boogerwood is quite different from Polywood: its forests are dominated by willow trees but the trees are smothered by native and exotic vines. Rooted in the ecotone above the clays, vines climb up trees, borrowing their architecture to capture the sun's rays. Without cows or other grazers (there are no deer in Tenoroc), the swamp becomes an impenetrable canopy of vines. On one walk in Boogerwood, I encountered a sow and a troop of piglets on the hiking trail. Encountering each other, we both paused and glanced at the impenetrable wall of vines hemming us in. We were at an impasse. Could we pass politely? What is the etiquette? Fear got the best of me and I shouted at the pig. Irritated more than intimidated, the sow and her piglets pressed reluctantly into the tangle mass of vines.

Do Willow Swamps Think?

In this section, I engage with a provocative line of argument in Eduardo Kohn's *How Forests Think* (2011). Kohn argues that semiosis is a fundamental property of life. Critters interpret the world and generate meanings that other critters, in turn, interpret. As an ensemble of interpreting and interpreted organisms, forests become thinking/feeling forces in their own right. Although Kohn does not tackle the question directly, it stands to reason that the diversity of a forest's organisms reflects the diversity of its thinking process. In terms of diversity, willow swamps in clay settling areas pale in comparison with the Ecuadorian tropical forests where Kohn conducted his fieldwork. Nor do they compare with Florida's subtropical floodplain forests, of which willow is a native component. If forest thinking emerges in the semiotic attunement of diverse organisms, does this mean willow swamps are somehow cognitively impaired? Attuned to the specter of anti-resilience, I plunge into the semiotics of willow and the damaged carrying capacity of the clay pond.

In his chapter *The Living Thought*, Kohn makes a case for thinking about organisms as complex, evolved signs of past environments. For example, Kohn instructs us to see the fantastic snout and tongue of the anteater as an evolved interpretation of a termite mound. The long, winding form of the anteater's tongue corresponds with the long, winding tunnels of the termite mound. Generation after generation, anteaters were propagated and re-propagated as worldly forms through the carrying power of termite mounds. Through arts of evolution, the predator evolved a set of morphological tools that enabled it to more skillfully raid caches of termite food. Doing so, the anteater body became a formal interpretation of the termite-mound morphology and a real-time interpreter of ongoing termite worlds.

Using Kohn's evolutionary semiotics, Carolina willow may be similarly conceptualized as an interpretation and interpreter. One phase of willow's morphological and evolutionary history takes place in margins of floodplain forests like the Peace River. The floodplain is a shape-shifting environment, especially as one approaches the river. Seasonally pulsing streams of water build up banks of silt and wash them away. Willow have evolved to take advantage of this fertile but rapidly changing environment. Willows do not sense the world with a snout and tongue or, for that matter, any of the perceptual technologies of an animal. So how do they *know how* to colonize the floodplain?

Willows think and feel their way in the world, I contend, through their cottony, wind-blown seeds. Willows disperse their fruit in early spring and a significant portion find their way to open water. In Florida, the timing of the dispersal coincides with the onset of hot spring weather when rivers and lakes recede and expose a band of muddy shore. This band of exposed shore persists "long enough for the seedlings to pass through [an] extremely vulnerable early phase and become established" (McLeod and McPhereson 1973). Riding the winds is a passive and capricious method of exploring the environment, but what willow trees gives up in control they make up for in coverage. Willows are profligate seeders, so called "r" strategists. Profligate seeding is a hallmark of disturbance-loving pioneers. A single willow tree makes thousands of cheaply made seeds (cheap in the sense that they do not require the fats or carbohydrates that go into, say, the flesh of a large nut) with short periods of viability.

Willow seeds require exposed wet soil to germinate. In a 1938 study, the botanist Herbert Moss discovered that germinating willow seeds develop fine hairs along the seedling's stem, called the hypocotyl, and incipient roots. These hairs are the primary absorptive organs of the seedling. Moss reported that the soil must remain moist for at least one week for the seedling to survive. "If the soil dried or was disturbed, the hairs were injured and the seedling died." McLeod and McPhereson (1973) argue that it is these fragile hairs — not a physiological imperative of the mature plant — that circumscribe willow to wet bare ground.

These fragile absorptive hairs are significant to the life history of the tree as they perform the sensory work of circumscribing the future-adult to its optimum niche: the floodplain. If the soils dry out and the hairs break, the seedling will fail to establish. The hairs are a primitive sense organ, equipping the seedling with a sensitivity for wet bare ground. The hairs-as-sense-organ function as a switch: intact or not intact, alive or dead. The fine hairs, like the tongue of the anteater, make the linkage between willows and wet bare ground, thus carrying willow along as a pattern in time.

Just a few paragraphs ago, I asserted that the sensing body of the willow apparatus was the parent tree and that it explored the environment with an army of cheaply made seeds. Now, I am asserting that the seedling is the sensing body and the absorptive hairs are the sense organ. There is no contradiction here. We need to understand these sensorial practices together. And we need to understand them as morpho-phenological knowledge: knowledge rehearsed and embodied in the enactment of species as lineage (see chapter two).

Willows, like all terrestrial plants, are sessile organisms. Dispersal is key to their exploration of space and to their extension as a form in time. Adult willow trees release thousands of seeds in a reconnaissance for disturbed wet ground. This reconnaissance joins present lives with future lives (as it once bound past lives into the present). The cottony hairs that coat the seed and give it its flying powers are, in a strong sense, placental: neither parent nor offspring, but critical in facilitating the reproductive linkage. The thinking and feeling of willow's wayfinding occurs at this generational juncture (Ingold 2011). Adult willow's wayfinding is a statistical calculation: release a bunch of seeds to the wind and see what sticks. The seed's wayfinding is binary: wet or dry ground, alive or dead. Together, these modes of interpretation help land the *genos*, the intergenerational line, in disturbed wet ground again and again (Rose 2012). Rethinking perception through the *genos* unlocks our understanding of perception as a technology of the body and refocuses our attention to the praxis of species as lineages, as *lines in the making*.

Conceptualizing willows as lines draws our attention to the tree as a niche- and history-making vector within Holocene and the Anthropocene geographies. In the Holocene, willows are an enduring landscape presence because patches of disturbance are continuously made and remade by rivers. When willows colonize a fertile patch of bare mud, they can help stabilize the shoreline and create niches for slow-growing trees that may eventually succeed them. Alternatively, a clump of willows can be washed away in a violent torrent. In either instance, floodplains form an ephemeral niche-space that willows have learned to exploit for their flourishing. Hence, their status as pioneers.

In the strange, Anthropocene world of clay settling areas, willows and the landscape conditions they have evolved to interpret have expanded in mining.

Missing are a host of wetland trees that would, in Holocene landscapes, succeed willow. These ghost species, while not present, shape how willow living is done in clay settling areas, transforming it into a climax species. The clay pond's steep slopes and low permeable clay soils create a flashy hydroperiod that only willow and tallow seedlings can endure. Other wetland trees might find a foothold in the clay were it not for the tall dikes and expansion of human-made environments that rupture long-distance ecological communications.

Willows have not achieved new Anthropocene agilities (Tsing 2017); rather, the carrying power of the landscape has been fortuitously recast for their flourishing. Although they have not gained new skills, they take on novel morphologies. Willows become a long-lived species; they also topple over in the mushy clays. The boles of the toppled trees get buried in the clays at odd angles and begin to reallocate growth into branches that curve upward to meet the light, forming the new primary stems.

By focusing on the unexpected flourishing of willow and the exclusion of other wetland trees, we see the violence of phosphate mining and the way it diminishes historical carrying power and gathers novel assemblages of organisms. As for the question of willow swamp cognition, here's my take: willow swamps think, but they think a rather singular, repetitive, bole-warping thought.

Fragmenting Connections (Scrap and Salvage Reprised)

Men with pickup trucks are constructing what appears to be a giant, space-aged insect in the middle of a cattle pasture. Dangling from a large crane, a sleek arc of the insect's carapace is being lowered into place. This gleaming, futuristic structure is the Innovation, Science and Technology Building. Designed by celebrity architect Santiago Calatrava, the Innovation, Science and Technology Building is the flagship building of the new Florida Polytechnic University.

Promoted as the MIT or CalPoly of Florida, the development of Florida Polytechnic has been plagued by controversy. With its lack of accreditation, untenured professorships, and intentionally bookless library, many observers have doubts about the university's long-term viability. Florida Polytechnic is being built on an unmined parcel of land donated by the Williams Company. Sited in the northeast corner of the property at the juncture of Interstate-4 and the Polk Parkway toll road, the Florida Polytechnic University is the centerpiece of a new development vision called the Florida High Tech Corridor. Hyped as the "Silicon Valley of the East," the Florida High Tech Corridor is a private-public initiative designed to attract technology firms to Florida through business-friendly taxes and a skilled local labor force. To date, the Florida High Tech Corridor has remained a mostly intellectual and policy vision. With the construction of Florida Poly, the vision is taking concrete form.

Capitalizing on this Silicon-Valley-inspired vision are a handful of real-estate development projects, the most prominent of which is the William Company's Village Center. Designed in accord with principles of new urbanism, famously elaborated in Disney's town of Celebration, Village Center is a 2,500-acre mixed-use community featuring 1,700 apartment units, two public schools, 1.3 million square feet of retail, a 350-room hotel, and a 2.9 million-square-foot corporate research park to ally with the university. In the northeast corner of the Polywood, the Williams Company plans to build a golf course. Given the small footprint of the campus and the 20-minute drive to the nearest shopping center, the Village Center serves an important role in the university's expansion.

The new development promises to "seamlessly integrate" with the other new developments planned for the region. These include the Polk Commerce Centre (currently in orange groves) and an expansion of the Lake Myrtle Sports Complex. Critics have suggested that the university and its attendant development is, in fact, a Trojan Horse for a more radical development vision for Central Florida: the Heartland Parkway. The Heartland Parkway consists of two proposed toll roads: one running north-south from Lakeland to Fort Myers and a second running east-west from Tampa to Port St. Lucie. The toll road projects would unlock future growth in Central Florida's semi-native pasturelands, orange groves, and ancient Lake Wales Ridge scrub ecosystem. Enthusiasm for the Heartland Parkway waned in the post-2008 recession, but is poised for a resurgence if and when the university takes off and traffic grows (thus adding justification for new roads). In the eyes of patient developers and large landholders, it’s just a matter of time.

These new developments will help fuse together the sprawling cities of Tampa, Lakeland, and Orlando into what has been called the “Orlampa” metropolitan region. As a landscape ecologist, this is my worst fear for the region. This sprawling mass of low-density development fractures what remains of the greenspace in the region. To the north of Tenoroc and Interstate-4 is one of the last big remaining Holocene landscapes in Florida: the Green Swamp. The Green Swamp is a mosaic of the flatwoods and cypress swamps. In my work, I use it as a point of reference to understand what Bone Valley used to be. Although fractured, weedy, and contaminated, the other large area of undeveloped green space is Bone Valley. For the last 20 years, state environmental managers have dreamed of a wildlife crossing at I-4 to connect Green Swamp to Bone Valley. As the region undergoes more growth, state wildlife advocates might get their wish. Currently there are plans to expand 1-4 from an 8-lane to a 12-lane highway. If the Department of Transportation moves on this expansion, it is likely they will use this opportunity to build a wildlife underpass that links the Green Swamp to Tenoroc. Tenoroc managers hope that the underpass will serve as a corridor for species like deer, and maybe even black bear, that are currently missing elements in the post-mining assemblage. The underpass, however, might also serve as a conduit for weedy species to move into the Green Swamp!

The wildlife underpass at I-4 is an element in the long-term ecological planning of Bone Valley carried out by ecologists in the Florida Department of

Environmental Protection and Fish and Wildlife Commission. At the center of this planning is the Integrated Habitat Network. The Integrated Habitat Network is a blueprint for a series of habitat corridors for Bone Valley. The goal of the network is to support animal migrations by connecting mining-altered green spaces in Bone Valley with relatively intact natural areas. The Integrated Habitat Network was conceived in the 1990s by the same group of ecologists who pushed for the Saddle Creek Restoration. Steeped in the cutting-edge landscape ecology at the time, the idea behind both projects was to restore ecological flows — both organisms and water — to the mining fragmented region. The plans ambitiously addressed the landscape-ecological failures of Bone Valley by reconnecting fragmented portions of the landscape with each other through habitat corridors. These corridors were planned primarily in relation to major rivers and their tributaries. Culverts and wildlife underpasses are key technologies in this politics of connectivity. Tenoroc and Saddle Creek— one of the few large pieces of publicly owned green spaces in Bone Valley — were critical to this hopeful vision. While sections of the network have been cobbled together, the Integrated Habitat Network is largely incomplete. The wildlife underpass at I-4 is not the only zone of disconnection.

A short story of disconnection: In the summer of 2013, I wanted to explore how Tenoroc's interconnected network of clay settling areas and pit lakes joined up with Saddle Creek. Borrowing a plastic yellow kayak, I paddled for several miles. The creek had been channelized, and it opened, here and there, to a pit lake, only to narrow again. I followed the creek into an unmined cypress swamp. I paddled the linear creek, passing by large stumps logged in the early twentieth century. I passed by a small opening in the creek that links to the pit lakes of another large mining area. Continuing on, suddenly I found myself in the most curious situation: Saddle Creek had come to a dead end. I looked around perplexed. Eventually, I turned my kayak around and head back up the creek. Later, looking over aerial photographs I discovered a startling error. What managers, for decades, assumed was a tributary of the Peace River was nothing more than a mining ditch! The actual Saddle Creek was not far off: it ran parallel to the mining ditch, but was obscured by an embankment. After spending millions of dollars to replumb the watershed and increase water deliveries to the Peace, Tenoroc's flowing water features and Saddle Creek do not connect.

Why should the projects linked to Florida Polytechnic and the Integrated Habitat Network be storied together? Here we have two competing sets of projects, both requiring corridors, that rival one another in their claim to space and the kinds of carrying power they set in motion. One set of projects we can confidently label "capitalist." The second we might label "green." But the green infrastructure projects — the Saddle Creek Restoration and the Integrated Habitat Network — only gain traction when capitalist projects hit the ground. Wetland mitigation associated with the construction of the Polk Parkway and the access road to Florida Polytechnic created the mitigations of Polywood and Saddle Creek. The ecological flows created in restoration are predicated on road building that further fractures the landscape region. This is yet another example of scrap and salvage (see last chapter).

Most wetland mitigation occurs either by replacing damaged wetlands onsite or through the purchase of mitigation credits from mitigation banks. In the case of the Polywood donation, the Department of Environmental Protection and the Williams Company worked out a deal such that wetland losses were turned into a land donation and the construction of the two water control structures. This was unconventional, but a similar set of negotiations helped funnel mitigation monies from the Polk Parkway construction directly toward Saddle Creek Restoration.

Conclusion

Polywood and its surrounding environments — Tenoroc, the Williams Company, Florida Polytechnic, a restored creek that dead-ends, Interstate-4 and its tributaries of toll roads — form a strange landscape ecology. This landscape ecology, as I've shown, has been transformed by mining and clay waste disposal and is now in the grips of restoration ecologists and real estate developers. It is also in the grip of the nonhuman. All of these actors, but most notably phosphate miners, have transformed the carrying power of the landscape.

Polywood, I have argued, is anti-resilient to Holocene ecologies but still retains the power to carry life. To understand just how Polywood carries life, we have had to attend to a jumble of human and nonhuman histories. As these histories converge, they add and subtract actors, induce transformations, prop up and negate the life conditions of the landscapes. First and foremost, then, Polywood is a jumble of histories with arcs of becoming that are very different from the Holocene landscapes that came before.

As a matter of conclusion, I wish to return to the question of ground. I have shown how phosphate mining has wounded the carrying power of the landscape; I have also shown the region continues to be infected by human designs. What I have not demonstrated is how the Saddle Creek Restoration or the real estate projects of the Williams Company land affect and may continue to affect Polywood's carrying power. Let me do so now.

During my not-so-natural history foray, Florida was emerging from a multi-year drought. When I visited Polywood in 2014, the drought had ended and Polywood was inundated with water. The clearing I explored, with hoof prints and prickly plants, was drowned in several feet of water. Polywood was full of water but so were the pit lakes at Tenoroc. Danon, Tenoroc's manager, worried that the volume of water threatened the Saddle Creek Restoration infrastructure. He closed the connection between Polywood and Picnic Creek. For several months, Polywood's water sat there and stagnated. But once the rains stopped, Danon continued to keep the connection closed. Polywood's water, he told me, had become hypoxic from lack of movement and aerobic decay. To release Polywood into the lakes would have killed or harmed the fish in the fishery. Polywood's water would have to be slowly drained off.

I relay this story to illustrate that Polywood's interior water regime is a highly volatile and contingent one. One manager's decisions, the vagaries of climate, and the physiography of clay soils make an erratic wetland. It is unclear how the plants and animals will respond to this watery flux; we only know that they will have to.

My second example requires that you imagine the future. Suppose that the William Company finds a buyer for Village Center and shopping malls, apartment buildings, and a golf course take over the property. What would happen to Polywood? My first thought goes to cattle. Dell would probably sell his herd. With the cattle removed from the landscape, a niche for vines would open up, and Polywood would begin to look a lot like Boogerwood. But suppose that the state ecologists successfully lobbied for their wildlife underpass and deer began to wander into Polywood. Perhaps they would eat the vines, and Polywood's swamps would retain their open canopy. But what if deer are pickier eaters than cows and like some vines but not others? Or what if there are too few deer to eat up all the vines? In each of these scenarios, a different pattern of carrying power prevails. But subtending all of these scenarios is a bit of *infra*structure: a lump of clay shaped into a bowl.

Chapter 5

Lake Apopka and the Trophic-Dynamic Aspect of the Plantationocene

At the end of the workday, the Nguyen family's boat and rubber slickers are covered in fish scales. Hoang, his wife Lihn, and their son Alex empty laundry baskets of fish onto a conveyor belt. Standing on the concrete loading dock, I watch as gizzard shad and long-nosed gar are conveyed up the bank of the canal and flop into a large plastic vat. Hoang and Lihn are Vietnamese refugees who came to the United States in the 1980s, fleeing the violence of the Indochina Wars. Like many diasporic Vietnamese, the Nguyens settled in Louisiana to continue their life's work as shrimpers and saltwater fishermen. The family continues to live outside New Orleans, but from October to December they rent a motel room in Central Florida and work the gizzard shad harvest at Lake Apopka.

It's an hour before sunset. Boats of fishermen — Latinos, white Iraq war veterans, and other Vietnamese — line up along the Lake Apopka canal to unload the day's catch. Jesse Jr. and his fiancée Tara are the managers of the dock operations. Jesse's friend Eric has been hired as an extra pair of hands. Eric shovels ice in between layers of fish. When the vat is filled, he reads the fish's weight off the digital scale and Tara records it in her ledger from the small plywood office a few yards away. Jesse Jr. mounts a small Komat'su forklift and loads the fish-filled bin into one of two refrigerated semi-trucks. He places an empty vat back on the scale. Eric tares the scale and reactivates the conveyor belt. More fish come down the line.

Once these trucks are full of fish, they will begin their journey to Raffield Fisheries in the Panhandle where they will be processed into crayfish bait. Alternatively, when the market is right, the shad is manufactured into cat food.

Despite their use as bait and cat food ingredient, shad have little commercial value. Gizzard shad, along with gar, are considered a rough or trashy fish. Instead, Lake Apopka's gizzard shad are harvested for the phosphorus in their biomass.

Lake Apopka is a large shallow lake transformed by the phosphorus-laden wastewater of large commercial farms. The farms were predominantly family-owned companies that specialized in winter vegetable production for chain grocery stores and large food corporations. Sweetcorn, carrots, celery, and radishes were grown in the former floodplain’s rich muck soils. Mucks are organic wetland soils that volatilize when exposed to the atmosphere. Although naturally fertile, phosphate fertilizers were applied to fields with zeal. Records of fertilizer applications in Zellwood are incomplete. However, what records we do have suggest that the volume of phosphates fertilizers applied to the lake were extraordinarily high.

The Lake Apopka farms were organized into a political and spatial unit called the Zellwood Drainage and Water Control District. The Zellwood Drainage District was a quasi-governmental agency created by the legislature in 1941 tasked with draining the lake’s northern marshes for agricultural development. It did so by creating a massive drainage apparatus composed of an earthen levee, an extensive network of canals, and immense fossil-fuel-driven pumps for moving water. This water control infrastructure was financed by a drainage tax levied on the farmer.

The Zellwood farms were what the Dutch call polders – reclaimed, low-lying lands protected by dikes.[8] The polderized farms were two feet below lake level. During the summer fallow season, farmers would open up their culverts to allow lake water to flood their fields. This flooding practice suppressed nematodes and mitigated subsidence of the organic mucks. When it came time to plant, this floodwater was drained from the fields and pumped over the levee and into the lake. It is this practice of flooding and draining the fields — in combination with fertilizer applications — that introduced immense quantities of phosphorus into the lake.

Beginning in 1947, Lake Apopka underwent what ecologists call "a catastrophic ecological shift." In a manner of one to two years, Lake Apopka shifted from a clear-water lake dominated by submerged aquatic vegetation to a turbid lake dominated by blue-green algae.[9] Fresh water ecosystems are notoriously responsive to phosphorus. According to the Redfield ratio (the stoichiometric relation between carbon, nitrogen, and phosphorus in phytoplankton), "a single phosphorus atom supports the production of as much phytomass as 16 atoms of N and 106 atoms of C" (Smil 2000). In other words, when carbon and nitrogen are abundant, a little phosphorus goes a long way in multiplying phytoplankton. From the 1940s to the

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[8] I use the terms "Zellwood farms" and "Lake Apopka farms" interchangeably. However, there was another large muck farm outside the Zellwood Drainage District operated by the Duda Company. The Duda company does not enter my analysis, although it is their field that was converted into the marsh flow-way.

[9] Blue-green algae are technically not an alga but a type of photosynthetic bacteria called cyanobacteria.

1990s, millions of pounds of phosphate fertilizer were applied to the Lake Apopka farms, a significant fraction of which was flushed into the lake. At first, the excess phosphorus fertilized the Holocene relations of the lakes. Underwater meadows of pondweed and eelgrass grew more luxurious; the population of sportfish multiplied tenfold. But soon the assimilative capacity of the pondweed and eelgrass reached a critical maximum and blue-green algae began to take over. These submerged macrophytes were vital to maintaining Lake Apopka's clear-water state: eelgrass and pondweed assimilated nutrients and stabilized the lake sediments by rooting. As the algae bloom enveloped the lake, it shaded out the pondweed and eelgrass. With the macrophytes gone, the lake's bottom was destabilized and replaced by a thick layer of fluid mud composed of dead algae and particles of muck. Wind action churned the lake’s sediments, introducing more phosphorus into the water column. Algae dominance intensified, blocking the meadows from reestablishing.

The shift in primary producers — from macrophytes to blue-green algae — inverted the lake's fish community structure, but also one of its customary uses: fishing. Prior to its collapse, Lake Apopka was a premier bass fishing lake, attracting sportsmen from across the U.S. who stayed at its many fish camps. Fishermen maintained a maze of channels through the pondweed as they hunted for largemouth bass. The bass, meanwhile, used these macrophyte beds as a hunting ground for fry and small prey. As the lake became turbid and the pondweed and eelgrass disappeared, bass — along with the fish camps — experienced a sharp decline. Shad are native to Florida lakes but they become a weedy “trash” fish as eutrophication eliminates their predators. Shad feed on zooplankton, tiny animals that feed on algae. Shad maintain the internal recycling of phosphorus in Lake Apopka by swimming and excreting. Like the wind that blows across the lake, large schools of shad churn phosphorus-laden sediments into the water column. Shad excretions introduce a soluble form of phosphorus that is readily available for uptake by algae. Shad, in their large numbers, function as another feedback mechanism that maintains Lake Apopka’s turbid, algal state.

From the 1950s to the 1990s the vegetable farms continued to discharge wastewater into Lake Apopka. Contaminated by fertilizers, pesticides, and dissolved muck, these discharges strengthened the degradation of Apopka, earning it the moniker of Florida's most polluted lake. Plagued by fish kills, mysterious wildlife deaths, and bad publicity, the State of Florida purchased the polluting farms in the late 1990s and began implementation of a multimillion dollar restoration effort focused on phosphorus reduction. Since 1998, fishermen have removed over 25 million pounds of gizzard shad, reducing phosphorus levels in the lake by 50% and algal levels by 43% (Coveney 2016).

On the opposite side of the canal from where the gizzard shad harvest takes place, an 800-acre engineered wetland slowly circulates lake water and accumulates phosphorus. This is the marsh flow-way. Water enters the flow-way via gravity and seeps through one of the wetland's four laser-leveled cells. As it passes through, the vegetation’s architecture acts as a giant filter. Phosphorus-laden sediments are physically removed from the lake water as they encounter the leaves and stems of wetland plants. The sediments drop out of the water and become incorporated into the soil. The wetland cells are made as flat as possible to encourage contact with the vegetation and to avoid the formation of streams that would "short circuit" the organic machine. Once the water passes through the wetlands, four large diesel pumps discharge it over a levee and back in to the lake, cleaner than it was before. These large pumps were repurposed from the massive drainage infrastructure that made vegetable production in this low-lying landscape possible. From 2003-2010 the marsh flow-way has removed 64 million pounds of suspended solids and 38,000 pounds of phosphorus (Dunne et al. 2011).

The gizzard shad harvest and the marsh flow-way are administered by the St. Johns River Water Management District. Water management districts are independent regional agencies, unique to Florida, that manage surface and groundwater resources. Water management districts issue water consumption permits, carry out water control programs, and conduct restoration in priority water bodies. Florida’s five water management districts’ jurisdictional boundaries roughly coincide with the regional watershed boundaries of the peninsula. Although weakened and hamstrung by budget cuts and conservative board appointments enacted by the Rick Scott administration (2010-present), water management districts are largely seen as a force for environmental good, with many prominent scientists on their staff.

Under the auspices of the water management district, Lake Apopka might be characterized as a cyborg ecosystem. The lake's ecology is not its own: a sophisticated technoscientific apparatus threads through the lake, gradually improving its trophic structure. The marsh flow-way — part wetland, part machine — functions as a giant kidney. The gizzard shad harvest is no ordinary fishery, but a highly orchestrated technical event involving boats, gill nets, refrigerated trucks, and manufactured markets. Both flow-way and the shad harvest materialize out of long-term diagnostic and feasibility studies carried out by the water management district in the 1980s and 1990s.

Not only do these technologies amass phosphorus, they also collect data. Within the marsh flow-way and across the lake are solar-powered water monitoring systems that continuously and remotely transmit data. My primary contact with gizzard shad fishermen came from interactions mediated by a fisheries biologist who was contracted by the district to collect data and monitor the catch. I travelled with the biologist from boat to boat as she recorded bycatch numbers and inspected fishermen's cargo to ensure that they were not also harvesting game fish for private sale. Likewise, at the loading dock, Tara recorded the weight of fishermen's daily catch in order to tabulate paychecks, but also to ascertain the quantity of phosphorus being removed by the catch. All of this data is funneled to two centers of calculation: the Lake Apopka field office on the lake's north shore and the water management district's central office in Palatka along the St. Johns River.

Data is a vital ingredient in the district's approach. Among district scientists, especially employees trained in recent decades, Lake Apopka’s restoration exemplifies what it means to do “adaptive management."[10] Adaptive management is an ecosystem management philosophy developed by C.S. Holling as an application of his theory of ecosystem resilience. If a system experiences a perturbation like hurricane or fire, it is said to be resilient if it is able to recover and return to its original compositional and functional state. Sometimes when a perturbation is too strong or internal relations too fragile, an ecosystem will cross a critical threshold and "flip" into an alternative stability regime. This is a catastrophic ecological shift, as exemplified in Lake Apopka's 1947 collapse. Once in this state, the ecosystem obtains a new equilibrium and resilience dynamics that make it difficult to return to the original condition.

Adaptive management has been described as "informed trial and error” and foregrounds the need for an ongoing stream of reliable data to help practitioners evaluate the performance of managerial designs and to weather the uncertainty inherent in complex systems (Gunderson and Holling 2002). Managers seeking to improve an ecosystem will diagnosis its problems, design and implement an intervention with the best possible data, and monitor the ecosystem’s response to that intervention. Based upon the feedback they receive from the monitoring program, the managers either stay the course or adapt the management plan in accord with their new understanding of the system. Importantly, adaptive management conceptualizes this system as both natural and social or, in their terminology, a coupled socio-

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[10] See Mary Jane Angelo's "Stumbling Toward Success" (2009) for an account of the Lake Apopka restoration as a paradigmatic case of adaptive management.

ecological system.

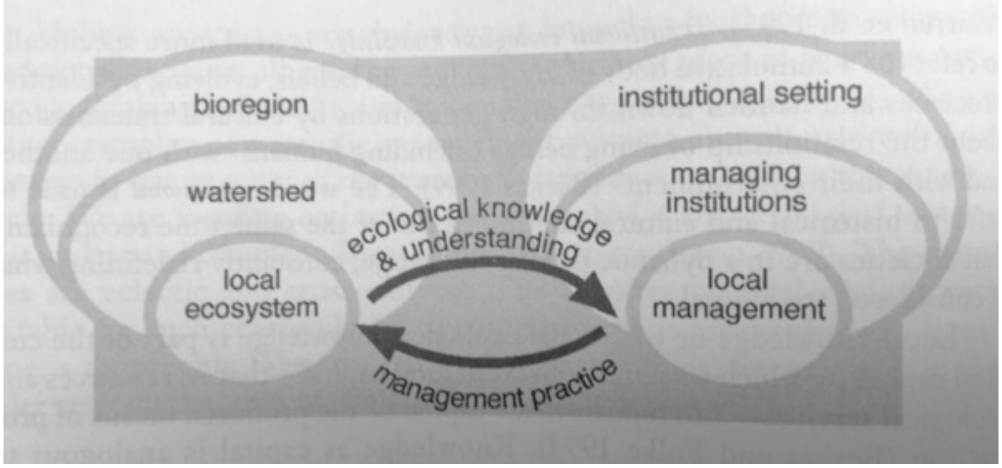

Figure 5. Conceptual model of a socio-ecological system. Note that "Lake Apopka" and "water management district" can perfectly replace "local ecosystem" and "local management." The arrows linking the natural and social compartments are cybernetic feedbacks. From Gunderson and Holling 2002.

Adaptive management carves the world into two basic domains, nature and society, which are conceptualized and represented as different compartments or spheres. Nature is constructed as *an ecosystem* — a cybernetic unity of biotic and abiotic elements. Society is understood as an aggregation of people organized in a hierarchy of institutions. Although conceived as distinct kinds, ecosystems and society are understood to behave according to the same general principles of systems theory. Adaptive management "is based on the assumptions that social systems are analogous to ecological systems [and] that social complexity can be analyzed using the same modeling principles as ecological systems" (Blanchard et al. unpublished). When nature and society interact, they do so through feedbacks of energy, material, and information (Figure 5). In rendering both ecology and society as systems (simultaneously as independent constructions and as a joint socio-ecological system), adaptive management offers the promise of resiliency through technocracy. Through science-based learning and flexible institutions, experts can engineer "adaptive capacity" into all manner of systems, thereby increasing their ability to absorb disturbances and creatively adjust to the challenges of our times.

Adaptive management and Holling's resilience theory have achieved global reach and recognition as environmental discourses. "The concept of resilience has in the recent past rapidly infiltrated vast areas of the social sciences, becoming a regular, if under-theorized, term of art in discussions of international finance and economic policy, corporate risk analysis, the psychology of trauma, development policy, urban planning, public health and national security" (Walker and Cooper 2011). Adaptive management is particularly ubiquitous among Florida environmental managers and "has been adopted as the guiding strategy of the massive Comprehensive Everglades Restoration Plan in south Florida" (Blanchard et al. unpublished). From 1988-1999, Holling was a professor in the Zoology Department at the University of Florida where he collaborated with Lance Gunderson, applying his ecological and managerial philosophies to the Florida Everglades and developing a mature synthesis of his ideas, known as panarchy.[11] In many ways, Holling's ideas were primed for acceptance in Florida due to the pioneering work of another systems ecologist at the University of Florida: H.T. Odum.

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[11] See Gunderson and Holling 2002 for a comprehensive treatment of the panarchy framework.

As Florida’s ecological places were conceptualized and managed as systems, they became enfolded in the technocratic infrastructure of the state. Through the state’s water management districts, ecological places became cybernetic ones, "a hybrid of machine and organism, a creature of social reality as well as a creature of fiction" (Haraway 1985). That a lake should become a cyborg ecosystem is particularly apt given the role lakes and limnologists played in formulating a systems approach in ecology, as I will discuss.

Understanding Lake Apopka as a cyborg ecosystem draws us into the ricocheting histories of systems ecology, theoretical and applied limnology, and the environmental managerial apparatuses of the state. It shows us the force of the ecosystem concept as a guide to empirical research and as a nature- and institution-making discourse. The socio-ecological system (SES) with its feedbacks between natural and societal compartments has been financed, engineered, and ideologically assembled to the great benefit of Lake Apopka. Lake Apopka as a SES has been actualized. And yet the SES fails, as a model, to capture many of the lake’s relations. The SES does not account for the gizzard shad harvest as a situated multicultural, multitechnical, and multispecies arrangement, involving (among other things) the skilled labor of Vietnamese refugees. Nor does it have a way of reckoning with the contradictory structures of ecological repair under capitalism. While the formation of water management districts is laudable and has done tremendous good, they remain, in essence, anti-politics machines.[12] Water management districts have limited power to do anything but mitigate the worst excesses of Florida's growth-oriented culture. Financed by an ad valorem tax on property, their very existence depends on the growth that they seek to protect the environment from. Adaptive management as political ontology and social theory is ill-equipped to deal with the complexities of race, culture, history, capital, and power. A new approach is needed.

Lake as Natureculture

In this chapter, I seek to understand the origin of Lake Apopka as a polluted, cyborg ecosystem from two historical vantages. I treat these historical perspectives in two essays. In the first essay, "Plantationocene Colonization," I grapple with the agricultural history of the lake. I document late-nineteenth- and mid-twentieth-century attempts to drain and farm its floodplain marshes. I am particularly interested in the 1947 collapse of Lake Apopka in relation to the rise of investor capital, the material transformations of the industrial plantation, and the social upheavals of WWII and the Great Acceleration. The second essay, "Genealogy for a Cyborg Lake," grapples with the history of the ecosystem concept and the technocratic construction of nature and society that is fundamental to the water management district's approach to restoring Lake Apopka. By layering these two histories, my goal is to see Lake Apopka as *an historical natureculture* — one that has been profoundly

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[12] I am thankful to Katrina Schwartz for teaching me about the relationship between systems ecology and water management districts as anti-politics machines, especially as it relates to the political failures of Everglades restoration (Schwartz unpublished).

wounded by the industrial planation and its fertility and that is fortunate to be the subject of state-of-the-art ecosystem management. By narrating these two stories together, I explore how the plantation and professional ecology develop into lake-altering designs; I also show how the plantation economy, writ large, literally feeds the rise of professional ecology.

The concept of natureculture emerges out of a dialogue between Donna Haraway and Bruno Latour. In *The Companion Species Manifesto*, Haraway uses the trope to capture "the implosion of nature and culture in the relentlessly historically specific, joint lives" of people and other species (2004). In Haraway's natureculture, humans and other species encounter one in another in any number of entangling and interpenetrating permutations, but within these encounters there is no evading the legacies and ongoing traumas of colonialism and capitalism. What counts as nature in both fiction and fact is made, re-made, and unmade in the situated projects of accumulation and conquest. In my framing, capitalist natures are fraught with erasures, extinction, invasion, and — as in the case of Lake Apopka — sudden collapse. They are also braided through with humans who care for and steward particular patches, attempting to erect a bulwark against the local and extralocal forces of destruction. In Florida, practitioners of ecosystem ecology and employees of water management districts are important sources of that resistance (even if financed by destructive growth).

Bruno Latour's conception of natureculture stems from the philosophical argument that Westerners — what he terms “moderns” — have a made a deep, enduring, and consequential category error that partitions the world into natural and cultural domains (1993). This partition constitutes what he calls the “Great Divide.” The Great Divide is fundamental to the cosmology and folklore of the moderns. For Latour, all humans live in naturecultures; however, the natureculture of the moderns is one which nature and culture have been symbolically sawed apart. Separating nature and culture is achieved through the labor of *purification*. Purification refers to the conceptual, spatial, and institutional sorting of messy worlds into natural and cultural boxes. Latour is particularly interested in the purification work that turns science and politics into separate institutional realms, one devoted to the collection of matters of fact and the discovery of natural law and the other to jurisprudence, policy, and the resolution of (all-too-human) matters of concern. The moderns’ techniques of purification generate a number of strange effects that, in his terminology, "proliferate hybrids." Latour argues that "the more we forbid ourselves to conceive of hybrids, the more possible their interbreeding becomes — such is the paradox of the moderns, which the exceptional situation in which we find ourselves today allows us finally to grasp" (1993). Were he writing in 2017, I venture, Latour would label this exceptional situation the Anthropocene and recognize that hybrids have begun to proliferate into evermore dangerous and degraded flavors.

From the vantage of critical landscape ecology, I am inclined to look for evidence in the Great Divide and its hybrid proliferations as landscape phenomena. Consider the 11-levee that partitions the Lake Apopka from the agricultural polders. Like the chainlink fence in chapter two, the levee symbolizes an engineered cut between (agri)culture and aquatic nature. In the case of the Lakeland Highlands Scrub and the Mosaic property, there was little blurring of boundaries; at Lake Apopka, however, water was continuously recirculated between the lake and the farms. As Bone Valley phosphorus was applied to farm fields, it fertilized vegetable monocultures at the same time as it fertilized the Holocene ecologies of the lake. The influx of phosphorus from Anthropocene to Holocene space, from culture into nature precipitated an abrupt, nonlinear shift in limnological relations. Hybrid ecologies of point-source pollution, algae blooms, and gizzard shad proliferated. If we imagine Lake Apopka geography in the visual idiom of John Conway's Game of Life — a pixelated mosaic of Anthropocene and Holocene cells — the Anthropocene pixels (representing farms) "flipped" their neighboring lacustrine cell from a Holocene to an Anthropocene state.

In this chapter, I am primarily focused on the materialization of a Great Divide within the adaptive management paradigm and Lake Apopka as an engineered socio-ecological system. This Great Divide has three defining features: 1) nature and society occupy separate realms; 2) nature and society are mirror images, governed by the same underlying dynamics; 3) nature and society can form a united system with flows moving across natural and social compartments. I contend that this particular construction of nature/society dualism is embalmed within the concept of the ecosystem. In part two, I offer a genealogical analysis of this Great Divide by examining the role limnology and limnologists played in developing ecosystem ecology into a scientific program. A hallmark of ecosystem ecology is a suite of methodological and cognitive tools for tracing the circulation of energy and materials through *trophic relations* — the interspecies economy of eating and being eaten. What kinds of trophic relations and intellectual histories, I ask, produce the cyborg ecosystem?

The ecosystem concept was forged in scientific practices and imaginations that made nature newly intelligible, but it also accreted a modernist managerial ideology that positioned systems thinkers as technocratic philosopher kings. It was the responsibility of ecologists to model nature and to guide bureaucracy toward a more harmonious rewiring of the socio-ecological system. This impulse, according to Peter Taylor (1988), was a fantasy of the new cybernetics and an anxious intellectual response to the Holocaust and other catastrophes unleashed by World War II. It was also certainly a response to the growing sense that nature must be protected from the violent incursions of industrial society.

Juxtaposing Haraway's natureculture (nature + culture as multispecies historical implosions) and Latour's critique of the moderns is instructive for seeing Lake Apopka as a complex gathering of multispecies histories, but also as a space remade by the ecosystem/society divisions that the "moderns" have enacted in the landscape. Unlike Latour, I do not see the bifurcation of nature and culture as a category error or fundamentally a matter of Western cosmology; instead I see the separation as a problem of metabolic rift (Foster 2000, Wachsmuth 2012). This rift, I contend, is manifest in what Haraway and others have called the Plantationocene (Haraway et al. 2016). Let me explain.

Plantationocene, for me, is a provocative shorthand for the surreal complex of machines that transform the fertility of the Earth into a surplus of modern humans. The key instrument of this translational work is the plantation. Anna Tsing (2012), following Sidney Mintz (1986), has argued that the plantation, with its disciplined ensemble of human and nonhuman elements, is the site where the scalability projects of modern capitalism got their start. Plantationocene names a history of coercive transformations — Africans into slaves, land into property, and Holocene ecologies into single-species monocultures — that produced extraordinary abundance through exceptional alienation and loss. For the moderns who benefited from plantation surpluses, the Plantationocene has had the strange effect of creating an ideology that humans are separate from nature; it did so by estranging the moderns from livelihood relations with local ecologies. The food surpluses of the plantation and intensive agriculture within the industrializing metropole globalized the geography of eating and severed people's trophic relations with place. The Plantationocene, in its capital-generating surpluses, produced two new class of people: 1) those who no longer needed to produce food from local landscapes to survive and 2) niche producers tasked with growing food for the multitude. Liberated from coppiced forest patches, diverted streams, and polycultured fields, peasants-turned-Plantationocene-consumers became free laborers who were displaced and lured into cities to participate in a greatly expanded civilizational division of labor. Populations swelled and the labor power of the masses was channeled into the capitalist enterprises of the elite. This process of urban-industrialization accelerated as chemical fertilizers became a replacement for land and increased the throughput of fertility in the world system. Plantationocene infrastructures, nourished by lithospheric phosphorus and atmospheric nitrogen, expanded population, the land area under cultivation, and the conurbations of the industrial multitude. All this growth put the squeeze on Holocene ecologies. In the United States, as the Plantationocene frontier spread and native peoples were displaced from their land, Holocene naturecultures became wilderness zones cordoned off from the farm and the city. The moderns had become separate from nature. With chemical fertilizers, the moderns had achieved a metabolic separation from the biosphere by learning to eat rock and air. Plantationocene names that strange historical naturalcultural condition.

In this chapter, I am interested in two manifestations of the Plantationocene natureculture at Lake Apopka: first, the histories of agriculture and fertilizer consumption that helped grow a multitude of moderns but that also caused the lake's ecology to collapse, and second, the epistemic labor of the moderns as they investigated and conceptualized nature as ecosystems and put that knowledge to work repairing fractured Holocene natures. These scientists and their projects, I contend, are fed and financed by the Plantationocene growth that they seek to protect nature from. In this, we come to understand Lake Apopka's restoration as another project of scrap and salvage in which a small fraction of the Plantationocene's wealth is reinvested in a landscape that may or may not be meaningfully repaired.

A guiding thread in this tour of the Plantationocene and Lake Apopka's cyborg ecosystem is the movements, transformations, and embodiments of phosphorus. The phosphorus apparatus is an indispensable geotechnical component of the Plantationocene and its revolutionary force. In my efforts to trace the social worlds of phosphorus I have learned that it is a protean character. Phosphorus is always shaping-shifting: Bone Valley rock is applied to Lake Apopka’s fields as highly processed fertilizer, assimilated into the biomass of winter vegetables, and discharged into the lake where it gives life to blooms of algae and swarms of shad. In addition to being ontologically supple, phosphorus is epistemologically slippery. As I tracked phosphorus both in the field and in the lake, I found it difficult to pin down. Evidence of its presence is overwhelming, but learning how much was applied to fields, where it was sourced, and how much entered the lake was challenging. Although I interviewed several farmers, breaching the topic about chemical inputs — phosphorus in particular — was difficult given the environmental stigma farmers both wear and refuse. I also found it difficult to pinpoint exactly when and how the lake was diagnosed with a phosphorus problem. It was long understood that nutrient pollution was damaging to the lake, but it is also true that Lake Apopka was subject to multiple environmental insults, the strength and relative importance of which were difficult for scientists and observers to sort out. Moreover, when Lake Apopka became an intense scene of scientific study in the late 1980s and 1990s, the phosphorus paradigm in limnology (the idea that P is the limiting agent in most fresh water ecosystems) was well established. The 1993 study by Aldridge et al. that established that Lake Apopka was limited by nitrogen (the result of its hypersaturation of P) was not ground-breaking: Lake Apopka's degradation had, in some sense, been anticipated in the general findings of prior whole-lake experiments and scientific literature reviews that demonstrated a strong correlation between phosphorus loading and the productivity of lakes. Phosphorus crystalized as a matter of concern at Lake Apopka across multiple timeframes, with different degrees of clarity, and amidst a surge of research into eutrophication in the 1960s and 70s. It did not materialize through the water quality studies of the water management district alone. In essay two, I describe the emergence of the phosphorus paradigm within the history of limnology.

PART ONE: PLANTATIONOCENE COLONIZATION

In the Holocene, Lake Apopka was the second largest lake in Florida (~50,000 acres). Located 15 miles west of present-day Orlando, Lake Apopka had clear water and was shallow (8-9 feet deep), mesotrophic, and dominated by submerged aquatic vegetation. Lake Apopka forms the headwaters of a group of lakes known as the Harris Chain which flow into the Ocklawaha River, a tributary of the north-flowing St. Johns River (SWIM 2002). On the lake's north shore, Apopka graded into an extensive sawgrass marsh, an important habitat for foraging birds and spawning fish. Underneath this marsh lay 8-10 feet of muck and peat: organic soils accumulated over 2,000-6,000 years as plants grew, died, partially decomposed, and forged the substrate for future wetland development (Hoge 2003). During the late nineteenth century, the mucks underneath Lake Apopka’s sawgrass marshes, along with other wetlands ecosystems in Florida — most prominently the Everglades — became the prize and fetish of a new agribusiness predicated on state land grants, water engineering, northern capital, racialized labor, and long-distance transportation networks.

In *Nature's Metropolis*, William Cronon described how the creation of east-west railroads established a new metabolic geography across North America. Corn and cattle raised on the long- and shortgrass prairies were shuttled to the growing metropolises of the Northeast. Chicago, serving as an important weigh station in this network, grew into a metabolic giant in its own right. The agricultural frontier expanded west into the temperate zone to dish up protein and carbohydrates for eastern city dwellers. To provide fruits and vegetables, however, the agricultural frontier had to make southern inroads, at least during the winter. The development of new southern rail lines and modes of refrigeration made long-distance transportation of perishable commodities possible, expanding the market geography of commercial vegetables and fruits. This long-distance trade in vegetables would become known as truck farming.

The expansion of truck farming into the South extended the "growing" season for northern consumers who, as part of their more health-conscious diets, increasingly demanded fresh produce year-round. This long-distance trade required copious amounts of ice. "A coastal trade in northern ice supplied the southern Atlantic seaboard while the interior South received its ice from north of the Ohio River. In all likelihood, the first refrigerated shipments of produce from Florida were cooled with ice brought by sea from Maine" (McCorkle 1992).

As the United States entered the Gilded Age, truck farmers pushed into tobacco and cotton territory and into the nation's only subtropical region: Florida. In the late nineteenth century, central and south Florida was very much a frontier state. The anti-Indian campaigns early in the century had cleansed the landscape of Seminoles and Miccosukee peoples, pushing them into the Everglades. Cracker settlers from Georgia and the Carolinas streamed into Florida with the passage of the Armed Occupation Act of 1842, a federal policy that offered 160 acres of land to gun-toting homesteaders who, the government hoped, would help defend the newly won frontier (Shofner 1982). These homesteaders were the among first Americans to settle Central Florida and dabble in commercial fruit and vegetable production. The earliest truck farms were small and experimental, hamstrung by lack of infrastructure and limited by the peninsula's extreme physiography and soils. At one extreme were the sand soils of Florida's ridges and flatwoods. Through irrigation and fertilizer use, Florida's ridges would become one the world's most famous citrus-producing regions, but during the late nineteenth century these landscapes were occupied by scrub organisms and the hardscrabble cracker and his sinewy cattle. Florida's more mesic flatwoods were slightly better for agriculture, but not much. Fruits and vegetables are nutrient-demanding crops, and with the chemical fertilizer industry still in its infancy, truck farmers sought out naturally fertile soils to establish their farms. The real promise for the new agribusiness ventures lay in the marshes and swamps that covered fifty percent of the state. In Florida's "swamp and overflowed lands" government boosters, northern capitalists, and pioneer farmers saw an exploitable cache of naturally occurring fertility. However, their agricultural potential was locked under a layer of water that would prove difficult to drain, given Florida's unrelentingly flat topography. This didn't stop boosters from dreaming.

Within booster discourses, Florida was exalted for its ability to grow exotic crops and to yield multiple crops per year. Florida's wetland environments were imagined as agricultural paradise. In the vast marshes of the Everglades, boosters fantasized of pineapples, sugarcane, rice, and winter vegetables organized into a grid of industriously tended, single-family farms (Hollander 2009). Booster visions wove together the Jeffersonian ideal of the yeoman farmer, dreams of the tropical plantation and its exotic bounty, and the get-rich-quick schemes of the carpetbagger. But to make this vision come to life, promoters would have to cleanse another enemy from the land: water.

During the late nineteenth century, agricultural drainage was already underway in the Midwest. "Special-purpose local governments" called drainage districts were invented to finance, engineer, and manage the drainage of wetlands. Eighty-five percent of the Midwest's' wetlands were drained for agriculture (McCorvie and Lant 1993). The national enthusiasm for wetland drainage invaded Florida; however, the drainage vision in Florida had a much older origin in the sixteenth- and seventeenth-century rice plantations of the Southeastern coastal plain. Rice was a lucrative crop in the antebellum period (Coclanis 2016). Rice plantations extended from the Carolinas to St. Johns River in North Florida. Slaves, imported from West Africa, brought with them the know-how to grow rice in riparian floodplains and tidal zones. Although the genealogical connection between rice cultures in West Africa and in the Southeastern low country is obscured by the "institutionalized white denial of the intellectual capacity of bondsmen," the strong similarities between the rice growing systems is highly suggestive of an African-driven technology transfer (Carney 1996). In both regions, a sophisticated system of levees and gates are used to drain and irrigate rice fields with the changing action of the tides.

Although rice was grown primarily in river floodplains, there is one important example of lake drainage that presaged the draining of both Lake Apopka and Lake Okeechobee.

> [O]n the swampy Albemarle Peninsula [in North Carolina]…a group of entrepreneurs identified Lake Phelps as an area suitable for timbering and agriculture in the 1780s. Because the nearby Scuppernong River was lower than the lake, they planned to build a connecting canal to drain the lake and expose its rich soil for agriculture. The Lake Company formed in 1784 and sent a ship to West Africa to procure slaves for the job. In the summer of 1786, the slave ship arrived back in the Edenton port. No time was wasted putting the young African men to work. The digging took two grueling years. According to one account, the overseer built cages around slaves as they dug, making them pass the muck out through the bars. While building canals, many slaves died from either respiratory disease or overexertion. They completed the six-mile canal in 1787, lowering the level of the lake enough to allow farming on 10,000 acres around its margin…. By 1790, 113 slaves worked cutting timber, maintaining the canal, and preparing the farmland for rice cultivation (Vileisis 1997).

The specter of slavery would haunt the labor regimes of both the Everglades and Lake Apopka well into the twentieth century.

Draining Lake Apopka

Attempts to drain Lake Apopka’s sawgrass floodplain for agriculture began in the late 1870s. Florida’s Internal Improvement Board (IIB), a Gilded Age bureaucracy, was tasked with issuing land grants of "swamp and overflowed lands" to private actors in exchange for dredging canals and building railroads. In 1878 James G. Speer and a group of local business chartered the Apopka Canal Company with $20,000. The company applied for a land grant of 14,500 acres from the IIB, which the company would receive if it successfully completed a canal linking Lake Apopka to Lake Eustis by 1881 (Shofner 1982). The canal’s purpose was twofold: 1) to lower the level of lake and drain the sawgrass marsh for agriculture, and 2) to create a new transportation corridor through the Harris Chain of Lakes to the Ocklawaha River.

Despite the optimism that characterized this period, the project was fraught with engineering and financial difficulties, like many drainage and development schemes in Florida at this time, most notably in the Everglades. Digging the canal proved much more challenging than the company’s president imagined. Speer complained of the unexpected financial costs and the “difficulty of making headway through the clayey bed” (quoted in Shofner 1982). To stay afloat, the company appealed to the IIB for a concession that would permit it to sell 3,000 acres of sawgrass land prior to its drainage. The IIB agreed, provided the money was spent on finishing the canal. After more than a decade of dredge building, failed excavations, and extensions from the IIB, the Apopka Canal Company was denied its land grant.

The company was sold to two wealthy stockholders from Philadelphia, Lemuel Davis and James M. Wilcox. In 1891, the Delta Canal Company was formed with Davis as its president. Two years later, the company completed 12 miles of canal from Apopka to Lake Beauclair and through Lake Dora and Lake Eustis to the Ocklawaha River. In addition to this central canal, the company dug 32 miles of lateral ditches that drained the sawgrass for cultivation. The new canal lowered the lake by four feet, drying the muck to a depth of three feet. This engineered waterway transformed the hydrology of the lake, downgrading it from the second to the fourth largest lake in Florida. The Internal Improvement Board issued the land grant (Shofner 1982).

The Delta Canal Company soon began advertising the sale of the mucklands and began plowing and planting sugar and rice, as well as corn, tobacco, and hemp. However, a series of cold waves and a fluctuating water table thwarted the farming enterprise. The company sold its 14,500 acres to the Johnson-Elliot Company, which recruited a handful of Southerners to settle the small agricultural town of Zellwood, located just north of the lake. However, they were only able to convince one farmer, Arthur King, to purchase a plot of muck and try his hand at farming. King described the muck as “one big manure pile just waiting to be farmed” (Swanson 1975). The Johnson-Elliot firm folded, but in its place sprang up Zellwood Florida Farms, capitalized by A.E. Hartcorn, a new arrival to the region with financial ties in New Jersey (Shofner 1982).

Zellwood Florida Farms developed a new angle on the agricultural development scheme: turning Lake Apopka's drainage and farm development into a tourist attraction. Inspired by Florida railroad men like Henry Flagler and Henry Plant, who built grand hotels as luxury destinations for their new rail lines, Hartcorn, Jones, and Dann constructed the Holly Arms Hotel in Zellwood— a comparatively modest hotel, albeit one equipped with steam heat and electric lights. They made a spectacle of the launch of a new dredge that was constructed to deepen the Apopka-Beauclair canal by holding a festival: “bands furnished music, there were two baseball games, foot races, and other competitive games, and a huge barbecue.” The firm hired a real estate developer from Orlando, H. Carl Dann, to promote mucklands for cultivation and to establish branch agencies in the north for handling sales. Dann advertised the farm zone as the “supergarden spot of the universe.” In 1918, he also arranged for a bus line through neighboring cities to draw tourists and would-be buyers to its first “gigantic” crop of potatoes — a crop that earned high prices and garnered public attention for its importance to the war effort. Unfortunately for the company, the potato crop rotted quickly after the harvest; the failure was attributed to a deficiency in phosphate and potassium. After experiencing the same problem with his 1912 potato harvest, Arthur King ordered superphosphate and sulphate of potash from the Wilson-Toomer Fertilizer Company in Jacksonville (Shofner 1982 and Swanson 1975).

By 1918 it was clear that Zellwood Florida Farms would not succeed. A number of its holdings were sold to the Armour Fertilizer Company, a Bone Valley phosphate producer. This transfer of assets, along with King’s purchase of fertilizers from the Wilson-Toomer Company, is the first evidence that Florida phosphates were part of the initial project design. Agriculture at Lake Apopka had faltered, but this had less to do with the farming practices than with the inadequacies of water engineering of the period to cope with the size and fluctuations of the lake (Shofner 1982).

In 1926, a hurricane swept across the lake and inundated the low-lying farms; the mucklands were abandoned. Over the following two decades, Lake Apopka's north shore was subject to neglect and the forces of rewilding, with one curious exception. In 1920, Richard Whitney, a wealthy New York investor, established a commercial peat-mining operation on the north shore and purchased Zellwood Florida Farms. Whitney started the Alpha Humus Company, later renamed the Florida Humus Company, which mined Lake Apopka's muck and sold it as a fertilizer and potting soil. Whitney would later serve as vice president of the New York Stock Exchange during the 1928 collapse and president from 1930 to 1938. In 1938, Whitney was found guilty of embezzlement and spent three years and four months in Sing Sing prison. But this fall from grace did not keep Whitney from imagining a new way of making a fortune from the muck. In 1946, he formed the Ramie Mills of Florida. Ramie is a fibrous nettle used for making twine, rope, and bagging fabric. Whitney planted 600 acres and built "a large Steelox building to house the mill" (Shofner 1982). Whitney was planning to manufacture shoe thread, but soon discovered that his ramie operation could not compete with new, cheaply-made synthetic fibers, like nylon. One farmer I spoke to says that he occasionally finds ramie growing wild in ditches. If this is true, it is a weedy remnant of failed venture capital.

Success, At Last — The Zellwood Drainage and Water Control District

In the early 1940s, the beat of war pulsed through the national economy. The United States entered into the conflict in the European and Pacific theaters, and Lake Apopka's farmlands were given a second life. Interest in food production accelerated, and new plans were hatched to meet that demand. In 1941 the Zellwood Drainage and Water Control District was formed in a special act of the Florida legislature. The Zellwood Drainage District (ZDD) was a self-taxing municipal corporation, closely modeled after the Everglades Drainage District, that developed and subsequently maintained the flood control infrastructure of the north shore. The legislation for the ZDD was crafted by House Representative Judge Charles O. Andrews Jr. It is unclear what motivated Andrews to champion the Zellwood cause, but his ties with the New York capitalist John F. White and his associations with the Florida Dehydration Company suggest a strong incentive to profit from the war.

The Zellwood Drainage District was financed by the Reconstruction Finance Corporation (RFC), a New Deal corporation founded in the wake of the 1928 stock market collapse to introduce liquidity into the foundering economy. The RFC loan totaled $487,500 and was used to construct an 11-mile levee, a network of canals, and two agricultural polders serviced by "pump houses with three diesel pumps handling 42,000 gallons per minute" (Swanson 1975).

John F. White, an official from a New York bank, first came to Zellwood to settle the debts of Richard Whitney after his financial and legal troubles. White ended up purchasing the bank's interest in Whitney's Florida Humus Company with a loan from Connecticut Mutual. Connecticut Mutual, in turn, purchased the bonds that the Reconstruction Finance Corporation held in the Zellwood Drainage District. In a 1943 map of the Zellwood water control structures, John F. White is identified as the district's president and Andrews as vice president. It is unclear how long White was involved with the ZDD, but at some point Andrews replaced him as president and served in a leadership position until his death in 1969 (Swanson 1975).

During the same period that the Zellwood's drainage infrastructure was under construction, the War Production Board, the U.S. Department of Agriculture, and the University of Florida agricultural extension office, known as IFAS (Institute of Food and Agricultural Sciences), collaborated to build the largest vegetable dehydrator in the Southeast. Owned by the Chicago firm Sokol and Company and sited on the muck, the Florida Dehydration Company transformed locally grown vegetables into war rations. During the war period, the government had placed a "freeze" on all dehydrated products, rendering it the exclusive purchaser of the company's output. Revealingly, John White was the dehydrator company's president and Judge Andrews served as its attorney (Shofner 1982).

Farmers named Duda, Lust, Hooper, and Clonts established winter vegetable enterprises on the muck. These were large, predominantly family-owned enterprises, many of which stayed in operation until the state buyout in the late 1990s. The farms grew sweetcorn, carrots, celery, radishes, and an array of common vegetables on properties averaging 500-1,000 acres. Farmers availed themselves of the expertise of local extension officers. In 1943, the Agricultural Agent of Orange County K.C. Moore wrote:

> About a dozen farmers who had experience in the Everglades section grew crops of cabbage, beans, potatoes, and corn there in the spring. A larger acreage is now under cultivation. Turnips, kale, cabbage, spinach, and carrots are being grown under contract with the large new dehydrating plant on the property. I arranged a conference between the Zellwood growers and Dr. F.S. Jamison [Vegetable Specialist for IFAS] in July. At the time they questioned him on the many details of the fall planting. The most important of these related to varieties and kinds of vegetables and to the proper fertilizer amounts and ratios. This was a most satisfactory meeting, and the growers believe it will result in an increased yield. … I have assisted these Zellwood farmers in various ways, and our county Machinery Rationing Committee has rendered their valuable services in obtaining needed equipment (quoted in Swanson 1975).

Although the water control and agricultural practices were modeled after the Everglades, the Zellwood farms were also experiments in Green Revolution agriculture, requiring new legal, financial, engineering, and agronomic alignments. The language of "trial and error" cuts through descriptions from the period. Getting these technologies to coalesce into a functional system required tinkering and was by no means guaranteed, as the failures of the turn of the century show. The experimental nature of the farms is closely tied to the story of the suitcase farmer — a trope that harkens back to the first attempts to tame the north shore. The suitcase farmer was "a black gold prospector" who took a gamble on farming the muck. If he lost the gamble, he would pack up his suitcase and move on. It is a story of the white working-class farmer and his exposure to risk in the attempt to strike it rich on the new agricultural frontier. One farmer I spoke to, Billy Long, recounted his experience in the idiom of gambling. In 1951, Long, a recent graduate from Virginia Polytechnic

Institute, came to Florida and planted his first crop of sweetcorn on 60 acres. That year produced a bumper crop and the gamble paid off, enabling him to purchase his uncle's farm. Long was eventually able to expand his operations to 800 acres in the muck and 700 acres in nearby flatwoods.

Within Florida's agricultural community, stories of Zellwood's most profitable farmers have developed into a kind of hagiography. The Florida Agricultural Hall of Fame is one site where these canonizing stories are produced. Inductees of the Hall of Fame are featured in publications like *Harvester*, a trade magazine of the Florida Fruit and Vegetable Association. The stories of agribusiness "pioneers" tout their hard work, ingenuity, and perseverance. They are tales of self-made men feeding the nation, reproducing family, and revolutionizing production. They provide an important window into the cultural valuations and the situated infrastructures that made the Green Revolution possible. Let's continue with Billy Long's story.

After hitting the jackpot with his successful planting, Long helped make Zellwood into Florida's premier sweetcorn producing region. Long helped sweetcorn breeders cultivate a variety of corn that would thrive in Central Florida. In 1960, Long introduced the "Gold Cup" variety of sweetcorn from the Harris Seed Company. The Gold Cup variety would become the standard for Zellwood and all of Florida, covering 85% of the state's sweetcorn acreage. It would also become the district's most iconic crop. During the Zellwood Sweetcorn Festival, huge batches were cooked up in "corn boils" as local people ate barbecue and listened to country music. In addition to introducing this seed variety, Long was credited for helping to design one of “the first in-the-field mobile packing houses,” known as a mule train. Stretched across multiple rows, this vehicle moved up and down the fields as workers picked corn and packed them into crates (n.a. 1994).

Long was also one of the first Zellwood farmers to grow carrots. He owned a large carrot-packing house and was instrumental in the development of the first carrot-concentrate co-op. After a wave of freezes devastated the citrus industry in the mid 1980s, Long helped convert an idle citrus-concentrate plant in Eustis into a facility for manufacturing carrot concentrate. The concentrate from Zellwood’s carrot producers would form a primary ingredient in Campbell’s V-8 Splash.

Another Agricultural Hall of Fame inductee was Ken Jorgensen. Jorgensen came to Zellwood as a supervisor for Beechnut Baby Food Company based in Rochester, New York. Beechnut was one of the first producers in the newly reclaimed mucks, but soon discovered that the farmland was too far away and its production too uncertain (Swanson 1975). Jorgensen stayed behind and formed Zellwin Farms, Inc., a 4,000-acre operation that specialized in a number of different vegetables marketed in mixed loads and sold directly to chain grocery stores like Kroger. Like Long, Jorgensen was involved in testing new crop varieties and tinkering with harvesting, handling, and packing technologies.

> Jorgensen is praised in the industry for implementing the use of hydrocoolers and vacuum coolers to remove heat from freshly harvested crops. Through trial and error, Jorgensen learned to use the coolers. “When we put corn in there, it would dry out,” said Jorgensen. “So we learned to add enough water to keep the corn moist. The coolers allowed us to get the heat out of crops and keep the product fresh for customers.” Jorgensen’s trial and error efforts were

> worth it and the technologies were soon adopted by many growers as essential tools for improving the quality, freshness, and reputation of Florida winter vegetables (n.a.1999).

These stories of pioneers and innovators, of course, have their shadow side. Missing from the celebratory accounts are stories of prostitutes working in the field with the mule train; DDT used in a war against the corn ear worm and sprayed from crop dusters onto workers in the field; disenfranchised African American and Caribbean men playing dice in the makeshift gambling halls of the labor camps; and the excessive fertilizer applications that led to the sudden collapse of Lake Apopka.

During my fieldwork, I collected oral histories from several farmers as a volunteer for the Zellwood Historical Society. The historical society was headed up by Angela Martin, the daughter of a former radish farmer. During this period, Martin was actively involved in collecting materials for a book on Zellwood for the Arcadia Publishing Company's *Images of America* series. This is a popular series that publishes short, photo-heavy, locally produced histories of small towns, cities, and regionally distinctive sites across the U.S. Like the book series, the historical society, under Martin's leadership, is actively involved in creating nostalgia. Given the environmental and labor abuses of the Zellwood agricultural area, Angela was in the difficult position of composing a nostalgic portrait of the Zellwood farmers while ignoring, denying, and minimizing the well-documented violence of the industrial farms. When I raised the question of pollution, she would tell me what her father told her: that "the water coming off my fields is like Perrier." (Radishes, it is worth noting, were the least fertilized crops in the Zellwood complex.) Missing from critics' accounts, she argued, was an appreciation of the societal goods that famers, like her father, provided. When leading school tours of the historical society, she would flash a handmade sign with the word "PERSPECTIVE" to her audience. The point of the flash card was to emphasize the need to appreciate the history of Lake Apopka from the farmer's point of view. Her historiographic practice is an effort to recast and revalorize the history of Zellwood agribusiness men who have been branded as polluters and environmental racists.[13]

I often think about Angela, the farmers I met through her, and the stories they tell themselves and told me with great hospitality and trust. Perhaps because of this hospitality and trust, I cannot outright reject their "perspective" in favor of a subaltern historiography. Stripped of its nationalist, racist, and patriarchal overtones, the basic story that they tell is correct: they grow the food we all consume. This is shared narrative across the food industry. For farmers, this is a personal truth, but it is also a structural and biopolitical truth of the Plantationocene: the human is fed — or more accurately *grown* — on the Green Revolution farm. Angela's historiography exists as a denial of structural violence. But it is a denial that, first, might be understood in the positive. The stories she weaves through the historical society's exhibits and publications are scrubbed of politics and unapologetically pro-white, pro-family, pro-agriculture, and pro-nation. Histories of labor and pollution are erased. Angela would not deny the humanity of black laborers or the value of a healthy environment, but her

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[13] See Dale Finley Slongwhite's *Fed Up: The High Cost of Cheap Food* (2014) for an in depth look at Lake Apopka farmworkers and their struggle for environmental justice.

fealty to the industrial farm (of which she is an economic beneficiary) takes precedence over any affiliation with civil rights and environmentalism that she might have. In the erasure of structural violence, we see evidence of an unvoiced, perhaps not fully conscious, affirmation of the racism and anti-environmentalism that underpins plantation surplus. Angela's is a complicated subjectivity to inhabit — one that deserves anthropological scrutiny.

The Florida Agricultural Hall of Fame and the Angela's storytelling practices are both local and idiosyncratic. Yet they also are embedded and must be read in the broader historical arc of the Plantationocene in which Euro-Americans treated black people and ecological landscapes as exploitable resources. I turn now to the racism inherent in the Zellwood operation and the Plantationocene more generally.

In 1941, at the behest of local agricultural lobby, the city of Apopka passed a vagrancy ordinance in response to wartime labor shortage. Vagrancy ordinances were commonplace in the Jim Crow South and enabled local police to arrest African American men in the streets and put them to work in the fields. During that same period workers from the Bahamas were brought to Central Florida to work in the muck (Shofner 1982). Placed in camps outside of the small town of Zellwood, these workers lived in squalid conditions with poor sanitation. At the end of the war, German POWs housed in a nearby camp in Leesburg were forced to pick vegetables for Zellwood growers. This history of coerced labor, of course, speaks to the genealogical continuities between colonial and Green Revolution plantations. Whether the labor was coerced, semi-coerced, or simply underpaid, racism is an indispensable feature of the Plantationocene and its biopolitics. Irrespective of successive shifts in the labor market — from an African American to a Caribbean, and, most recently, Latino work force — Zellwood growers treated workers as inputs, and eventually replaced them as specialized machines and automation came along. The exploitability of nonwhite labor dovetails with its ultimately disposability.

As I have developed this analysis of the Plantationocene and its fertility apparatus, I often felt pressed to engage with Foucault's notion of biopolitics, which he elaborates in *Society Must Be Defended* (2003). Strangely, agriculture is missing from his list of nineteenth- and twentieth-century biopolitical projects. The Plantationocene discourse holds the promise of a more illuminating recasting of biopolitics and the forces of biopower that massify human life and make it governable. This biopolitics is necessarily a biogeochemical one. Foucault's arguments about the centrality of racism to the biopolitical state take on a richer significance in as much as they allow us to see how slavery and the racialized labor of the plantation are requisite to feed and proliferate the moderns.[14]

Biopolitics refers to the nineteenth-century invention of sovereign power organized around the promotion of human life in the aggregate. The rise of biopolitics coincides with the strengthening of the nation-state as a political form through such institutions as medicine, education, and public health. Power emerges through the ability of the state to control the life processes of the multitude, engendered through

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[14] In Latour's framework, the category of the moderns is racially unmarked. Perhaps this is an elision, akin to Angela's, that reveals his unwillingness to think about race and racism.

techniques of accounting, surveying, and conceptualizing its subjects as manageable populations, but also as citizens with all manner of new rights and responsibilities. Foucault converges on questions of racism as he confronts a jarring paradox: within the new biopolitical regime of "making live," authoritarian states perpetuate the most violent atrocities in world history.[15] I quote a string of passages that help ground the discussion.

> I think that, broadly speaking, racism justifies the death-function in the economy of biopower by appealing to the principle that the death of others makes one biologically stronger insofar as one is a member of a race or a population, in so far as one is an element in a unitary living plurality…
>
> In the nineteenth century — and this is completely new — war will be seen not only as a way of improving one's own race by eliminating the enemy race (in accordance with the themes of natural selection and the struggle for existence), but also as a way of regenerating one's own race. As more and more of our number die, the race to which we belong will become more purer…
>
> We can understand…the link that was…established between nineteenth-century biological theory and the discourse of power. Basically, evolutionism, understood in a broad sense — or in other words, not so much Darwin's theory itself as a set, a bundle, of notions (such as: the hierarchy of species that grow from a common evolutionary tree, the struggle for existence among species, the selection that eliminates the less fit) — naturally became within a few years during the nineteenth century not simply a way of transcribing a political discourse into biological terms, and not simply a way of dressing up a political discourse in scientific clothing, but a real way of thinking about the relations between colonization, the necessity for wars, criminality, the phenomena of madness and mental illness, the history of societies with their different classes, and so on. Whenever, in other words, there was a confrontation, a killing or the risk of death, the nineteenth century was quite literally obliged to think about them in the form of evolutionism (2003).

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[15] Foucault's earlier omission of race from his analysis of biopolitics inspired Ann Stoler's *Race and the Education of Desire* — a book that takes up question of colonialism and the plantation, but not its biopolitical force.

Foucault concludes his essay with a reflection on World War II and the racism of the Nazi state. The Nazis, he argued, were a paragon of biopolitical disciplinarity. “Controlling the random element inherent in biological processes was one of the regime’s immediate objectives.” Foucault was interested in eugenics as a locus of biopolitical control, but had he been interested in agriculture he might have appreciated the formative role German industrialists played in developing the chemical fertilizer industry. It was German scientists Fritz Haber and Carl Bosch who, in the run-up to World War I, invented a process to fix atmospheric nitrogen into ammonium. This ammonium was used for bombs and munitions, but also for fertilizer. During the late nineteenth century, Germans also had a global monopoly on potash. It is, of course, during this same period that the United States developed its phosphate monopoly. Viewed stereoscopically, the monopoly power exerted by Germany and the United States over the chemical elements of fertility deepen the genealogy of biopower. How might we see the relationship between fertilizer, racism, and the death-function of war in the United States during World War II?

I am urged to respond to this question by imagining German POWs and African American picked up on vagrancy charges working side by side in the vegetable fields of Lake Apopka. In the German POW, we confront a projection of the United States as the moral victor with the farmer as the heroic, food-producing sidekick to the soldier. In the African American picker, we find the enduring figure of the slave and the structural racism that underpins the agricultural wealth of the United States and much of the world. The Nazis’ racism toward the Jews and Americans’ racism toward the African are not symmetrical. The labor power of the African makes him too valuable to be killed. The African American population becomes a resource that must be parasitized before it is rendered obsolete by technological advances. To rethink biopolitics and the Plantationocene through this parasitism, we are also taken into another biological imaginary – one that is distinct from but also compatible with the social darwinism Foucault brought to light. We are also brought closer to understanding the racial and biogeochemical complexion of Anthropocene environments like Lake Apopka. The cultural eutrophication of the lake and the racialized health disparities of former workers sprayed with pesticides are formed in the same locus of biopower: the Green Revolution plantation. But to understand the biopolitical force of the plantation, we must tie it to consumption and embed it as a node of power in the trophic structure of global capitalism. In short, we might understand the global plantation in relation to a crude figure: a massified Euro-American anthropos devouring the Earth and coercing others in the making of its meals. I conclude with a final description of Lake Apopka as an industrial knot of Plantationocene biopower.

The Green Revolution and World War II form an important ratchet point in the history of the Plantationocene and its scalable designs. Food preservation technologies, like the refrigerated railroad car, canning plants, precooling plants, and the carrot-concentrate co-op, were innovations that facilitated new economies of scale. To see this clearly, let’s return to the Florida Dehydration Company at Zellwood and its relationship to the productivity of the farms. The dehydration plant is a technology for preserving agricultural surplus, turning perishables into commodities that can be economically transported long distances and stored for long periods of time. Feeding an army (and growing a population) requires surplus-generating farms, transportation infrastructure for distributing that surplus, and mechanisms for arresting its decay.

Prior to World War II there were 18 dehydration plants in operation in the U.S. With the declaration of war, the government approved the construction of 200 new plants. This decision was rationalized by a need to reduce the quantity of packaging metal used in canning and to save on shipping space. In one year alone the government expected to save 136,000 tons of metal by shipping dehydrated rations instead of canned goods (Amenta 1943). The Florida Dehydration Plant was built to handle immense harvests of the Zellwood's Green Revolution farms. According to a manager, "Our plant capacity is 125 tons of fresh vegetables a day and we will use this much every day that it is available, so you can see that your farmers also have a job in growing these vegetables." Zellwood farmers were easily able to supply this tonnage both before and after the war. In 1985, the Orlando Sentinel reported that following per-acre yields: 20 tons of celery, 11 tons of cabbage, 5 tons of sweet corn, 3.5 tons of carrots, and 1 ton of radishes. "By contrast, a typical row crop such as soybean, which is not grown on muck, yields about 1,300 pounds per acre in Florida." Moreover, "the muck farms also get at least two harvests per crop each year, which stretches the productive capacity of the acreage. Zellwin farms, for example, harvests about 9,000 acres of crops annually from 4,000 acres of land. There are almost 9,000 acres in the Zellwood Drainage District, and more than 4,000 on muck outside the district" (Jackson 1985). Although the timing of the harvest could not always produce a steady stream of vegetables to the dehydrator, the total harvest well exceeded the capacity of the plant.

This industrial bounty was founded on water- and nutrient-retention properties of the muck, but also the supersaturation of plant nutrients through fertilization. No comprehensive data on fertilizer application rates for Zellwood farms exists. However, two references, one from 1944 and another from 1996, give us a glimpse of fertilizer application rates at Zellwood's founding and at its end. The 1944 reference comes from a bulletin from the Florida State Horticultural Society (Dowdell 1944). In it, the author reports the application rates of 0-12-18 (NPK) fertilizer for three crops: 1,000 pounds/acre for potatoes, 800 pounds/acre for carrots, and 500 pounds/acre for spinach. This translates to 120 pounds, 96 pounds, and 60 pounds of phosphate/acre respectively. During this period only the first agricultural polder of 2,600 acres was developed and operational. By the 1980s, some 18,000 acres of mucklands were in cultivation. A conservative estimate of total phosphate application for all the farms in 1991 was 273,000 pounds (Crnko 1993). Given these figures, I estimate the total phosphates applied to the Apopka agricultural area to be 10 million pounds, give or take a few million. This is a tremendous amount of fertilizer. Much of this phosphorus became embodied in crops and exported off the farms; much of it was flushed into the lake, nourishing algae blooms and gizzard shad. In this bifurcation, we see the fertilization of forms — both human and algal — that topple Holocene diversities that came before. We live on a planet that is getting hotter and hotter but also one this growing more and more eutrophic. This process of hypereutrophication — the condition of overfeeding and overeating — creates a deadly overabundance of Plantationocene life.

PART TWO: GENEALOGY FOR A CYBORG LAKE

In 1887, the limnologist Stephen Forbes delivered a paper titled “The Lake as Microcosm” to the Peoria Scientific Association. The paper is considered a classic in freshwater ecology and is credited for anticipating studies on food webs, key ideas in population and community ecology, and Arthur Tansley’s concept of the ecosystem. In the paper, Forbes established lakes as model systems in which it is possible to study the whole suite of biological interactions found in the ecological world writ large. Forbes imagined a lake as a self-contained world in which it was possible to inventory all the species and describe their relations as a “community of interest.” “[The lake] forms a little world within itself, a microcosm within which all the elemental forces are at work and the play of life goes on in full, but on so small a scale as to bring it easily within the mental grasp” (1887). With knowledge of the community in miniature, ecologists could extrapolate to larger, less-well-bounded environments that are difficult to study holistically.

For Forbes and the legions of systems ecologists he inspired, lakes mirror the macrocosm. Despite the bold theoretical proposition, the paper does not develop into abstract exegesis; instead it offers a comparative natural history of the lakes of northern Illinois and southern Wisconsin. At the empirical heart of the paper is the question: why do some species appear in some lakes and not others? The central axis of comparison in Forbes' paper is between "fluviatile" lakes and the isolated "watershed" lakes formed in the depressions of glacial outwash.[16] Below he describes the grouping of lakes that he calls "fluviatile." I quote at length:

> The fluviatile lakes, which are much more numerous and important, are appendages of the river systems of the State, being situated in the river bottoms and connected with the adjacent streams of periodical overflows. Their fauna is therefore substantially that of the rivers themselves, and the two should, of course, be studied together.
>
> They are probably in all cases either parts of former river channels, which have been cut off and abandoned by the current as the river changed its course, or else are tracts of the high-water beds of streams over which, for one reason or another, the periodical deposit of sediment has gone on less rapidly than over the surrounding area, and which have thus come to form depressions in the surface which retain the waters of overflow longer than the higher adjacent lands. Most of the numerous "horse-shoe lakes" belong to the first of these varieties, and the "bluff lakes" situated along the borders of the bottoms, are many of them examples of the second.
>
> These fluviatile lakes are most important breeding grounds and reservoirs of life, especially as they are protected from the filth and poison of towns and manufactories by which the running waters of the state are yearly more deeply defiled.

Reading his essay, I was struck by two things. First, I was struck by the gap between Forbes' theorization of lakes as self-contained microcosms and his description of lakes as highly connected systems. Fluviatile lakes are defined by their spatial connections to rivers that dramatically alter their species compositions and

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[16] In other moments of Forbes' essay, Lake Michigan and some European lakes become important loci of comparison; for instances, Lake Michigan becomes relevant as he queries why so few deep-water Great Lakes species like sculpin inhabit small but deep lakes.

dynamics during periods of high flood. When Forbes describes the more hydrologically isolated watershed lakes, we are not given a picture of self-enclosed ecological bubbles; instead we are invited to see the historical formation of an entire lake district generated in the slow-motion action of glaciers. Lakes are not test-tube universes but lively pockets of water with complex time-space entailments. The concept of the microcosm does not materialize out of his empirical description. Secondly, I was surprised by Forbes' lack of abstraction. In the twentieth-century, Forbes' paper inspired a generation of ecologists who were drawn to mathematics, cybernetics, and high-level abstraction. Forbes, by contrast, works in a descriptive natural history mode. In his essay, we get a portrait of lakes as utterly particular — one developed through a flatfooted commitment to document and inventory what's there. Through his natural history descriptions, we even catch a glimpse of people! We learn of defiling upstream factories, sportsmen who stock lakes with game fish, and summer resorts that crop up on gravelly beaches of watershed lakes. These anthropogenic entanglements are not the point of his essay, but nonetheless there they are, baked into the descriptive cake.

In his portrait of limnological entanglements across the landscape, in time, and among various critters — including the colonizing and industrial Euro-American — Forbes is much closer to a Harawayan formulation of lake as *natureculture* than he is to lake as microcosm. How might have Forbes descriptive and analytical account shifted if he could have availed himself of the intellectual resources of our time (or even of his! I am thinking here of George Perkins Marsh and his 1864 book *Man and*

Nature)? Alert to the interpenetrations of nature and culture and vested with the tools of ethnography, history, *and* the natural sciences, Forbes might have learned to see Illinois and Wisconsin's lake-dotted geography otherwise. Through a naturalcultural lens, Forbes account of the lakes and their interspecies relations may have mostly stayed the same, but he would have learned to see this Midwestern lake district as a geography cleansed of its native human occupants and colonized by a people in the midst of the "second Industrial Revolution." From this observation, he may have grown curious about the new rail lines extending into the Great Plains, shuttling corn, cattle, and other frontier commodities to the metropolis being erected on the shores of lake Michigan (Cronon 1991); the proliferation of drainage districts that turned wet prairie into agricultural fields; and to the pollution of factories, stockyards, and urban sewers that was already defiling his precious lakes! In short, he would have begun to notice a world under invasion, but not fully purged of its nonhuman Holocene ecological relations.

He might also have become curious about a new class of urban elites, made wealthy in this frenzy of industrial change, who turned lakes and their shorelines into recreation grounds and summer homes. Who were these elite Americans? How did their wealth relate to the agricultural colonization of the frontier? How were they fed? Was he one of them?

Of course, it would be an unfair anachronism to blame Forbes for anticipating food webs and key ideas in population and community ecology, but not Haraway's natureculture. After all, in the nineteenth century, Euro-American biologists were still confronting Holocene worlds that, from their vantage, were easily confusable with what Enlightenment thinkers called Nature. Universal Nature did not block Forbes or other naturalists of the period from seeing the diversities, specificities, or relationalities of ecological places. It may, however, have impaired them from becoming curious about the new American civilization and the hybrid natures it had begun to proliferate. Society — nature's opposite — was at once too distant and too close, too artificial and too naturalized to see with fresh eyes. In any case, Forbes was interested in lakes.

Or was he?

In the paper's introduction, we are invited to see the lake as a microcosm of a much larger ecological universe. But by the essay's conclusion, the macrocosm that the microcosm was to reflect has metamorphosed into something else: the lake has become a scaled-down analogue of capitalist society. This is a strange turn. I outline the concluding argument.

Within a lake, competition between species is "fierce and continuous." Rather than producing life-dissolving disorder, this fierce competition generates an equilibrium state that "accomplishes for all the parties involved the greatest good which the circumstances will at all permit." This equilibrium is achieved through natural selection and the culling of the unfit. "Just as certainly as the thrifty business man who lives within his income will finally dispose his shiftless competitor who can never pay his debts, the well-adjusted aquatic animal will, in time crowd out his poorly adjusted competitor for food and for the various goods of life." Forbes spells out his argument in relations to the predator-prey cycle. Why is it that predators do not overexploit their prey and thus propagate their own extinction? The answer is that natural selection has honed predators and prey into forms that modulate the "rates of destruction and of multiplication" to prevent overexploitation and the collapse of both species. This, of course, is achieved without — I paraphrase — mercy, charity, sympathy and magnanimity. Forbes interprets this equilibrium as evidence of "the final beneficence of the laws of organic nature." Universal good emerges out of nature red-in-tooth-and-claw in a process that is identical to, or at least the mirror image of, the universal good generated by market competition and the ruthless self-interest of the capital-owning class. Capitalist society is nature's doppleganger, as seen through the lacustrine microcosm.

In making this analogy, Forbes is performing what Engels, critiquing Darwin, called the "conjuror's trick." In this trick, theories of nature are projected onto society, edifying "their validity as eternal laws of human society" (Sahlins 1976). Such ricocheting projections between nineteenth natural history and political economy produced revolutionary intellectual insights (I am thinking, of course, of Darwin and Wallace's famous reading of Malthus's *Principles of Population*), but it also left natural scientists with an impoverished sense of human history, diversity, culture, and power. Forbes was fully capable of noticing the Euro-American encroachments on the lakes he studied, but his Victorian conception of society — deeply informed by Herbert Spencer's social organism (see below) — prevented him from following up in any serious ethnographic sense. Nature was to be encountered and studied through field methods, whereas society was intelligible through armchair evolutionary theory. This methodological asymmetry blunted his knowledge about concrete social histories, at the same time that it turned Euro-American-style capitalism into the most advanced form of nature. In the appeal to universal law, nature and society became analogues. However, they also were also constructed as separate spheres, with the institutions of science cleaving attentively to the former. Forbes' natural history stops where lakes end and civilization begins. This bias for nature as "nature" set up a pattern in which ecologists learned a lot about the structure and function of lakes and the ecological places, but learned relatively little about the structure and function of society. At the same time that society was ignored empirically, scientists availed themselves of natural philosophy and political theory to become armchair sociologists. This tradition, I contend, was transmitted from Spencer through Forbes to the mid-twentieth century ecologists who developed the ecosystem concept.

Across the reflective surface of the lake, Forbes erected a Great Divide. On one side: American civilization as the most advanced form of nature. On the other: a pristine lake (almost) untouched by humans. But below its surface and along its shorelines, hybrids were proliferating.

One of these hybrids, I contend, was Forbes himself and the elite practice of limnology that he was helping to bring into being. To understand Forbes' limnology as a naturalcultural hybrid, let's return to the chapter's Plantationocene hypothesis. I have thus far argued that Euro-American civilization and its division of labor is predicated on the parasitization of biospheric, lithospheric, and atmospheric nutrient stocks and the labor of nonwhite people. This parasitization broke the trophic link between Euro-Americans and local ecologies and deepened the sense that the moderns were divorced from nature. The intensification of surplus-generation through scientific farming and chemical fertilizers expanded the civilizational division of labor. Within this expansion, we see a surge of investment in new scientific institutions and practice. Professional naturalists confronted the study of ecological places from the alienated positionality of an urban-industrial consumer. Walking into natural areas to conduct research, they crossed the threshold from culture into nature as a detached and objective observer. This knowledge-generating transgression produced, on the one hand, a systematic accounting of natural processes in which the human is abstracted from the account and, on the other, a proliferation of hybrid attachments between field biologists, their institutional dependencies, and the concrete natural formations that became their objects of study. Scientific texts are made through such contact, but they obscure (among other things) the trophic relations that feed their making. This might be identified as a core distinction between natural history and what has been called traditional ecological knowledge.

In his essay "The Social Organism," Herbert Spencer advances arguments similar to the one I am making about the Plantationocene, but within the racist idiom of social darwinism (1860).

> As we advance, we see that while the upper class grows distinct from the lower, and at the same time becomes more and more exclusively regulative and defensive in its functions, alike as kings and subordinate rulers, as priests, and as military leaders; the inferior class becomes more and more exclusively

> occupied in providing the necessaries of life for the community at large. From the soil, with which it comes in most direct contact, the mass of the people takes up and prepares for use the food and such rude articles of manufacture as are known; while the overlying mass of superior men, supplied with the necessaries of life by those below them, deals with circumstances with which, by position, it is more immediately concerned. Ceasing by-and-by to have any knowledge of, or power over, the concerns of the society as a whole, the serf class becomes devoted to the processes of alimentation; while the noble class, ceasing to take any part in the process of alimentation, becomes devoted to the coordination and movements of the entire body politic (1860).

In Spencer's theory, the organism is a microcosm of the body politic. The functions distributed across the organism's cellularity and organs are akin to the division of labor within a society. Over evolutionary time, society, like organisms, grows in mass and functional complexity. In capitalist society, the inferior class exists in an agricultural role, transforming the fertility of the soil into "alimentation" of the superior class of statesmen, business leaders, professionals, and scientists. This construction bears directly on the racism of nineteenth-century evolutionism described in the last section, but it is also important to notice that it refracts the central insight of Marx: that value is produced through exploitation of the worker and the soil.

Given the importance placed on agriculture in land-grant universities in the Midwest, Forbes — a reader of Spencer and a professor at the University of Illinois (a land grant institution)— may have understood that his position as researcher and the knowledge he generated were animated and subsidized by the wealth of the agricultural frontier. The geographical superimposition of the agricultural frontier atop the Midwestern post-glacial environment is important to the historical development of limnology. The Midwestern universities that developed around glacial lakes became hotspots of limnological inquiry, including the University of Wisconsin, founded on the shores of Lakes Mendota and Monona, and the University of Michigan, surrounded by numerous small kettle lakes (Golley1993). Had Forbes been able to the grasp the metabolic (and ultimately parasitic) relations between city and countryside he may have seen his own scientific practice, the subsidies underpinning the University of Illinois, and the fouling of his study sites in a new light.

The practice of limnology is a hybrid formation created by the moderns in their scientific, theoretical, and managerial contact with lakes. Perhaps the most powerful and enduring contribution of this practice is the ecosystem concept itself. Embalmed within its ideational structure is Forbes' nature/society dualism. In Holling's adaptive management, we find Forbes' conceptualization of nature and society almost perfectly intact. Society is nature's opposite but also its twin, governed by the same underlying dynamics. For Holling, the relationship between nature and society is organized not around metabolism, but scientific management. Management exists to make nature more "natural" and resilient in the face of the destructive practices of industrial society. The resulting SES is not a hybrid natureculture (although it proliferates these, as with the Vietnamese gizzard shad harvest), but a technocratic relation between compartmentalized nature and compartmentalized society. The SES re-purifies what had been contaminated through contact with society. It is a process of re-boundarying nature and culture through hybridization. What happened to Forbes' microcosm to make it shed the lake and gain the ecosystem and, eventually, the technocracy and anti-politics of adaptive management?

Before moving on to address this question, we should acknowledge another hybrid effect of the Plantationocene: cultural eutrophication. Here, the line between Plantationocene excesses and the hybrid ecologies of toxic algae blooms, fish kills, hypoxia, and trophic cascades is more direct. Limnologists and cyanobacteria are made from the same stock of phosphorus, but it is also important to appreciate that limnology and cultural eutrophication are co-produced in the conventional sense of co-production. Over the course of the twentieth century, cultural eutrophication became a hot topic of limnology and lake management. As a matter of fact and as a matter of concern, cultural eutrophication co-emerged with professional limnologists who studied it.

Going forward our task is twofold: 1) to trace how Forbes' nature/society dualism was pulled into the ecosystem concept, and 2) to chart how limnologists identified phosphorus as the primary agent of eutrophication in fresh water ecosystems. To answer both of these questions we must turn our attention to Linsley Pond and the lab of G. Evelyn Hutchinson. Before we do so, let's briefly clear up a small but not insignificant confusion in the history of ecological ideas.

In *A History of the Ecosystem Concept in Ecology,* Frank Golley details the influence that Forbes' "The Lake as Microcosm" paper had on twentieth-century ecology. In it, however, he erroneously attributes to Forbes the following quotation: "A lake is an old and relatively primitive system, isolated from its surroundings. Within it matter circulates, and controls operate to produce an equilibrium comparable with that in a similar area of land. In this microcosm, nothing can be fully understood until its relationship to the whole is clearly seen…. The lake appears as an organic system, a balance between building up and breaking down in which the struggle for existence and natural selection have produced an equilibrium, a ‘community of interest,’ between predator and prey.”

The quote actually belongs to Hans-Joachim Elster (Dagg 2011). Elster made this statement when summarizing, not quoting, Forbes’ paper for an audience at International Limnological Society meeting in Stuttgart, Germany in the 1970s. This misattribution and its uptake by historians of science is important in as much exaggerates Forbes’ anticipation of the Arthur Tansley's ecosystem concept. Tansley developed his idea of the ecosystem in the 1935 publication "The Use and Abuse of Vegetational Concepts and Terms” — nearly half a century after “The Lake as Microcosm” was published. Tansley conceptualized the ecosystem as an integrated system of organic and inorganic factors situated in the “multitudinous physical systems of the universe, which range from the universe as a whole down to the atom” (Tansley 1935). Although Forbes was interested in the equilibrium of the lake (a concept drawn from physics), it was an equilibrium produced through the eating relationships among organisms. Forbes was not concerned with the fluctuations of energy, nutrients, and matter in lakes. Ecologists, however, would become interested in this biogeochemical flux and they would use the lacustrine microcosm and the ecosystem concept to make this flux visible.

Hutchinson's Legacy

Standing on the shore of Linsley Pond on June 2, 1946 you would have observed a swimmer paddling across the small lake with a sample of radiophosphorus in one hand. The swimmer was G.E. Hutchinson, the "father" of modern ecology (Zimmer 2011). Hutchinson was using this radioisotope to test a hypothesis about the cycling of phosphorus across the living and nonliving components of the lake. "By taking water samples at different locations and depths and analyzing them for radioactivity, he tracked the phosphorus from the surface water into phytoplankton and then, as the plankton died (or were eaten) and their remains sank downward, all the way to the lake bottom. From there it was released back into the water column and taken up again by phytoplankton" (Fellman 2004). This was the first experiment to use a radioisotope as a tracer in an ecosystem study.

Linsley Pond was Hutchinson's microcosm. "From the 1930s until the late 1970s, the Yale biologist…and a legion of his students…examined every facet of Linsley — its biology, chemistry, and geological history. In the process, Hutchinson and company discovered some of the general principles that govern living communities. The concepts of biogeochemical cycling, paleobiology, and biodiversity; a method for delineating biological niche; the mathematics of population ecology — all flowed, in part, from Hutchinson's research at Linsley Pond" (Fellman 2004). Hutchinson did not imagine the lake as an analogue of society, but he did treat it as a model system that could shed light on general ecological dynamics. Hutchinson's virtuosity as a scientist was linked to his methodological pluralism. His use of mathematics, conceptual models, and radioisotopes would come to define modern ecology, but it was his use of comparative natural history that served as the foundation of his scientific practice. Overshadowed by his theoretical contributions to ecology is a three-volume treatise on the natural history of lakes.

In his commitment to natural history and the study of whole-lake systems, Hutchinson is an heir to Forbes. He is also heir to Vladimir Vernadsky, the Russian polymath largely credited with developing the field of biogeochemistry. In his book *The Biosphere*, Vernadsky developed a picture of the Earth as a dynamic complex of chemical cycles, utilizing insights from mineralogy, marine chemistry, biochemistry, and evolution (Golley 1993). Inspired by Vernadsky's work, Hutchinson began tracing the cycling of chemical elements, starting with phosphorus, in Linsley Pond. This tracing methodology was developed in the radiophosphorus experiment described above; however, by the late 1940s when this study was published, limnologists were already acquainted with the idea that energy and nutrient flows could be tracked through ecosystems. At the University of Wisconsin, Chancey Juday and Edward Birge were involved in a systematic survey of the energy budget of Lakes Mendota.[17] However, it is Raymond Lindeman's 1941 publication of the "Trophic-Dynamic Aspect of Ecology" that was the true milestone (Golley 1993).

Raymond Lindeman received his PhD at the University of Minnesota and was a postdoctoral researcher under Hutchinson at Yale. Lindeman conducted his

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[17] The energy budget is a concept developed by German limnologist August Thienemann (Golley 1993).

dissertation research on Cedar Lake Bog. Adopting Forbes' microcosm as his model, Lindeman, along with his wife Eleanor, surveyed the organisms and physical properties of this small, late-successional Minnesotan lake (Golley 1993). This was the first study to put empirical meat on Tansley's conceptual skeleton. Lindeman developed the ecosystem concept by describing the flow of energy across trophic levels among different classes of organisms (e.g. primary producers, secondary consumers, tertiary consumers). He described these trophic relations as a "food chain." By linking the eating relationships of various organisms to the energetic structure of the physical universe, the lacustrine microcosm became an ecosystem. Hutchinson later reflected that Lindeman's paper was the first "to indicate how biological communities could be expressed as networks or channels through which energy is flowing and being dissipated, just as would be the case with electricity flowing through a network of conductors" (quoted in Golley 1993). Indeed, Cedar Bog Lake and Linsley Pond were newly envisioned as ecological nodes within an "interplanetary flow of energy" (Zimmer 2011).

This focus on energy as a kind of natural currency would form the ontological crux of the research for another Hutchinson student: H.T. Odum. Odum took the metaphor of energy flows as electrical circuits and made it literal, appropriating the symbol system of the electrical engineer to diagram ecosystem relations and flows. He then applied this tracing method developed in lakes and turned it into a tool for mapping every possible type of ecosystem. He would eventually extend this method to study the cybernetics of society.

Before going on to Odum, I want to touch briefly on the question of phosphorus cycling and the science of cultural eutrophication.

During the 60s and 70s cultural eutrophication became a flashpoint of the new environmental movement. Decades of nutrient loading from agriculture, human sewage, and laundry detergents were transforming some of the most valued freshwater ecosystems in the United States. Lake Eerie, Lake Washington, and Lake Apopka were among three important lakes plagued by algae blooms, fish kills, and hypoxia. These "dying" lakes sparked a surge of interest in the causes of eutrophication. Although limnologist understood eutrophication as part of the aging process of a lake, it was becoming evident that humans were accelerating the process. It was also clear to most scientists that the eutrophication arose from pollution, but "it still had to be proven scientifically that the crucial factors were neither vitamins, trace elements, or other obscure unspecified factors" (Vollenweider 1987).

Three important limnological studies helped establish the consensus that phosphorus was the primary agent of freshwater eutrophication. The first was a comprehensive literature review conducted by Richard Vollenweider in 1968. In this review, Vollenweider examined multiple lakes and found that the trophic structure of the lake was directly proportional to nutrient loading rates (Canfield et al. 2000). In a biographical account, Vollenweider wrote: "In my previous studies of lakes in several countries, I became intrigued with the observation of how closely limnological properties reflect properties of the catchment basin. This, of course, is now standard knowledge, but at the time the prevailing view was still that of lakes as self-sufficient microcosms" (Vollenweider 1987). Vollenweider's report was never published but was widely circulated. Its message was rapidly grasped by limnologists in North America who used it to charter an agreement between Canada and the United States to curb nutrient loading in the Laurentian Great Lakes (Vollenwieder 1987). The unpublished report is hailed as a classic.

The second piece of evidence came from the whole-lake experiments carried out by David Schindler and J.R. Vallentyne as part of the Canadian Freshwater Institute. The institute, in cooperation with the Ontario government and local logging companies, established an experiment station in a remote wilderness area with 50 small lakes. In an iconic experiment, the scientists split Lake 227 in two with a heavy sea curtain. On both sides of the curtain the scientists applied nitrogen and carbon (in the form of granulated sugar) and on only one side they applied phosphorus. The side applied with phosphorus turned pea green (Schindler et al. 2016). An aerial photographic of the half-eutrophic lake gained wide circulation and demonstrated to a concerned public the primacy of phosphorus as the agent of eutrophication. This photograph helped lead to a ban on phosphates in detergents.

A third demonstration of phosphorus limitation in lakes came from the work of W.T. Edmondson on Lake Washington. Edmondson was a student of Hutchinson and assisted with the radiophosphorus studies at Linsley Pond. In 1951, Edmondson published an article showing a correlation between anoxia and phosphorus accumulation in the benthos of Lake Washington. Edmondson tracked changes in Lake Washington for the next three decades. He showed how the size of algal blooms grew in proportion to phosphorus influxes from sewage from the growing city of Seattle. Edmondson treated Lake Washington as an unplanned whole-lake experiment (Edmondson 1991). In 1963, he persuaded the city to divert its sewage into Puget Sound instead of the lake, “after which he documented the lake’s recovery” (Schindler et al. 2016). Edmondson’s research at Lake Washington helped cement the phosphorus paradigm at the same time it demonstrated the ability of a lake to recover after phosphorus loading was reduced. (Halting phosphorus loads to Lake Apopka did not stimulate a gradual improvement because macrophyte loss maintained the lake in a degraded alternative stable state.)

Collectively, Vollenweider’s multi-basin analysis, the Canadian whole-lake experiments, and Edmondson’s long-term case study of Lake Washington established the phosphorus paradigm as a scientific fact with sweeping political implications. It also affirmed Justus von Liebig’s law of the minimum, the essential insight of agricultural chemistry that launched the fertilizer industry. Like agricultural crops, the growth of aquatic plants is limited by the biogenic element in least supply — which for lakes and vegetables is phosphorus.

A Cybernetic Vision

H.T. Odum and his systems ecology obtained prominence in the 1960s and 70s, during the frenzy of Florida's Great Acceleration. In the aftermath of the second world war, Florida experienced a tsunami of immigration and suburban growth. This growth created extraordinary wealth but also environmental crises that were impossible to ignore. Fires raged in the Everglades; Lake Apopka fouled the senses and impaired downstream water quality; and ecological landscapes across the state rapidly went the way of the bulldozer. Alarmed residents, both old and new, demanded that the state take action. "The environmental movement hit Florida with particular force because it challenged the state's traditional boosterism. For 150 years progress had been a measure of new residents, tourists, railroads, highways, houses, condominiums, shopping centers, orange groves, sugar fields, cattle ranches, and phosphate mines. Whatever 'developed' the state was good; whatever hindered development was bad. Then development became suspect" (Blake 1980).

It is in this milieu that Florida's water management districts were formed and systems ecology took on new institutional importance. In 1971, Reuben Askew, the progressive governor who passed legislation creating Florida's water management, met with H.T. Odum and other academic ecologists to chart a new environmental vision for the state. As the environmental movement swept across Florida, water management districts were imbued with an optimism that they could repair the mistakes of the modernist engineering that came before. This shift in intellectual and managerial orientation is best reflected in the transformation of the Central and South Florida Flood Control District — the agency, along with the Army Corps, responsible for the disastrous flood control program that diverted floodwater from the Everglades and caused it to catch fire. With the 1972 passage of the Florida Water Resources Act, the Central and South Florida Flood Control District became the South Florida Water Management District (Blake 1980). The South Florida Water Management

District, along with the other four districts, adopted an ecosystem approach to study the state's natural resource problems and hired a cadre of experts and scientists, many of whom were trained in the new systems ecology at the University of Florida by H.T. Odum

The son of a regional planner, Odum believed that systems ecology could serve as a rational basis for organizing nature and society. Peter Taylor characterizes Odum's philosophy of systems engineering as one of "technocratic optimism," forged in post-World War II research and development programs, such as the Atomic Energy Commission and the National Science Foundation (1988). Particularly influential in the formation of ecosystem ecology was the new science of cybernetics, developed in the Macy conferences (1946-1953). Participants included such notable figures as Norbert Weiner, Margaret Mead, Gregory Bateson, and G. Evelyn Hutchinson. Taylor describes the ideology of the new systems theory:

> In the systems view, living and nonliving feedback systems alike obeyed common mechanical principles, including their mode of evolution. Data could be used to elucidate directly the dynamics of systems. And, once scientists understood the dynamics of systems, those systems would be controllable, enabling society to become free from catastrophes (1988).

The shock and trauma of the second world war, Taylor argues, spawned new hopes of a rational social order among the interdisciplinary participants of the Macy conferences. Among social scientists, in particular, there was the hope that, "Freedom from holocaust, and other social upheavals, might be achieved through the construction of an all-encompassing system of feedback" (1988).

Measurement, data collection, and modeling were important to Odum's scientific work and the systems ecologists that he trained.

By collecting data for an entire system and summarizing them in flow diagrams, the systems ecologist could act as if the diagrams represented the system's dynamic relations. This approach, it should be noted, might require some arbitrary internal aggregations, such as species being summed into trophic compartments. The flow diagrams, when transformed into computer models, could be used by systems ecologists to generate predictions about the future or about responses to perturbations (1988).

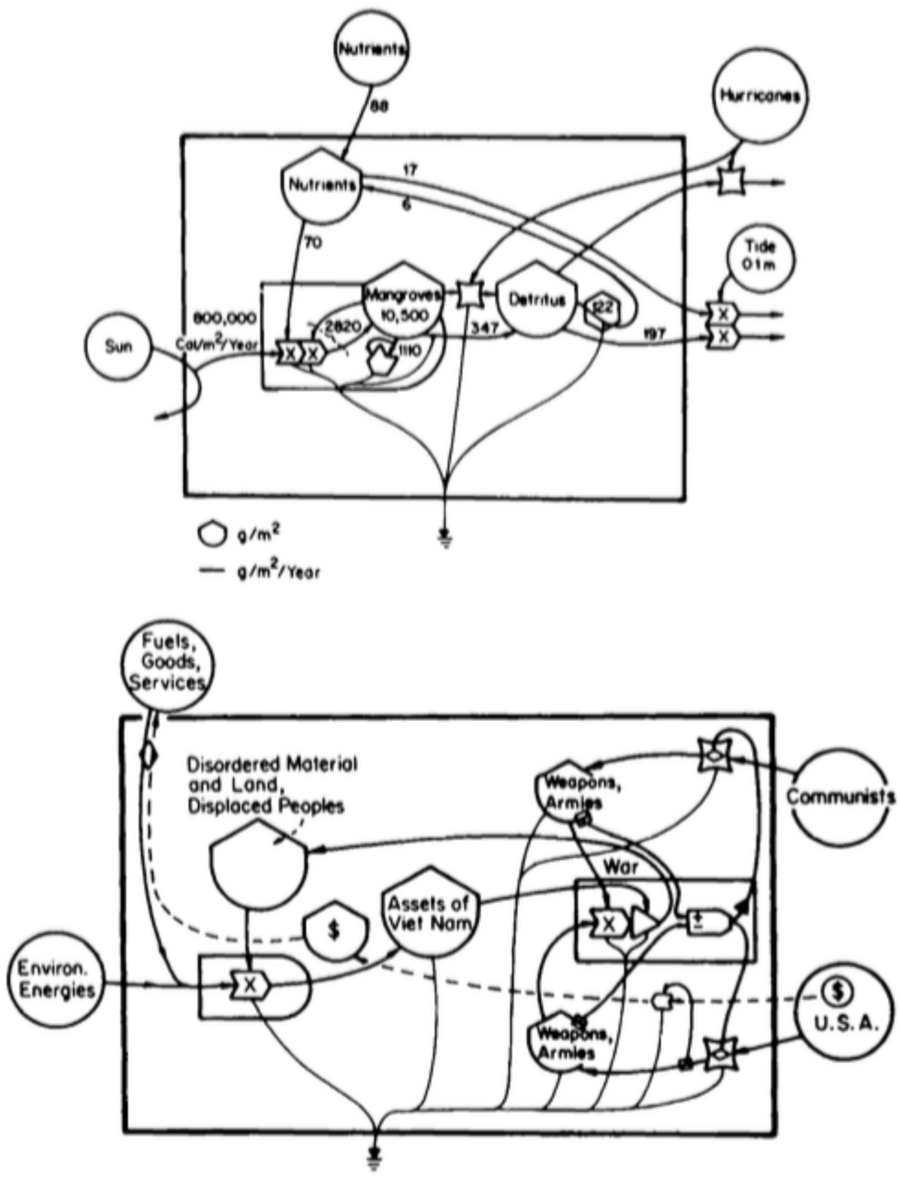

Figure 6. Cybernetic diagrams comparing the mangrove ecosystem (top) and the Vietnam War (bottom). From Taylor 1988.

As Odum matured as a thinker and scientist, he became increasingly interested in environmental engineering as a tool for helping society circumvent the disordering effects of the war and the overexploitation of natural resources, fossil fuels in particular. In this project, society was imagined and modeled as yet another system structured in cybernetic feedbacks with the natural world. Placing society in his circuit diagrams required that institutions, nations, and cities be turned into compartments receiving and delivering flows. Components of ecosystems and societies could be united in the circuit diagrams, but they were also systems governed by the same general dynamics as ecosystems. For example, Odum developed a cybernetic model of the Vietnam war that was based on a model of mangrove dynamics (Figure 6). War is analogous to the disordering effects of a hurricane on the mangrove system. War, Odum thought, "would drain energy away from 'the maintenance of the structure of whole countries'" (Taylor 1988). In this comparison, we see Odum's willingness to place society inside of nature, but also to use natural system dynamics as a model of the social.

Odum's technocratic approach to the management of nature and society, although influential, especially in the field of ecological economics, became increasingly arcane. Abstract concepts like "emergy" and the "maximum power principle" were difficult to translate into practice. But this does not belie his influence. Odum re-awakened the impulse of the naturalist to assume the role of armchair sociologist. With his universal theory of energy flows, Odum — much like Spencer with his universal theory of evolution — was disposed to see the ecosystem as a microcosm of society, sans lake. He was also inclined to see society within the macrocosm, which was also figured as an ecosystem. Missing entirely from his approach is the possibility of seeing humans and their social arrangements within the purview of history, natural or social. In Odum's approach, the universality and flexibility of the model displaced natural history as the basis for knowing the world. Lured by abstraction, Odum had pulled Forbes' nature/society dualism into a new frame: the ecosystem as universal form.

In the historical linkages binding Forbes to Odum, the lacustrine microcosm shed the Spencerian social organism (with Hutchinson), gained biogeochemistry (with Hutchinson), morphed into the ecosystem (with Tansley), shed the lake (with Odum), revived armchair sociology (with Odum), and became the tool of technocracy (with Odum and Holling). This concrescence of ideas is the inheritance of adaptive management and resilience thinkers. And it is Lake Apopka's inheritance too. Of course, there are differences between Odum's and Holling's approaches. Resilience theory casts ecosystems as more elastic and unpredictable than Odum did and foregrounds the need for managers to cope with uncertainty and risk. Despite these differences, the technocratic vision is retained – one that counterposes nature and society as systems conjoined by feedback. And it is ultimately adaptive management's impoverished ontology of the social, an inheritance from Spencer, that has helped make the socio-ecological system into an anti-politics machine.

CONCLUSION: PATTERNS OF HYPEREUTROPHIC NATURECULTURE

Plantationocene economies of scale organize our lives and make us up in the flesh. In this chapter, I have used Plantationocene to name an historical process of exponential human growth and fecundity. This explosive growth is nourished by a biopolitics of agricultural intensification and expansion. I have used Lake Apopka as a site from which to view the situated emergence of the Green Revolution plantation and its surplus life. Within the factory-like arrangements of the vegetable field, the Zellwood plantations achieved scalability in the continuous throughput of chemical fertilizers. This throughput helped nourish the rapid growth in human numbers, but also the proliferation of ecology-shifting blooms of algae.

The Anthropocene is not just a time of outsized human disturbance (Tsing 2017) and warming climate, it is a crisis of eutrophication. The fertilization of the Earth has made humans weedy; and the spillover from our plantation has created troubling abundances in the world's waters too. Blooms of algae and blooms of humans are feral outcroppings made from the same biogeochemical stock. In hypereutrophic Lake Apopka, we encounter a microcosm in which the nineteenth-century story of progress has run its course; in its place, we confront the curse of growth. But we do not need to look for Man's image in the dynamics of algae blooms and gizzard shad to see the outsized human multitude. Instead, we just need to look at the edges of the lake. An aerial time lapse view of Lake Apopka from 1947 to 1990 would reveal a greening lake slowly colonized by sprawl.

After World War II, the revolutionary advances in agricultural production used to defeat the Axis powers were channeled toward the growth of a new suburban populace. As a spokesperson of the Florida Dehydration Company put it:

> We are not building a plant for war purposes only, but it is our intention to continue after the war and it is our belief that only a plant that is able to handle a large variety of materials will be able to do so. Besides this, an outlet for finished products must be had. In other words, a large sales organization,

and a knowledge of how to market dehydrated products (1943).

Farm boys turned soldiers returned from the war to become suburban homeowners. Many of these men were stationed in Florida and settled in the Sunshine State after the war, helping to spur a real-estate boom and realize the dreams of boosters. Air conditioning, the automobile, bulldozers, and the G.I. Bill materialized the new suburban matrix (Mormino 1996). The phosphorus apparatus, with a renewed focus on triple superphosphates, provided the biogeochemical basis for this economic and demographic takeover. What would it mean to study suburbanization as a feature of Plantationocene scalability?

The ability to "scale up" agricultural production, to make more and more food, is a hallmark of the Green Revolution. Scalability was achieved by a steadily amplification of nutrient flows. Fertilizer producers, farm owners, and the complex of food processors and distributers entered into alignments that turned rock into food and food into human bodies. Surpluses of cheap food transformed how we ate and what it meant to be American. The prefix *super-* in *supermarket* is a clue that scalability is at work at both the production and consumption ends of industrial food systems. Row upon row of identical can goods; dehydrated meal packets, soups, and spices; fresh fruit and vegetables heaped up like cannonballs: these items bear the signature of scalability's reach into the diet and bodies of the moderns. Novel subjectivities and affective attachments congeal around the supermarket. Consider the cliche of the coupon-clipping housewife, the class performance of shopping at Whole Foods, the thrill of buy-one-get-one-free. The supermarket is an inviolable social fact, so familiar it has been almost entirely overlooked by anthropologists. Attention to the scalability of food systems can make the supermarket strange.

Grappling with Plantationocene, I have anchored much of my analysis in World War II. World War II is widely recognized as a pivot point. In a 2007 article, Steffen et al. use World War II as the start date for what they term the Great Acceleration.[18] The Great Acceleration names the postwar trajectories of exponential social and environmental change. Steffen et al. give empirical and visual weight to this exponential change with a series of j-curve graphs. These graphs plot the accelerating rise of Anthropocene proliferations and Holocene losses. Graphs of fertilizer production and consumption; (urban) population growth; the number of McDonalds franchises; rates of biodiversity loss are accelerating phenomena that, when plotted, take on a j-curve shape. These j-curves have become iconic of the Great Acceleration.

What happens to our understanding of the Great Acceleration if we overlay and story these j-curves in relation to phosphorus and its stunning postwar amplifications? As a fertilizer scholar, I am tempted to propose a kindred term to conceptualize this transformative period: the Great Eutrophication. The Great Eutrophication names the historical process that generates weedy, plantation-fertilized lifeforms that swarm and degrade the Earth. These lifeforms are nonhuman and human. Thinking the world in terms of the Great Eutrophication I ask: Is the accelerated throughput of fertilizers flipping our planet from a Holocene to an

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[18] See also McNeill and Engelke 2014.

Anthropocene stability regime much like the pulse of phosphorus that transformed Lake Apopka? Might we see the lake's collapse, the suburban colonization of Florida, and the layered j-curved crises of the Anthropocene arising from the same tidal wave of industrial fertility? To answer in the affirmative is to give weight to Plantationocene as a theory of global crisis — one that places fertilizer, surplus life, and the trophic relations of the moderns as a root cause of a more-than-human holocaust.

One response to this holocaust from the perspective of systems ecology and U.S. environmentalism is restoration. Restoration rights the wrongs of industrialization. Yet it is a vision steeped in a fantasy of wilderness that splits nature from culture and erases histories of colonization. However, restoration ecologists do not deny that nature and culture mix. Observing Lake Apopka in the 1990s, there would have been no mistaking it as a natural and cultural space. The lake literally stank with those entanglements. And yet people held out hope that the lake might be purified of its polluting contact with (agri)culture, that phosphorus loading could be reversed, and that we could recover some semblance of Nature untouched. To recover nature untouched, however, created the paradox of touching the lake. Given the scale of environmental trouble across Florida, the state created special scientific institutions capable of managing and potentially reversing degradation. At Lake Apopka, water management districts used systems ecology to grasp the ecological complexity of the lake and generate knowledge (buffered from politics) that could be rationally used to extract the offending matter. Doing so would restore the proper separation between nature and society, even as it turned the lake into a cyborg.

As I conclude this chapter, I turn from the theoretical back to the concrete. Leaving the lacustrine microcosm and the Great Eutrophication behind, we take a final tour of Lake Apopka. The goal of this trip is to see what kind of nature Lake Apopka is becoming, now that it is being restored to its "natural" state. Hop in my car and let's go for a drive.

We turn onto Lust Road to access the newly opened Lake Apopka Wildlife Drive. The wildlife drive has been etched atop the 11-mile dike constructed by the Zellwood Drainage District. We look out onto the lake. Despite the decades of water quality improvement, Lake Apopka is still eutrophic: it has not switched back into a macrophyte dominated state, although patches of eelgrass are returning. The water color has improved and so has the odor. As the water quality of the lake has improved, alligators have become abundant and draw visitors by the carload.

We turn and look out at the expanse of former vegetable farms that are succeeding into wetlands. Native sawgrass ecology has not re-emerged. The plants are a mix of native and exotic and reflect the histories of fertilizer additions, agricultural disturbance, and restoration water levels in ways that are difficult to discern. Lake advocates are working to get the north shore restoration area officially designated as a bird sanctuary. Wading birds flocked to these anthropogenic wetlands. The possibility of attracting bird lovers is a primary impulse behind the wildlife drive. Eco-tourism will replace farming as a local economic engine, or so restoration proponents imagine. Partnering with the Disney Company, the Friends of Lake

Apopka — a local coalition of environmental advocates that spearheaded the state buyout of the farms — and the water management district have organized Birdapalooza. Birdapalaooza is an annual festival that features guided tours of Lake Apopka's birds, wildlife, and environmental history. When Angela Martin attended the first Birdapalooza, she complained to the tour guide about his characterization of the farmers as polluters. It is likely the tour guide told the following story: After the state buyout of the farmers, the water management district flooded the Zellwood farmlands and delighted as thousands of wading birds descended on the soggy fields. The birds had a feeding frenzy, but were eating from toxic pesticide hotspots that the district scientists did not know about. To their horror, the birds got sick and died in droves. One scientist told me of a wood stork she found frozen in paralysis. Day after day, she encountered the same poisoned bird, unmoved and starving from its perch.

The wildlife drive is designed as an eco-tourism attraction, but it is also part of the Lake Apopka Loop Trail. Cycling is a popular activity among a new class of affluent suburbanites who are settling Lake Apopka's southern shore; for them, the Loop Trail that encircles the lake is an attractive amenity. Unlike the poor agricultural town of Zellwood to the north, the small town of Winter Garden is flourishing. It has become a bedroom community to the city of Orlando, with renovated theaters and hip restaurants. On the outskirts of town is a New Urbanist subdivision with energy-efficient homes and walkable, kid-friendly streets. If you follow the shoreline you will also encounter the new luxury community of Bella Colina. The homes are a cross of McMansions and Italian villas. The actor-comedian Chris Tucker is one of the homeowners in the development. Running east-west and subtending these developments is Colonial Drive. Colonial Drive, aptly named, is where the multitude live, shop, and consume. In the aftermath of the 2008 recession, when I began my fieldwork at Lake Apopka, Colonial Drive bore the morphology of a boom geography gone bust. Platted subdivisions with roads, sidewalks, and storm drains sat empty, devoid of houses or construction. Nonfunctioning stoplights hovered over intersections that opened to empty fields where shopping-center development was halted. Today these subdivisions and shopping centers have been completed, and more are on the way. The Plantationocene economy is back to boom.

Let's return to our aerial time lapse of Lake Apopka from 1990 to the present. The forces of suburbanization are becoming even more intense; meanwhile, the lake is becoming less green. As the lake improves, there are new opportunities for recreation and lakefront development. As the audio tour for the wildlife drive describes: "It's the hope of the St. Johns River Water Management District that new recreational opportunities on this former farmland will not only improve Lake Apopka's water quality but also improve the quality of life for local residents, including a return of sport fishing, that will stimulate economic activity to fill the void when the farms were retired" (SJRWMD 2016).

We are children of the Plantationocene. Nature is our playground. The wealth and knowledge generated by our growth can make Holocene fragments whole.

Conclusion

The Pull of the Anthropocene: Pedagogies for a Multispecies Aikido

The moment of dominance, prayed for, worked for, sacrificed for, by generations of the noblest spirits, marks the turning point where the blessing passes into the curse. Some new principle of refreshment is required. — Alfred North Whitehead

One must always be aware, to notice—even though the cost of noticing is to become responsible. — Thylias Moss

Critique is a rant without a world. — attributed to Lauren Berlant

The Anthropocene is a terrifying, planet-warping basin of attraction. Can we collectively imagineer a way out of its grip?

I am fortunate to be able to write this conclusion in Florida as a postdoctoral fellow at the University of South Florida in Tampa. Florida is a state that I have learned to love, even as I grieve and fear its transformation. As part of my position, I taught Introduction to Cultural Anthropology. The first part of the class was organized around the familiar themes of the discipline — culture, race, power, sex/gender, kinship, etc. The second part focused on more-than-human approaches: multispecies, STS, world-systems theory, and the Anthropocene. The class demographics were a mix. The class had students from the Midwest, the Caribbean, Latin America, South Asia, and Ghana; a female basketball recruit from Denmark; Evangelical Christians; Muslims; ROTC recruits and veterans; non-traditional students; gays and lesbians.

And there were, of course, students from Florida, many of whom grew up in the area and whose parents worked for Disney, Publix, and the space industry. On the first day of class, I had the students tell a brief story about how they and their people came to live in Florida. Of the 45 students, only one student had grandparents who were born in Florida. Only one more had parents who were born in the state. The student whose grandparents were from Florida lived in the Bone Valley mining district and came from a long line of mullet fishermen. Her father owned a trucking company and contracted with Mosaic hauling phosphogypsum and other kinds of mining-related dirt. For the class period devoted to "anthropology of things," I asked students to bring in an object for a round of anthropological "show and tell." The young woman from Bone Valley brought in her mullet net and showed us how to cast it on the lawn outside the classroom.

Teaching this course was part of my job, but I also treated it as an occasion for ethnography. My "how I came to Florida" icebreaker gave me a window into who Floridians are and who they are becoming. Except for the net caster, the students were all recent migrants who knew little about Florida's history, politics, and ecological places.

As we entered the second half of the class and veered into nonhuman territory, I gave a handful of lectures that outlined my research. I discussed how colonialism and capitalism set in motion the Holocene/Anthropocene transition and gave rise to patchy landscape ecologies of weeds, ghosts, and remainders; I drew diagrams of the phosphorus apparatus and explained my theory of the Plantationocene, the Great

Eutrophication, and the crisis in human numbers; and I talked with them about Florida as a frontier geography and as space where human and nonhuman life are entangled and very much at stake. To my surprise, the lectures went over well: I anticipated (even hoped for) some pushback from conservative students. Whether my lectures rang true or not, no one denied that crisis was becoming the new ordinary.

I tell this story about my class, not to point out its successes but, rather, to acknowledge its unevenness. I encouraged my students to become curious about Holocene/Anthropocene landscapes. To help them appreciate arts of noticing (Tsing 2015), I took them on a "natureculture" walk on the University of South Florida campus. The University of South Florida is a beautiful campus in many regards, but it also partakes in design features that are iconic of Florida suburbanism. The campus is a maze of parking lots and empty lawns (where native ecosystems could be cultivated but are not). While the campus is pedestrian-friendly, the school is locked between two busy highways crowded with strip malls and chain stores.

As we walked, I asked them to pay attention to the parking lots and the lawns. On one hand, this was absurdist natural history; on the other hand, it focused their attention to the pervasive nonliving elements that are an enduring part of the landscape. It was just a short walk to our destination: a spindly nature area gouged by athletic fields, tennis courts, and more parking lots. This was our Holocene fragment. Lacing through the fragment is a running trail dotted with exercise stations. Because the nature patch is so small and such an irregular shape, the running trail folds in on itself like intestines. This nature area was a former scrubby flatwoods that has since succeeded into oak hammock due to fire suppression. Just outside the nature area is a chainlink fence. On one side is ordinary mowed lawn; on the other side, an athletic track where the university pole vaulting team was practicing. At this site, we conducted a quick, informal botanical survey. The students got the point of the exercise: the ecology of the athletic field consisted of a single species of highly manicured turf grass; the less-manicured lawn had many different plants growing among the turf. They also noticed how the fence inscribed two different lawn-making regimes that accorded with different university functions.

We moved into the remnant flatwoods. I showed them remnant pityopsis, prickly pear, and andropogon growing in the scrubbiest patch of the nature trail. It was hard to get them to notice or care about plants. We were a big group and many of the students wandered off into private conversations. But I wanted them to see this next thing, a ghost in the landscape: an abandoned gopher tortoise burrow. I raised my voice and made them gather round. When I found this burrow on my own, I couldn't believe it. This scrub patch was unbelievably small — just a few square yards or so. Yet here was a burrow, albeit the only one. The carapace-shaped entrance was still in good shape but the burrow's apron — the dirt dug up in front of the hole — was grown over with plants. Only recently was this burrow abandoned or its occupant vanquished, I conjectured. Despite the fuss I made, few students seemed to care about the gopher tortoise either. Some of the young women were irritated to be outside. Nevertheless, I persisted.

I pointed out wounded oaks colonized by fungi and saw palmetto overgrown with lack of fire; I pointed out the invasive rosary pea growing on the forest edge, sprouts of cogongrass, and Brazilian pepper; I pointed to the wall of vegetation made luxurious by the soccer field's irrigation system. We walked as a disorganized hoard, ignoring the exercise stations, and jumping from one section of trail to the next, circumventing the less interesting meanders. I blazed ahead, encouraging them to speed walk: there was something else I wanted them to see. We exited the nature trail and entered a different part of campus. We stepped over a concrete-laden ditch that ran along the road. We have to cross this Anthropocene stream, I said. We crossed the stream and the road to arrive at our final destination: an Anthropocene lake fed by the Anthropocene pond. I took the class to visit a retention pond. We walked around the pond. I pointed to the moorhens and their chicks and to the native purple aster successfully competing in the cattail fringe. We were approaching the end of class and students had begun to defect, leaving those who were sincerely committed to the exercise. The natureculture tour concluded as we contemplated a culvert that drained into an adjacent pond. As we stood there, I was attacked by fire ants — an invasive, biting ant from South America introduced to the Southeast in the 1930s. Disturbance-loving insects, they thrive in the path of bulldozers; they also thrived in the chemical disturbances of the USDA in their mission to eradicate the pest (Buhs 2004). I took off my shoes and socks and smashed ants against my bare legs and feet.

The tour was over. But a small group of students walked me back to the classroom. On our way back, we talked about environmental deregulation under Trump. We talked about how Scott Pruitt is gutting the EPA and the president of

Exxon is Secretary of State. For some of the students this was news. And in our conversation, I confessed that there was much I didn't know and much I did not want to know: many of the most important stories about this administration, I explained, were too emotionally difficult for me to follow. When it comes to dismantling of the EPA, the nuclear standoff with North Korea, the GOP Tax Plan, the assault on federal lands, the Keystone Pipeline, and the U.S.'s exit from the Paris Accord, I am an ostrich with my head in the sand. The current wave of ecological disfigurement is more than my soul can bear. We live in an age of anxiety, but also an age that gives us ground for legitimate feelings of hatred and despair. I can't blame my students for refusing the knowledge, thinking, and feeling that the Anthropocene asserts and the shape-shifting work that becoming responsible commands.

It was a rollercoaster of a semester. In addition to Hurricane Irma and the cyclones of the Trump administration, Tampa residents were tormented by a string of murders perpetrated by an individual characterized by the local police and media as a serial killer. Everyone, including me, needed a reprieve. I cancelled the final exam. In its place, I gave my students a new assignment, one that befits the applied focus of the USF Anthropology Department. I called the assignment "Other Worlds Are Possible." I asked the students to take the more-than-human anthropology we developed and imagine *something, anything* that might make a more just, verdant, and livable world. (I stole the MacArthur Foundation's slogan.) Students were encouraged to dream up multispecies "alternatives to our embeddedness in violence" (Rose 2004). In order to give them a sense of the assignment, I proposed my own intervention: the University of South Florida Institute for Suburban Agriculture and Dead Space Rewilding. The point of the institute, I explained, was to gently ween people off their attachments to the phosphorus apparatus, promote a multispecies politics of degrowth, and restore native ecology to parking lots, golf courses, and lawns. In order to foster phosphorus sustainability, the institute would encourage the spread of composting toils and the use of human excrement as a manure in their yards-turned-farms.

The students got the gist, but when it came time for them to imagine their own intervention they got stuck. The mullet fisherwoman, however, had an idea. She proposed that we eat the wild horses that have become an invasive presence in the American West. Once we eat up all the horses, we can restore buffalo to the prairie (also in need of restoration). But after re-wilding the buffalo, we might learn to eat them too. Her proposal captured the spirt of the assignment and I used it as springboard to talk about meat and meat-eating in the Anthropocene. I explained that more biomass is tied up in livestock than all wild animals combined. When we consider the environmental impacts of livestock production and the quality of life of the animals, might we imagine how we might move toward a meatless society. As soon as I said, "meatless society," the class erupted into a collective groan. Giving up meat was impossible, they said. The very thought unthinkable. Okay, okay, I said, then what about reducetarianism or more ethical meat eating, as with eating invasive horses? Another student spoke up and explained that her family in Cuba raises and eats guinea pigs. And couldn't we eat guinea pigs in the United States? she asked. What about insects, I rejoined, I am ready to eat insects! At the suggestion of eating horses, guinea pigs, and insects, a student broke into the conversation to say: can we please move on to another topic, this conversation is making me sick!

I share these stories from my classroom as a dispatch from the Florida Anthropocene, one year into the spectacular terror of the Trump Administration. All is not well with the world, and most of my students — smart, ordinary people who live in, contribute to, and inherit our regional Anthropocene — have few imaginative resources to draw upon in conceiving of alternatives. For many of them, the Florida Anthropocene is a comfortable place with nice beaches. For others, it is fraught with stress and precarity. For my students, the industrial mode of life is here to stay. Unsurprisingly, the “Other Worlds Are Possible” assignments were a disappointment, full of solar panels and techno-fixes that I explicitly discouraged them from proposing.

I point to this failure of imagination as a general symptom of what Heather Swanson, evoking Hannah Arendt, calls the “banality of the Anthropocene:” the inability to see, let alone imagine alternatives to, everyday forms of environmental violence (Swanson 2017).

Why is it easier to imagine the end of the Holocene than the end of capitalism? To me, the answer is obvious. The capitalist world-system is simply more powerful than the Holocene order of things. The Anthropocene revolution is well underway. Weaving through the bodies of the billions of humans and their Plantationocene companions are so many ordinary inertias that all but guarantee that

Earth will plunge into a total Anthropocene attractor. The Holocene, its ecologies, its peoples, and its stabilities will likely be lost forever. Unlike Lake Apopka, there is no guarantee that this forward switch will be stable. Indeed, it is likely to be a chaotic attractor, fraught by climatic flux, food panics, disease outbreaks, and war. Anthropocene dystopias are already being lived and the groundwork for more continues to expand. This groundwork for expansion is what both parties in the United States champion as economic growth. When the only political position is growth, I better understand my students' imaginative shortcomings and their lack of optimism for the future.

This lack of optimism, however, is not the same thing as pessimism. Pessimism dwells in impossibility. A lack of optimism suggests an ambivalence about currently available options. I too am ambivalent about mainstream political imaginaries, especially on the left. The intellectual and imaginative failures of the left, in my opinion, are startling. The Democratic Party, like the GOP, is transfixed by growth. And most leftists, even the most radical, are transfixed by humanism — the biopolitical project of massifying the quantity and quality of human life. Industrialism is an epoch-killing force. Humanism, as a freedom project, depends on industrial wealth and is measured in terms of people's access to that wealth. For anthropologists, so committed to the human, the lethal force of humanism has been difficult to see. Humanism has taught us to champion the subaltern without questioning what should count as the prize. Now that the Holocene has become subaltern, should we reward the Earth with more industrialism? The answer for me is a resounding *No!*

How to refuse industrialism and stay committed to human freedom. That is the question. I don't have answers, but I do have intuitions. I also trust the recent turns in our discipline. With the multispecies and, now, geological turn in anthropology, our discipline is advancing new structural imaginations that may help us resist the pull of growth, industrial humanism, and the Anthropocene. The time for dithering is over: we must pursue alternative political realities with daring. This daring can and should begin in universities. It must infect the classroom, the campus, and the administration with the goal of transforming the whole assemblage into a livable landscape (Wright 2017). In crafting this university and its attendant anti-Anthropocene politics, we on the left must eventually reach out to those on right, strategically and carefully, in the spirit of refreshment and mutual aid. This will not be easy and we will likely lose. Despite the odds, we cannot relinquish the imperative to be daring with our thinking, our pedagogies, and our modes of creating universities. I conclude with a desideratum.

What we need is a new social movement, akin to and aligned with civil rights and indigenous movements, that wages multispecies peace and places the industrial mode of life in its sights.

What we need is a revitalized bioregionalism that places more and more people (who, in aggregate, become fewer and fewer) in agro-ecological relation with Holocene landscapes, both remnant and restored.

What we need is for the moderns to become unmodern, to dismantle their *monsters, and co-invent a humbler path of anthropogenesis that gives our wounded Earth a chance to heal.*

What we need is a multispecies aikido: arts of bending Anthropocene forces into their own undoing.

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