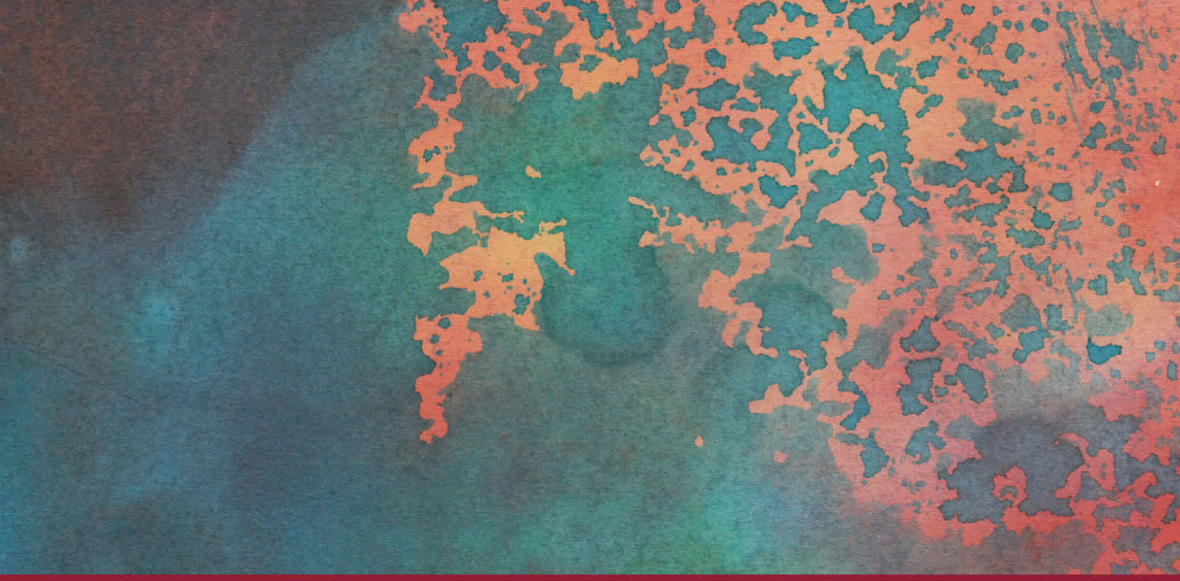
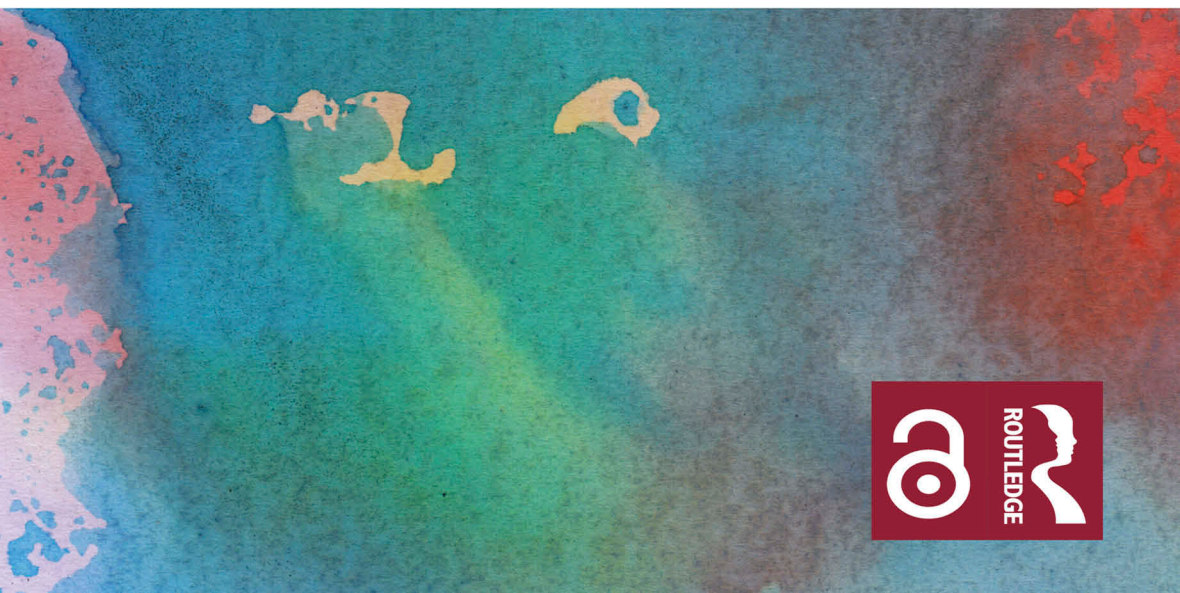


Routledge Environmental History

A GLOBAL ENVIRONMENTAL HISTORY OF COASTAL DUNES

Joana Gaspar de Freitas



A Global Environmental History of Coastal Dunes

This book provides a holistic perspective on coastal dunes, highlighting new insights into present-day challenges to show that narratives, along with numbers, graphics, and computer models, have a role to play in climate change science, policymaking, and citizenship awareness.

Adopting a cross-disciplinary approach, this book combines fiction, history, and science, to discuss past, present, and future ways of living in coastal areas. Dunes are hybrid environments, a combination of natural elements and human agency; they tell stories of values, traditional wisdom, institutions, empires, technology, vulnerabilities, coastal management, adaptation, and sustainability. Drawing on the past, Joana Gaspar de Freitas unpacks a diverse and fascinating history of dunes, linking knowledge, methods, and approaches from several case studies across the world, including France, Portugal, Brazil, Mozambique, New Zealand, USA, and the UK. The book connects the bio geophysics of global change with the main driver of transformation—human agency—to integrate and address nature-society issues, taking human and nonhuman agents into account. In following the choices, paths, and strategies that created today's coastal landscapes, the book generates greater awareness and understanding of how to shape coastal futures.

This is an engaging, original, and, fundamentally, important book that fills a gap in our knowledge of cities, infrastructure, economies, and cultures built on shorelines. A key read for scholars, researchers, and students in environmental history, environmental science, sustainability, coastal land management, and climate change.

Joana Gaspar de Freitas is an environmental historian at the Center for History, in the School of Arts and Humanities, at the University of Lisbon, Portugal. She has held fellowships at the Rachel Carson Center (Munich, 2015), the Linda Hall Library (Kansas City, 2014), and the Instituto de Estudos de Literatura e Tradição (Lisbon, 2011–2018). Between 2018 and 2024, she was the principal investigator of the project "Sea, Sand and People: An Environmental History of Coastal Dunes" (2018–2024), funded by an ERC Starting Grant. She is currently one of the editors of the journal *Coastal Studies and Society*.

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A Global Environmental History of Coastal Dunes
Joana Gaspar de Freitas

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A Global Environmental History of Coastal Dunes

Joana Gaspar de Freitas

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Nature always finds a way. I will find mine, my way.

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It is impossible to thank everyone who has contributed to this book in some way, sharing knowledge, providing references, guiding me through archives and dunes, reading my drafts, laughing at my ideas, listening, or hugging me in times of despair. I will do my best to name a few, regretting not being able to tell the stories that connect me to each person mentioned here.

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Abbreviations

ADG	Archives Départementales de la Gironde (France)
AMA	Archive Municipale de Arcachon (France)
AICNF	Arquivo do Instituto de Conservação da Natureza e Florestas (Portugal)
AHM	Arquivo Histórico de Moçambique
AHU	Arquivo Histórico Ultramarino (Portugal)
ANTT	Arquivo Nacional Torre do Tombo (Portugal)
BISA	Biblioteca do Instituto Superior de Agronomia (Portugal)
BNP	Biblioteca Nacional de Portugal
BNF	Bibliothèque Nationale de France
LHL	Linda Hall Library (US)
NARA-CP	National Archives and Records Administration—College Park (US)
NARA-WDC	National Archive and Records Administration—Washington DC (US)
NHA	Noord-Hollands Archief (The Netherlands)
NAKG	The National Archives—Kew Gardens (UK)

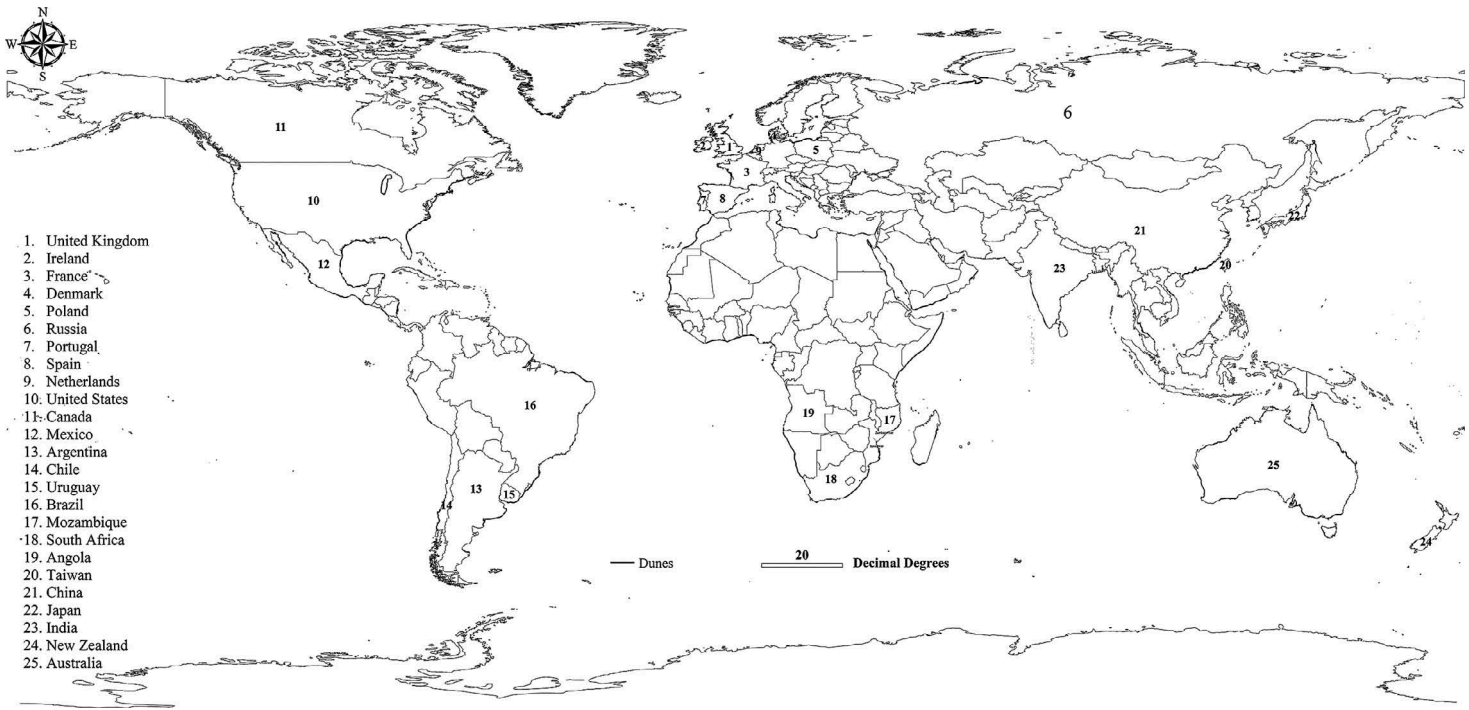

Figure 0.1 World map with the countries referred to in the book
Source: Map by D.M.R. Sampath

Preface

A path through the dunes

The singularity of being a historian of dunes

"I'm a historian who studies coastal sand dunes." This is how I introduce myself in talks, conferences, lectures, and classes. I do so because I am a historian, by heart and training, but my research topic traditionally belongs to the natural sciences, which often confuses people. Such confusion is particularly evident on the faces of the scientists and wannabe scientists who attend a conference presentation to hear about dunes, only to discover a historian talking about them. Meanwhile, audiences composed of historians and future historians find my fascination with dunes bizarre: after all, what is interesting about big piles of sand?

I have dealt with this feeling of doing something eccentric for many years. In 2002, when I was pursuing a Master's in Contemporary History, I came across an open call for a research position on a project called DATACOAST: Diachronic Analysis of Small Climatic Oscillations with Impact on the Coastal Zone—Natural and Anthropogenic Impacts. Apart from long summer holidays spent on the beach, I knew little about coasts at the time. However, I had taken some classes in archaeology during my history degree, and I remembered learning that coastlines had shifted over millennia due to sea-level fluctuations associated with glacial and interglacial periods. Prehistoric communities adapted to these changing environments by exploiting different resources in intertidal waters and estuaries. Despite lacking prior experience, I needed a job, so I applied. Needless to say, I got it.

I spent the next two years trying to finish my Master's thesis on political history while combing nineteenth and twentieth century newspapers at the National Library of Portugal for information on coastal areas. The DATACOAST project sought to bring together history, archaeology, geology, climatology, and biology to study the evolution of the Portuguese coast, highlighting the interaction between land, sea, climate, and people. It was an innovative interdisciplinary approach to coastal zone research in Portugal.

Being part of such a project gave me specific knowledge of how natural coastal systems work, and of the methods and tools used in environmental studies. I also met then the person who would teach me almost everything that I know about coasts: Professor João Alveirinho Dias, who later became my PhD co-advisor. He was the first of the many scientists I have had the privilege of working with. Most importantly, it was while I was involved in the DATACOAST project that I discovered my paper dunes!

According to Anna Tsing (2015), unpredictable encounters change us. I had seen dunes many times before, of course. Still, I did not expect to find them in the archives. On one of those many days in the National Library, when I was scouring nineteenth century newspapers for information on coastal erosion and sea flooding, I read that populations were more afraid of sand than they were of the sea. I remember asking myself, "Sand? What's the problem with sand?" Little did I know, this question would set me off on a quest to understand more about coastal sand dunes and the people who live near them. A quest that has taken me around the world, physically and virtually, on a journey through time to collect local stories about dunes and people and connect them with current global coastal management challenges.

Why write such a history?

I started my career as a biographer of the first elected president of the Portuguese Republic, Manuel de Arriaga. Now, I tell stories of dunes to show that dunes have a history. For a historian, it is strange to write about dunes. How do I commit to paper a flowing landform that spans so many geographies and time scales, and which is so deeply entangled with human life? As the abundance of work on rivers attests, I am hardly the first to attempt to address the fluidity of materials and landscapes.[1] Rivers, as both things and processes in and across time, share many similarities with dunes. Like water, sand infiltrates text and easily overflows scholarship. Dunes, like rivers, can only be approached by stretching our minds and imaginations. Dunes and rivers are not singularities, but multiplicities made up of trillions of particles and shaped by the ever-changing forces, processes, and beings of earth's unpredictable and complex systems.

One might be tempted to dismiss dunes as much ado about nothing. After all, what relevance can ignored things like a sand dune have in a world that thinks globally across continents and oceans, countries and nations, people and cultures? Tom Cohen's work (2019, 1–15) on the big issues and the small things of history is deeply inspiring. The big issues of history, Cohen explained, are political and economic systems, religions, empires, institutions, revolutions, influential people, and technological innovations. Big things are phenomena of weight and lasting importance that set the stage for smaller things to happen. These are the forgotten, unknown, and unvoiced figures, places, and events that have barely left a mark on history—the dust of the historical record. A grain of sand is nothing. "What is the sense of looking

hard at something of no consequence?" Cohen asks. The answer, he concludes, is "completeness, connections, the boundaries of normal." Completeness provides the details, rather like DNA sequencing. Connections establish the links between the local and global, between small and large trends. The boundaries of normal evoke strangeness—the salt of the narrative. As Cohen noted, strangeness and oddity contain elements of the normal, but also confront it. Strangeness challenges values, institutions, and principles. Liberating action and thought, it tests the normal and defines its limits (Cohen 2019, 6–7). This is why I like dunes so much. They are a strange subject in the humanities and while scientists know them well, they are not used to reading stories about dunes. As oddities, dunes challenge the way we see the world. They were sites of legend and mystery. They were once dreaded as a destructive force that threatened communities and livelihoods. In the past, they were fought, stabilized, and turned into green forests. They are now seen as natural resources, important ecosystems, coastal defenses. Dunes are complex and contradictory phenomena: while they give hope, they also create false expectations. The multiplicity of dunes allows us to explore a variety of issues, including perceptions, fears, values, traditional knowledge, resources, local economies, property, land reclamation, state power, risks and vulnerabilities, climate change, coastal management, and nature restoration policies.

Dunes are an example of the traditional declension narratives of colonial resource exploitation and landscape transformation. They have much to say about the arrogant desire to fix the world and narrow view of it as an ecosystem services provider. But, dunes are also the inspiration for various works of literature, cinema, music, and art. Dunes bind people to a sense of place and common purpose, as shown by the campaigns organized to protect them. Actions, books, movies, and songs heighten emotion, affection, and care for these natural phenomena. Dunes are a place of encounters, where species and things meet, as Anna Tsing (2015) observed in reference to trees and mushrooms. Dunes help us feel that the planet, humans, and the more-than-human are bound together in a perpetual cycle to ensure the continuity of life. Dunes are fluid, creative tools for thinking about the future of coasts and the people living on coasts.

Like the German historian Joachim Radkau, I believe that environmental history is a fundamental tool for critical thinking, for analyzing and discerning between political and economic agendas or other major fashionable trends (Corona 2009). Environmental history can inform coastal management by broadening temporal horizons, explaining general and particular conditions, and scaling-up from the local to global contexts or vice versa (Freitas 2020). Using history to observe "the accidental chain of events that led us here" allows for a long-term, multi-perspective view of human–nature relations, expanding the ability to see possible futures, alternative paths, and opportunities not yet considered or even dreamed of (Harari 2017, 68–69). This is crucial because the future is not yet written (McNeill 2011, 356); it is in the making.

DUNES in book format

This book was made possible by a European Research Council grant (no. 802918) that funded the project *DUNES: Sea, Sand, People*. For five and a half years (2018–2024), a team of researchers of different nationalities and backgrounds spent their days learning, laughing, discussing, and producing new insights about dunes at the School of Arts and Humanities of the University of Lisbon. Several researchers from different parts of the world joined us over the course of the project, which began as an individual venture before expanding into a collective international experience. Reflecting on the knowledge produced by DUNES, this book is an effort to link and make meaning of the individual case studies that provided the basis of the papers published by the team and some invited colleagues.

This book seeks to explain how dunes fit into the Anthropocene. This is a daunting task, as it requires covering many centuries, geographies, cultures, and ecosystems. A large part of this narrative is about Europe and regions once under the aegis of the Iberian and British empires. This book does not grant equal attention to each place, with some recurring through the text in detail, and others appearing only briefly. This is because my topic of interest is more predominant in some areas than others. After starting in Europe—namely, the Netherlands, France, the United Kingdom, Denmark, Spain, and Portugal—this book follows imperial networks and the connections therein, mostly tracing the history of dunes across the United States, South Africa, Mozambique, Australia, and New Zealand. This book covers other areas of the globe as well, as the map (Figure 0.1) shows, in order to provide a general overview, introduce different perspectives, and make broad comparisons. As dunes exist almost everywhere on the planet, finding information is hardly difficult and many other stories could have been told.

Decisions regarding which locations, people, events, sources, and references to include in this book reflect my own knowledge and time limitations. I gave preference to places I knew or had more data about, and to historical sources and literature written in languages I could read and access. For instance, since the beginning of the project, I have been searching for a case study in Asia. Although many Asian countries have coastal dunes, I was not aware of any that had significant problems with sand in the past or made significant efforts to stabilize them using vegetation. As a historian, primary sources are essential for my work and, in the case of Asian countries (e.g., Japan, China, and India), language is an almost insurmountable barrier to archival research. There are scientific studies on coastal forests and wind-blown sand, but these are relatively recent, with little information on the more distant past. Meanwhile, the little data I have managed to find on Asian dunes come mainly from secondary literature, such as a paper explaining how deforestation on Kinmen Island, Taiwan, since the thirteenth century produced a barren sandy environment and the burying of several villages in the seventeenth century (Tsai 2003). Another examines the Fujian region of southeastern China,

where historical evidence indicates the occurrence of natural disasters related to moving sands during the Ming Dynasty between the fourteenth and seventeenth centuries (Hu et al. 2022). Conrad Totman (1989, 1985), an expert on Japanese history, also wrote about the sand forests of the archipelago, some of which were planted in the seventeenth century, including the Nijinomatsubara Forest. Nonetheless, I decided to exclude Japan, Taiwan, and China from this book because I was unable to access and read Japanese and Chinese primary sources, and I had no way to establish the origins and context of local sand drift and sand afforestation knowledge and practices.

Historical sources presented a similar challenge for several other countries, like Mozambique and New Zealand. While I aimed to offer plurality and move beyond the European worldview, the information I had largely pertained to European contexts. Such sources tend to take an official institutional perspective and often present biased opinions on local ways of knowing. To address this problem, Sujit Sivasundaram suggests looking for alternatives by prioritizing non-European sources and other types of historical records (Sivasundaram 2010). However, in my experience, this is not always feasible. When possible, using oral tradition and archaeological evidence, collaborating with colleagues working on the ground, reading the available sources against the grain, and seeking out other points of view—especially in terms of those, human and non-human, without a (direct) voice in the archive—helped overcome some of the research limitations. The proactive pursuit of an approach that involves "revisiting what we think we know and actively listening for what has been silenced," which often leads to unlearning our ways of doing things (Soto Laveaga 2020, 441, 446) or adopting new ones, was essential to mitigate bias, lack of material, and personal constraints. Traveling to sites and archives made it possible to meet people who were generous in sharing their views and experiences of history, beaches, dunes, and life in general. These encounters humbled me. As I became aware of other realities, expanded my ideas, and reevaluated my opinions, I came to recognize how I have yet to master many of the issues I deal with here.

As a historian, I am bound to produce true histories. However, the past, like the present, can be interpreted through multiple lenses and explained in various forms. This book offers my own interpretation of dunes and their entanglements, with narrative choices rooted in my experiences. While I have generally opted for a chronological narration, there are some instances where nonlinear progression is more suited. Although, as Steve Mentz (2020) observes in *Ocean*, this produces messier historical accounts, it is more appropriate for the fluid, sandy subject of this book, particularly insofar as it deals with different places and times. As such, some stories run parallel in time, while others move back and forth. This book, like my wanderings on the sand, is canon free—an experimental work[2] interweaving historical narrative, scientific analysis, and self-reflection. The result is a patchwork of chapters shaped by my relationship with the subject, the source materials, the surprises and pitfalls of research, and the choices and doubts that troubled me as a historian and an individual.

Notes

1 Some of these ideas about rivers were discussed in an online lecture by James Scott (Feb. 2021), organized by the York University: https://niche-canada.org/2021/02/28/james-scott-how-to-write-like-a-river/
2 I am not the first to do this; Robert Rosenstone (1992) has authored an excellent paper on this issue, while Tom Cohen's (2019) work is particularly insightful for writing history from a fresh perspective.

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1 Pulling the dunes out of the archives

Sand dunes?! What are sand dunes?

For most people, dunes are simply an extension of the beach—piles of sand with patches of vegetation blowing freely with the wind—a desolate arid landscape to some, an extraordinary, wild scenery to others. More scientifically, they are referred to as, "aeolian landforms that develop in coastal situations where an ample supply of loose, sand-seized sediment is available to be transported inland by ambient winds" (Martínez, Psuty, and Lubke 2004, 3). There are multiple dune systems, with local conditions dictating dune type (e.g., crescentic, parabolic, linear, star), form and dimension, vegetation, and stability or mobility. Although I use the generalization and collectively refer to them as "dunes," they are actually diverse and unique, like fingerprints.

Dunes may seem like little more than mountains of sand, but there is much to say about these windblown landforms. Indeed, even after years of study, I still find myself amazed by how remarkable they are. Coastal sand dunes are formed by a particular combination of processes working together, the perfect confluence of elements and forces. Longshore drift, tides, and waves bring sand to the beach. From there, many factors play a role in the transport of the sand to form the dunes. Few people standing on the shore on a sunny day are aware of the ideal grain size of the sand (0.625–2 millimeters) or the characteristics of the rock particles needed, plus the mechanical energy expended between the wind and the terrain surface, for a sudden gust or a steady breeze to lift and carry the sand. How many people know that the right balance between wind speed, atmospheric humidity, temperature, surface slope, and the biotic crusts (mosses, lichens, fungi, and other organisms that hold the sediments together) is crucial to setting the sand in motion? And that, once lifted by the wind, sand moves like a living creature through creeping, reptation, saltation, and suspension (Warren 2013)? Geologists know this, of course. However, there are so many variables involved in dune formation and evolution that few can presume to understand them all. Vegetation also plays a determinant role in the process. Plants adapted to this specific environment form obstacles to the wind and trap sand around their stems, contributing to sediment accretion and growth, creating embryo dunes and foredunes—that is, the parallel ridges that develop along the beach (Warren

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2013). Vegetation influences the mobility and stability of the dunes: unvegetated or only partly vegetated dunes are active or semi-stabilized, while dunes covered by vegetation are stable and less prone to shifting (Robin et al. 2023). The complex interplay between these geomorphological forces and ecological processes explains the fluidity and singularity of the morphology and function of these systems (Doody 2013). Wallace Kaufman and Orrin Pilkey (1979), a conservationist and marine geologist, respectively, liken the constant rising, falling, and marching of the dunes to whales swimming beneath the sand. Such a comparison reminds me of the sandworms in Frank Herbert's *Dune* (2005), the giant beasts that live under the sand creating waves on the surface as they move to attack any creature that dares to tread on their domain.

Located at the interface between the sea and the land, coastal dunes are unique dynamic ecosystems found in almost all latitudes, in cold, temperate, and tropical regions. Dunes have multiple environmental functions—their special features are the source of landscape and species diversity. Indeed, the harsh environmental conditions of dunes—soil mobility, temperature extremes, salinity, and lack of fresh water and nutrients—have resulted in the strong specialization of their flora and fauna. Dunes also play an important role in the coastal sand-sharing system, in which the dunes, beach, and offshore bars actively store, release, and exchange sand with one another in response to energetic events; this way dissipating storm wave energy and minimizing its effects on landward areas (O'Connell 2008; Martínez, Psuty, and Lubke 2004; Psuty 2004; Psuty and Ofiara 2002). Dunes also provide services such as carbon sequestration, pollutant filtration, and water purification. They support a wide range of socioeconomic activities, providing livelihoods for local populations (food, fuel, medicine), raw materials (sand), recreational uses (housing, resorts, leisure, and sports), as well as aesthetic, psychological, and therapeutic opportunities (Nordstrom 2008). Given their intrinsic value and the goods and services they offer, dunes are considered highly relevant ecosystems.

Interest in dunes burgeoned following the publication of British explorer Ralph Bagnold's (1941) seminal work, *The Physics of Blown Sand and Desert Dunes*. Over the last few decades, scientific research on coastal dunes produced an abundance of literature. In an attempt to understand the processes and functions of coastal dunes, scientists have collected data on geomorphology, plant community dynamics, ecophysiology, biotic interactions, environmental problems, and conservation issues. Scholars have made significant efforts to develop an integrated approach to these systems, highlighting the need to include local stakeholders in coastal management (Martínez, Maun, and Psuty 2004). However, something is missing from this picture, namely, the other factors that shape dunes.

Exploring the dunes in the archives

Over the years, I have become fascinated by these massive bodies of grains of sand. The dunes I discovered in the archives reveal something not immediately apparent to those who see them or study their physical and ecological

aspects: dunes are hybrid environments. Formed over millennia, they are the products of the interplay between natural material processes within socio-historical contexts (Greer et al. 2018). Human things and practices are so deeply embedded in coastal areas that social, cultural, and symbolic dimensions define these landscapes as much as their oceanographic, geomorphological, sedimentological, and ecological features (Schama 1995; Arruda 2011; Freitas and Dias 2015). Finding the paper dunes made me realize that dunes can be examined in new ways, opening up diverse opportunities to learn from them.

During fieldwork, scientists observe, measure, and evaluate the dunes, examining them as a dynamic environment born from the encounter between the sea, the sand, the wind, and the vegetation. In the archives, I found evidence of all these natural elements, as well as of the human bodies, knowledge, institutions, practices, and technologies that have molded the dunes over the centuries. Parish registers, official reports, laws, personal memories, newspapers, maps, and photographs tell the unknown stories of the dunes. In her work on the beaches of California, Elsa Devienne, who I met at a conference in Lorient in December 2021, sought to uncover the "invisible history of a hybrid landscape" (Devienne 2021). The history of the dunes is also invisible because they have been largely ignored. As Isaac Land, Robert James, and I have discussed in an editorial for *Coastal Studies and Society*, some coastal

Figure 1.1 Fieldwork: looking for paper dunes in the archives, 2022
Source: Photo by J.G. Freitas

environments—such as sandy tracts and shallow waters—are overlooked or disparaged because of their ubiquity, unstable nature, ambiguous function, and marginal location (Freitas, James, and Land 2021). Lacking any of the glamor of beaches and the ocean, dunes fit this description perfectly. As Gavin Bridge (2021) noted in *Thinking with the Grain*, social histories and geographies of sand "have not ranked among the elemental stories through which we have come to know the Anthropocene." Writing about life in the Bering Strait, Bathsheba Demuth (2019) observed that there is not *a* story about modernity, but many—the ice, the whales, and the tundra all providing different insights. In this respect, the stories of dunes can also invite us to ponder universal questions about humanity and the environment (Somerville 2020).

The more I look into the history of the dunes, the more I see that they are made up of so many different forces, beings, things, and convergences—from the sea, wind, sand, and vegetation, to bodies, perceptions, values, knowledge, politics, fences, and bulldozers. The paper dunes of the archives have much to say about the many lives and meanings of the physical dunes, and yet so much more about people. Not so long ago, dunes were typically regarded as dangerous, as dreadful environments and places of fear. In many countries, the wind blew dune sand inland, covering agricultural fields, farmhouses, and villages, forcing communities to abandon their homes and land. Windblown sand silted harbors and river mouths, making navigation difficult if not impossible, creating wetlands considered the cause of miasmas and disease. Historical documents reporting these problems described the dunes as a threat that had to be fought and eliminated. In the nineteenth and twentieth centuries, various governments, local authorities, and private individuals promoted costly land reclamation schemes to stabilize the shifting sands, limiting or preventing their movements with the use of fences, grasses, and trees. In doing so, they sought to transform the dunes into green forests, mitigating the risk while improving the landscape and making it profitable.

This history can be explored in so many ways and seen through so many lenses. The shifting sands know no borders. The process of large-scale sand stabilization spread through Europe to span the globe, with similar initiatives undertaken in the Americas, Africa, and Oceania. As empires colonized new territories, the creation of settlements, extraction of resources, and introduction of new agricultural techniques caused dune instability and sand drift. Practices to solve the problem were disseminated through imperial networks, shaping new coastal environments. Expertise and knowledge about dune stabilization travelled from Portugal to Angola and Mozambique, and through the web of the British Empire to the United States, South Africa, Australia, and New Zealand. As such, the history of dunes is connected to and enables the exploration of other histories, including those of nation-state building, land reclamation, resource exploitation, institutions, experts, and the circulation of information, people, and species.

The domestication of the dunes was also a step forward in the transformation of beaches into more desirable spaces. Attitudes toward the coast began changing in the nineteenth century. Rather than a place to be avoided, the seashore became a playground for elites, who had discovered the therapeutic benefits of bathing in the sea. According to John Gillis, "in the Western tradition, the sea has always been an alien environment" (Gillis 2012, 7). This perception changed drastically in the twentieth century, as people moved to the littoral, cities grew up along the coastline, and a house with a "sea view" became a major social aspiration. The concentration of populations and infrastructure on the seashore, together with the construction of large dams on the main rivers and other hard engineering works, disrupted the sand transport cycle and upset the precarious equilibrium of coastal areas. In many cases, the coastline—the imaginary frontier between the mighty ocean and the civilized land—is little more than a narrow strip of sandy beach and dunes. It is this liminal territory that protects human infrastructure and livelihoods from rising waters and storm surges. In recent decades, the conservation of beaches and dunes has become a global priority through a host of legal protections and institutions. Beaches threatened by erosion are replenished with sediment from elsewhere, bulldozers are used to rebuild lost dunes, and hard engineering structures are established to trap sand. These actions are driven by economic, political, social, and cultural values, which have changed significantly over the last century.

Building bridges, filling the gaps

I have read a lot about beach–dune systems over the past few years, learning about their morphology, ecological processes, conservation, protection, enhancement, and uses. That said, I am not a scientific expert in these matters, but a historian. This makes a difference to what I can bring to the table. In my reading, I have noted some research gaps. For instance, Karl Nordstrom, a leading expert on dune management, has called for further studies to document the feasibility of alternatives for restoring coastal systems in respect to their long-term impacts. According to Nordstrom, the problem lies in the lack of funding for longitudinal studies, which means that cumulative effects are not well documented (Nordstrom 2008, 141–144). However, this is not entirely correct. Archives and historical sources are replete with information about the trial and error of past interventions in dune management, including proposals, initiatives, feedback, successes, and failures. Another example can be found in *Coastal Dunes: Ecology and Conservation* (Martínez and Psuty 2004). Bringing together the contributions of numerous dune specialists, *Coastal Dunes* underscores the need to develop an international long-term strategy for coastal management, involve all stakeholders in decision-making processes, and promote the international exchange of information and expertise. Focused on the present and future, these suggestions are based on the scientific knowledge about dunes established in the latter half of the twentieth century. However, coastal management and the international exchange of information on dunes have centuries of history, one rarely acknowledged.

There is more to it, of course. Coastal dune restoration projects are extremely complex, with many goals, facets, and mechanisms, some of which are in conflict. While the dunes are at the core of such projects, the drivers of change are human (Martínez, Gallego-Fernandez, and Hesp 2013). However, the political, economic, and cultural contexts and decision-making processes behind such initiatives are not well known, especially for those undertaken before the twentieth century. There are many gaps, not so much in the science of dunes, but in the history of dunes. Looking at contemporary dune management, it seems that initiatives are constantly undoing and repeating what has been done before, much like Penelope's weaving and unweaving of the shroud in the *Odyssey*. This has great socioeconomic costs. Scientists and authorities often miss these long-term entanglements because there are not enough local and global studies linking current and past dune management values, strategies, actions, and unattended consequences. This is what I can bring. After all, the role of a historian involves unearthing information from past experiences, so that the results and lessons of history can provide insights to address today's challenges.

People and dunes have influenced each other's stories. Writing their common history is both a personal challenge and a professional risk. The object of history as a discipline has traditionally been humans and their actions. A dune is not an entity, but an assembly of many things. What does it mean for history—in terms of its methods, scope, practice, and stakes—to have a nonhuman object? The anthropologist Eduardo Kohn reflected on this matter in his own discipline when he wrote about how forests think. According to Kohn (2013, 15), going "beyond the human is in large part about learning to appreciate how the human is also the product of that which lies beyond human contexts." The unsettled sands have certainly changed my own path. Will they also unsettle the boundaries of my discipline, or is this simply a case of much ado about almost nothing? Perhaps, but I like to think of dunes as an opportunity for creative dissent. The absence of a body or physical established demarcations combined with their instability and mobility makes dunes transgressive phenomena that cross geographical, political, social, and cultural domains. With their impossible limits, they symbolize porosity and fluidity, undermining confidence in grounded beliefs and values. Dunes are the antithesis of fixity, rigidity, constancy. They can evoke ambivalent feelings of dread and fear, surprise, wonder, and hope (Nieuwenhuis and Nassar 2020). Their radical and disruptive potential can and should be used to advance critical thinking.

Dune stories are simultaneously local and global in scope, both micro-histories and worldwide issues. They are small things that help explain big ones—ideas, empires, nations, institutions—and how they change over time. Dunes can be used to explore the impact of domestic places and unknown people over the course of history (Cohen 2019). Dunes bridge scientific and humanistic approaches. Thus, I view them as a strange and surprising way to stir the academic waters, transgress into different fields, mix concepts, merge ideas, and integrate history into environmental debates and policymaking. In

this book, I seek to combine what is known about these complex environmental, technical, and cultural systems and promote fluid thinking about possible sustainable ways of living with the flowing coasts of the Anthropocene. This is also a personal response to a comment I have heard all too often about my profession: "History? Urghhh! What's the use of that?" Dunes are my "slow hope", my alternative stories (Mauch 2019), a way to rethink life positively in times of crisis and fear.

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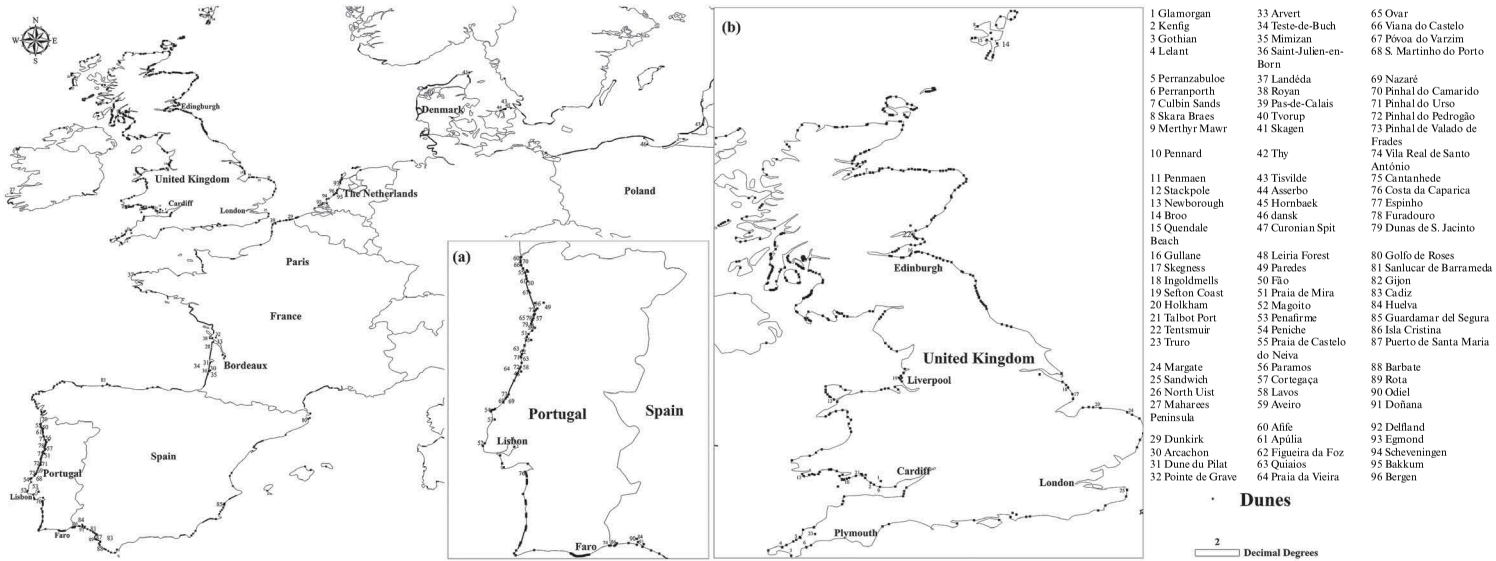

Figure 2.1 Map of Europe with the location of the regions and places mentioned
Source: Map by D.M.R. Sampath

2 The moving dunes

At the end of the lands, a visit to an emblematic place

On a cold February morning, we found ourselves in front of the Basilique de Notre-Dame-de-la-fin-des-Terres, that is, the Basilica of Our Lady of the End-of-the-Lands, a gray church on the southwestern coast of France. Located in a large open area in the village of Soulac-sur-Mer, the church is an impressive building, less so for its size and architectural features than for what it means to me. How many years have passed since I first read about the place? Five? Eight? Too many for sure… Nevertheless, that chilly day, I found myself gazing upon the building alongside my colleague, Ignacio García-Pereda. We walked around the building while waiting for the custodian. According to the schedule posted on the church door, the person was late. During our wandering, we noticed a bricked up arch on the right side of the edifice, and its back windows half buried in the ground—a sign that both the landscape and the building had changed over the centuries. Finally, the custodian arrived and we were able to enter the church. The interior was dimly lit and cozy. To our surprise, the nave was on a level lower, which meant that we had to descend some stairs to reach the main body of the structure. There, among the religious objects, we found several stone plaques bearing the records of the church—a story that should not be forgotten.

Why did we travel so far from Lisbon to see this church? The answer is simple: it is an iconic site. Built in the 1200s, the church was swallowed by dunes in the eighteenth century. For years, the local population fought unsuccessfully to save the basilica, eventually abandoning it to the sandhills in 1744. Only its tallest pinnacle remained in sight—a landmark for all those who navigated the coast, the last vestige of the old village of Soulac, buried beneath the sand. The edifice that can be seen today was excavated in 1860 and restored in 1910. Seeing it, it seems impossible that such a massive building could have been buried by the dunes, especially when the sea is at least half a kilometer away. However, a closer look reveals that the ground around, carpeted by vegetation or stone pavement, is sand. Built in the nineteenth century, the new Soulac-sur-Mer was constructed on the dunes covering the remnants of the old village. This is not *terra firma*, even today. The Basilique de Notre-Dame-de-la-fin-des-Terres is a symbol of

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Figure 2.2 Basilique de Notre-Dame-de-la-fin-des-Terres, Soulac-sur-Mer, France, 2022
Source: Photo by J.G. Freitas

endurance on the one hand, and a powerful warning of the dangers of living on the coast on the other.

Tales of windblown sands

The Soulac case is one of many in Europe, where there are dozens of folktales about towns, hamlets, dunes, and drifting sands.[1] These anecdotes, however, are seldom widely known or disseminated. The bulk of such tales are local narratives preserved in the old descriptions of travelers or recounted as curiosities by provincial tourist guides. For instance, according to an old legend, the French city of Dunkirk owes its name to a church founded by Saint Eloy and dedicated to Saint Peter. Located on the sandy coast, the church is known as "Dune-kirk" or the "Church of the Sandhills." In the United Kingdom, some parts of the Welsh county of Glamorgan tell of the ancient borough of Kenfig, where "at one time the sand came like snow, and covered a cottage, whose inmates had to be dug out" (Morris 1907). The old town, castle, and church were buried beneath sand brought by a storm (Lewis 1849, 445–456). Such examples are abundant in the British Isles. For instance, in the parish of Gwithian (or Gothian), Cornwall, large tracts of land were covered

by sand during a violent storm in the twelfth century. Windblown sand was a persistent problem. According to oral tradition, whole farms were buried under 10 to 12 feet of sand. A local resident claimed that his great-grandfather told him stories about a farmhouse buried overnight, with the "family being obliged to make their escape from the chamber-windows." The ruins of the house, "which had never been seen by the oldest man living, were again exposed to view in consequence of the shifting of the sand in the winter of 1808–9" (Lysons and Lysons 1814a, 112–130). Another Cornish tale tells of Lelant, a large town whose population was driven south in an effort to escape the dunes menace. By 1780, the sand level was almost as high as the churchyard wall (Lysons and Lysons 1814b).

The brothers Daniel and Samuel Lysons collected several of these stories from South West England, but one of the most interesting is the legend of Perranzabuloe, a Cornish parish. The name of the parish is derived from the Latin *Sanctus Piranus in Sabulo* or St. Piran in the Sands. Piran, a holy man, is thought to have swum from Ireland to the English coast in the fifth century, arriving at what became Perranporth, where he died some 200 years later. According to legend, the first oratory dedicated to the saint was built near the beach, but was later overwhelmed by sand. Erected between the ninth and eleventh centuries, the second shrine became a pilgrimage site in the fifteenth century. However, by 1755, it too had fallen victim to sand—already half-buried in the dunes, the porch so covered in sand that it was difficult to enter. Anticipating the building's ruin, the parishioners deconstructed it stone by stone and erected a third church, which was consecrated in 1805 (Lysons and Lysons 1814c; Dexter 1923; Steers 1953). Another reference to this story mentions a northwesterly wind sweeping sand across the once-green meadows of the parish, encroaching on the ill-fated building (Trelawny 1846). Some of these stories are underpinned by a moral tone. Over the years, such episodes have been read through different lenses and disseminated for different purposes. In this case, the tale was used to illustrate the vicissitudes of the Church on the British Isles threatened by wicked forces, which Trelawny represented as wind and sand.

In Wales and Cornwall, the menace of sand is a common theme in many legends. But, my favorite is the famous story of Culbin Estate in Scotland, about which much has been written. Visiting the area at the end of the nineteenth century, George Bain (1900) described it as a place of great dreariness, unspeakable loneliness, and utter desolation, where silence reigned supreme and solitude was absolute. Located on the south coast of the Moray Firth in northeastern Scotland, this once vast and abundant farmland was destroyed by a terrible tempest. In this Scottish countryside, stories and superstitions were as abundant as grains of sand—the frequent discovery of flint arrowheads, old coins, iron nails, fishing hooks, and pottery feeding the local imagination. Amid a constantly changing landscape, human skeletons concealed in the sandhills and rumors of smugglers and illegal cargos of brandy and tobacco hidden in the dunes helped forge the tale of Culbin falling prey to a

catastrophe in bygone times. The estate was large and abundant and considered the garden and granary of Moray, with a stone mansion and fertile orchard. Comprising almost 4,000 acres of land divided into tenant farms, the estate produced wheat, oats, and barley. In the autumn of 1694, the loose sediment cast out from the sea and accumulated on the shore was picked up by wind in a massive sandstorm. As Bain noted, "The drift, like a mighty river, […] steadily and ruthlessly, grasping field after field, and enshrouding every object in a mantle of sand" (Bain 1900, 20). People fled for their lives, taking their cattle with them. Returning after the gale, they could find no traces of their old existence. In such situations, "human misfortunes and physical calamities have been commonly associated by the old superstitious feelings […] with moral turpitude and wickedness" (Bain 1900, 15–16). In this case, it was believed that the place had fallen under a curse—a case of divine retribution, whereby the impishness of the Laird of Culbin, who made his servants work on Sundays, was punished.

Of course, stories of drifting sand are not unique to the British Isles. They are also common on the North Sea coast, including the region of Jutland (Denmark). There, the church of Tvorup was lost to the dunes twice between 1680 and 1750, a problem dating back to the fifteenth century (Knudsen and Greer 2008; Sortfeldt 1920). This raises the question of why churches seem to have been more affected than other structures. In fact, this was hardly the case, with houses, farms, and roads also disappearing under the sand. Nonetheless, as emblematic buildings, religious edifices are more frequently mentioned in written records, symbolizing the loss felt by the entire community. Moreover, as my colleague and friend Gerry Bigelow pointed out in a conversation, churches were often the tallest buildings in a town—their burial thus illustrative of substantial sand accumulation. A short story about Jutland written by the famous Danish author Hans Christian Andersen (1858), *En Historie fra Klitterne* (Story from the Sand Dunes), reinforces Gerry's argument that church steeples and spires emerging from the sandy ground were spectacular landmarks. Andersen's story spoke of a shipwreck survivor cast ashore to thrive among the dune dwellers on the western coast of Denmark, where fishermen built huts to live during the spring. These fisherfolk had tales of their own, one of which explained how sand dunes appeared on the coast. According to this tale, a dead body was found on the beach and buried in the churchyard. Immediately thereafter, "the sand began to fly about, and the sea broke in with violence." Following the advice of the village wiseman, the grave was opened. The peasants realized that they had buried a merman and that the sea would not rest until it had him back. The corpse was taken to the shore and released into the water. The flying sand stopped almost immediately, "but the dunes that it formed are still there" (Andersen 1858). Sandstorms must have been common in this part of the Danish coast, as Andersen included them in his narrative, even describing an event that took place in the town of Skagen. His description of the sand whirling about, covering the houses and forcing the inhabitants to crawl up the chimneys to escape, sounds remarkably similar to the tales told in the British coastal areas of the North

Sea. Finally, in the last scene, the protagonist, Jorgen, dies inside the church,[2] which is then covered by rolling waves of sand on a stormy night. The protagonist is entombed in the magnificent building, itself enshrouded by the dunes, with only the tower visible above the sand—a burial monument worthy of a king (Andersen 1858).

Katie Ritson, who I first met in a conference in Brazil, referred to this piece by Hans Christian Andersen in her book about the shifting sands of the North Sea, asserting that "literary texts can be repositories for […] cultural memories" (Ritson 2019, 28). Such a statement can be applied to the anecdotes about sand in many places, including Portugal. For example, the Forest of Leiria on the central western coast is said to have been planted by King Dinis in the fourteenth century to prevent the dunes from destroying adjacent agricultural fields (Borges et al. 1897, 4). Although I have come across this tale in several books, I have not found any historical data to confirm the connection between the planting of the forest and the hazard of sand. Another story related to the same monarch concerns the disappearance of the village of Paredes. In 1282, King Dinis ordered the creation of a settlement of some 30 people at a specific site on the coast in order to encourage fishing and trade. The village thrived until the sixteenth century—its decay and eventual abandonment attributed to the sands that choked the harbor and destroyed the houses (Brandão 1650; Anonymous 1868). Similarly, in northern Portugal, tales claim that, at the end of the 1300s, a terrible storm blew enough sand from the coast to cover the village of Fão. After fleeing for safety, the villagers returned to find that nothing remained of their homes. They dug into the sand, but were unable to recover their belongings (Lopes 2019, 86).

A more recent account is again about the region of Leiria. According to lore, during the French invasion of the early 1800s, locals hid their possessions in the sands, in order to keep them safe from Napoleon's army. It is said that these treasures are still there, waiting to be found. Getting rich by finding such treasures was the dream of the protagonist of *A Batalha sem fim* (Endless Battle), a novel by one of my favorite Portuguese writers, Aquilino Ribeiro, on the hardships of living in the fishing community of Mira. In this novel, a young fisherman determined to make a better life for himself puts all of his efforts into searching for the lost gold—digging tirelessly in the vast dune field surrounding his seaside community (Ribeiro 1932). As in Kobo Abe's famous book, *Woman in the Dunes*, which is set in Japan, the dunes bind and break the main characters. Unable to escape the sand trap, the dunes both fascinate and oppress them (Abe 2006).

The facts beneath the sand

The abundant data produced by remote sensing, geoprospecting, archaeological excavations, carbon and optically stimulated luminescence (OSL) dating, and historical sources on sand drift far outweigh the tales and stories. Such data have revealed the vestiges of numerous sand-inundated settlements

concealed under the dunes, demonstrating the persistent struggle against windblown sand in coastal environments since prehistorical times (Griffiths 2015). There are several well-known cases, including the Neolithic village of Skara Braes on the Orkney Islands, an archipelago in northern Scotland, and the Bronze Age settlement at Gwithian in West Cornwall (Brown 2015). As for Portugal, I asked my friend, the archaeologist Ana Cristina Araújo, for some examples, and she named two prehistoric sites: Magoito and Palheirões do Alegra, to the north and south of Lisbon, respectively (Soares 2003; Araújo 2016). In respect to later periods, the archeologist Peter Brown identified at least 18 medieval places affected by sand across the British Isles, with particular concentrations in Cornwall and South Wales, including Perranzabuloe, Merthyr Mawr, Kenfig, Pennard, Penmaen, Stackpole, and Newborough (Brown 2015, 12, 15). Many of these sites are known since the beginning of the twentieth century, with various intellectuals, clergymen, archaeologists, and local antiquarian societies interested in examining the ruins and objects often found in the sandhills (Higgins 1933). More recently, some public entities, such as Historic Scotland, have sponsored coastal zone assessment surveys, enabling the identification of more archaeological sandscapes (Ashmore et al. 2011). According to Brown, there are probably still a significant number of undiscovered sites, many of which may only be discovered by chance, such as those exposed by the storms of 2013–2014 (Brown 2015, 15).

Between 2010 and 2014, my friend Gerry Bigelow, a former professor at Bates College in Maine in the United States, coordinated a team of archaeologists, geologists, biologists, and historians in a research project studying extreme environmental changes on the coast of the Shetland Islands in the United Kingdom over the past 2,000 years. The project included the excavation of Broo, a community of four farms buried by sand in the seventeenth and eighteenth centuries. When I first heard about the site, I was thrilled. While Gerry's team worked with the material effects of sand drift events, observing them in the field, I was looking for similar cases in the archives. Gerry sent me substantial amounts of information about Broo, which I read enthusiastically. In the summer of 2022, Gerry and I had the opportunity to discuss the dynamic relationship between dunes and people at the European Society for Environmental History Conference in Bristol. At the conference, we held a roundtable with several colleagues from various fields, including Antonio Ortega-Santos (history), Derek Jackson (geomorphology), and Katie Ritson (literature). For this reason, Broo had to be included in this book—particularly insofar as it is representative of the many cases of farmland rendered useless for agricultural purposes by sand drift that I discovered in historical sources. It is also an apt example of the association between climate change, human activity, and transgressive sand dunes, highlighting the importance of connecting historical records, archaeological findings, and field observations to improve our understanding of past events.

Broo is located in the southern part of Mainland, the main island of Shetland, almost 200 kilometers north of Scotland. The place can be found on a terrace approximately 40 meters above sea level and 1.7 kilometers inland from Quendale Beach. The extensive area of grass-covered sand dunes was once a prosperous township with productive agricultural lands (Kelley et al. 2018; Bigelow, Jones, and Retelle 2007). In 1774, Reverend George Low noted that the once lucrative estate had become a wilderness as a result of drifting sand, the area resembling an Arabian desert on a windy day (Low 1789). The exact location of Broo was unknown before the research project, with only a few geographical reference points found in the available historical records. This information and an exploratory Ground Penetration Radar survey enabled the identification of the remains of the Sinclair family residence. Archaeological works revealed the existence of two stone-walled buildings that had been gradually buried at different times. The removal of tons of windblown sand exposed the remaining vestiges of the buildings. Artifact typology and OSL dating of the sands covering the structures determined that the episodes of sand drift occurred in the fourteenth and sixteenth centuries, as well as a later phase that led to the abandonment of the place between 1680 and 1710 (Kelley et al. 2018; Bigelow, Jones, and Retelle 2007). However, according to local knowledge, passed on to me by Gerry, the dunes continued moving until at least the late nineteenth century.

While the British Isles have a significant amount of data on windblown sand hazards, they were not the only area of Europe affected by the problem. The southwestern coastal areas of France were particularly troubled by moving dunes. In this region, archaeological evidence has revealed the existence of several medieval sites lost to the sand, such as the monastery of Saint-Nicolas-de-Grave, founded near the mouth of the Gironde River in 1092, and covered by the dunes in 1259, and later between 1293 and 1300 (Coquillas 2001). The iconic Basilique de Notre-Dame-de-la-fin-des-Terres is another example from this period. In the fourteenth century, a new door was opened 3.6 meters above the initial ground level and a ten-step stairway installed to provide access to the lower church nave. This door is still in use; I passed through it during my visit. The ancient entrance is visible on the south side of the edifice, the bricked-up arch partly buried in the sandy soil. One of the hypotheses regarding these architectural changes is that the sand covering the surrounding area and engulfing the church and blocking the entrance forced the local populace to find another way to enter the building (Caillosse 2015, 223–224). In 1580, French philosopher Michel de Montaigne also referred to the dune problem in *Essais*, describing how his brother's lands in Arsac, near Bordeaux, had been covered by sediment from the sea, which had formed mountainous dunes that had steadily moved inland, conquering the country (Montaigne 1580, quoted by Saint-Jours 2009). According to historian Pierre Caillosse, more sand drift events occurred from the end of the 1500s onwards. There is also a significant increase in available data about these incidents. As Caillosse suggested, this may be a consequence of having

more historical information due to better archival conservation. Alternatively, it may be due to a surge in dune mobility. In fact, in this part of France, there is a greater number of events between the sixteenth and eighteenth centuries (Caillosse 2015, 225–226). For instance, in Soulac, the first documented account dates to the end of the sixteenth century. It was during this period that the drifting episodes at Broo, Perranzabuloe, Culbin, Tvorup, and Paredes, among others, occurred. Meanwhile, from the sixteenth century onwards, the amount of data on sand hazards increased in several countries.

Denmark is one such example. Lamb and Frydendahl (1991) noted the existence of sand drift records from 1427, whereas other historical sources point to a phase of active dunes between 1550 and 1850 (Clemmensen and Murray 2006). According to data collected by Sortfeldt regarding the *flyvesandets* or drifting sands of Thy in northwestern Jutland, the problem began around the 1500s and remained prevalent over the next two centuries. The region's arable lands and pastures were deeply affected; the sand covered townships and manor houses, forcing people to move churches to new locations (Sortfeldt 1920). In fact, this became common practice in European coastal dune areas. For instance, on the east coast of Scotland, the church of Gullane was "so incommodiously situated beside the seashore" that it was constantly assaulted by sand, such that neither the church nor the church graveyard could be used anymore. Consequently, the church was moved to the neighboring town of Dirleton (James VI 1612). In Soulac, as mentioned earlier, rather than moving the church when it became uninhabitable, the inhabitants built another one several kilometers inland.

The phenomenon of moving dunes in the early modern period was not exclusive to northern Europe, with similar cases have been reported in Portugal. Problems caused by drifting sands occurred occasionally before the sixteenth century. For example, as recorded in the chronicles of Friar António da Purificação and studied by a multidisciplinary team, in the thirteenth century, the dunes silted St. Rita Lagoon, which provided fish to the nearby Convent of Penafirme, located to the south of Peniche (Purificação 1642; Ramos-Pereira et al. 2019). In Fão in the north, archaeological research confirmed the occurrence of sand drift in the 1300s that destroyed the necropolis of Barreiras (Almeida et al. 1990; Cunha 1994). However, the majority of known events happened after this period, especially in the eighteenth century. Ancient ecclesiastic registers attest that the *areas da praya do mar* (sea sand) inundated some arable lands and hamlets that belonged to the Monastery of São Romão do Neiva in northern Portugal (São Tomás et al. 1651, II, 326). The so-called *invasões de areias* or "sand invasions" are also mentioned in the *Memórias Paroquiais* (Parishes Memories), a compilation of answers provided by local priests to a survey administered by the Portuguese government in 1758. The dunes were referred to by the clerics of several coastal villages, such as Paramos and Cortegaça, one of whom described the ocean as an incessant sand-throwing machine, asserting that the strong northerly winds cast sand onto the surrounding land, rendering it useless.

Windblown sand silted the nearby lagoons, blocking access to the sea and contributing to the flooding of the surrounding fields. Portugal also had its moving churches. According to a priest from Lavos, sand drift forced the local inhabitants to head inland and relocate the church on at least two occasions between 1628 and 1743. Writing in 1758, the cleric added that construction had not yet been completed, but it was already possible to attend mass in the new temple (Capela and Matos 2011, 547).

The aforementioned cases are just a few examples of the sand drift problems that the geographers Michèle Clarke and Helen Rendell identified as having impacted a "quarter of a million hectares of coastal land in Western Europe" over the last 700 years, namely, the Atlantic and North Sea coasts of the United Kingdom, Ireland, France, Spain, Portugal, Denmark, and the Netherlands (Clarke and Rendell 2011, 2014, 415). Environmental proxy data, archaeological vestiges, and historical records indicate the occurrence of multiple sand drift episodes over the centuries. However, the same data also suggest that these events escalated between the sixteenth and nineteenth centuries as a result of an increase in dune mobility in Europe at this time. This raises the question of what triggered such aeolian activity, and whether it was a natural phenomenon or due to human influence.

Explaining sand drift: Combining scientific and historical data

Dune building has occurred over decades and millennia, shaped by three main boundary conditions: sand supply, wind, and vegetation. Dune systems are subject to a "wide range of spatial and temporal scales," from the instant transport of grains of sand to powerful events that cause significant changes, such as storms or tsunamis (Gao, Kennedy, and Konlechner 2020, 2). For some time now, scientists have been studying the particular large-scale sand drift phenomenon that occurred between the sixteenth and nineteenth centuries, seeking explanations for such an increase in dune inland migration. According to research, the "synchronous character of aeolian accumulation along Europe suggests a common driving factor," with changing patterns of atmospheric circulation and vegetation indicating that climate is this common factor (Costas et al. 2012; Kasse 2002).

In fact, it is generally accepted that sand drift in this period is connected to the greater intensity of North Atlantic storms during the Little Ice Age (LIA) (Lamb 1995; Clarke and Rendell 2006), a time of cold climatic events in the North Atlantic region between 1550 and 1850 CE (Bradley and Jones 1993; Bond et al. 2001; Costas et al. 2012). It is worth noting that LIA periodization varies, with some considering it to have lasted from 1500 to 1850 (Trouet 2020, 79; Mann 2002), while others date it earlier to the fourteenth century (Easterbrook 2016). Such periodization issues are largely due to the lack of instrumental climate records in the past. While paleoclimate proxies—such as ice cores, tree rings, and sediment deposits—together with archaeological and historical records offer alternative data, they lack the accuracy of modern instruments, doing little to mitigate uncertainty. This is compounded by

the fact that the LIA appears to have started earlier in the Arctic region (c. the thirteenth century) and later in the lower latitudes (Miller et al. 2012). Moreover, in some areas, like the Atlas Mountains in Morocco, the LIA was associated less with colder temperatures than with wetness (Trouet 2020). Possible causes for LIA climatic fluctuations include changes in solar activity (e.g., the sunspot cycle), volcanic eruptions, and shifting patterns in atmosphere and oceanic circulation (e.g., the North Atlantic Oscillation or NAO) (Bond et al. 2001; Shindell et al. 2001; Trouet et al. 2009; Scourse, Trouet, and Raible 2010; Vaquero and Trigo 2012). Storminess and other major climate elements in Europe are linked to the NAO, which determines mean wind speed and direction, seasonal heat and moisture, the path and number of storms, and induces variations in ocean temperature, current patterns, and ice-cover in the Arctic (Hurrell et al. 2003; Abrantes et al. 2005).

For a layperson like me, understanding how the NAO works can be challenging. In the 1990s, James Hurrell (1995) explained its influence on regional temperatures and precipitation, later emphasizing its major effect "in surface air temperature, winds, storminess and precipitation over the Atlantic as well as the adjacent continents" (Hurrell and Deser 2009, 231). Writing for a general audience, Valerie Trouet, a dendrochronologist, provided a good explanation about such complex mechanism. According to Trouet, in the North Atlantic, there are two major atmospheric pressure centers, the Azores High and the Icelandic Low, which oscillate. High pressure is associated with warm and sunny weather, while low pressure is associated with clouds, rain, and wind. The difference in pressure between the two centers is greater in some years than in others. When the pressure in the Azores is higher than normal, the pressure in Iceland is lower, resulting in what is called a positive NAO. During negative NAO periods, the pressure difference between the Azores High and the Icelandic Low is small. This has implications for the European climate, with a positive NAO producing wet and stormy weather in the British Isles and Scandinavia, warm and mild temperatures in central Europe, and drought in the southwestern part of the continent. In contrast, a negative NAO brings wetter weather to the south, while the north is drier than normal. Through a comparative study of cedar rings in the Moroccan Atlas Mountains and stalagmite records from a cave in Scotland, scientists developed a 1000-year reconstruction of the NAO known as the NAO Index. In doing so, they realized that while the NAO was generally positive throughout the Middle Ages, it changed to a more regular or negative phase after 1450, when the LIA started (Trouet 2020, 85–89; Trouet et al. 2009).

At this point, readers unfamiliar with such climate phenomena are probably asking how this is related to the dunes. Greenland ice core analysis, discontinuous instrumental data, and archival records provide strong evidence of increased storminess periods during the LIA, which affected the Northwest Atlantic and North Sea (Clarke and Rendell 2009; Lamb 1995). The term "storminess" is used to describe the frequency and intensity of low-pressure systems, coupled with high winds and storm surges (Carnell, Senior, and Mitchell

1996; Clarke and Rendell 2009, 2011). For example, there is evidence to suggest that westerly winds over southern Europe were stronger during the LIA (Bradley and Jones 1993; Costas et al. 2016, 88). Traditionally, dune formation has been related to drier and colder climates due to vegetation decline and the exposure of sand to aeolian activity. However, more recent and improved records indicate a stronger connection with wind power (Chase 2009; Costas et al. 2016, 83). Several studies reinforce that dune activity is primarily driven by wind power. Indeed, even in "humid climates, exposed dunes can be mobilized" (Tsoar et al. 2009; Costas et al. 2012; Roskin et al. 2011). The lack of cohesion between the grains makes sandy soils more susceptible to wind than any other type of soil. According to Tsoar (2005), this is a limiting factor for vegetation growth, even more so than the amount of rainfall. Studies conducted in Israel and Brazil (Ceará) show that low wind power, rather than increased rainfall, allows vegetation to develop, facilitating the stabilizing of dunes (Tsoar 2004; Tsoar et al. 2009). Vegetation acts as a buffer preventing sand erosion, and once dunes are matted with vegetation, this protection can only be destroyed under extreme wind power (Tsoar et al. 2009). According to Jackson, Costas, and Guisado-Pintado (2019), increased storminess—resulting in stronger winds, more storm wave erosion and salt spray, and higher rates of vegetation burial by the sand coming from the beach—combined with lower air temperatures, may have affected the annual growing season of vegetation and weakened vegetative development, facilitating wind erosion and sediment destabilization and promoting widespread coastal dune rollover. Weakened and unstable foredunes may have become sources of aeolian sand and inundated landward areas. That said, the LIA was not a continuous period with consistent climatic characteristics. Temporary stages of dune re-vegetation and stabilization may have occurred during intra-LIA phases, which were characterized by increasing temperatures and reduced storminess (Jackson, Costas, and Guisado-Pintado 2019).

There is a consensus between climatic data regarding increased storminess, the OSL dating of sand, and archaeological and documentary records, confirming that dune mobility was a widespread phenomenon during the LIA (Clarke and Rendell, 2009; Provoost, Jones, and Edmonson, 2011). However, despite the general increase in storminess during this period, storm tracks in the North Atlantic are controlled by the NAO and do not have the same spatial impact everywhere. This means that dune mobility may have varied at the regional level, influenced by local climatic variability and specific factors (Clarke and Rendell 2006, 2009; Provoost, Jones, and Edmonson 2011; Tudor, Ramos-Pereira, and Freitas 2021). The physical characteristics of a specific site are important determinants, including the its geomorphology, marine and estuarine conditions, hydro- and sediment dynamics, the orientation of the coast, and the extension of the fetch area (Provoost, Jones, and Edmonson 2011). Moreover, other factors are necessary for dune building and mobilization, such as sand supply (Clarke and Rendell 2009). For example, in Portugal, a negative NAO was more common during the LIA, producing wet winters. This promoted soil erosion in inland mountain areas, increasing river discharge, supplying more sediment to

the coast for feeding the littoral drift—that is, the current that runs from the north to south along the western shore of the country and distributes sand along its beaches. Coupled with strong onshore winds, this may have contributed to the building and transgressive behavior of dunes on the Portuguese coast (Clarke and Rendell 2006; Tudor, Ramos-Pereira, and Freitas 2021).

All this suggests that "dune mobility cannot be directly related to a perturbation in a single boundary condition because dune activity is an integrated biogeomorphological response to all boundary conditions" (Gao, Kennedy, and Konlechner 2020, 2–3; Delgado-Fernandez, O'Keefe, and Davidson-Amott 2019). In addition to the fact that there can be a delay between an event and system response, geomorphological responses are nonlinear to boundary condition changes (Gao, Kennedy, and Konlechner 2020; Tsoar 2005). Essentially, the complexity of the factors and systems involved makes it extremely difficult to determine the exact impact of the potential drivers of dune mobility in a short period (Gao, Kennedy, and Konlechner 2020, 2–3). This complexity only increases when anthropogenic factors are included.

Human activities are drivers of change and must be considered, particularly when seeking to understand local variability. Over the past centuries, humans have played a significant role in dune mobility or stabilization. Settlements, agriculture, and deforestation have profoundly altered landscapes. Pollen records and archaeological vestiges evidence that the clearcutting of forests to create farmland, keep livestock, establish hamlets and villages, and obtain fuel for iron ore and charcoal production has been practice since the Roman Empire, if not earlier. In medieval times, human impact increased with the intensification and expansion of land use, exacerbating soil degradation and its vulnerability to wind and rain erosion. In central Europe, forest exploitation between the seventh and fourteenth centuries led to a significant reduction in woodland areas from approximately 94 percent to 15 percent, contributing to hillslope erosion, floodplain accumulation (Lungershausen et al. 2018), and an increase in the volume of sediment accumulating on the coast through fluvial discharge.

Forest clearing was not exclusive to central Europe and was also practiced in dune woodlands. According to Provoost, Jones, and Edmonson (2011), pollen and peat layer analysis reveals that dune woodlands occurred naturally on many European coastlines—including those of Poland, Denmark, Sweden, the Netherlands, Belgium, Germany, France, and the United Kingdom—until the Middle Ages. The deforestation of these areas seems to have followed a similar pattern. In the Netherlands, for instance, pollen diagrams of the area extending from Katwijk to Velsen on the coast between Leiden and Amsterdam indicate the existence of a beech forest in 800–1000 CE. Radiocarbon dating and archaeological remains show that this forest was cleared in the twelfth century. After this period, the region was covered by the Younger Dunes, which Zagwijn (1971) attributed to the disappearance of protective forest cover. In the thirteenth and fourteenth centuries, the local vegetation was sparse and mainly composed of herbaceous plants. Large-scale sand drifts subsequently affected the area throughout the fifteenth and sixteenth centuries.

In the context of Portugal, Nicole Devy-Vareta (1985, 1986) has called attention to the progressive destruction of forests in the Middle Ages, especially in the littoral zone, due to their proximity to urban centers. As a result of population growth and agricultural development, deforestation intensified in the fifteenth and sixteenth centuries, as cities grew and, promoted by Portuguese maritime expansion, naval construction and metallurgy production escalated the demand for timber and fuel. This deforestation resulted in the rivers becoming increasingly silted due to the amount of sediment they carried. In a letter written in 1491, King João II referred to the damages the sand was causing to the agricultural fields on the margins of the Mondego River to the north of Lisbon. Soil erosion was further attributed to the burning of the woods in the watershed basin (Baeta-Neves 1980–1993, III, 139–140). In the sixteenth century, several Portuguese ports located at river mouths experienced issues with sandbanks that hindered navigation (Polónia 2002, 152, 154, 156), particularly as ships became larger and maritime and fluvial traffic increased.

During this period, the lower temperatures, higher rainfall, and increased storm activity may have affected crop production, pushing the population to expand their fields to marginal areas next to the coast (Kelley et al. 2018). According to the historian Petra Van Dam (2010), the Netherlands underwent a phase of dune reclamation from the thirteenth century onwards, with the draining of peaty beach plains and wetlands, digging of canals, use of dunes for herding, collecting of fuel and sods, breeding of rabbits, and mining for sand and peat corresponding to the expansion of nearby villages. Portuguese records from the thirteenth, fifteenth, and sixteenth centuries reveal a similar pattern (Baeta-Neves, 1980–1993, IV, 204–205, V, 57–58). For instance, King Dinis ordered the draining of the Ulmar wetlands, near the sandy area of Leiria, and their use as "bread lands" (Brandão 1650, 192, 195). The expansion of settlements and agricultural practices in the vicinity of dune fields and the increase in fishing and seashore resource exploitation contributed to the trampling of dunes and destruction of vegetation cover (Provoost, Jones, and Edmonson 2011). These activities increased and intensified in the following centuries. In the case of Broo, the most recent phase of aeolian transgression (1680–1710) occurred during the LIA. However, other factors contributed to the catastrophic event that led to the abandonment of the farm. In this respect, Kelley et al. (2018) suggested that sheep and rabbits may have been a significant cause of sand dune vegetation destruction. The harvesting of such vegetation for domestic use may have led to the same outcome. In the case of Soulac, historical sources point to the indiscriminate use of dune woodlands, a scarce resource in the region. Here too, cattle were left to graze on the dunes, consuming the vegetation. The trampling of the dunes by animals and humans was an additional factor, with people frequently walking the dunes in search of wood and cattle and to access the sea for fishing (Caillosse 2015, 215–216).

The scientific and historical data presented throughout this chapter support the argument that the specific climatic conditions of the LIA and increase in human activities exacerbated the supply of sand to the coast and dunes as well as

the destruction of their protective vegetation cover, leaving the sand more susceptible to strong winds. At the same time, the urgent need for more land for food production promoted the expansion of cultivated areas toward the shore, making populations more vulnerable to sand drift as the dunes progressed inland. The numerous legends about towns lost to the dunes, some of which have persisted over the centuries and become detached from the historical events in which they are rooted, confirm the long and perilous history of sand drift. Frequently mythologized, these stories are the remnants of a collective memory of this natural phenomenon, a way of transmitting information that could assist future generations in dealing with the same hazard (Brown 2019).

Notes

1 Sand drift is the movement of windblown sand due to changes in the climate, sea level, or sediment availability. Anthropogenic factors can also contribute to this phenomenon (Doody 2013). Although scientific definitions differ, in this book, I use "sand drift," "drifting sand," "active dunes," "transgressive dunes," and "moving dunes" to describe the inland movement of the dunes driven by the wind.
2 This church is likely the *Sanct Laurentii* Church, which was located approximately 1 kilometer southeast of Skagen. The church was overrun by sand in 1775 and abandoned in 1795. Its tower was maintained as a landmark for navigation and has become a symbol of the sand drift disaster (Clemmensen and Murray 2006).

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3 Dealing with sand drift

Experiencing the dunes: Contrasting voices

The Portuguese called the sand drift *inundações de areia* (sand floods), while Dutch records mention *zandverstuivingen* (sand drifts). Meanwhile, the Spanish referred to *arenas volantes*, the French to *sables volants*, and the Danes to *flyvesandets*—that is, the flying sands. While terms like "flying sands" are almost poetic, the actual experience of windblown sand—the sharp stinging sensation of being hit with small grains of sand while standing on the beach on a windy day—is hardly pleasant. The minute rock particles that make up sand are fierce little things; abrasive and utterly pervasive, they stick to skin, clothes, bags, and food. As anyone who has been at the beach can attest: sand can be a nuisance.

After the European Society for Environmental History meeting in July 2022, Gerry Bigelow sent me an email about the DUNES roundtable, the open-mic session that I had organized, in which participants and audience members shared their views on research and personal feelings about dunes. The animated discussion highlighted the kaleidoscope of possible approaches to the sandhills, which can be considered from a geomorphological, ecological, historical, literary, and emotional angle, among others. Based on his two years of excavating in or near dunes, Gerry noted in his message that sand dunes as a place to appreciate nature or enjoy the "beach experience" are very different from them as a place to work. To this he added, "they are not great places to live unless one becomes very adapted to sand as an element in one's life." This sentiment echoed in my mind over the next few days, resonating with my observations of historical sources, which present two contrasting views of the dunes: reflections by those who saw them as nothing but wastelands, and descriptions of those who forged their lives and livelihoods from the sand.

Legends, folktales, and accounts of villages lost to the sand depict the dunes as dark entities, moving inexorably toward valuable fields, buildings, and households. A nineteenth-century English traveler who sketched the landscapes of Landes in southwestern France portrayed them as gloomy and barren, adding that dunes evoked a "strong sense of loneliness, a grandeur and intensity of desolation" (Brown 1878, 10). In the midst of this sad

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scenery, he continued, a few isolated huts stood in the middle of a miserable field, sown with poor crops and spotted with a few meagre-looking cattle. In the face of such a dreary backdrop, the traveler pondered:

> When of old the scared peasants beheld the irresistible advance of these strange ministers of destruction [the dunes], they had no other resource than to fell their woods, abandon their dwellings, and surrender their "little all" to the pitiless sand and devouring sea. What could avail against such a scourge?
>
> (Brown 1878, 12)

Such depictions of dunescapes as wrecked worlds whose communities were defenseless against the dangers of sand are ubiquitous in travel writing, including George Bain's (1900) account of the Culbin Sands in Scotland and Carlos Pimentel's (1873) description of the Portuguese coast. In these narratives, collapse and social breakdown due to dune encroachment are presented as imminent and inevitable. The cases of abandoned villages and farms reinforced this grim impression. However, history, archaeological evidence, and folklore also confirm that people have long lived and thrived right next to dunes. As historian Tim Soens noted, depending on the region, hazards like floods, avalanches, and earthquakes were part of everyday life (Soens 2018, 174). Certainly, sand drift can be added to this list. Populations living in hazard-prone areas, as Greg Bankoff (2009) has shown, developed coping cultures based on local knowledge, which enabled them to endure through adaptive strategies. My previous work on the Portuguese coastal populations provides several examples of how these communities built lifestyles suited to their harsh dynamic environment (Freitas, Bastos, and Dias 2018).

Found in a plethora of accounts, the view of the dunes as desolate wastelands was characteristic of nineteenth-century imaginings. Reading these impressions, I was always curious about those who dwelled on or near the dunes, typically described as poor peasants passively waiting for disaster to strike. I found myself wondering whether these people shared this view of the dunes and how they survived in such a hostile environment. The problem is that they left almost no trace of their existence. At a conference in Granada in May 2022, Marco Armiero referred to this phenomenon as "the trap of the archives." As repositories of the official or institutional version of events, he argued, archives make it difficult to find the voices of those on the margins of society. Like Pierre Caillosse (2015, 309) noted of his research on Soulac, I had to read between the lines of travel narratives, bureaucratic reports, and judicial and notarial documents to locate those who lived near the dunes. By moving beyond the dominant narratives of the nineteenth century and considering the work of colleagues interested in the medieval and early modern periods, I was able to see that far from useless and empty land, the dunes were a familiar landscape that provided protection from sea hazards and important resources for the local rural economy.

Living with the dunes

In Holland, "the oldest settlements were situated at the high parts of the Old Dunes, safe and dry places, where fields for agriculture could be laid out" (Van Dam 2010, 69). Although there were some fishing villages on the coast, these were probably established after the formation of the Young Dunes. The low inland stabilized sands, known as the Old Dunes, were formed before 1,000 CE, when different phases of sea level oscillations occurred. The Younger Dunes were produced in a later period of aeolian activity at the end of the Middle Ages, when waves of sand rolled over the old dune landscape, creating rows of high sand ridges and interdune valleys. Between the Old and the Young Dunes were peaty beach plains, which became the site of draining and reclamation initiatives in the 1300s (Van Dam 2010).

In the County of Holland, a former province on the western coast of the Netherlands, the count had the right to the wilderness—an uninhabited expanse that included the peat bogs and the dunes along the rivers and the sea. According to Petra Van Dam, this did not mean that the area was a desert. Most people lived in the Old Dunes, their villages and fields creating "islands of civilization" in the landscape. At the same time, the count leased the right for peasants to raise animals, and collect firewood and sod from the Young Dunes (Van Dam 2010, 71; Stein 2022, 151), which were too mobile to allow permanent settlement (Jelles 1968, 19). Domanial records from the fourteenth century onwards reveal diverse dunes uses. First and foremost, they were hunting grounds for the privileged, with game reserved for elites. However, judicial records and ordinances from the fifteenth to eighteenth centuries indicate that poaching was fairly common (Jelles 1968, 33). Dunes were also used for the commercial exploitation of rabbits, which were introduced to Northern Europe in the thirteenth century with the purpose of meat and fur production. The rabbits lived in a semi-wild state protected by the dune tenants (*duinmeiers*), who had contracts with the count allowing them to install warrens—that is, rabbit management units—in the sand ridges (Van Dam 2010, 63). For centuries, the dunes were a source of agricultural sod, which was used to enrich soil, feed livestock, and for thatching roofs. Woody species that grew on the dunes were used for fuel and as material for farm fences. Moreover, people from the surrounding villages paid to graze their herds in the dunes. Formal regulations on this practice existed since the fifteenth century, although J. Jelles (1968, 51–52, 25), former administrator of the Provincial Estates of North Holland, suggested that these were based on much older customs. From the fifteenth and sixteenth centuries onwards, human activity in the Old Dunes increased. Consequently, the dunes were levelled, the sand was mined and sold for construction and ship ballast, and the remaining sandy soil was enriched with manure to grow fruit and vegetables (Van Dam 2010, 75, 77). With the cultivation of the backcountry, the Young Dunes were practically all that remained of the wilderness (Jelles 1968, 17).

The settlement of dunes in France also bears striking similarities to that of Holland. An inherited cautionary measure, villages and hamlets were located at a secure distance from the coast, protected by sand ridges and wetlands (e.g., ponds and salt marshes), which acted as buffers against sea flooding (Garnier 2018, 12; Lemaire 1927, 13). According to Calloisse, coastal erosion or sea flooding were not a problem in Soulac, as "the houses of the parish […] were located in the XVIII century in the rear of a sandbank 400 to 4 000 meters large. Winter storms caused no damage to the population" (Caillosse 2015, 196). The wetlands of Soulac were vulnerable to sea flooding and high tides, but they were mainly used as pastures and only turned into productive fields in the nineteenth century (Caillosse 2015, 205). As in the County of Holland, dunes had multiple uses, including as hunting grounds for the nobility and collective reserves for villagers, who paid to exploit the area's natural resources (Garnier 2018, 11). Based on his reading of judicial and notarial sources and a survey conducted in 1478, the historian Jacques Péret (2019) argued that the dunes of Arvert, to the north of Soulac, were the basis of extensive economic activity between the fifteenth and eighteenth centuries. Such activities included grazing and the collecting of grass and wood, traditional communal practices with ancient medieval roots. Pierre Buffault (1942, 78), former head of the French Forests and Waters Service, confirmed the longevity of some of these activities, noting that the dunes and wetlands were vital to the economy of the commune of Soulac. Given the poor agricultural output of the Landes and western Gascony, which had sandy soil, pluriactivity may have been a strategy to overcome meagre crop production and periods of shortage (Caillosse 2015; Buffault 1942, 121). In these marginal territories, located far from central institutions and authorities, the dunes functioned as an intersection between the rural and the maritime worlds and between legal and illegal practices. Indeed, in addition to providing resources and opportunities to earn legal income, the dunes provided the perfect hiding place for looted goods from shipwrecks (Péret 2019, 21).

Certainly, the grazing of cattle on dunes was one of the oldest and most frequently cited uses along the European coastline. In Portugal's Gelfa region, the sandspit between the Aveiro Lagoon and the ocean was used as pasture for cattle since at least the end of the thirteenth century. In the late fourteenth century, the area became a base for *xávega*, a fishing practice in which nets are pulled ashore from the beach (Bastos et al. 2017, 140). In the United Kingdom, in 1377, the dunes of Skegness in Lincolnshire were leased by the lord of the Manor of Ingoldmells to peasants in search of pastures for their livestock (Massingberd 1902, 178–179). In some areas of Denmark, the Netherlands, Great Britain, Scotland, and France, locals collected marram grass (*Ammophila arenaria*), a pioneer species of the dunes, for various domestic and agricultural purposes, including thatching, winter fodder, soil enrichment (Provoost, Jones, and Edmonson 2011), and the weaving of baskets and mats (Lysons and Lysons 1814). There are similar mentions of using the dunes for grazing and vegetation cutting in the cases of Broo and Culbin

(Bampton, Kelley, and Kelley 2018; Ovington 1950). Another common practice was the mining of sand from beaches and dunes. For example, in seventeenth-century Cornwall, after lighters carried sand up river as far as the tides would allow, the sediment was transported on wheels or horseback to wherever it was needed to improve the soil for grain production ("The Improvement of Cornwall by Sea Sand…" 1675). According to the Lysons brothers (Lysons and Lysons 1814), King Henry III (1216–1272) formally legalized the transporting of sea sand for manure. Legal documents from later periods attest to the multiple uses of sand, including fertilizer, glass or brick production, and construction. However, as it is not always possible to identify the provenance of such sand, it is difficult to confirm that it came from the coast (e.g. Lyte 1911; "House of Commons Journal, 20 February 1610" 1802). In some regions of Portugal, like Fão, sand was such an important resource that local authorities had to regulate its extraction (Lopes 2019, 133).

Such regular contact meant that the dunes were natural to the local population. As part of their daily existence, locals viewed the dunes as a feature of a well-known landscape, offering a non-negligible contribution to the equilibrium of the domestic economy (Péret 2019). Like all intimate things, dunes had different names depending on the region (see Figure 3.1). In fact, "dune," the most commonly used term today, only came into widespread circulation

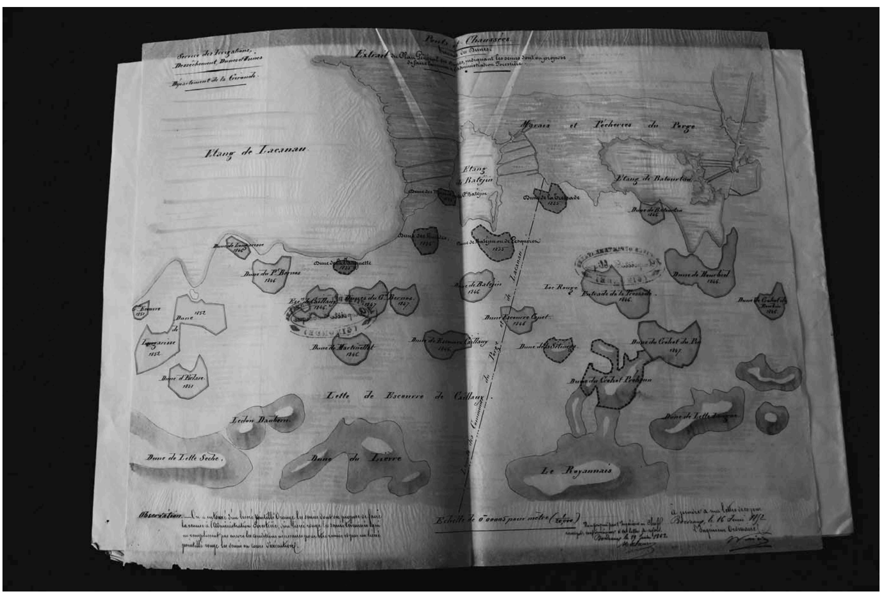

Figure 3.1 Example of dunes with specific names. Extract from the General Plan of the Dunes, showing the sowings and areas proposed for sowing by the French Forest Service, 1852

Source: Photo by J.G. Freitas. Original document held by the Archives Départementales de la Gironde, Bordeaux, France

after the nineteenth century. According to Emmanuel Garnier (2018, 6), the French word *dune* comes from the Flemish *duin* of Celtic origin meaning *duno* or hill. Before other terms were used, for instance, locals and travelers referred to the sands around Arvert as *montagnes de sable* (sand mountains) or *montagnes d'Arvert* (Péret 2019). Near Soulac, they were called *piquey* (e.g., *piquey de Lillan), terrier* (e.g., *terrier de Saint-Nicolas*), and *puys* (hills in Gascon; e.g., *puys du Bois*) (Buffault 1942, 123–128; Caillosse 2015, 218–219). In Great Britain, dunes were often referred to as "sandhills" ("Act for Preservation of Meadows, Lands and Pasturages, Lying Adjacent to Sand-Hills, 1695," n.d.), although some English documents use the older Norse terms "meols" or "meales" (Massingberd 1902, vi). In Portugal, dunes were typically referred to as *areas* (sands) and *medos* or *medões* (hills) (Pimentel 1873; Borges et al. 1897). Some dunes were identified by specific names, such as the *Medo Inglês*, a navigation reference located on the southern margin of the mouth of the Tagus River, on whose northern bank Lisbon is situated (Silva, Batalha, and Vasconcellos 1857). In Spain, dunes were generally known as *arenas* or *médanos* (Mira 1906), although some were given particular designations, such as the *Puig Gros, Puig de Sol ixent*, or *Puig Petit* in Golfo de Rosas on the Catalan coast (Ferrer y de Lloret 1895, 20).

Coping with sand drift: Local strategies

While dunes were valuable resources for local economies, they were also troublesome. For instance, although "the useful sands" of Cornwall were prized for soil enrichment, they were also described as a threat:

> [B]lown up by the wind and drown abundance of good land; some houses, yea and some churches and chappels are even buried with it. So that the hills sides that are towards the sea, may be thought like those sandy desarts we read of in Arabia, nor has any art been hitherto thought of, to prevent its devastation.
>
> ("The Improvement of Cornwall by Sea Sand…" 1675, 294)

However, it would be wrong to assume that people did nothing to protect against such hazards. Certainly, the nineteenth and twentieth century saw government-backed and publicly financed efforts against dune encroachment. Nevertheless, long before such formal initiatives, threatened populations developed their own strategies for dealing with this problem. As my colleague Gerry Bigelow noted, they adapted to sand as an element in their lives. These measures, some dating to the medieval or early modern periods, are not well known, being scarcely mentioned and scattered across historical records. As such, it is important to note that what I present here is only a general overview. Detailed information on these coping strategies can only be obtained through in-depth research in local archives, which was not the aim of this study. I am also not the first to provide examples of coping with sand dunes

and the use of sand-binding grasses by local populations. For instance, Clarke and Rendell (2014) tabulated records and references on the subject, including data from Denmark, the Netherlands, Britain, Ireland, and France. Here, I seek to build on and add to such research.

One of the oldest strategies for dealing with drifting sand was to maintain the vegetation cover. Historical sources reveal two specific measures to achieve this: protection and planting. The former involves prohibiting the uprooting or cutting of grass, while the latter refers to the proactive practice of planting such vegetation. Anxiety regarding dune stability was directly related to the need to maintain a coastal barrier against sea flooding and prevent sand drift. Clarke and Rendell (2014) found records mentioning a directive for the protection of marram grass in the Netherlands in 1354, and suggestions that locals were responsible for planting it in the Delfland region in 1443. According to Clarke and Rendell data, other countries did not adopt such strategies until the sixteenth century. However, my research indicates that Great Britain and the Netherlands had long established traditions in this regard. The court rolls of the Manor of Ingoldmells, Lincolnshire, provide a fascinating account of the tenants and affairs of the estate. A case brought before the court in 1325 revealed the following information about the dunes:

> It is ordered to attach William Elrykes, and John son of Walter to answer to the lord, because they mowed the "dunes," and the herbage outside the bank of the sea against the defense of the sea for the salvation of the country. […]
>
> William Elrikes is distrained by iiij cows, because he mowed the brambles outsider the sea bank, which is the defense of the whole community of the vill of Skegnesse, against the custom used.
>
> (Massingberd 1902, 91–92)

These excerpts highlight the importance of the sandhills as a form of coastal protection and the existence of a custom related to their preservation. Nevertheless, transgressions did occur. A report from 1411, for instance, described the trial of five men on the charge of cutting the thorns and grasses ("sines") of the meales of Skegness "to the grave damage of the lord the king" (Massingberd 1902, 222). In 1429, John Richemond and John Lyndyssay were similarly prosecuted for cutting the grass "growing upon the meles at Skegnes" and taking their haul to Newcastle and York "without license" (Massingberd 1902, 263–264). In the fourteenth century, Holland began appointing dune wardens—officers subordinate to the forester responsible for the management of the Wilderness—to police the dunes and arrest transgressors. The senior dune warden, first mentioned in 1390, was tasked with looking after the surrounding villages and coordinating the planting of marram to protect them from the drifting sands (Stein 2022, 150). In a chapter on "*helm* planting" in Holland, Jelles included archival records from the Abbey of Egmond evidencing that, in 1440, the local population was obliged to plant

helm (marram). Like the English cases mentioned earlier, this information was preserved because it involved a legal dispute between Lord Egmond, who required all tenants to plant the grass, and the local abbot, who disputed the notion that abbey lands fell under this obligation. Jelles argued that such an obligation probably existed as a custom before the fifteenth century, and that it was put into writing because of a dispute over or deviation from this custom. Until the seventeenth century, other ordinances were produced to maintain and regulate the planting of protective vegetation by those who leased the dunes. Thereafter, the States of Holland and local councils began supporting the planting of *helm* through subsidies granted to local administrators (Jelles 1968, 24–26).

It is worth pausing here, so that I can clarify two things: just what marram actually is, and why this plant is so important. In fact, I consider marram to be one of the cornerstones of this book, a protagonist so to speak. In the story of dunes, marram is either the hero or villain, depending on your perspective. As with everything in life, marram or *Ammophila arenaria* (L.) Link is a complex agent that cannot be simplified as something "good" or "bad." While coastal dune environments might appear indistinguishable to a layperson, this is far from the case. Although dunes are primarily comprised of sand, their environmental conditions vary widely—not only from one region to another, but in terms of the proximity of the dunes to the sea. Plant species living in this harsh environment must be able to withstand salt sprays, extremely permeable and mobile substrates, high surface temperatures, intense radiation, and strong winds (Garcia Novo et al. 2004). Also previously named as *Psamma arenaria, Arundo arenaria*, and *Calamagrostis arenaria, Ammophila arenaria* is a pioneer species native to European coastal areas from the North and Baltic Seas to the Mediterranean and the Black Sea. This remarkable plant thrives on mobile and semi-fixed dunes because it is able to tolerate water scarcity, high temperatures, and the instability and low nutrient status of dune soil. It is also able to withstand being buried by sand. In fact, marram grows vigorously in response to burial by rapidly producing its stems, making it particularly well-suited to growing on dunes closer to the beach. Meanwhile, its rhizome and roots contribute to the retention of the mobile sand (Huiskes 1979). Aware of its special characteristics, people have long used it to bind sand, that is, to promote dune stabilization. Colloquially, *Ammophila arenaria* is known as marram or marram grass in English, *oyat* or *élyme des sables* in French, *helm* in Dutch, *strandhafer* in German, *sandhjaelme* in Danish, *estorno* in Portuguese, *grama de las dunas* or *bárron* in Spanish, and *sparto pungente* in Italian (IUCN 2000). Of course, there are also regional variations. In the United Kingdom, for instance, historical sources refer to marram as "matweed," "bent," "starr," "rush," and "beachgrass." Such variations can make it difficult to identify whether sources are talking about *Ammophila arenaria* or one of the many other plant species native to dunes, such as *Elymus arenarius*. While I distinguish between plant species where possible, I generally refer to *Ammophila arenaria*.

Figure 3.2 Patches of *Ammophila arenaria* in Monte Gordo beach, Portugal, 2023
Source: Photo by J.G. Freitas

Let's move on… Similar regulations were implemented across Europe. In Flanders, Belgium, laws prohibiting the cutting and grazing of dune grasses were issued on September 7, 1531, and May 2, 1613, the severe penalties underscoring the recognition of vegetation as crucial to the stability of the natural dykes that prevented coastal flooding. In 1736, the measure was implemented to protect the village of Dunkirk, as the dunes surrounding the port were in bad condition (Bidé 1736). In Denmark, ordinances restricting the use of dune vegetation were introduced in 1539, and reinforced in 1543 and 1548. Cattle grazing, the harvesting of grasses for roofing, and the collection of wood for fuel were forbidden (Sortfeldt 1920; Jensen 1994; Knudsen and Greer 2008). In the United Kingdom, in 1561, Queen Elizabeth I passed a decree imposing a fine or punishment on anyone who contributed to the extirpation of marram (Brown 2015, 28; Trelawny 1846, 280–281). The relationship between sand drift and vegetation cover is perfectly established in an ordinance passed by the Parliament of Scotland at the end of the seventeenth century in response to the demise of the Culbin estate in 1694. In such respect, the "Act for Preservation of Meadows, Lands and Pasturages, Lying Adjacent to Sand-Hills, 1695" declared:

> Our sovereign lord, considering that many lands, meadows and pasturages lying on the sea coasts have been ruined and overspread in many

> places of this kingdom by sand driven from adjacent sand-hills, the which has been mainly occasioned by the pulling up by the root of bent, juniper and broom bushes which did loosen and break the surface and skin of the said hills. And particularly considering that the barony of Culbin and house and yards thereof, lying within the sheriffdom of Elgin, is quite ruined and overspread with sand, the which was occasioned by the foresaid bad practice of pulling the bent and juniper, therefore, his majesty, with advice and consent of the estates of parliament, for preventing of the like prejudices in time coming, does strictly prohibit and discharge the pulling of bent, broom or juniper of sand-hills for hereafter, either by the proprietors themselves, or any other whomsoever, the same being the natural fences of the adjacent countries to the said hills; certifying such as shall contravene this act, they shall not only be liable to the damages that shall then ensue, but shall likewise be liable in the sum of £10 of penalty, the one half thereof to belong to the informer, and the other half to the judge within whose jurisdiction the said contravention shall be committed.

As noted, in addition to protective measures, dune maintenance also involved the practice of actively planting vegetation. The Netherlands seems to have pioneered it, but other regions have also done so. In the eighteenth century, increasing sand damage in Lancashire, where the dunes played an important role in protecting against coastal flooding, resulted in the Parliament of England issuing "Act for the More Effectual Preventing of the Cutting of the Starr or Bent." This document also formally asserted that planting vegetation on the sandhills was "an effectual method for keeping the same firm and solid, and which the owners of the said lands are at great costs and charges, in yearly setting planting for that purpose" (16 George 2 c.33 1742 quoted by Clarke and Rendell 2014, 422). Other sources demonstrate that local people used grasses to stabilize the dunes and protect their households (Lysons and Lysons 1814, 167–185; Lewis 1849, 45–52). For instance, in Gothian, the fields had already been lost to dune encroachment, a fate that would have been shared by the church if not for the quick action of the church wardens. According to the Lysons brothers,

> [W]ith all the possible expedition, [the churchwardens] caused large plantations to be made of a species of rush, which grows abundantly in that neighbourhood, and by the rapid spreading of its long fibrous roots, affords the only know method of checking the progress of the sands.
>
> (Lysons and Lysons 1814, 112–130)

In Kenfig, *Arundo arenaria* was used to stabilize the dunes, with tenants on adjoining farms required to provide at least one day of labor a year to help sow this grass (Lewis 1849, 445–456).

The use of grasses was not the only strategy. According to Peter Brown (2015, 24), wooden fences found in medieval sites in the Netherlands appear to have functioned as "sand-breaks." In Soulac, Gascony, barriers were built

to block the sand and prevent its progress. In 1742 and 1748, a palisade and wall were erected to protect the nearby church of Verdon. Where the first was built by locals using bushes, the second was made of stone and mortar and paid for by the authorities, who wished to safeguard the royal chapel. Ditches were dug to keep the military batteries safe at the Pointe de Grave. Maps from the eighteenth century show that some gardens and houses were surrounded by hedges. Pierre Caillosse asserted that local populations were perfectly aware of the value of vegetation and woodlands for stabilizing the sands and the need to maintain them. Another solution involved clearing affected buildings, using human and animal labor to remove the sand. Also, when fields were impacted by dune encroachment, tenants and landowners regularly asked for reductions in rents or tax payments. Despite such measures, Caillosse concluded that the population of Soulac did not receive sufficient external support to deal with sand drift. Significantly, no planting occurred. The absence of the large landowners in this marginal region explains the relative neglect of this problem (Caillosse 2015, 310–316, 319, 322).

Like most countries, Portugal lacks detailed studies examining how populations handled the problem of coastal sands. The work of Ana Isabel Lopes (2019, 2023), on Fão, on the northwestern Portuguese coast, is an exception. According to Lopes, in 1587, King Filipe I authorized the collection of taxes from the region to finance the protection and restoration of the Fão church, which had been covered by sand. Similar taxation measures were introduced in 1662 and 1826, and again later in the nineteenth century, when it was known as "*real da areia*." In the eighteenth century, fences were used to protect property and, in some cases, like that of the church, the sand was removed (Lopes 2019, 134, 136, 151, 155). The people of Fão, Afife, and Apúlia were aware that vegetation was essential for preventing sand drift, with numerous regulations prohibiting its cutting and imposing fines on transgressors (Neiva 1987; Lopes 2023). Similar laws were implemented elsewhere in Portugal. The Municipality of Figueira da Foz, whose jurisdiction included the beaches of Quiaios and Lavos, passed an ordinance prohibiting the digging and disturbing of sand, as well as cattle grazing and the cutting of bushes, grasses, and trees (Código das Posturas Municipais do Concelho da Figueira da Foz 1877). This nineteenth-century regulation may have been the written form of an older oral tradition. Later, at the beginning of the twentieth century, some northern coastal areas developed a cultivation practice known as the *masseiras* to cope with demographic pressure and dune encroachment. On the inland part of the dunes, locals removed sand until they reached the soil underneath; they then fertilized it with seaweed (*sargaço*) to produce vegetables (Oliveira, Galhano, and Pereira 1990; Lopes 2019, 128). Something similar had been done in Andalusia, Spain, by the people of Sanlucar, near the mouth of the Guadalquivir River, who faced poverty, unemployment, and drought. In 1742, they attempted to cultivate the dunes to produce food. They created small plots of land protected by sand walls and maintained by vegetation, and planted fruits and vegetables able to grow in

sandy soil, such as potatoes, tomatoes, onions, watermelons, and melons. These dune vegetable gardens came to be known as *navazos* (Llauradó 1884, Vol. 1, 536–542).

Evidently, many of the uses of the dunes clashed with the need to protect and maintain their vegetation cover. The abundance of decrees on the matter prove that despite such prohibitions, people kept harvesting dune grasses and allowing their animals to forage in the sandhills. In Denmark, ongoing flouting of such regulations led to their reinforcement through harsher punishments in 1543 and 1548. Based on his research in the archives of Viborg and Copenhagen, Sortfeldt contended that West Jutland's distance from the capital meant the rules were not fully enforced, resulting in the inhabitants of the dunes continuing to use the vegetation to feed their cattle and roof their houses. According to Stortfeldt, this resulted in destroying the remaining cover and blowing the sand further inland with the problem persisting long into the eighteenth century (Sortfeldt 1920). Rabbiting was also particularly damaging, at least in the Netherlands and Britain (Van Dam 2001), where their feeding habits and building of warrens destroyed the vegetation cover, exposing the sand to the winds. From the fourteenth century onwards, the proliferation of rabbits increased vulnerability to sand inundation in many areas of Britain (Brown 2015, 30). Jelles (1968) identified another conflict in this respect, namely, the opposition between farmers and hunters in the seventeenth century in the County of Holland. The former were against the exploitation of game and rabbits in the dunes because these animals ate the crops on the adjacent land and contributed to sand drift.

The unique combination of the climatic conditions of the Little Ice Age and human practices between the fourteenth and nineteenth centuries promoted the increase of the aeolian activity of the dunes. In some cases, efforts were ineffective and nothing could be done to prevent the transgressive dunes from burying fields, houses, and hamlets. As I mentioned at the beginning of this chapter, descriptions of these events, which sometimes only came to light much later, often conveyed an impression of catastrophe or collapse (e.g. Bain 1900), evoking images of annihilation or disappearance (Clarke and Rendell 2014, 416). However, sand drift was not a sudden event that occurred in a few hours or days without warning. In fact, such events fit the concept of "slow disaster" as defined by Scott Gabriel Knowles (2020, 197), insofar as they involved a long-term process spanning across time and generations. This means that people had time to prepare and retreat, which they often did. Of course, this raises the question of whether retreat should be considered a defeat or a coping strategy. I believe it is the latter.

Archaeological evidence and historical records indicate that, although dune sand must have been a problem, settlements were able to maintain their viability for several years—giving communities enough time to save building materials. According to Brown, at some point, it may have been easier to relocate to "nearby settlements rather than attempting to re-establish their previous living conditions" (Brown 2015, 12, 20–21). In the case of Broo in

the Shetland Islands, data suggest that the farmhouse was vacated in stages (Bigelow, Jones, and Retelle 2007). Meanwhile, Soulac was abandoned in the first half of the eighteenth century and a new church was built inland, with the villagers spreading between Jeune Soulac and Verdon. Caillosse (2015, 334) described the process of relocation as sign of resignation on the one hand and a pragmatic response to a hazard that could not be controlled on the other. This is consistent with what Tim Soens (2018) noted for sea floods: coastal communities did not seem to collapse or end due to sand drift. However, the fact that they survived and endured as a whole through adaptation does not mean the experience was not disruptive for some groups or individuals.

The dunes as a dreaded landscape

As discussed, historical sources about people who made their livelihoods on the dunes are limited and scattered. Indeed, such individuals are largely only indirectly accessible through official documents, as they rarely articulated their own existence in archival records. In contrast, there is an abundance of writing from sojourners, outsiders who compared the dunes to a raging sea during a storm, "offering to the eyes nothing but a whiteness that wounded, a monotonous perspective, a naked mountainous landscape, a frightening desert" (Brémontier 1797, 2, 7–8). The man I just quoted, the French Nicolas-Thomas Brémontier, believed that the constant influx of sand from the sea meant that the dunes would continue to grow, such that the fertile area around Bordeaux, in northwestern France, would invariably be covered by 300–400 feet of sand. In a century, he announced, the villages of Teste, New Mimizan, and others in Gascony would no longer exist. I examine Brémontier's story in the next chapter, but suffice to say, many of his contemporaries shared his perspective. These men represent a turning point in the history of the dunes. These travelers, military men, royal agents, administrators, tax collectors, engineers, and other experts shared a common feature: they were strangers to the dune land. Arriving to such a place, they were confronted with a world very different from their own—one they found wild, uncivilized, fascinating, and uncontrollable, fueling the creation of stereotypes, stories, and myths about the dunes. As Péret (2019, 11–12) reminds us, the images produced by these individuals cannot be found in the testimonies of locals, who saw their territory in a concrete way, without literary flourishes. Moreover, Caillosse (2015, 230) noted the accounts of these outsiders were not neutral, they were driven by the mission that had taken them to the dune country.

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4 Turning dunes into forests

The highest dune of Europe: Sand, humans, and trees

The day after visiting the Basilique de Notre-Dame-de-la-fin-des-Terres in Soulac-sur-Mer, I found myself climbing the Dune du Pilat, near Arcachon, with Ignacio García-Pereda. Walking on dunes is generally prohibited in Portugal, making this a novel and exhilarating experience. A difficult one too, I must admit. Hiking up such unstable ground is no easy task, and the dune was much bigger than I had expected, even with its claim to be the "highest in Europe!" Our breathing labored, we finally made it to the top and immediately understood that the trek was worth the effort: it was as if we were standing on the back of a great white whale stranded on the shore, trapped between the sea and the forest. I was utterly dazzled by the view, the sharp contrast of the light and hue of the colors—the blues, the greens, and the ivory. Strolling along the back of this giant, I truly understood Nicolas Brémontier's concern that the nearby fields would be lost to this lumbering sand colossus. Indeed, the Dune du Pilat is still moving. I could see the tiny grains of sand slowly sliding downhill, invading the forest, burying the skeletons of dead trees, and encroaching on the living ones. This forest is the legacy of a struggle that began at the end of the eighteenth century, the remains of a valiant effort to prevent disaster. A camping park and a wooden house can be seen nestled among the pines, the next victims of the dune. How many years until they too are swallowed? It was only as I stood there, looking out at the forest, that the fearful stories about the dunes of Gascony became real to me.

Near the town of Teste-de-Buch, Ignacio pointed out the two monuments dedicated to Nicolas Brémontier, the hero in the fight against the local dunes. Hidden among the trees between two roads, the older monument is a simple design of pink marble. Erected in 1818, the monument's inscription declares that, in 1787, under the directive of King Louis XVI, the General Inspector of the Bridge and Roads Services (*Service des Ponts et Chaussées*) successfully stabilized the dunes by transforming them into a forest. Unveiled in 1878, the other monument is a bust of Brémontier on a white stone pedestal. Located in a small residential area, the bust symbolizes the gratitude of the littoral population of Arcachon for Brémontier's arresting of the sands by planting

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Figure 4.1 Dune du Pilat and the pine forest, France, 2022
Source: Photo by J.G. Freitas

pines. Such dedications notwithstanding, Nicolas-Thomas Brémontier (b. Tronquay, 1738–d. Paris, 1809) is a controversial figure: much has been written about what he did or did not achieve, whether his work was original or an appropriation, and whether he was deserving of the attention he received in tributes and textbooks (Gillet-Laumont, Tessier, and Chassiron 1806; Buffault 1897; Bert 1900; Lafargue 1949; Sargos 1998). This dispute does not interest me. Of far greater importance is what his achievement meant for dunes around the world in the following centuries.

Certainly, the use of grasses and trees to stabilize dunes was old knowledge. Indeed, the previous chapter provided several examples of how populations throughout Europe employed vegetation to prevent the sand from being blown by the wind. What changed at the end of the eighteenth century? Why was Brémontier's work a turning point in dune intervention if he was not the first to use vegetation in this way? I contend that, in the context of the Enlightenment and the ideologically and economically complex processes of the emergence of modernity, Brémontier's endeavor became a means by which states could take control of peripheral territories—in terms of both resources and people—previously perceived as wastelands.

The longstanding empirical use of vegetation to deal with drifting sand in different regions and countries can be perceived as a multicentric event: the

development of a local strategy based on local wisdom and driven by the need to solve a circumscribed problem with the available resources in a context of relatively sparse transregional connections (Bayly 2004). However, these geographically limited practices began changing in the early modern period when what historian Christopher Bayly (2004) called "archaic globalization" began bridging regions that had functioned as almost separate worlds for centuries, integrating them as "interacting parts of a system, communicating by migration regimes, capital flows, cultural transfers" (Middell 2019, 10). While there was already some transfer of knowledge about dune stabilization before the eighteenth century, historical sources confirm that the circulation of this information boomed after the 1700s. The climatic conditions of the Little Ice Age and the increase in human practices exacerbated the problem of the moving dunes: the more people were affected, the more urgently a solution was needed. Consequently, in various places, experts were tasked with finding remedies and spearheaded attempts to control the sands.

Dunes in the Enlightenment: Men, knowledge, and practices

The 1700s are often referred to as the Age of Science and Reason, Enlightenment, and Revolution. Indeed, amidst the American and French Revolutions and the advent of the Industrial Revolution, the eighteenth century saw the burgeoning of universities, academies, and scientific societies alongside the publication of journals, encyclopedias, and dictionaries. The 1700s were marked by the birth of a new vision of society—one "civilized, rational, and committed to the general advancement of man" (Molesky 2016, 325). This century also saw the "emergence of the resolute, aggressive modern nation-state and the rise of 'polite, industrious, and commercial societies' throughout the world" (Bayly 2004, 88).

In contrast with earlier periods, when information on the drifting of dunes was scarce and scattered, dunes became a subject of widespread concern. The topic was addressed in articles, papers, and essays, debated in scientific societies, and included in official reports. Such interest contributed to the dissemination of the perception of dunes as barren and nefarious things. In line with this view, strategies were developed to fight the drifting dunes and transform them into something useful for society. This goal resonated deeply with the vision of the Enlightenment, ideally expressed by Candide, Voltaire's famous character who exhorted his fellow citizens to "cultivate their garden," a garden that had since "become the whole world" (Molesky 2016, 356).

Such views circulated throughout Europe via personal networks, the press, and scientific societies. An account in *Philosophical Transactions*, a journal established by the Royal Society of London for Improving Natural Knowledge in 1660, provides one of the most curious examples of knowledge transfer about dunes within certain learned circles. In a letter published in 1668, Thomas Wright—a "sufferer by the Deluge"—presents the "curious and exact relation of a sand-floud, which hath lately overwhelmed a great

tract of land in the County of Suffolk" (Wright 1668). The letter describes the damage caused by drifting inland sands between Lakenheath and Brandon, England, and the strategies used to stop them. Such strategies included the erection of hedges, which were "set upon another, as fast as the sand levelled them," the raising of sand banks, and the laying of some "hundreds of loads of muck and good earth upon [them]." After presenting the facts, Wright, attributed the "reason and cause of this strange accident" to the sandy soil of the county and the vigor of the wind in the region (Wright 1668, 724–725). From its observations to its experimentation, discovery, reasoning, and transmission, the narrative displayed a mindset fully aligned with the spirit of the learned men of the Enlightenment. Wright's letter was later translated into French by M. Gibelin (1787), a member of the Medical Society of London, and read and mentioned by Brémontier (1797, 29–30), who was also associated with several scientific societies.

Two intersecting approaches toward the dunes emerged from the mid-eighteenth century: namely, practical and theoretical action based on older local practices. Although Brémontier is the most prominent figure in dune stabilization, there were others, some whose efforts predate those of the French engineer. For instance, in 1724, King Frederick IV of Denmark appointed Johan Ulrich Røhl (c. 1675–1754) to address the issue of the *sandflugten* affecting Tisvilde, a small town located on the north coast of the island of Zealand. The king had already ordered a commission to find a solution to the problem of the drifting sand, but attempts using the old fence system had been unsuccessful. It is unclear why Frederick IV appointed Røhl, a monastery administrator in Oldenburg, a German country under Danish control. Nonetheless, Røhl proposed sowing the sands with several plants common on the peninsula of Jutland—including *marehalmen* (*Elymmus arenarius*) and *klittetaget* (*Arundo arenaria or Ammophila arenaria*), that is, marram grass—and erecting fences to protect the planting areas. In 1725, Røhl mixed seeds he had brought from Jutland with others he had from Oldenburg, covered them with seaweed, and built the fences. He also ordered the digging of deep and wide ditches with turfed sides to trap the sand and prevent cattle and game from eating the vegetation. Later, he planted conifers, laying the foundations of the forest in Tisvilde Hegn. He faced several difficulties, notably, storms, animals, and the lack of labor and wagons. However, according to a report from 1735, the sand drift was controlled and the nearby towns and fields were free from danger. A monument erected in Tisvildeleje in 1738 to celebrate the sand stabilization, the *sandflugtsmonumentet*, praises the action of the king and governors and recognizes the ingenuity and diligence of Røhl (Binderup 2021; "Johan Ulrich Røhl" 2011; Jacobesen 2005; Bernichow 2003). While little is known about Røhl, his connections, or where he learned the approach applied in Tisvilde, he was one of the first men to be recognized for his work on the dunes.

Scientific societies and academies played an important role in spurring progress on the issue of dunes. Functioning as cosmopolitan networks

transcending national boundaries, they were fundamental to the circulation of knowledge throughout Europe. They were spaces of intersection between the sciences and techniques, stimulating research, innovation, and the exchange of know-how among intellectual, military, political, and administrative elites (Burgel 2021). Some academies and societies had specific intentions, working as bodies for agriculture, literature, medicine, and so on to promote the development and application of useful learning to facilitate the growth of local or national economic interests (Withers 2007). In order to encourage specific breakthroughs, certain institutions launched competitions offering prizes to those who could find the best practical solution to a given problem. For instance, in 1768, the Philosophical Society of Danzig (present-day Gdansk, Poland), recognizing the danger of dune migration, announced a prize for the best answer to the question: What are the most useful and least costly means to prevent the rampant silting up of the Danzig Spit and to help prevent the further growth of sand dunes? J.D. Titius, Professor of Natural History at the University of Wittenberg, who had visited Danzig and was familiar with the situation, wrote a short treatise on the subject[1] and won the prize. Asserting that the sand had been brought by the wind from the Baltic Sea, Titius recommended the restoration of the forest through the planting of conifers (Gerhardt 1900, 287; Brown 1884, 98–99).

This example is one of many. Another is the Royal Holland Society of Sciences and Humanities (*Hollandsche Maatschappye der Weetenschappen*), founded in Harlem in 1752, which announced a similar competition in 1773, with applicants invited to answer the following questions:

> [What] trees, shrubs and plants can grow on the sand dunes besides the marram grass (*Arundo Arenaria*) and the blackthorn (*Prunus Sylvestris*) as a defense against the sand drifts? Can they be planted? Can we also benefit from some other plants on our seashores? Have any tests been done here in the country? And what were the results?
>
> (Bosch 1774, xiv)

However, the responses were not satisfactory, and the deadline was extended to 1777. In 1778, the prize—a gold medal—was awarded to the physician, scientist, and painter, Johannes le Francq van Berkhey (b. Leiden, 1729–b. The Hague, 1812), who had authored a natural history of the Netherlands (1769–1805) ("J. Le Francq van Berkhey" n.d.). In his report to the Society, Berkhey (1774) noted the existence of plants in other countries that grew in the dunes, although he questioned their suitability for Dutch conditions. As an alternative, he provided a list of potential native species for the intended use based on his own experience and contacts with herbalists and dune dwellers. However, he emphasized that none were as effective at preventing sand drift as marram. The problem with this grass, van Berkhey continued, was that it was often planted in poor conditions, without the care that "the ancients used to give it, which jeopardized the plant's effectiveness." As mentioned in the

previous chapter, the use of marram had long been established in Holland. Indeed, the planting of marram was formally regulated in 1758, including the establishment of general conditions for contractors who undertook the task of planting the dunes in order to ensure the quality and success of their work (Jelles 1968, 30). Van Berkhey criticized the inadequate methods of transplanting marram to active dunes. If these dunes were still causing problems for landward areas, he wrote, the fault was not with the marram, but with the way it was being used. Van Berkhey further suggested the simultaneous introduction of other native plant species in order to enhance the success of marram cultivation (van Berkhey 1774).

Meanwhile, in France, the Desbiey brothers, Guillaume (1725–1785) and Louis-Mathieu (1734–1817) made a presentation to the Royal Academy of Sciences, Arts and Belles-Lettres of Bordeaux, of which the latter was a member, on their experience of stabilizing dunes on their estate in Saint-Julien-en-Born[2] (Sargos 1998, 262). In 1769, the brothers planted seeds for pine, *Ulex europeus*, and *Spartium scoparium*, and covered them with branches for protection. After a few years, the seeds grew into a rich mat of vegetation, covering the sand. However, this vegetation was later destroyed by cattle (Mouls 1866). In 1776, the Desbieys' lecture was included in a paper sent to the Academy of Bordeaux, which was holding a competition soliciting proposals for the best way to develop the Gascony moors (*Landes de Gascogne*). Marked by the rational spirit of the Enlightenment, the Desbieys stated their desire to contribute to the expansion of agricultural production to feed the population—the strength of the Empire—by improving a land that nature had condemned to be sterile (Desbiey 1776).

Similarly seeking to subdue nature in the interest of human industry, in 1778, King Louis XVI sent the Baron Charlevoix de Villiers, a naval engineer, to Gascony to investigate the potential construction of a port in Arcachon Bay and an artificial navigation channel between the bay and Bordeaux. After a thorough observation of the region, de Villiers concluded that before any construction could take place, it was necessary to eradicate the evil that threatened the bay and the lands stretching from the Pointe de Grave to Bayonne: namely, the drifting sands. The worst affected area, he pointed out, was the village of Teste-de-Buch, an important area of the Landes and the center of the trade that passed through Arcachon Bay. The existence of patches of dune forests in some areas demonstrated that it was possible to stabilize the sand by planting trees. Broadly speaking, de Villiers (1779) proposed starting the works in the seaside dunes—sowing pine seeds and plants adapted to the sandy soils and erecting protective fences—in order to create an obstacle to the sand drifting from the ocean. In terms of plant species, de Villiers suggested the *genêt*, referred to as *Spartium scoparium* by Mouls (1866); *gourbet*, identified either as *Elimus arenarius* (Gironde 1806) and *Ammophila arenaria* (Bert 1900; Gondran 2009); and *gruau*, which I have been unable to identify.[3] De Villiers justified the need for such interventions on the basis of safeguarding the bay—particularly insofar as its navigation

was threatened by siltation—and the productive lands surrounding it. Underscoring the urgency of the task, he emphasized that the region would benefit from vast forest resources in two decades, resources that would stimulate trade and help finance duties to the monarchy.

Two other erudite men of science are worth mentioning in relation to the development of sand stabilization in the late 1700s: Erik Viborg (b. Bedstred, 1759–d. Copenhagen, 1822) and Friedrich August Ludwig von Burgsdorf (b. Leipzig, 1747–d. Berlin, 1802). An eminent Danish veterinarian, Viborg was deeply interested in economic botany and published several works on the importance of certain plants as fodder or medicine. In 1787, the Royal Danish Academy of Sciences awarded Viborg a prize for his treatise on the use of vegetation to control sand drift (Viborg 1788). He also received a royal stipend to have his treatise translated into German, so that the people on the west coast of Jutland could use it (Viborg 1789) as a manual for dealing with the issue of the dunes. Viborg highlighted the methods applied locally in Denmark, noting that other approaches used abroad were not suited to the Danish context. In his work, Viborg assessed three particular species of sand-binding plants: *klittetaget* (*Ammophila arenaria), marehalm* (*Elymus arenarius*), and *seenegras* (*Carex arenaria*). According to Viborg, locals often confused the first two species and called them *marehalm klitetag* or *hielme*. Well aware of the difficulties of sowing plants on seaside dunes, he provided instructions for building fences to break the wind and advised sowing a mixture of *Pinus silvestris* seeds with the aforementioned sand-binding vegetation. Viborg gave several examples of local practices and explained how they varied from place to place. In discussing what people in different communities were doing, he reviewed the approaches in view of local resources and which practices tended to achieve better results. In 1790, Viborg collaborated with the Danish Commission responsible for dune control to successfully apply his guidelines (Bang 1904).

Friedrich August Ludwig von Burgsdorf, the second figure worth noting, played a significant role in the theoretical and practical development of forestry science. In his youth, von Burgsdorf travelled to Holland, England, and France. Later in life, he became a member of the Council of the King of Prussia, Chief Forester of the Kurmark Brandenburg, a Professor of Forestry, and a member of several scientific academies in Europe, including societies in Berlin, Frankfurt, Leipzig, Mainz, Saint Petersburg, and London. In his seminal two-volume manual on forestry (Burgsdorf 1788, vol. I, 1796, vol. II), von Burgsdorf devoted a chapter to the subject of sands, asserting that foresters needed to know how to control and transform them into forests. With so many regions of Prussia affected by the sand, he argued, it was imperative that Prussian foresters learn to deal with the problem. After all, he added, cultivating such wastelands was undeniably beneficial, particularly in terms of increasing productive areas and protecting neighboring fields. Over the course of the chapter, von Burgsdorf provided detailed instructions on how to stabilize the sands. Interestingly, he proposed that the area first be mapped to

evaluate the geographical features of the sands and surrounding area. This included identifying any valleys, lakes, wetlands, and woods, which could be used to support the work and offer a stable point to begin construction. According to his instructions, fences should be installed near the origin of the drifts to create a barrier against wind. In addition to fences, von Burgsdorf prescribed that the sand be covered with pine branches in specific geometric patterns, thereby delimiting enclosed areas to ensure the protection of the seedlings and prevent gusts of wind from blowing the sand away (Burgsdorf 1808, vol. II). However, von Burgsdorf made no mention of the ocean when referring to the issue of sands. As such, rather than coastal sands, he was likely speaking of the active inland drifting sands characteristic of northwestern Europe, including the Netherlands, Flanders, Denmark, Lower Saxony, Westphalia, Brandenburg, and northern Poland. The regions make up the so-called European "sand belt" (Fanta and Siepel 2010, 14). While these inland sands are beyond the scope of my study, von Burgsdorf's teachings are relevant insofar as they influenced later approaches to coastal dune stabilization.

Reading and analyzing these reports, I was struck by the fact that they essentially propose the same thing. First, the use of pioneer plant species to trap and hold the sand, thereby reinforcing the dunes, which are still active landforms. Second, the planting of trees to stabilize the dunes, rendering them inactive. "Did these men know about each other?" I found myself asking, "Were they aware of the similar efforts being done in other places?" Van Berkhey (1774), for instance, acknowledged that other countries and regions, including the English and Northern coasts, had different sand-binding plants and trees, although he considered them unsuitable for Holland because of climatic differences. Holland is a special case because it was one of the first areas where a central authority implemented sand control measures, with Dutch authorities motivated by the importance of dunes as natural dykes protecting the lowlands. These works were frequently cited as a reference by other nations. Drawing on Bernichow (2003), Jacobesen (2005) noted that prior to Røhl's appointment, the Danish administration first turned to Dutch dyke and dune experts. Meanwhile, Viborg was well acquainted with Røhl's work. In addition to directly comparing the situations on the coasts of Jutland and Zealand, Viborg referred to the trees planted in Tisvilde and how they demonstrated the viability of transforming dunes into forests (Viborg 1789). Røhl's work was also known outside Denmark. For example, written much later, Paul Gerhardt's (1900) work on dune stabilization in Germany recognized Røhl's contributions. Interestingly, Gerhardt did not mention von Burgsdorf, strengthening my argument that the forester was not talking about coastal dunes when he described the means of sand stabilization. That said, in 1808, von Burgsdorf's forestry manual was translated into French by J.J. Baudrillart, who worked for the General Administration of Forests. By this point, von Burgsdorf's work was considered a classic treatise on forestry, a science that was well developed in Germany (Burgsdorf 1808, vol. I) and one that other countries were interested in promoting.

The circulation of knowledge among learned men and through scientific societies is easier to trace than other networks and contacts. According to Elias Burgel (2021, 137), the transfer of technical knowledge on early hydraulic infrastructure and dune plantation may have occurred between Holland and France during the seventeenth century, largely through the campaigns for the drainage of wetlands, which were carried out with the support of Dutch experts. In Brittany, for example, the fight against the sand began around 1760, with the financial support of the regional authorities. When the staff of the Bridge and Roads Services visited the area in the 1780s, they believed the plants used by the locals to stabilize the sands were of Dutch origin. This is difficult to confirm, but certainly, earlier botanical transmission could have taken place. Despite the possible influence of foreign experiments, the engineers of the Bridge and Roads Services recognized the value of local interventions and used them as a basis to reinforce the dykes protecting the region from coastal flooding (Charpentier 2009, 86–87).

In Gascony, local landowners like the Desbiey and de Ruat family were making experiences on their properties, investing their own capital to address the issue of sand encroachment. Just a few short years after the Desbiey brothers' experiments in their estate in Saint-Julien-en-Born, François de Ruat, Captal de Buch, petitioned the king and ministers to get their support to override traditional grazing rights to protect newly sown vegetation on the dunes of his property in Teste. As lords of the Captalat de Teste-de-Buch, the de Ruat family had long battled dune encroachment, with attempts to cultivate vegetation cover made under Jean-Baptiste de Ruat (1676–1739) in 1713. Although he was successful, in 1734, his efforts were undone by a deliberate fire set by those who opposed his initiative. His son, Alain de Ruat (1716–1776) attempted to organize the replanting of the dunes by local landowners in 1746. However, the family's desire to convert part of their sandy land into a pine forest faced opposition from various interested parties regarding rights to the dunes. Compounding matters, the de Ruat family lacked the official support necessary to carry out their plan. Nevertheless, determined, between 1782 and 1787, François de Ruat promoted the first dune works in the region, with the assistance of Jean Baptiste Peyjehan (1753–1803), who came from a family of forest-owning pine resin merchants from Teste (Ragot, n.d., 62–63).

Jacques Necker, the Director-General of Finances under King Louis XVI, was informed of François de Ruat's intentions in 1778. That same year, Necker and Antoine de Sartine, the Minister of Marine Affairs, sent de Villiers to Gascony to study the possibility of developing the local navigation infrastructure. In 1779, de Villiers advanced the need to stabilize the dunes before commencing construction on a port. These figures must have known each other, or at least been aware of one another's ideas. According to historian Fernand Labatut, it is likely that de Villiers knew the Desbiey brothers given their shared concern regarding the need to stabilize the dunes. Over the course of his travels, de Villiers established informants among the local population and elites of various regions. He met for sure François de Ruat and was aware of his project, experiences, and difficulties with the dunes (Labatut 2009, 63, 66, 77).

Standing on the shoulders of giants

The discussion of the dune problem was particularly concentrated in the Bordeaux region, when Nicolas Brémontier arrived in this febrile environment in 1770,[4] as a subengineer of the Bridge and Roads Services. Like others before him, he was officially tasked with aiding the development of the vast wastelands of Gascony. Both the central and local government were determined to improve the Landes and exploit its resources through agriculture and forestry, and the construction of roads and canals was considered vital to cultivating industry and facilitating trade (Brémontier 1933). He remained in the region until 1780, when he was sent to Brittany, but he returned four years later as chief engineer in charge of the works and projects related to ports, canals, river navigation, roads, and drainage of wetlands. Upon his return, Brémontier decided to take on the task that would make him famous: stabilizing the dunes. In 1786, he successfully secured financial support from the government to trial some interventions in the dunes and wrote to François de Ruat asking for permission to conduct these experiments on his lands in Teste. Brémontier enlisted the help of Peyjehan,[5] who had assisted in de Ruat's stabilization project and was well-acquainted with the countryside.

Labor began in March 1787, and continued intermittently until 1789, when it was brought to a halt by the French Revolution (1789–1799) (Ragot, n.d., 65). Seeds were sown between 1791 and 1793, with several interruptions due to the political and administrative instability. Lacking the funds necessary to pay the workers, Peyjehan was forced to use his own resources to secure the project (Sargos 1998; Caillosse 2015). The letters exchanged between Brémontier and Peyjehan about the progress of the work reveal their difficulties with labor and funding, as well as the close collaboration between the two men—one acting on the ground to solve the day-to-day problems, while the other maneuvered in the high political and administrative spheres in an effort to maintain their joint venture. These letters are housed in the *Archives Départementales de la Gironde* in Bordeaux. Visiting this archive was a remarkable experience. After reading about these figures for so many years, holding their original papers—written and signed in their own hand—was humbling. I frequently go to the archives for what I call "fishing expeditions," searching somewhat blindly for the traces of dunes in an immense ocean of information. If I am lucky, several days of searching will unearth a few new details here and there. To my amazement, the archives of Bordeaux house several boxes labelled "Dunes," each containing dozens of documents from 1751–1950 about the local sandhills.

In 1795, several members of the Commission of the Society of Natural History and Agriculture of Bordeaux visited the experimental site to evaluate Peyjehan and Brémontier's work. The commissioners considered it a success. In the following years, other representatives of various institutions were similarly impressed by the results and praised what had been achieved in the dunes of Teste (Caillosse 2015). The recognition of local and regional authorities was an important step in ensuring financial and logistical support for

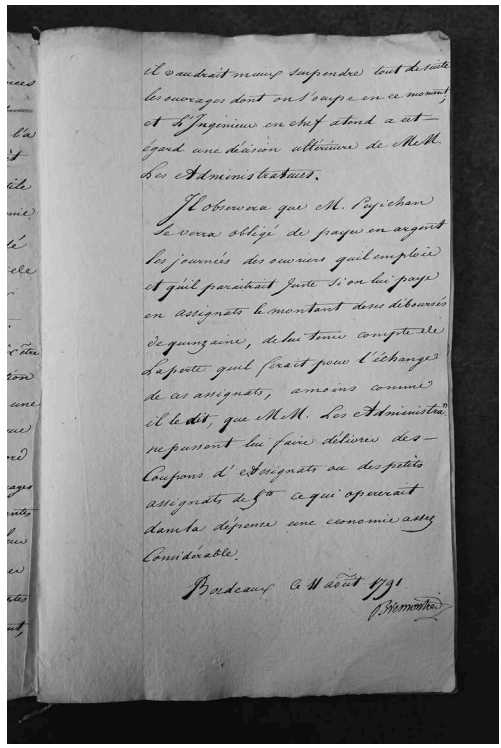

Figure 4.2 Report on the work on the dunes, signed by Brémontier, 1791
Source: Photo by J.G. Freitas. Original document held by the Archives Départementales de la Gironde, Bordeaux, France

the venture. Indeed, such support was key to overcoming administrative difficulties and issues related to labor, competing interests, usage rights, and so on (Brémontier 1797, 68–73). However, the future and expansion of the project depended on the assistance of more highly placed individuals, especially in such times of revolutionary turmoil. With this in mind, Brémontier published his famous report on the trials at Teste, *Mèmoire sur les dunes et particulièrement sur celles qui se trouvent entre Bayonne et la Pointe de Grave, à l' embouchure de la Garonne* (Memory about the dunes, particularly those between Bayonne and Pointe de Grave, at the mouth of the Garonne River). There, he presented a detailed portrait of the dunes, depicting them as a heaving ocean, a roiling desolate expanse that would cover everything. Speaking to those who had never seen them, he emphasized that the dunes were in a state of constant and unpredictable flux—growing, receding, merging, and separating with the wind. The chief engineer explained how they were formed by sand from the ocean, the grains of sand picked up and dropped by the wind in an endless process that would inexorably destroy most of Bordeaux (Brémontier 1797).

Of course, Brémontier exaggerated the magnitude of the threat in order to justify the importance of his work. He presented the fixing of the dunes as an impossible task, or at least one too expensive and difficult to guarantee. He belittled other interventions, claiming that Danish initiatives, among others, had failed in the long run. With this pessimistic narrative, he prepared the stage to unveil his solution—*the* solution—for the large-scale control of dune mobility. Given its vast spatial and temporal scope, and the considerable financial and human resources it would require, Brémontier considered it a task only the government could undertake. Nevertheless, he reiterated, no other project would be more useful or beneficial to France: the threat of the dunes would be eliminated, the useless sands transformed into productive forest. To support his argument, Brémontier listed the benefits of such an endeavor, as well as an estimate of the cost and time (30–35 years) it would take to achieve it (Brémontier 1797).

Brémontier's report is at the center of a dispute over who actually developed the sand stabilization first. Several authors argue that it is impossible that Brémontier was unaware of his contemporaries, namely, de Ruat, the Desbieys, and de Villiers (Mouls 1866; Buffault 1897; Sargos 1998; Caillosse 2015). However, in addition to never mentioning them by name, Brémontier changed the date of his account from 1797 to 1776, before de Villiers was sent to Gascony. Brémontier was aware of earlier attempts in other countries. He had read the translation of Wright's (1668) letter (Gibelin 1787), referred to the cases of Denmark and Holland, and noted several "unfruitful" attempts in France. Brémontier ignored them and had a reason for doing so, as he made clear in a speech to the Academy of Sciences of Bordeaux in 1798:

> The only reward to which I aspired, and to which I believed I was entitled, was *to claim the honor of a discovery* which provided the infallible means of slowing down the progress of the sea over the land, of reducing the losses of commerce, […] by fertilizing a territory […] which seemed condemned to eternal sterility.
>
> (Brémontier 1798, 8–9; my italics)

Brémontier did not invent the technique that made him famous, nor did de Ruat, the Desbieys, de Villiers, Røhl, van Berkhey, Viborg, or any of the other learned men who wrote about fixing the dunes. The practice was established over the centuries by different communities on the coasts of Europe. All of these men gained their eminence by standing on the shoulders of giants—the common folk who had long lived with the dunes. However, through their networks and connections, these educated men produced work aligned with the spirit of the Enlightenment, which sought to improve nature and advance the wealth and power of the emerging nation states. These learned men made visible a sandy environment unknown or ignored by the majority, their writing disseminating their conception of the dunes to a wider, even transnational, audience. Yet, it was Brémontier who gained prominence and who overshadowed many of the proponents of the same ideas. Why was this so?

Simply put, Brémontier was particularly persistent and convincing in arguing for the advantages of dune reclamation and was able to see his project through to completion. Through frequent reports and voluminous correspondence, in which he repeatedly invoked the apocalyptic threat of the dunes and need to protect the common good, he succeeded where others had failed (Labatut 2009, 87). Eager for success, he gained influence with the authorities of Bordeaux and Paris, enabling him to accomplish his goals despite the difficulties and the sociopolitical turbulence of the time (Mouls 1866; Buffault 1897; Sargos 1998; Caillosse 2015). Finally, on July 2, 1801, the Consuls,[6] headed by Napoleon, approved measures to continue the plantations at Teste in accordance with Brémontier's plan. A commission chaired by Brémontier as chief engineer was appointed to run the operation and provided the funding necessary to cover the costs involved (Labatut 2009, 89). In 1802, a triumphant Brémontier was appointed the General Inspector of the *Ponts and Chaussées*.

Brémontier's legacy

Brémontier used other people's ideas and existing knowledge, had Peyjehan test them *in situ*, corrected and improved the procedures (Tassin 1802; Labatut 2009, 92), and published the results, thus producing what became known as "Brémontier's method." This raises the question of what these techniques entailed and why they were soon adopted by other countries.

Many attempts to transform dunes into forests were unsuccessful due to the failure of the plants to take root in such a harsh and unstable environment. The continued influx of sand from the ocean only exacerbated such issues, often burying and killing any vegetation. Like de Villiers and Viborg, Brémontier realized that any attempt to stabilize the dunes first required halting the influx of sediment from the sea. To achieve this, he erected wattle hurdles and boards along the coast, some 40–50 meters from the high tide mark, thus creating windbreaks and preventing the sand from being driven further inland. When the accumulation of sand against the fence became too high, the structure was raised or a new one was built. In this way, the sand from the sea gradually formed a littoral dune or foredune that acted as a protective barrier. This system was key to the success of dune fixing.

Meanwhile, on the leeward side, in the protected areas, the surface of the dunes was covered with shrubs—as recommended by the likes of the Desbieys and von Burgsdorf—to protect the pine seeds sown with sand-binding plants. In a few years, this fast-growing vegetation would become a dense thicket. Five or six years later, once the trees had reached maturity, seeds were sown on the leeward side of the first crop. This pattern was repeated, eventually establishing a swathe of productive forest. Brémontier recommended sowing continuous strips of 50–100 meters. To protect the young plants in the first years, he suggested a cover of pine branches and bushes or building bush fences if these materials were not available in the surrounding areas. Like von

Burgsdorf, Brémontier proposed building parallel and transversal fences forming square areas to provide shelter from the wind, with seeds sown within these protective enclosures. Situated closer to the sea and vulnerable to the salt winds, the first rows of trees were invariably gnarled and stunted. Nonetheless, they offered protection to those growing further inland, eventually producing wood to build new covers and fences. Brémontier also warned that the most difficult areas to immobilize were those most exposed to prevailing winds. Protective structures were unnecessary in sheltered areas. Even after the work was completed, it was important to retain some workers for maintenance: to replant seeds in areas where seeds had failed to germinate, rebuild damaged fences, and keep animals away from the young plants (Brémontier 1797). Based on Peyjehan's experiments at Teste, Brémontier later dismissed the need for internal fences, arguing that covering the seedings with branches offered sufficient protection.

Brémontier also confirmed the importance of planting the pine seeds with other plants, especially *genêt*, to shelter the young trees (Brémontier 1798). In a subsequent report on the dunes of Calais, Dunkirk, Ambleteuse, and Boulogne published in 1804, he noted that many dunes were covered with *hoyia* (*Ammophila arenaria*). In such situations, pine seeds could be sown in between the grass, which offered good protection. He also advised the planting of *hoyia* on dunes lacking any vegetation whatsoever. The stabilization of the dunes of La Mancha and the North Sea was a relevant issue, not only in terms of protecting agricultural fields and increasing the value of the wastelands, but because they functioned as coastal barriers protecting the inland areas from flooding (Bert 1900, 258–263).

In the following years, Brémontier's instructions were applied by engineers in charge of stabilizing the dunes along the Gascon coast. However, as time went on, engineers made adaptations according to the circumstances and their own experience. For instance, although Brémontier established the principle of the "littoral dune," it was only in 1850–1860 that the Bridge and Roads Services and Administration of Waters and Forests developed it into a specific technique considered essential for the stabilization process. The idea was to create a dyke to prevent sand from the ocean feeding into the existing dunes. Therefore, an artificial littoral dune was built along the coast: a simple bank of sand with certain dimensions and a certain slope. To achieve this, a bush fence or palisade was built 30–50 meters from the high tide mark. As soon as the sand ridge on the ocean side reached the height of the structure, the fence was raised or rebuilt—a process repeated until the dune reached the desired height of 10–15 meters above sea level. The artificial dyke was then planted with *gourbet* (Bert 1900, 94–97; Buffault 1897, 146–156). The techniques used for the vegetation cover and the way the seeds were sown varied according to the peculiarities of the site, the materials available in the surrounding areas, and the skill of the engineer or forester coordinating the work.

The French monarchy supported the physiocratic doctrines of colonization of the Landes and the dunes, and encouraged projects that could develop

such wastelands into valuable resources. This opinion was shared by the new regime established in the wake of the French Revolution (Labatut 2009, 18). With the decrees of July 2, 1801, and December 10, 1810, the French Republic assumed the right to carry out the tasks necessary to stabilize the dunes and placed these areas under common law in the name of the public interest (Biré and Halgan 1890). After the restoration of the monarchy, Louis XVIII passed a law on February 5, 1817, entrusting the management of such operations to the Bridge and Roads Services, putting an end to the work of the Commission of Dunes. However, from 1818, it was decided that once the pine trees were seven years of age, the dunes would pass into the hands of the Administration of Water and Forests, which was responsible for the protection and exploitation of forests, and maintenance of the work initiated by Bridge and Roads Services engineers. In 1857, under the Second Empire, a law established the obligation of villages to drain and reforest their common pastures, which led to the sale of land and the arrival of private investors in the afforestation process of the Landes. In 1862, the Administration of Water and Forests took full control of all facets of the dune stabilization process, including responsibilities of the Bridge and Roads Services, whose tasks primarily comprised the continued sowing of seeds (Bert 1900; Buffault 1897).

Although beset by interruptions and setbacks amid the sociopolitical upheavals in France during this period, dune afforestation had the support of various regimes and institutions, all of whom were driven by the desire to increase productivity and revenue. Historians like Jacques Sargos and Samuel Temple have argued that the French state used dune afforestation to extend its dominion and consolidate its power, integrating the lands and populations on the margins into the national sphere (Sargos 1998, 283; Temple 2011, 15). By the end of the nineteenth century, the once-barren landscape of dunes, wetlands, and sparsely vegetated plains had been replaced by thousands of hectares of forest. The result is impressive: a seemingly endless sea of pine. Driving through narrow rural roads from Soulac to Teste-de-Buch, I marveled at the landscape—privately owned but uniformly transformed into plots of pine, planted and felled at the same time, and planted according to the same principles, as Ignacio explained to me, recalling his training as a forester at the École Forestière de Nancy.

Following Brémontier's instructions, the French generalized the work of dune stabilization, establishing a standardized system and set of rules. Significantly, they demonstrated the viability of transforming vast sandy areas into forests, this way providing a successful example for other countries, which soon copied the techniques and the associated ideology to reinforce their own attempts at centralizing power and resources. I develop this theme in the next chapter.

Notes

1 Brown (1884, 98) presents a tentative English translation of the title of Titius' treatise, "On the restoration of the woods on the coast, especially plantation of White Pine, as the only means of effectually arresting the calamity."

2 The lecture was entitled, "*Mémoire sur l'origine des sables de nos côtes, sur leurs funestes incursions vers l'intérieur des terres, et sur les moyens de les fixer, ou du moins d'en arrêter les progrès*"; however, there are no surviving copies of the original text (Desbiey 1776).
3 It is possible that the French referred to *Avena nuda* as *avoine à gruau*.
4 According to the catalogue of the Brémontier's exhibition organized by the Municipal Archives of Arcachon in 1988, the engineer arrived in Bordeaux in 1766 ("Brémontier. Un Ingénieur du 'Siècle des Lumières' 1738–1809" 1988)
5 Both Pierre Peyjehan Jeune (ex. Ragot n.d.; Caillosse 2015) and Jean Baptiste Peyjehan (ex. Sargos 1998) have been identified as the man who worked for Ruat and Brémontier. In letters between Brémontier and Peyjehan, the latter usually signed "Peyjehan Jeune," with no first name. However, a notarial document dated October 28, 1791 [ADG, box Dunes, SP 903] suggests that Jean Baptiste Peyjehan, Jeune, trader, was responsible for the sowing of the dunes of Teste.
6 France was governed by the Consulate between 1799 and 1804. The Consulate's executive consisted of Napoleon Bonaparte, who wielded all power, as well as Emmanuel-Joseph Sièyes and Pierre-Roger Ducos. In 1804, Napoleon abolished the Consulate and declared himself emperor ("Consulate" n.d.).

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5 Sowing the sands

Dune afforestation: A matter for the state

"What is a dune?" senator Marcel Barthe asked the French Senate on October 26, 1891. "A dune," he explained:

> [I]s not a productive terrain, it is a mass of sand produced by wind accumulation, which any storm can disperse and transport to other places. A dune is unexploitable soil, unproductive […]. When the state expropriates a community or a landowner of a property in the mountains for a reason of public utility, the state acquires a certain property. On the contrary, when it decides to fix a dune, the result is uncertain.
>
> (Barthe 1891)

Indeed, as Barthe emphasized, when the state assumed the responsibility for stabilizing the dunes, this included the potential risks and losses involved in dealing with such an unstable and unpredictable environment. This raises the question of why the state would choose to take on such a responsibility.

According to Heinrich Cotta (1763–1844), the founder of the Royal Saxon Academy of Forestry in Tharandt, Germany, the answer is simple: "only the state manages for eternity." Historian Joachim Radkau (2008, 140) quoted Cotta in describing the widespread concern over the shortage of timber in Europe in the 1800s. Touted as the solution to this urgent problem, afforestation was increasingly seen as a matter for the state and public institutions. As I argue in this chapter, the dunes were part of the crusade to expand Europe's timberland, with a number of modern states undertaking large-scale land reclamation projects intended to convert dunes into forests. However, even if integrated into major national reforestation schemes, the transformation of dunes into forests had its own peculiarities. Significantly, this state-led enterprise was not so much aimed at turning a profit, but at reducing property damage and improving a perceived wasteland, while extending the state's jurisdiction over the peripheral coastal territories.

Reflecting the spirit of modernity, governments marshalled scientific knowledge, created specialized services, allocated financial resources, and

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developed the legal apparatus necessary to ensure the success of sand reclamation efforts. In this chapter, I describe how power and knowledge came together to create a new coastal landscape. However, rather than presenting dune forests as the materialization of the monolithic and "planned agential power of the state" (Nustad and Swanson 2022, 935), I focus on the constellation of institutions and actors assigned to sowing the sand, the practices and knowledge that emerged from the interactions between people, dunes, and trees, and the challenges of dealing with such highly dynamic environments.

José Bonifácio Andrada e Silva: A Portuguese trailblazer

Twenty years ago, when I first became interested in dunes and began my research at the Portuguese National Library, one figure stood out: José Bonifácio de Andrada e Silva (b. Santos, 1763–d. Niterói, 1838). A naturalist, Andrada e Silva was responsible for introducing the method of sand afforestation in Portugal, publishing a manual on the subject in 1815. Born in Brazil, then a Portuguese colony, he studied at the University of Coimbra in Portugal, where he held several important positions, including a professorship and intendant of mines and metals of the kingdom. Reading his accomplishments and contributions, I found myself wondering from whom and where he acquired his knowledge of dunes.

In 1790, with a stipend from the Portuguese government, Andrada e Silva embarked on a ten-year journey across Europe to acquire the technical knowledge necessary for Portugal's development. He was in Paris between 1790 and 1791, when Nicolas Brémontier was conducting his dune stabilization experiments in Teste. He spent two years studying at the School of Mines in Saxony (Germany) where, given the reliance of metallurgy on wood for fuel, he became interested in forestry—a subject he pursued under the tutelage of Friedrich von Burgsdorf (García-Pereda 2018), mentioned in the previous chapter. In his travels to Prussia, Denmark, Holland, England, and Scotland, Andrada e Silva met and studied with esteemed scholars like Alexander Humboldt and Antonio Volta. The Luso-Brazilian naturalist also became a member of several scientific academies and societies in Lisbon, Paris, Berlin, Stockholm, London, Edinburgh, Philadelphia, and Rio de Janeiro (Silva 1815; Reis 2003; Soromenho-Marques and García-Pereda 2017). In addition to rich personal networks and membership to the learned circles of Europe, Andrada e Silva visited key areas where the problem of dunes was being discussed and solutions were put into practice. Armed with ample knowledge, he returned to Portugal and applied it to the country's development.

Upon his return, in 1802, Andrada e Silva was tasked with planting pine trees in Couto de Lavos, where the sands were destroying the fields and jeopardizing the local fishing industry, reducing tax revenues (Silva 1826, vol. V, 84–85). In 1815, he published a manual on coastal sand seeding based on his experiences in Lavos in 1905–1906, the knowledge acquired in Prussia and Holland, and the available literature on the subject, with von Burgsdorf

emerging as his main reference (Silva 1815). Introducing his thesis on dune afforestation, Andrada e Silva explained that such initiatives would not only protect nearby fields from sand encroachment, but expand Portugal's productive lands. The new forests would also improve the climate, prevent the siltation of rivers and harbors, and provide valuable resources—including timber, resin, and tar—for national development. This was a common argument for the benefits of sand reclamation at the time. Like others before him, Andrada e Silva presented a series of instructions to achieve the stabilization of the dunes using fences, branch covers, sand-binding plants, and pine trees (primarily, *Pinus maritima*). He adapted von Burgsdorf's ideas to the particular geography of the Portuguese coast, accounting for the materials available and the specific conditions of the site in order to reduce costs. He was also aware of and made reference to Brémontier's achievements in Gascony. Regarding the role of the state, Andrada e Silva argued that only a good central administration and the introduction of new laws based on scientific principles and old knowledge could create more forests and maintain existing ones (Silva 1815).

Dune afforestation in the nineteenth century

Portugal

Sand reclamation did not begin with Andrada e Silva's experiments. Several interventions had been conducted before in Vieira, Aveiro, and Ovar, although these were unsuccessful. Ana Isabel Lopes (2023) has explored the efforts of the Benedictine monks to protect the monastery lands from sand encroachment on the northwestern coast. From 1780, the monks of São Romão de Neiva and São Martinho de Tibães planted pine trees to stabilize the sands in Viana do Castelo and Póvoa do Varzim. Although evidence is scant, I believe that, like other regions of Europe, Portuguese coastal communities had long used marram and pine trees to stabilize the dunes. Certainly, more research utilizing regional archives and on older periods is necessary to elucidate the work of local institutions and people in this matter, with Lopes' (2019, 2023) work signifying an important step in this regard. These first experiences were sporadic, haphazard, and often short lived (Rego 2001; Lopes 2023). In Couto de Lavos, for instance, the pines planted by Andrada e Silva on the sands did not survive—the turmoil unleashed by the Napoleonic wars putting a swift end to the work, the local population burning the fences and many of the young trees as they fled (Silva 1815, 2).

In the first half of the nineteenth century, the French invasions and Peninsular War (1807–1813), relocation of the Portuguese royal family and court to Brazil (1807–1821), rise of liberalism, collapse of the old absolutist regime, outbreak of civil war (1832–1834), and subsequent sociopolitical divisions resulted in marked political, economic, administrative, and social instability. In this context, it was almost impossible to take any action to use and

improve the territory. Nonetheless, even in these troubled times, some measures were undertaken, indicating concern about the afforestation of the sands. For instance, in 1823, King João VI ordered the administrator of the Forest of Leiria to sow more pine on the shore near São Martinho do Porto, whose harbor was under threat of siltation (*Diário do Governo* 80, April 4, 1823, 685). The same monarch appointed a commission to find a solution to protect the fields of Leiria and Nazaré (*Diário do Governo* 276, November 22, 1824, 1304–1305). In 1824, the Administration of the Kingdom Woodlands (*Administração Geral das Matas do Reino*) was created to manage and maintain the public forests—a task made significantly larger by the incorporation of the estates of the Crown and the abolished religious orders in 1834. This expanded scope included the littoral pine forests of Camarido, Foja, Urso, Pedrogão, Leiria, Valado, and Vimeiro e Mestras, and it was at these sites that the Administration began its forestation work (Rego 2001, 31–32). Twenty years later, in 1848, the Municipality of Peniche initiated the afforestation of local public land in order to create a protective barrier against the influx of sand from the nearby beaches (*Diário do Governo* 266, July 28, 1864, 2379). However, these actions, including the creation of the Administration of the Kingdom Woodlands, were relatively superficial efforts by the government to protect some localities and sustain the production of timber, an essential resource (Melo, 2017, 42–43).

Holland

At the beginning of the nineteenth century, many countries in Europe followed the French in launching their own sand-reclamation programs, hoping to expand their agricultural and forestry resources. In Holland, Jan Kops (b. Amsterdam, 1765–d. Utrecht, 1849), the Secretary of the Commission of Superintendence on the Research on Dunes, presented a proposal for the agricultural exploitation of the dunes in 1799. The gist of his proposal involved securing the dunes closest to the sea using marram and dividing the valleys of the inner dunes into small plots cultivated by families. Although the plan was rejected as untenable by the Dutch authorities, the idea of farming the dunes gained traction. In 1824, State Commission member Daniel Gevers van Endegeest (b. Rotterdam, 1793–d. Oegstgeest, 1877), proposed draining the dune area from Scheveningen to Bergen in order to transform it into agricultural land. His plan was put into practice in 1828, when King Willem I purchased a large tract of dune land near Bakkum and began implementing a number of improvements, including the erection of windbreaks, planting of vegetation (marram, poplars, and willows) to protect the valleys from sand drifts, construction of a dune canal, and establishment of a tree nursery (Jelles, 1968, 56–76).

Although dune intervention was primarily motivated by agricultural needs, both Kops and van Endegeest, impressed by French successes, were interested in promoting afforestation (Jelles 1968, 97). Supported by Willem I, the

reclamation scheme in Bakkum included the creation of a tree belt to safeguard productive land. The project was a marked success. Indeed, by the end of the nineteenth century, when the Bakkum dune estate was transferred to the Province of North Holland, it contained 110 hectares of woodland. According to Jelles (1968), the Province of North Holland came into possession of this territory at a time when the reclamation of dunes through afforestation was very popular, especially with conifers. The project continued with the establishment of a nursery and the introduction of the Corsican pine. In 1899, the Dutch Forest Service (*Staatsbosbeheer*) was established in close connection with the Dutch Heather Company (*Nederlandse Heidemaatschappij*), founded in 1888, to promote the cultivation of the wilderness and planting of monoculture forests. Of course, this was inland in the Old Dunes rather than coastal wilderness (Oosthoek 2018b).

Denmark

In Denmark, the fight against the shifting dunes was strengthened by the Sand Drift Act of 1792, which required the parishes on or near the dunes to plant marram grass. The country already had some experience in the stabilizing of dunes, including the previous attempts of Johan Ulrich Røhl and Erik Viborg. Between 1792 and the 1890s, afforestation schemes in Tisvilde Hegn, where Røhl worked, favored a mixed composition of Scots pine, red spruce, and beech forest, planted in different phases. Other areas of Zealand were also targeted during this period, leading to the creation of the Asserbo and the Hornbæk plantations, among others (Binderup 2021). In northwest Jutland, the work initiated by Lauritz Thagaard, Johann Riegels, and Christian de Thygeson in 1799 successfully halted sand drift in the Thy area and led to the establishment of a landscape of heather and forest by the 1890s (Knudsen and Greer 2008). According to Mette Wilkie (2002), the legal framework created in 1867, in which the state assumed responsibility for fighting the sands, was essential in supporting these large-scale stabilization programs. After the passing of this act until the 1950s, swathes of Danish dunes were converted into forests (Jensen 1994).

Prussia

The afforestation of the Danzig dunes on the Baltic coast of West Prussia is an interesting case study of how the spread of knowledge and experience inspired attempts to solve a shared problem. As noted in the previous chapter, influenced by the practices in North Jutland, J.D. Titius proposed using marram to stabilize the dunes before beginning afforestation—a thesis for which he was awarded the 1768 Danzig Natural Science Society prize. Some two decades later, with the problem of the dunes persisting, Sören-Biörn (b. Astrup, 1744–d. Danzig, 1819), a Dane living in Danzig, noted "that in his native country large stretches of shifting sand had been fixed by planting sand

grasses" (Wessely 1873, 223) and insisted in the use of marram, willow, and other types of wood. In 1795, he was entrusted with stabilizing the local dunes, and consulted on similar works on the Curonian Spit (present-day Russia). However, the arrival of Napoleon's troops on Prussian soil in 1807 put a stop to the work. It was not until 1814, when Prussia reclaimed Danzig, that operations were resumed, starting with repairing wartime damage. Writing in 1873, Joseph Wessely (Vienna, 1814–1898), the director of the Forestry School in Mariabruun and author of a book on sand drift published in Vienna, argued that while Sören-Biörn implemented the first systematic dune fixing in Prussia, he lacked sufficient understanding of dunes themselves, failing to recognize the value of the littoral dune, and employing unnecessarily expensive processes. In this respect, Wessely emphasized the improved accuracy and efficiency of dune control since Sören-Biörn (Wessely 1873, 225). Nevertheless, Sören-Biörn's methods were influential for many years and were later refined and expanded on by his successor, G. Krause (Gerhardt, 1900, 425), who produced a textbook on dune stabilization, based on the work he directed from 1820 to 1856. All of these interventions were funded by the Prussian government.

Spain

In Spain, afforestation as a means of solving the threat of dune encroachment was discussed from the late eighteenth century. In 1782, Gaspar de Jovellanos (b. Gijón, 1744–d. Puerto de Vega, 1811), a member of the Economic Society of Madrid known for his economic writings, proposed the afforestation of the dunes surrounding his hometown of Gijón. Although the Municipality of Gijón had already completed some hard engineering works to protect the urban area from the sea, the sand presented an insidious threat—piling up during wind storms and ruining houses and fields on the outskirts of the town. With the aim of "completely liberating the city from the sands," Jovellanos suggested constructing a fence around the affected area, removing the accumulated sediment via municipal brigades, and the division of the land into plots to be distributed to those interested in planting vegetable gardens. Outside the fence, Jovellanos recommended the planting of pine trees on the dunes. As espoused elsewhere, he noted that the benefits of such an enterprise included mitigating the threat of the dunes while enhancing the region's resources and beauty (Jovellanos 1782; Machicado 2011).

As in other parts of Europe, in Spain, the first decades of the nineteenth century were marked by the invasion of Napoleon's troops, war, the spread of liberalism, recession of the old laws and institutions, and the conflict between liberal and conservative parties. It was a period of great political and economic instability, social tension, and administrative fragility. Nevertheless, it was during this tumultuous period that the first General Forest Administration (*Dirección General de Montes*) (1833–1842) was founded. Specializing in the history of forests, my colleague, Ignacio García-Pereda, compared the

emergence of forest administration in Spain with the dynamic attitude toward new experiments in forestry in France after the revolution of 1789, a fertile environment for interventions like that of Brémontier. In Spain, liberals waded through the remnants of the old regime in building a new administrative system, one technically and professionally sound enough to support the modern state's pursuit of progress and wealth (García-Pereda, 2021, 39). This view resonates with my understanding of the Portuguese context, where liberalism similarly shaped political ideas and advocated for administrative reforms that promoted the development of technical education and the professionalization of public services.

Britain

The British Isles offer an abundance of historical information on battling sand drift and the planting of marram grass. However, comparing such data with that on afforestation is somewhat disappointing because dune reclamation schemes did not gain the same prominence in Britain that they did elsewhere. That said, there is a significant research discrepancy in this case as the bulk of my work is from official documentation, rather than private archives. But in Britain private archives likely contain more information about dune interventions in the eighteenth and nineteenth centuries because such initiatives were largely left to landowners (Oosthoek, 2018, 133–134). For instance, on the Sefton Coast, in Northwest England, Richard Formby established a small plantation of sycamore, ash, and other species on his estate in the 1790s. Later, in 1887, the estate's new owner, Charles Weld-Bundell, introduced pines based on his knowledge of the successful intervention in Gascony. The famous Culbin Sands were afforested by a local proprietor in 1839, the growing of conifers on the landward side of the area encouraging others to follow suit. In Norfolk, the Earls of Leicester initiated tree planting on the coastal dunes of their Holkham estate in the 1850s to protect the countryside from the encroachment of the sea (Haggard, 1906, 467; Steers, 1937, 501; Clarke and Rendell, 2014, 422–423). As in Holland, dunes played there an important role as coastal barriers. Noting that the Earl had originally planted trees as shelter and ornament rather than for commercial purpose, Mr. Woods, the Earl's agent at Holkham, asserted that they had since emerged as the ultimate means of land reclamation and a valuable asset to the country (Royal Commission on Coastal Erosion, 1909a, 25–26). Further detail of these private interventions requires more in-depth research, beyond the scope of my project.

The building of modern states and the stabilization of the dunes

The construction of modern states implied, among other things, the effective control of the nation's citizens, territory, and resources. To achieve this, governments had to understand the quantitative and qualitative realities of what

they actually had to manage. They did so by sponsoring the production of knowledge, investing in educational and technical institutions, and building essential infrastructure like roads, bridges, and railroads to shorten the distance between the capital and the peripheries. Governments also promoted their institutional presence at the local level through the implementation of public services and general standardization of legal, judicial, and fiscal matters (Branco 2003; Silva 1998). In the second half of the nineteenth century, Portugal was in the process of becoming a modern state—the country's political, economic, and social stability allowing for public investment in material development. In this respect, "growth" and "progress" emerged as keywords of the time.

The expansion of state forestry from the 1850s is a prime example of the growing reach of the modern state. In Europe, state forestry included "not only actual woodlands managed and exploited by state agencies, but also legislative efforts […], public education initiatives (forest academies), the emergence of state-funded forest science, and the integration of forestry into the symbolic metabolism of many European nations" (Oosthoek and Holzl, 2018, 7). Within this forestry framework, dune stabilization had its own developments. Decades of trial and error in various coastal locations led to significant improvements in dune stabilization processes (Wessely, 1873, 228), with this know-how subsequently disseminated by travelers, experts, professional and scientific networks, state propaganda, and a flourishing literature on the subject.

Legislation and knowledge production

Forest development was a major concern for many European countries, widespread and pressing timber shortages prompting governments to action. In addition to the expansion of resources, state interest in promoting afforestation was related to protection and disaster prevention. According to Cristina Joanaz de Melo, a forest historian, the debates in Portuguese parliament from the middle of the nineteenth century highlighted the importance of trees for retaining excess rainwater, preventing extreme runoff, and reducing flooding, as well as improving river navigation, draining tidal lands, and containing sand drifts in coastal areas (Melo, 2017, 72). Portuguese deputies discussed the legal framework necessary for such forestation on several occasions. However, the legislative projects presented in the 1840s and 1850s were not approved because they touched on the highly sensitive matter of property issues and the limits of state governance within the private domain (Melo, 2017, 77–79). This controversy was shared by other countries, the subject debated in the political arenas of Spain, Britain, and France, among others.

Despite the difficulties, driven for the desire to improve and protect resources, afforestation remained a prominent concern in Portugal. Following a similar political path to Portugal, in 1863, Spain passed a law known as *Ley de Montes*, which gave the state the authority to take over and manage public

woodland and assume responsibility for the dunes and other nonarable land. Of course, the mere existence of a legal principle does not guarantee its effective application. The Spanish state lacked the resources—that is, the personnel, money, and knowledge—required to apply this law. In fact, one of the most pressing issues for the Iberian states was the lack of information about their own territories. Both Portugal and Spain recognized the urgent need for knowledge about their natural resources—the soil, minerals, water, fauna, and flora at the basis of the agriculture, forestry, fisheries, and mining sectors, particularly insofar as such information was integral to their public management. It also soon became clear that any attempt to expand national forests and forestation efforts had to be supported by proper recognition of the existing resources and the best locations to promote afforestation. In Spain, this led to the creation of a commission for the mapping of forests in 1868, and subsequent launch of a general afforestation project in 1879. In this respect, the commission identified candidate areas—mainly wastelands and dunes—on the understanding that afforestation would improve their climatic conditions (Corral, 2017, 46–47).

Similarly, in 1867, the Portuguese government commissioned the Geodesy Service to carry out a thorough assessment of all wastelands and flood-prone areas—namely, mountains, heaths, and dunes—that might benefit from afforestation. The report provided the first diagnosis on the dune situation at the national level, presenting valuable information on the location, extent, condition, and damage caused by the coastal sands (Ribeiro and Delgado 1868; Rego 2001). Such data helped the Portuguese government troubled with the Herculean task of cultivating the barren lands of the country to prioritize a specific part of the territory: the coastal areas. In 1872, Portugal passed a law establishing and extending public forest domain to dune areas allowing the government to convert them into state-managed forests. This was an easy step, since most of the coast—including the dunes—was already public property. In the following years, the consolidation of the political elite and reinforcement of state authority saw the ratification of two significant decrees. Passed on March 6, 1884, the first established the state's right to afforest all areas, including mountains and watersheds, considered risk-prone. The second law, approved on October 2, 1886, gave the state the authority to expropriate private lands if the owners were unable to undertake afforestation work themselves. In 1886, the General Forest Administration was replaced by the Forest Service, a new body under the supervision of the Ministry of Agriculture (Melo, 2017, 86–87, 111–112). According to Cristina Joanaz de Melo, the Portuguese national afforestation law of 1872 was one of the first of its kind in Europe, preceded only by France, who introduced such legislation in 1860. Similar laws were passed in Switzerland in 1876, Spain and Italy in 1877, and Austria in 1884. These laws, however, tended to prioritized the afforestation of mountains, which were considered more troublesome. Meanwhile, Spain only promulgated legislation pertaining to the reclamation of the sands and estuaries in 1888 (Melo, 2017, 127–131).

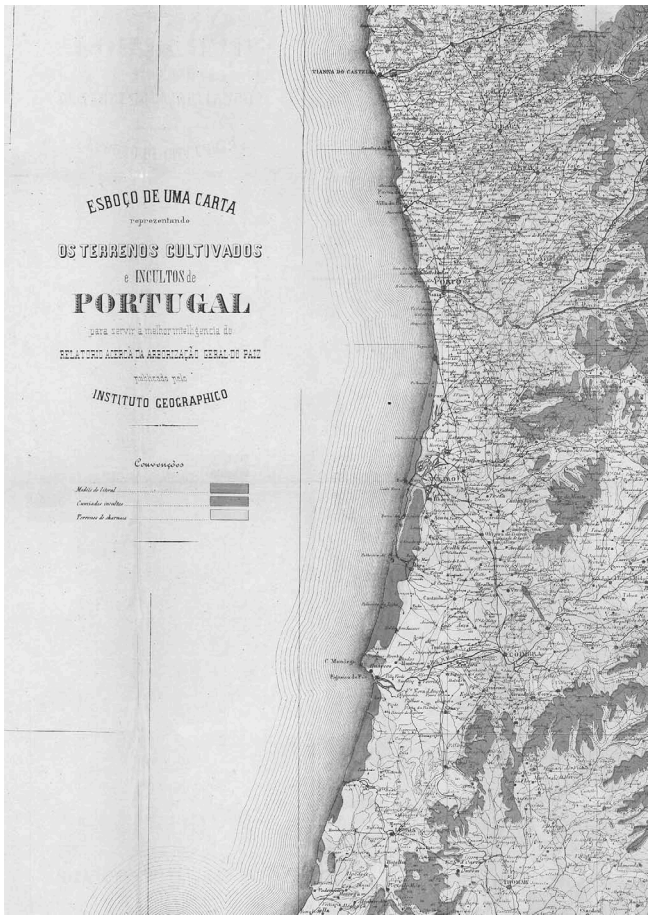

Figure 5.1 Detail of the survey map made by the Geodesy Service in 1868, identifying the areas to be forested in the mountains and on the littoral of Portugal. The dark spots on the coast are the mobile dunes between Espinho and Pederneira

Source: Ribeiro and Delgado, 1868. Adapted by J.G. Freitas. Original map held by the Biblioteca Nacional de Portugal

Education and technical training

The period between 1850 and 1880 proved fundamental for the establishment of scientific forestry in Portugal. Based on the teachings of Andrada e Silva, the General Forest Administration sowed the sands adjacent to some public pine forests near the coast, including the forests of Leiria, in 1854, as well as those of Urso, Medos, Vil de Matos, and Ceiça, between 1859 and 1862 (*Boletim do Ministério das Obras Públicas* 1857, 3: 212–215; 1864, 1: 92–99, 2: 199–208). However, these interventions fell under the auspices of regular

forest maintenance, with these forests threatened by the constant shifting of the nearby sands. Planting trees in barren dunes presented an entirely different challenge, one requiring specialized personnel and coordination.

To secure such knowledge, the Portuguese government looked abroad for expertise and sent students to the forestry schools of Germany and France. In 1857, the politician Venâncio Deslandes was tasked with preparing a forestry course, based on those taught in the institutions of France (Nancy), Germany (Tharandt, Honhenheim, and Wumtemberg), and Spain (Villaviciosa and Oden) (Magalhães, 1864; Melo, 2017, 76, 102–103). In Spain, forestry education had been supported by the Crown and government since 1843, including the provision of funding for the likes of Agustín Pascual, Esteban Boutelou, and Antonio Campuzano, to study at the School of Tharandt (García-Pereda 2018, 32–35). The Spanish state also founded the *Escuela de Ingenieros de Montes* (1847) and *Colegio Oficial de Ingenieros de Montes* (1852). In contrast, Portugal only began cultivating forestry education in the 1860s, when Bernardino de Barros Gomes (Lisbon, 1839–1910) and João Maria de Magalhães (1835–1896) were sent to the schools of Tharandt and Nancy, respectively. After completing his studies, João Maria de Magalhães visited Gascony and toured Saxony, Bavaria, Wurtemberg, and Austria, reporting on sand stabilization practices. He was also well-acquainted with Brémontier's method and the French legislation on the subject (Magalhães 1864). Meanwhile, in 1864, the Lisbon Institute of Agriculture (*Instituto Agrícola de Lisboa*), founded in 1852, presented its first course on forestry. Several of the institute's students—including Carlos de Sousa Pimentel (1873), Henrique de Mendia (1880), Egberto Magalhães Mesquita (1885), Júlio Henrique Viana (1885), and António Mendes de Almeida (1886)—were responsible for the main dune afforestation works in subsequent decades (Devy-Vareta 1989; Radich and Alves 2000; Melo 2017, 76; García-Pereda 2018, 32–35).

The work of the Forest Service: Practical learning and progress

In the late nineteenth century, Portuguese foresters produced many reports, theses, books, and official briefings on their regular work in the dunes. Employed by the Forest Service, these men coordinated seeding and planting operations, initially following the instructions supplied by Andrada e Silva and the methods promulgated by von Burgsdorf and Brémontier. Like elsewhere in Europe, in Portugal, the first task of dune stabilization involved the creation of a littoral dune to retain the sand from the ocean. However, after their initial attempts, Portuguese foresters began adapting these imported procedures to the specificities of the Portuguese case, introducing changes to the orientation of the fences or the materials used, and giving preference to local sand-binding plants (Pimentel, 1873, 107–115; Administração Geral das Matas, 1875; Andrade, 1904). In addition to the physical features of beaches and dunes, their dispatches provide highly detailed records of the work from

planning to execution. They meticulously described the construction of fences, including the materials used, the length and width of the wooden planks and the distance between them, and the number and length of the lines of fences built, the planting of vegetation cover, including the kilograms of seed per hectare and type of bush covering; as well as the roads and warehouses built, labor employed, total cost of the materials and operations, and progression of the sown areas by region and year (Viana 1885; Mendia 1881; Mesquita 1884; Administração Geral das Matas 1875; *Boletim da Direcção Geral de Agricultura* 1904; Andrade 1904).

In 1896, the Ministry of Public Works appointed a commission of experts to analyze the dune situation in all coastal regions and draw up a methodical plan for their stabilization. Given the scope and cost of afforestation projects, the commission was asked to prioritize the most vulnerable areas. Dividing the coastal region into sections corresponding to ten administrative units, the commission produced a rigorous representation of Portugal's littoral areas, providing invaluable information on dunes, land use, and ownership in these territories. The foresters responsible for such systematization determined the existence of a dune area of 37,000 hectares, asserting that stabilization could be achieved within 50–60 years, providing that the available budget was increased (Borges et al. 1897).

Spanish developments

Spain lagged behind Portugal in the stabilization of dunes. In fact, it was only after the passing of the watershed afforestation law in 1888 that the Forest Council (*Junta Facultativa de Montes*) prioritized interventions to control flooding and immobilize the sands that endangered urban areas. They began with the dunes of Cádiz and Huelva (Melo 2017, 132), which had already been identified as troublesome. Indeed, according to a note published in the *Revista de Montes*, the forester Luis Heraso had already been appointed to examine the situation on the coast between Portugal and Cadiz ("Personal," 1887). Around this time, Primitivo Artigas, a Spanish forester and Professor of Forestry, included a chapter on dune stabilization in his handbook on scientific forestry, referring to Bremóntier and revealing his familiarity with the Portuguese developments in the field, specifically citing the achievements of Carlos de Sousa Pimentel in this respect. Artigas identified some particularly problematic dunes in Spain, notably those of the Golfo de Rosas on the Mediterranean coast between Barcelona and the French border, as well as those located on the Atlantic coastline from Portugal to Cadiz (Artigas y Teixidor 1890). Artigas had already written about the dunes of Rosas, where he was from, in an attempt to draw attention to the destruction caused by the *arenas voladoras*, a problem he was convinced could be solved by afforestation (Artigas y Teixidor 1875, 1879).

The 1890s and 1900s saw the burgeoning of studies and interventions on the Spanish coast, accompanied by a growing literature on the subject (Artigas y Teixidor 1896, 1908; Castro 1900, 1905a, 1912; Mira 1906). In 1895, a royal decree ordered the cataloging of dunes, drifting sands, and related damage in

both the Spanish interior and on the coast, with such information considered necessary for developing a national plan on the issue of dune encroachment.[1] According to historian Ignacio Diez del Corral, it is unclear whether such a catalog was ever produced, although some dune stabilization proposals at the time appear to be connected to such an inventory, including those of Luis Heraso (1890) in Huelva, Javier de Ferrer y Lloret (1895) in Rosas, and Francisco Mira y Botella (1897) in Guardamar del Segura (Corral, 2017, 51–54). Several of these proposals led to concrete outcomes. In Guardamar del Segura, intervention was initiated under Francisco Mira in 1900. In Cadiz, work began in Isla Cristina, in 1902, and Puerto de Santa Maria, Rota, and Barbate in 1905 (Kith & Tassara 1946).

Like their Portuguese peers, Spanish foresters produced detailed reports on the procedures used to build littoral dunes, install fences, and select vegetation. They also ruminated on some of the challenges they encountered, balancing the knowledge acquired through formal training at the *Escuela de Montes*, and the know-how gained through practical experience. They were also aware of the experiments being conducted across the border and expressed interest in how the Portuguese were dealing with the same issues (Castro, 1905b). In October 1904, Ángel Fernández de Castro visited the dunes of Vila Real de Santo António in southern Portugal, which is very close to Huelva. He was able to compare the methods used and the results obtained with those of his own country (Castro, 1905a), noting that they were relatively similar. Foresters' personal reports indicate that they used Brémontier's method as a base, adapting the techniques to the specific physical and human features of the places where they were operating. In doing so, they account for the unique climatic, geographic, oceanic, and human attributes of the site, as well as the budgetary and labor concerns of the project. That so many aspects had to be considered when seeding the dunes demonstrates that the process and its success involved far more than the application of a standard technique.

Dune afforestation in the twentieth century

At the beginning of the twentieth century, Iberian governments strengthen the purview and authority of their forestry services through the introduction of new legislation. Spain created ten regional Hydrological and Forestry divisions in 1901, and the Afforestation Law (*Ley de Repoblación*) in 1908, while Portugal established the Forest Regime through legislature passed in 1901 and 1903. These laws addressed a variety of topics, including the highly sensitive legal, political, and social issue of afforestation on private land for the public good. In the case of Portugal, the Afforestation Law of 1903 defined three levels of state intervention: a total forest regime for public lands, a partial compulsory regime for municipalities, and a voluntary partial regime for private individuals, to whom the state offered tax-free benefits to encourage the planting of trees on their properties (Corral 2017; Radich and Alves 2000; Rego 2001).

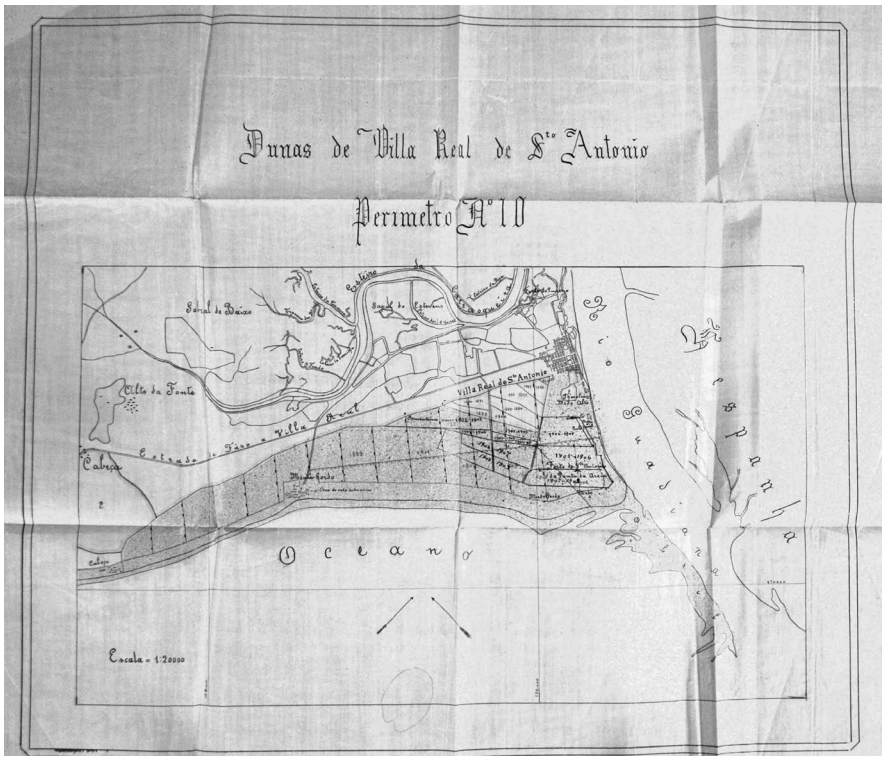

Figure 5.2 Plan of sowings of the dunes of Vila Real de Santo António, Portugal, 1897
Source: Borges et al., 1897. Photo by J.G. Freitas. Original drawing held by the Arquivo do Instituto de Conservação da Natureza e das Florestas, Lisbon, Portugal

In Portugal, the first two decades of the 1900s were characterized by an increase in sand stabilization work, promoted by the new Forest Regime and facilitated by a higher budget. While such operations were relatively unaffected by the fall of the monarchy and establishment of a republican political system, in 1910, the extraordinary economic and military crisis of the First World War (1914–1918) did hinder progress. Nonetheless, recognizing the importance of dune stabilization, the Republican government expanded the existing legal and institutional framework to further consolidate such efforts. In 1911, the new administration appointed a commission to update the 1897 report and propose any necessary improvements to current procedures based on advancements in the field (*Diário do Governo* 12, January 6, 1911, 197). In 1919 and 1922, the government passed a series of laws encouraging private landowners to increase the forest area on their properties and expand the financial resources of the Forest Service (*Diário do Governo* 88II, April 17, 1919, 1277; 195II, August 25, 1922, 3078-3079). Meanwhile, municipalities frequently requested that the Forest Service undertake afforestation on

municipal land in order to minimize the threat and damage of dune encroachment (Rei 1924; Rego 2001; Freitas 2004, 613).

Despite the diligence of the institutions and personnel involved in coordinating such works, progress was slow and suffered a number of setbacks. Given the time and labor required, administrations were often short of money and specialized personnel (Administração Geral das Matas 1875, 61). The problem affected both Portugal and Spain. For instance, although operations in Huelva began in the early 1900s, they only gained momentum in 1924, due to a lack of financial resources (Kith & Tassara 1946). Portuguese and Spanish foresters often described similar obstacles, including the hindrance of climatic conditions. In Guardamar, Francisco Mira (1906) identified the strong winds, scarcity of rainwater, and high temperatures as the main obstacles to the growth of the trees. It was frequently necessary to reseed and replant large areas because the plants failed to take root or were lost to the sea or extreme weather conditions. Fences regularly required repairing or replacement. On several occasions, littoral dunes were damaged by the waves during storms and had to be rebuilt or moved inland (*Boletim da Direcção Geral de Agricultura* 1904; Andrade 1904). Of course, the human factor was another significant obstacle. Noting the many challenges he had to overcome in the afforestation of the dunes of Mira, Figueira da Foz, and Cantanhede in Portugal, Manuel Alberto Rei emphasized the negative effects of negligence. In the case of municipal forests, lack of care and vigilance resulted in locals overexploiting the grasses and wood and allowing their cattle to graze on the young plants (Rei 1924). Consistent maintenance and policing were key to the survival and success of these interventions.

The dunes under the Iberian dictatorships

Dune afforestation was promulgated as a major national campaign by the Portuguese regime of *Estado Novo*, the corporatist state in place from 1933 to 1974. The discourse justifying the interventions used many of the arguments popularized in the nineteenth century. Focusing on impending catastrophe and economic loss, state propaganda emphasized the role of sand in the siltation of ports and navigation channels and destruction of agricultural lands. As a threat to profit and production, the dunes were cast as contributing to the impoverishment of the country. Of course, such discourses were underpinned by a political agenda: by disseminating a Manichaean view of the sands as an evil threat, the authorities' fight against them was elevated to the level of a civilizing mission. In this sense, in 1938, the state approved a new forest plan promoting the forestation of mountains and communal lands and promising to completely stabilize the coastal dunes within five years ("Plano de Povoamento Florestal" 1939).

The Portuguese Propaganda Service later wrote that, before the intervention of the new regime, dune control in Portugal was a disgrace compared to other European countries (*Cadernos do Ressurgimento Nacional* 1940). But,

according to figures presented in the 1939 Forest Plan, among other sources, the main afforestation efforts were carried out before 1936, which means that the *Estado Novo* only completed dune stabilization—effectively building on a century of progress and achievement (Freitas 2004; *Cadernos do Ressurgimento Nacional* 1940; Germano 2000). As mentioned, three different political regimes in Portugal—the monarchy, the republic, and the dictatorship—actively supported and facilitated dune stabilization and afforestation. That said, the dictatorship had what previous initiatives lacked: the financial, knowledge, and bureaucratic resources needed to finish the job. Also, the *Estado Novo* was more effective in harnessing such endeavors for political capital, turning it into a crusade, endorsed by its own propaganda machine, that demonstrated the state's patriarchal power over nature and the nation. Indeed, the 1940s were probably the last time the dunes were considered a terrible threat and that the fight against them was politicized. At the time, the regime still spread the work of stabilizing the dunes as a beneficial undertaking, celebrating the transformation of the landscape, the correction of the climate, and the creation of a better and safer environment for the people. Dune stabilization was promoted as a contribution to the next generations. In this respect, the corporative state claimed to be fulfilling its mission of planting for the future, particularly insofar as Providence had given it the responsibility and the power to guarantee the continuity of the nation (*Cadernos do Ressurgimento Nacional* 1940).

A similar pattern emerged in Spain, which set national goals for afforestation based on the Afforestation Plan of 1939, which included the dunes. After the Spanish Civil War (1936–1939) and emergence of the Francoist dictatorship (1939–1975), forestry policy followed the national ideology of economic self-sufficiency as a means of recovering from postwar economic crisis. Using cheap labor—of which there was an abundance due to the high rate of unemployment—the regime invested in large-scale plantations to increase forest revenues. Like Portugal, the Spanish state frequently abused its authority to eliminate any local opposition to such plans. It was during this period, for example, that the dunes of Huelva were earmarked for expanded afforestation. In Almonte, the state bought land and pressured local landowners, with the threat of expropriation, to increase the forest area, advocating the stabilization of dunes by planting pine and eucalyptus (Espina Arguello and Estévez Herranz, 1993, 98–100).

In Spain, as in Portugal, sand stabilization was a matter for the state, as it was considered a social necessity and outside the scope of the private sector (Corral, 2017, note 62, 64). The works were supervised by local Hydrological and Forestry divisions, which were responsible for the

> correcting, fixing and foresting of the numerous dunes that spread along the Atlantic and Mediterranean coasts, such as those of the Golfo de Rosas, in Gerona, Guardamar, in Alicante, and those from Almonte, Odiel, Barbate and Isla Cristina, in the provinces of Huelva and Cadiz.
>
> (*Patrimonio Forestal del Estado* 1954, 129)

By the 1950s, "dune works" essentially involved maintenance, with listed state forester duties mainly including the replanting of vegetation, extension of the littoral dune, and rebuilding of some contention walls (*Patrimonio Forestal del Estado* 1954). Like Portugal, state-run afforestation efforts were used for propaganda and to glorify the mission and outcomes of the dictatorship (Iriarte Goñi 2017, 29–31). That said, the problem of the dunes seems to have been less politicized in Spain than in Portugal. Coastal dune stabilization was a secondary concern compared to inland areas, which garnered greater attention from the Spanish Forest Service.

In 1964, a commission of Portuguese experts asserted that dunes still presented a threat, especially in southern Portugal. Nonetheless, located on the north coast, Portugal's main dune fields were considered to be under control and the adjacent lands safeguarded from any danger (Caldas et al. 1965). Ten years later, just before the end of the dictatorship, an official report proclaimed that the dune problem had been solved (*Projecto do IV Plano de Fomento*, 1974, 282). This was not exactly true, but it was no longer relevant; the paradigm of coastal management was changing, and other knotty issues concerning the dunes emerged over the next few decades.

The British exception: Afforestation as a private matter

While most European countries with sand dune problems shared the assumption that sand fixing and afforestation was a state responsibility, Britain thought differently. Those who supported the role of the state in dealing with environmental issues, such as deforestation and sand drift, tended to emphasize the state's ability to sustain efforts for the common good. In contrast, the British believed that political actions were usually guided by immediate concerns, and that only private individuals thought long-term and considered their descendants (Radkau 2008, 140; Aldhous 1997, 283).

In a report on his travels to England in 1870, Henry Leeds, Conservator of Forests in Bengal, India, asserted that although the country did not have immense forests, English landowners and the men they employed as stewards and managers of their forests had good knowledge of forestry, based on their valuable experience (Brown 1883, 2). Quoting Leeds, John Croumbie Brown claimed that Britain was in a unique position in Europe because it had no forestry schools and had produced little forestry literature. A colonial botanist in South Africa, Brown felt that forestry science training and knowledge were desperately needed in both Britain and her colonies (Brown 1886, 218). In 1887, a lectureship in forestry was finally established at the University of Edinburgh, a primarily scientific university providing comprehensive training for the colonial services ("The Forestry Department of Edinburgh University" 1921).

Leeds was astute in his observations of informal forestry knowledge among those who associated with the many forestry enterprises in Britain. This know-how is evident in the inquiries made by the Coast Erosion Commission, a royal commission appointed in 1906 to investigate the coastal

encroachment, including the extent of damage and the possible reclamation of tidal lands. Two years later, the scope of the commission was expanded to include the exploration of afforestation as a possible solution to unemployment in times of crisis. Over the course of their appointment, the commissioners interviewed representatives of various boards, local authorities, officers, landowners, engineers, and geologists. In addition to investigating the situation on the British coastline, the commissioners physically inspected the sea defenses of Belgium and Holland and requested information from the governments of France, Germany, the Netherlands,[2] Belgium, and Denmark regarding their coastal defense and reclamation measures as well as the role of the state on such matters ("The Coast Erosion Commission" 1911; Royal Commission on Coastal Erosion 1911).

Between 1906 and 1911, the Coastal Erosion Commission produced three reports. These reports contained ample information about dunes, as many of those interviewed were familiar with their use for coastal protection and the dangers of sand drift. For example, C.E. Howlett, Clerk to the Commissioners of Woods and Forests, informed the Commission on Coastal Erosion some areas used the Dutch faggot method, supplemented by the planting of marram grass, to create protective barriers. According to Howlett, such measures were hindered by the tendency of farmers to strip the dunes of marram, which they used for thatching purposes (Royal Commission on Coastal Erosion 1907, 18). Asked about the planting of maritime pine to immobilize the sands, Clement Rid, a member of the Geological Survey, responded that although he had not observed the practice in Britain, it had achieved good results in France. William Wheeler, civil engineer and author of the book *Sea Coast*, was well-acquainted with the work done in Jutland and Norway. Another engineer, William Shield, referred to his own experience in Port Elizabeth in South Africa regarding the planting of sand for land reclamation (Royal Commission on Coastal Erosion 1907). The interview with J.M. Wood, the man responsible for the forests of Holkham Estate, elicited valuable insights regarding the dune stabilization experiments conducted on the estate and the particularities of this coastal forest (Royal Commission on Coastal Erosion 1909a). There are many examples of private dune stabilization and afforestation initiatives. In port areas like Exeter, Carnarvon, Pembrey Harbour, and St. Andrews, marram was planted to prevent the siltation of the estuaries (Schleicher 1917). Between 1898 and 1905, the Railway & Docks Company paid for the planting of bent grass (marram) in Port Talbot, Swansea Bay, to prevent sand from drifting into the channel. As some of the dunes were located on private land adjoining the Port Talbot docks, the company asked the landowner, Lord Jersey, for permission to plant marram on his estate ("Planting Bent Grass on Sandfields…" 1898; "Bent Planting on Sandhills" 1905).

In its third and final report, the Commission on Coastal Erosion recognized the importance of dunes for coastal protection and the value of planting marram to bind the sand and prevent drift. In respect to the use of trees, the commissioners noted that, "in the UK, experiments do not appear to have

been made on a large scale," and referred to some private afforestation endeavors, such as those on the shores of Moray Firth (i.e., the Culbin Sands) and Holkham (Royal Commission on Coastal Erosion 1911, 17). The conclusions of this working group are particularly interesting insofar as they reveal conflicting perspectives on afforestation and coastal erosion as matters of public interest and duties of the state. In regard to afforestation, the delegates did not hesitate to recommend the setting up of a comprehensive national afforestation scheme, noting that it would lead to the creation of a labor-intensive industry and profitable use of land (Royal Commission on Coastal Erosion 1909b, 52). However, when it came to defending the coast from the incursions of the sea and sand, the Commission rejected the notion that the state had any responsibility whatsoever, emphasizing that coastal erosion (and presumably, by extension, dune encroachment) was an entirely local matter ("The Coast Erosion Commission" 1911).

Until the First World War, the British government practiced a *laissez-faire* forestry policy, supported by cheap timber imports from overseas. However, the war disrupted shipping and trade, and the demand for domestic timber nearly destroyed the existing forests. In 1919, the British government passed the Forestry Bill and created the Forestry Commission with the purpose of acquiring and foresting land to replenish the country's severely depleted woodland areas (Aldhous 1997; Oosthoek 2018a). However, according to historian Jan Oosthoek, the Forestry Commission could only afford to buy "cheap, marginal, upland areas," which meant that the bulk of afforestation took place in inland mountainous areas (Oosthoek 2018, 140). In contrast to other countries and periods, sand drift was not a major problem at this time, but some proposed the conversion of dunes into forests in order to control and profit from these areas (Carey and Oliver 1918, 86). In this sense, the Forestry Commission afforested several dune fields, creating the Culbin, Tentsmuir, and Newborough forests. For example, although local landowners afforested the Culbin Sands in 1839, the forest was felled during the First World War. Between 1921 and the 1950s, the Forestry Commission steadily acquired land in this area, increasing the forest extension. Following the example of Gascony, the British foresters first used marram and maritime pine; however, when the latter failed to grow effectively, they turned to Scot, Corsican, and contorta pine. Progress in the first years was described as tedious and costly. It did not help that the area was used for military exercises between 1943 and 1944. Before 1946, the work primarily comprised sand immobilization, planting, and weeding. It subsequently came to include thinning vegetation and road-making, with many of the operations mechanized ("Culbin Forest History 1921–1951" 2014). Similarly, in 1924, the Forestry Commission purchased Tentsmuir, Scotland, a region of heathland, marshes, bogs, and dunes, where they planted Scots and Corsican pines. Like the Culbin Forest, it was used for military training during the Second World War (1939–1945) (Cunningham, Gallacher, and Luurtsema 2014, 19–20). Additionally, extensive plantations of Corsican pine took place in Newborough

Warren, Wales, after 1948 (Doody 2013, 43). As geographers Michèle Clarke and Helen Rendell (2014, 421) asserted, "afforestation remained the management tool of choice well into the twentieth century in Britain with the fundamental aims of arresting sand movement and providing commercial forestry."

Final thoughts

In concluding this chapter, I would like to emphasize that the campaigns for dune stabilization launched throughout Europe, influenced by the French model, were never merely about controlling the dunes. On the contrary, they were part of a broader set of the ideas, political motivations, economic interests, and environmental anxieties that characterized this time period. The events examined in this chapter were shaped by a view of wealth and economic growth that left no room for unproductive landscapes. Such a utilitarian perception of nature determined that all land should be put to some use, if not by private individuals, then by the state. While forests were useful and profitable resources, the barren wastelands of the dunes were perceived as indicative of poverty and neglect. The literature produced in the first half of the twentieth century confirmed the widespread belief that trees offered multiple benefits and enhanced the economic and aesthetic value of coastal areas. Moreover, afforestation interventions led to the creation and expansion of roads, railways, drainage systems, communication networks, and housing (Teixeira 2016), adding value to these once peripheral regions.

In France, Spain, and Portugal, afforestation legislation and the expansion of the forestry regime provided a legal framework through which the modern state could expand its control over marginal areas—particularly dunes and mountains on private and communal property—in name of the common good. Some governments and regimes even used dune afforestation as a way to consolidate their moral authority as tutelary figures of the nation, building symbolic landscapes linked to national identity and representing monuments of collective effort. To achieve their goals, states invested significant sums of money to support surveying and mapping projects, send individuals to study abroad, and establish technical education institutions and specialized services. Although state intervention and the scientific rational management of forests contributed to dune stabilization in the twentieth century, climate also played a key role in this process. Indeed, the end of the Little Ice Age in the nineteenth century led to a decline in dune activity (Jackson, Costas, and Guisado-Pintado 2019) and facilitated the success of dune afforestation.

Notes

1 The Royal Decree of December 7, 1895 established the need to "proceed with the utmost diligence with the formation of a provisional Catalogue, by provinces, of the dunes and flying sands of the Spanish coast and inland, including only those that

are currently causing manifest and significant damage to the adjacent populations and agricultural properties" (Corral, 2017, 54).

2 In 1906, the Foreign Affairs Office received a report from Sir Henry Howard, who was stationed in The Hague, in reply to a request about dune afforestation in the Netherlands [NAKG, FO 368/34/9].

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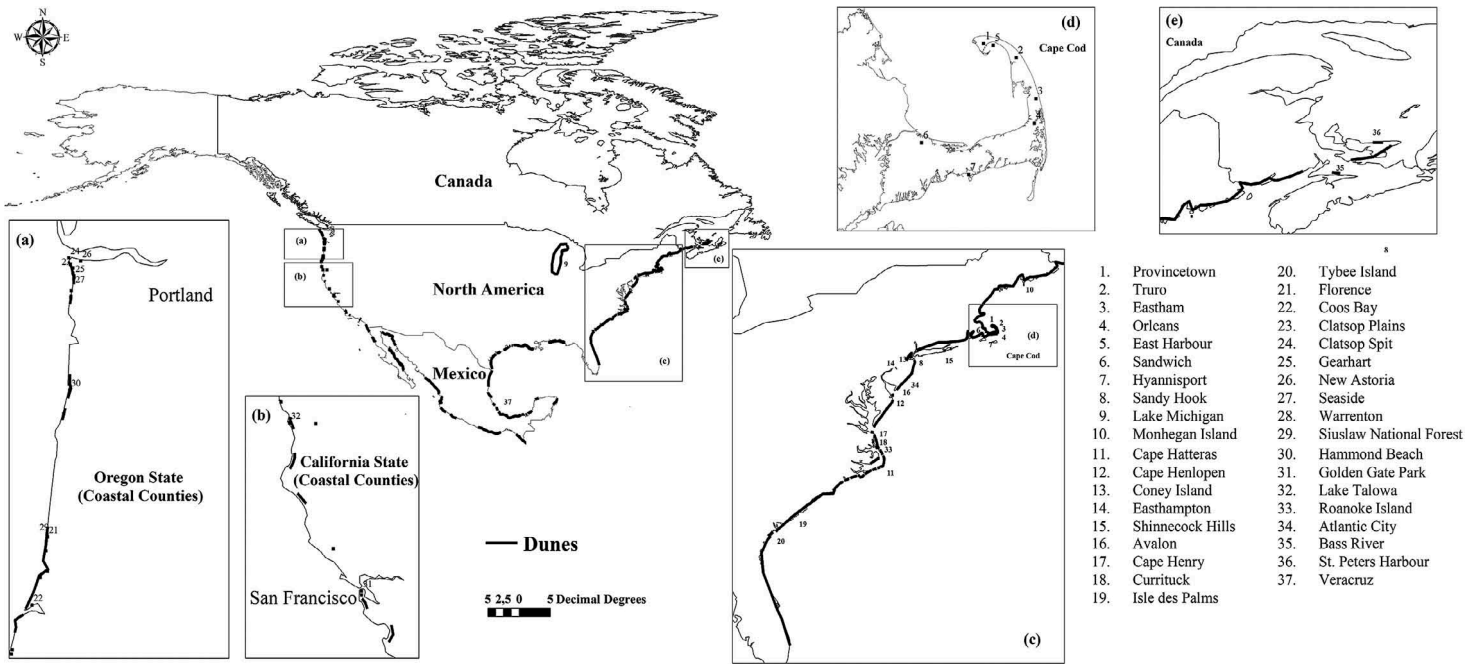

1. Provincetown
2. Truro
3. Eastham
4. Orleans
5. East Harbour
6. Sandwich
7. Hyannisport
8. Sandy Hook
9. Lake Michigan
10. Monhegan Island
11. Cape Hatteras
12. Cape Henlopen
13. Coney Island
14. Easthampton
15. Shinnecock Hills
16. Avalon
17. Cape Henry
18. Currituck
19. Isle des Palms
20. Tybee Island
21. Florence
22. Coos Bay
23. Clatsop Plains
24. Clatsop Spit
25. Gearhart
26. New Astoria
27. Seaside
28. Warrenton
29. Siuslaw National Forest
30. Hammond Beach
31. Golden Gate Park
32. Lake Talowa
33. Roanoke Island
34. Atlantic City
35. Bass River
36. St. Peters Harbour
37. Veracruz

Figure 6.1 Map of North America with the location of the regions and places mentioned
Source: Map by D.M.R. Sampath

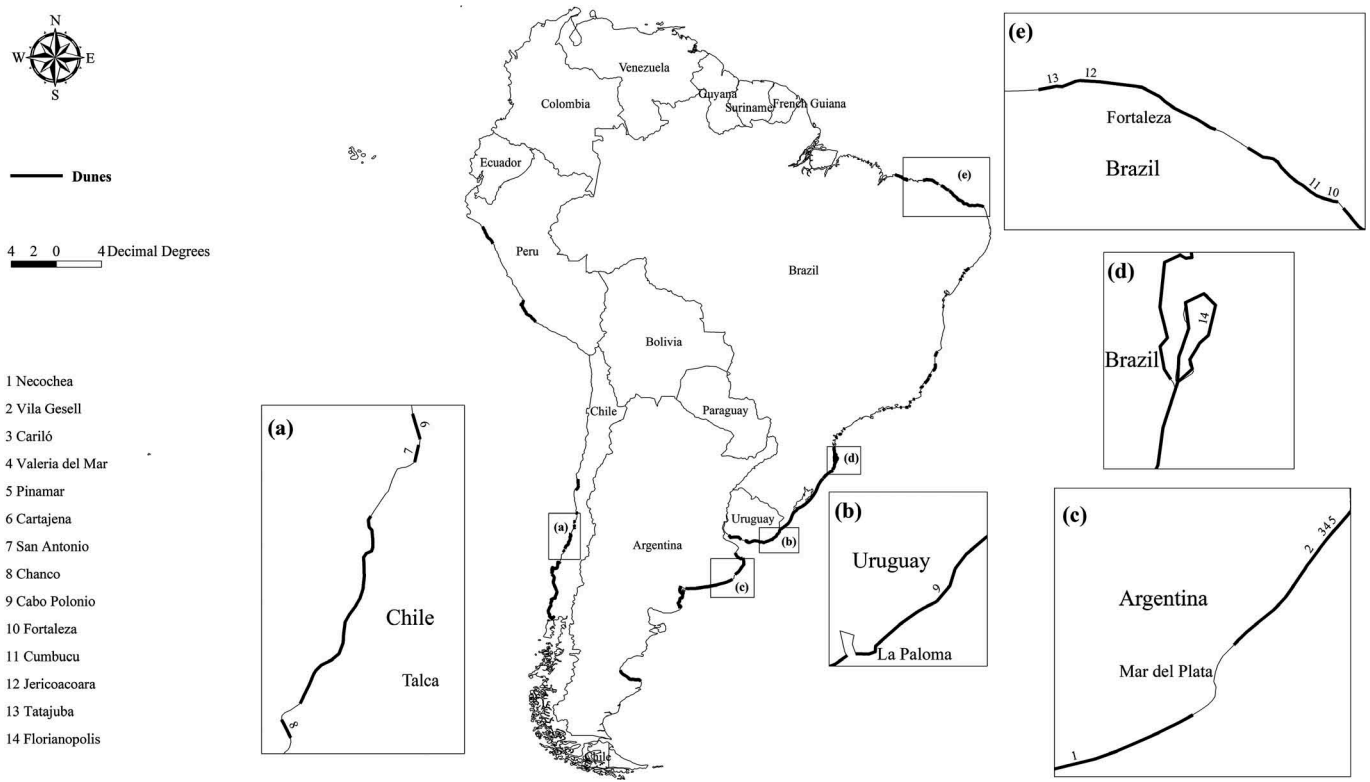

Figure 6.2 Map of South America with the location of the regions and places mentioned
Source: Map by D.M.R. Sampath

6 Crossing the Atlantic

Discovering the Cape

A library with an ocean view. What better place is there for a historian to work on a book about beaches? I wrote the first lines of this chapter in the Provincetown Public Library on a cold winter's day in 2022. Sitting in front of a large window overlooking the channel, the water almost as gray as the sky, I marveled at my surroundings. Provincetown Public Library is unique: behind me was the mainsail of the *Rose Dorothea*, a fishing schooner, built by Captain Francis Santos and installed in the library in 1986. Seeing it was a breathtaking surprise, certainly not one I expected as I ascended the stairs to the library's second floor. After the initial "wow moment," I gazed at it for some time, delighted and bewildered by the sight of a boat housed within a library. The day before, I had seen the dunes of Cape Cod for the first time, having long wanted to visit the peninsula. Novelist Sara Ware Bassett (1933) wrote, "our lives are like the ever shifting sands which ocean currents whirl in the ebb and flow of their unresisting tides." Certainly, it was the tides of life which brought me to the shores of Cape Cod: first, mentally, through historical written sources and maps collected over the years, and then physically, to the sandy beach of the Cape itself.

I first came across Cape Cod in Kansas City in 2014, when I received a fellowship from the Linda Hall Library to study their US Army Corps of Engineers collection. Poring over the Corps' files on coastal areas, I stumbled upon the drifting sands of Truro and discovered that settlers had been planting beachgrass to stabilize the dunes since the eighteenth century. This piece of information immediately caught my attention. While I was aware of the centuries-old dune problem in Europe, I had not considered the presence of similar issues in the United States. Moreover, the emergence of dune mobility as a problem and attempts to resolve it appeared to correspond to events on the other side of the Atlantic. Several questions popped into my head at once. Why were the sands drifting near Truro? Where did the settlers learn the strategy of planting grasses on the dunes? Was this a case of knowledge transfer or local practice? Which beachgrass did they use? Was it native to the area or imported? To answer these questions, I set the Army

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Corps aside and dove into the history of Cape Cod. At Linda Hall, I gathered information that later became the foundation of a hypothesis on dune stabilization in Cape Cod, namely, that the European settlers brought with them the knowledge and the means—that is, the beachgrass species—that they used to stabilize the sands. In this chapter, I show how this hypothesis is only partially correct: while eighteenth-century settlers had the know-how, they used local vegetation to put this knowledge into practice.

Much has been written about the history of the European settlement of Cape Cod, the hardships and struggles of inhabiting a new territory and transforming it into a homeland, while depriving others of their birthright. Such literature has highlighted the complex political, social, economic, and environmental dynamics of settler colonialism and dispossession (Cronon 1983; Bolster 2008). Although I take these issues into consideration, my focus lies in how this settlement was deeply troubled by the hazard of drifting sand, both a natural phenomenon and a consequence of European arrival at the Cape. Indeed, dunes are ubiquitous, existing long before any written accounts of the region; they are intrinsic to local geology. The strange configuration of the peninsula was shaped by glaciers during the last Ice Age and later by changes in sea level. North of Truro, the tip of the peninsula was formed by the deposition of sand carried by longshore currents, the dunes later created by the winds and held in place by vegetation (Holmes, Hertz, and Mulholland 1998, 17; Oldale 1980). Pollen-based analyses suggest that once the Cape supported many tree species, with pitch pine and oak thriving in poor soils, red oak and beech in richer soils, and a variety of white pine, pitch pine, hemlock, beech, yellow birch, and others around ponds and lakes (Holmes, Hertz, and Mulholland 1998, 17). The region's geography, climate, and dry and nutrient-poor sandy soils made for a unique and fragile ecosystem. Comprising small trees, shrubs, grasses, lichens, and mosses, the current existing forests provide a thin vegetation cover over the fine sand, which is still the most impressive and "defining feature of the Cape" (Cumbler 2013, 214).

When I first learned about Cape Cod's shifting sands and the anxiety they caused to those living on the peninsula, I realized there were incredible similarities between this American stretch of land and coastal regions on the other side of the Atlantic. My interest in detailing the history of the sands of Cape Cod is not rooted in micro or local history, but in the connections to the European context. In addition to expanding the geographic scope of my research, the history of Cape Cod provides a starting point for tracing the spread of the sand problem along the Atlantic coastline of the United States, including the barrier islands off New Jersey, Maryland, and North Carolina. I conclude this chapter with some short stories about the dunes and their afforestation in Mexico and Argentina; they are an appetizer—signaling the potential histories that can be written about dunes in different parts of the world.

Environmental challenges to settling the Cape

First encounters

The religious, social, economic, and environmental pressures of early modern Europe set the stage for the era of exploration. In 1498, John and Sebastian Cabot arrived at Cape Cod en route to Virginia, the first documented visitors to the region. This was only formally named Cape Cod in 1602, by Bartholomew Gosnold, whose voyage was sponsored by English merchants, in reference to the large schools of fish populating the peninsula's waters. The reported abundance of fish spurred the interest of the major European fishing nations—France, England, Portugal, and Spain—in the area (Dunnell 1993, 14; Holmes, Hertz, and Mulholland 1998, 69). Later, in 1605, Samuel de Champlain, a Frenchman, called it "Cap Blanc" on the basis of another distinctive feature: its sandy landscape. Although Gosnold also mentioned the sand (Holmes, Hertz, and Mulholland 1998, 22–23), Champlain was more emphatic, describing the peninsula replete with dunes. The coast, he wrote, was high and full of sand, but also wooded and pleasant to the eye. Champlain went ashore at Mallebarre (Nauset Harbor), where he visited a native settlement and observed the agricultural produce, trees, and lands (Champlain 1632, 82–84).

In 1614, Captain John Smith departed London for America in search of whales, gold, and copper, and failing that fish and furs. He, too, noticed the sand at the Cape, which he described as a "headland of high hills of sand, overgrown with shrubby pines, hurts and such trash." Although it did, he admitted, have an "excellent harbour for all weathers" (Smith 1616, 38). A few years later, in 1620, the *Mayflower* arrived at what would become Provincetown harbor. Upon landing, the Pilgrims found a terrain of sandhills, forested with oak, pine, sassafras, juniper, birch, holly, vines, as well as some ash and walnut. It was here that the Pilgrims first glimpsed Native American life, namely, the Pamets, who inhabited the Province Lands, which they called Chequoket (Dunnell 1993, 8–12). These indigenous peoples led rich and complex lives long before the Europeans arrived, with sociopolitical systems organized around village-based chieftainships, extensive trade networks, and elaborate cultures and beliefs (O'Brien 2010, 3). On the peninsula, Native American peoples thrived on fishing and hunting, butchered beached whales, collected shellfish, foraged, and planted corn (Bradford and Winslow 1622). These populations maintained a crop-based subsistence economy, practicing a slash-and-burn agriculture that prepared the soil for the planting of beans, corn, and squash, a good combination for such sandy, low-nutrient soil (Friedman 1992, 44–46).

Settling in the Province Lands

The Pilgrims first settled in Plymouth, on the continental side of the bay, before expanding in search of trade and agricultural land. Initially, Massachusetts Bay and Plymouth were two separate colonies, with Cape Cod

included in the latter, until they merged to form the province of Massachusetts Bay in 1691. In the New World, land was claimed by the King of England on the basis of "discovery" and "non-use" and then granted to a company for settlement, typically ignoring the rights of the original inhabitants. That said, the English at times recognized some Native American claims to the land (Holmes, Hertz, and Mulholland 1998, 21), promptly purchasing it, replacing the Native American system of group ownership and usufruct with English rules of individual property. These deeds and "legal" means of land transmission were merely deceptive ways of dispossessing Native Americans of their territories, as they were unaware that such transfers were permanent and that they were giving up their homelands for good (O'Brien 2010, 3, 7, 10, 97; Cronon 1983).

Land grants and purchases were followed by the renaming of the territory, founding of towns, and the establishment of religious and legal institutions—the pillars of settler society (Cronon 1983). In 1630, the Council for New England granted the Plymouth Colony a patent for the lands of Cape Cod, upon which the towns of Sandwich, Barnstable, and Yarmouth were founded. Later, the scarcity of arable soil led to the division of the colony, with some moving to the Nauset area, where Samuel Champlain had visited the Native American village, and renaming it Eastham. The settlers also negotiated with the sachems of Nauset and Monomoyick to acquire the territory to the north known as the Outer Cape or Province Lands. In 1700, people from Eastham moved northward to Pamet, which was incorporated into the colony as Truro in 1709 (Holmes, Hertz, and Mulholland 1998, 23, 26–27; Dunnell 1993; "A Topographical Description of Truro" 1794). Initially a destitute fishing settlement, Provincetown, on the Cape's hook, was made a precinct in 1714 and incorporated as a town in 1727 ("A Description of Provincetown" 1802, 201; Jennings 1890).

European settlement in Cape Cod during the seventeenth and eighteenth centuries was characterized by agriculture, particularly the cultivation of corn and wheat, animal husbandry, and some maritime activities, such as whaling, fishing, oystering, and salt production (Holmes, Hertz, and Mulholland 1998, 27–28). However, environmental conditions differed significantly across the peninsula. The Upper Cape enjoyed varied terrain, abundant wooded areas and sources of fresh water, and thriving agriculture. In contrast, the Lower Cape was characterized by large areas of marshland, which provided winter fodder for cattle, but included a considerable expanse of barren and unproductive sandy soil (Friedman 1992, 66–67; "A Topographical Description of Truro" 1794, 197). By the end of the eighteenth century, soil depletion made even larger tracts of land unfit for cultivation, resulting in "young men [being] sent to sea very early in life" ("A Topographical Description of Truro" 1794, 198). Meanwhile, Provincetown flourished due to its excellent harbor, which was open to the south, sheltered from storms, and deep enough for ships to anchor there. "Its importance is incalculable," Timothy Dwight asserted in 1828, noting the growing number of vessels and absence of other safe harbors

on the perilous coast of Cape Cod. "Almost every day strangers visit Provincetown from different parts of the world," he added (Dwight 1828, 85, 87). Given the remarkable success of the cod fishery off the banks of Newfoundland and the rich revenues of fish trade, agriculture was relatively underdeveloped, with the local population almost entirely reliant on the Boston market for any kind of vegetable products ("Description of Cape Cod, and the County of Barnstable" 1791, 149–150).

The drifting sands

Exploring the Cape in the 1820s, Dwight described the villages, hamlets, and houses of Truro and Wellfleet, scattered across the valleys and sheltered from the winds by barren sandhills. Between Eastham and Orleans, he observed, windblown sand had laid waste to acres of land, leaving a bleak landscape with no settlements or living creatures. Underscoring the dreariness of the landscape, he noted:

> When and where this evil will stop, cannot easily be calculated; for the sand spreads a perfect sterility in its progress, and entirely desolates the ground on which it falls. The impression made by this landscape cannot be realized without experience. It was a compound of wilderness, gloom, and solitude.
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> (Dwight 1828, II, 90, 89, 78–79)

Similarly, in his impressions of Cape Cod, Henry David Thoreau—the American naturalist, essayist, poet, and philosopher—identified the sand as the great enemy of any settlement on the peninsula. In doing so, he listed several examples of how the daily routines of the inhabitants of Provincetown were disturbed by the sand and the peculiar habits that they had developed to deal with it:

> The houses were formerly built on piles, in order that the driving sand might pass under them. […] [The] natives of Provincetown assured me that they could walk in the middle of the road without trouble even in slippers, for they had learned how to put their feet down and lift them up without taking any sand. […] The cellars, as well as the wells, are made in a circular form, to prevent the sand from pressing in the wall.
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> (Thoreau 1866, 203–208)

However, the dune problem was far more serious than even these travelers described. Historical sources evidence significant concern about sand encroachment by the early eighteenth century, with windblown sand threatening settler livelihoods and Provincetown harbor. An act passed in 1745 described the issue as follows:

> Whereas there are certain meadow-lands within the township of Truro, in the county of Barnstable, on which many of the inhabitants of said town depend for their hay, and the said meadow-lands lies adjoining two long, sandy beaches, on which no fence can well be made to stand, and by reason of cattle and horses trampling and feeding there the beach grass, which was wont to prevent the driving of the sand from the beaches to the meadows, is destroyed, and a great part of the meadow already covered with sand, and become useless for grass, and the whole in danger of being buried with the sands, if not timely prevented.
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> ("An Act to Prevent Neat Cattle and Horses Running at Large" 1878, III, 209)

To stop the destruction of the beachgrass, the act prohibited the pasturing of cattle on beaches and meadows, with transgressors fined ten shillings a head.

Pasturing was just one of the causes of the loss of the vegetation cover on the dunes. Another was the use of the forest resources to supply the settlers' need for timber for the building and repair of houses and ships. The forests also provided the wood used as fuel for cooking, heating, and salt works, as well as the resin to produce pitch and turpentine (Westgate 1904, 18–19). The consequences of the disappearance of the vegetation growing on the dunes were felt more or less a century after the landing of the Pilgrims. In 1714, Provincetown was declared a precinct, under the jurisdiction of Truro, a decision which sought to regulate settlement, and migratory fishing and trade. This same act emphasized the necessity of preserving the harbor, which was in danger of being dammed due to the cutting of the trees and bushes that had kept the sand from being blown into the bay. To avoid such a disaster, the act prohibited the barking or boxing of trees for turpentine (Brinkley, Hedge, and Brown Junior 1854, 6–7). The regulation of the area's forests was further addressed in 1727, when Provincetown was redesignated as a township. Although the inhabitants were allowed to cut down trees and take the materials needed for building and industry, such as the construction and maintenance of wharfs, workhouses, and fish flakes, they were to do so without wasting or spoiling the existing resources. In 1727, despite, Provincetown gaining powers and privileges as a township, the Province of Massachusetts Bay held the title deed to all province lands within the town's jurisdiction area—a title that later passed to the Commonwealth of Massachusetts (Chase et al. 1893, 7–8). The public ownership of such land posed significant challenges to their management, with increasing calls for the right to use and exploit its resources. Meanwhile, the silting of the harbor continued to be a pressing issue in the ensuing decades. The mentioned act of 1745 sought to prevent the damages caused by cattle grazing on beaches of Truro and the East Harbor; a measure later revived in 1767 and 1772 (Brinkley, Hedge, and Brown Junior 1854, 8–12).

During the Revolutionary War (1775–1783) and the War of 1812, the British seized Provincetown harbor, cutting off communications between the town and the continent (Pitman et al. 1865). The Cape's location and

harbor conditions rendered it a key target for enemy naval powers, while its economy, based on offshore fishing and reliance on resources from the mainland, made the local population acutely vulnerable. Indeed, during the American Revolution, Provincetown lost most of its inhabitants to British raids and the restrictions on maritime activities (Rich 1883). In addition to political and economic constraints, the communities of Cape Cod faced ecological pressures. Deprived of fishing trade, many turned to agriculture, becoming more vulnerable to bad weather and its effects on crop production (Friedman 1992). For instance, in January 1763, some Truro residents organized a committee and petitioned for tax relief because of the damage caused by frost and high winds in the previous winter. They also complained that their most fertile lands and meadows had been buried under sand. Answering the petition, the House of Representatives approved the payment of an annual sum to Truro to aid the protection of beaches and maintenance of fences (The Acts and Resolves… 1890, IV, 631). The expansion of farming activities also increased the pressure on the meagre natural resources of the Cape (Holmes, Hertz, and Mulholland 1998, 27, 42; Friedman 1992, 185–187). Writing in the nineteenth century, Reverend John Simpkins claimed that the thin sandy soils of Eastham had been greatly impoverished, if not destroyed, by heavy tillage, extensive land-use, and insufficient use of manure (Simpkins 1809, X, 74–75).

Governing the land, reclaiming the sand

During the first century of settlement in New England, town governments were primarily responsible for overseeing a range of matters related to the environment, including property division, demarcation of grazing areas, fishing, common resource use, and land or resource disputes. Over time, the Cape inhabitants sought direct action from the colonial legislature, the Massachusetts General Court, on the regulation of resources and the solving of environmental problems (Friedman 1992, 71–74, 120; Rich 1883). Striking a balance between protecting and exploiting natural assets was a difficult task for authorities at all levels, as they had to manage not only dynamic ecosystems, but the conflicting interests of neighboring communities, individuals, and their domestic animals.

Laws were largely ignored throughout the eighteenth and nineteenth centuries, residents disreguarding warnings and continuing to fell trees for fuel and other purposes. The harmful consequences of such actions led the selectmen of Truro to petition the General Court for measures to protect East and Cape Cod Harbors. In 1825, a commission was appointed to assess the danger of the drifting sands, which were likely caused by deforestation (Brinkley, Hedge, and Brown Junior 1854, 14–16). It was clear to the commissioners that the destruction of the dunes' vegetation cover and the combined action of the wind and waves posed a serious threat to the harbor. They proposed reinforcing the measures already in place, namely, the prohibition of cattle and cutting of bushes and trees. They also

recommended the cultivation of beachgrass "as the best, if not the only effectual measure that [could] be adopted to prevent the drifting of the sand." Significantly, the commissioners noted that Provincetown residents were already planting beachgrass to protect their homes (Sampson and Marston 1852, 6).

Indeed, planting beachgrass had long been practiced in the Cape. As one record noticed in 1791, "some of the inhabitants [of Eastham], are now, endeavouring to stop the progress of the devouring sands, by planting bunches of beach grass, which takes root easily and spreads fast" ("Description of Cape Cod, and the County of Barnstable" 1791, Feb., 75). Similarly, in 1802, another record remarked, "great attention is now paid to the transplanting of beach grass, on the side of the hills and other naked spots near the town" ("A Description of Provincetown" 1802, 197). This was further corroborated by Dwight's notes regarding his travels to the Cape, an informant reportedly telling him that the people of Truro were legally required to cultivate beachgrass every April (Dwight 1828, 81). Although Dwight was likely referring to an earlier statute, in 1825, the proprietors of the Eastern Harbor's meadows and beaches, recognized as a political body, were given authority "to raise monies for the purpose of making fences, setting out or planting beach grass" or other tasks considered necessary for the preservation of their properties ("An Act to Incorporate the Proprietors of Eastern Harbour…" 1825, Feb. 11).

In the nineteenth century, the threat of drifting sand to the Cape Cod Harbor escalated, moving from the local and state to national level of governance. In 1826, the Massachusetts Legislature passed a resolution instructing their representatives in Congress to request federal support to prevent the destruction of the Cape Cod Harbor. Congress allocated more than 3,000 dollars, and continued funding efforts to stabilize the sands in the following years (Brinkley, Hedge, and Brown Junior 1854, 17–18). Between 1830 and 1839, the Massachusetts General Court initiated an extensive and systematic attempt to reclaim the sand dunes of the Province Lands by planting beachgrass, with the military responsible for carrying out operations (Westgate 1904). Explaining the interest of the War Department and Congress in this issue, Colonel J.D. Graham of the US Army Corps of Engineers, who was in charge of the survey for the preparation of the military and hydrographic chart from 1832 to 1834, emphasized the deep-water harbor's provision of refuge and shelter throughout the year as well as its importance as a naval base in times of war (Pitman et al. 1865, 2). The survey map drawn by Graham between 1833 and 1835 details the transplanted beachgrass areas.[1]

Between 1830 and 1835, the beachgrass planting program was supervised by an officer named Bowley (War Department, n.d.). The work was resumed in the 1850s by Charles Blunt, then a Lieutenant of Engineers, who managed the Congressional funds provided for the grass restoration efforts (Brooks Junior and Loring 1853). Writing to General Totten, the Chief Engineer, about the operations, Blunt accused the inhabitants of Provincetown of being extremely negligent with their cattle, making him hesitant to recommend further funding of beachgrass planting efforts (Blunt 1854, Mar. 8). On June

20, 1845, after the planting season had ended, Blunt reported on the progress of the project, explaining that 120 acres of grass had been planted in patches of different sizes, rather than a continuous strip, depending on their exposure to wind, availability of water, and likelihood of repair. Particularly interesting to me, Blunt noted in the letter that, "few of the old hands were available and a large proportion of the labourers were Portuguese, totally unacquainted with this set of work—after a few days however they did extremely well" (Blunt 1854, Jun. 30).

Meanwhile, in 1854, the State of Massachusetts passed an act requiring that a resident of Provincetown be nominated to oversee and prosecute those who destroyed beachgrass, bushes, or pines on the Province Lands. The act also required the annual election of a three-person committee in charge of planting pines, bushes, and grass on any public or private property if necessary to protect the harbor ("An Act for the Protection of Province Lands…" 1854). The passing of this act indicates that neither the prohibition of the destruction of vegetation nor the practical action of cultivating beachgrass had been fully effective. Indeed, many inhabitants resented the restrictive measures. As one observer noted, wood depredation was "mostly carried by the poorer class of the community, who, perhaps, think that their pinching want of the article of fuel justifies them," while wealthier inhabitants exhibited a complacent attitude toward the problem (Marston, Swift, and Boyden 1838, 5).

Throughout the nineteenth century, Truro residents submitted petitions complaining about the negligence of Provincetown in preserving its land, resulting in the loss of meadows, silting of the harbor, and obstruction of the road between the two towns (Small 1852a, 1852b). New commissions were appointed and reports produced on the problem of the silting of Cape Cod Harbor and the danger of a sea breach via the East Harbor severing Provincetown from the Cape. Some of these commissions even visited the region and interviewed locals about their knowledge and preferences regarding the situation. During the US Civil War, the strategic relevance of the harbor justified further maintenance works to reinforce the coastal defense system. The military used beachgrass and fences to strengthen the dunes, seeking to protect their function as a coastal barrier between the ocean and Truro (Brooks Junior and Loring 1853, Jan.; Brinkley, Hedge, and Brown Junior 1854, Feb.; Pitman et al. 1865, May; Chase et al. 1893).

For 200 years, the sands were a significant concern for the residents of Cape Cod and the various municipal, state, and national authorities (Westgate 1904, 10). As evidenced here, there was a shared commitment at multiple levels—from local residents and town governments to the State of Massachusetts, US Congress, and the military—to protect the Cape's harbor. However, the end of the nineteenth century saw a shift in ideas about sand dunes, the harbor, and the Cape itself. In the wake of the Civil War, the extension of the railway system and the decline of maritime activity contributed to the burgeoning of tourism, which reshaped the local economy of the Cape as it became a popular seaside destination (Friedman 1992, 341). As several

Provincetown residents explained to a group of Public Reservations Trustees at a hearing in 1893, the dunes were no longer a terrifying danger, but a spectacle attracting tourists. Townspeople placed greater emphasis on the preservation and beautification of the Province Lands, advocating the planting of trees to hold the sand in place. The Standing Committee of the Trustees subsequently proposed that the Board of Harbor and Land Commissioners appoint a superintendent to "successfully check the further progress of destruction" by "wisely directing the routes of travel across the sands, by watching for and attending to the beginnings of wind cuts, and by inducing a gradual reforesting of the dunes." As a servant of the state, the superintendent was to preserve the verdure of the region in order to sustain its viability and interests, including its popularity as a summer resort (Chase et al. 1893, 11, 13, 28–29, 31, 36).

Establishing links, providing explanations

Dunes, a recognizable landscape?

The planting of beachgrass to immobilize dunes was practiced in Cape Cod from the late eighteenth century. Reading about such activities, I immediately wondered where the settlers had learned this strategy. Did they hear about the benefits of beachgrass from those who lived on the Cape's sandy soil long before they arrived? Certainly, Native Americans explored the local resources and modified their environment by burning underbrush to facilitate the growth of certain plant species for game and through the practice of slash-and-burn agriculture (Holmes, Hertz, and Mulholland 1998, 55, 64). Both of these practices may have impacted on the vegetation cover of the dunes. However, it is unclear whether Native Americans experienced problems with sand encroachment before the Europeans arrived. Historical records only refer to the sand as an impediment to colonization and a nuisance to new ways of life.

As Ruth Friedman (1992) has pointed out, the settler system of environmental use differed from that of the Native Americans—one that was more managerial and based on English ideas about landscape, common and private property, utility, and improvement (Stilgoe 2015). Europeans introduced domesticated cattle to the area and allowed their animals to roam the fields, meadows, and dunes. They cut trees for building material and fuel, and grass for fodder and animal bedding. Where the Native Americans used hoes to till small plots of land, settlers plowed large tracts of land, replicating the type of agriculture with which they were familiar. In *In English Ways*, David Grayson Allen explained that the New England settlers continued the regional laws and customs of their homeland in respect to agricultural, land ownership, and governance (Allen 1981, 4–5). In some places, the reproduction of English practices depleted the fertility of the soil, forcing farmers to expand into neighboring areas and colonize new land (Cronon 1983). In the Cape, the sandy local ecosystem was generally unfit for agriculture, prompting inhabitants to pursue other activities, men usually spending most of their lives at

sea. Nevertheless, by the mid-eighteenth century, the disappearance of the woodlands and pressure on the dune vegetation cover had resulted in growing issues of soil erosion and sand encroachment. This was not unprecedented: centuries of deforestation and farming in Europe, along with the climatic conditions of the Little Ice Age, had resulted in the occurrence of numerous sand drift events.

If settlers brought their old farming and husbandry practices with them to the New World, they may also have brought their knowledge of sand drift and dune stabilization in Europe. When the Pilgrims set foot on Cape Cod, they immediately recognized the sandhills, which they considered "much like the downes in Holland" (Bradford and Winslow 1622, 3), suggesting that such sandy landscapes were not completely alien to them. Certainly, Holland had long planted marram to stabilize the dunes. From the outset, Provincetown was a popular stop on sea routes, where traders, smugglers, whalemen, privateers, and fishermen from different nations met and shared folktales (Kittredge 1968; Dunnell 1993, 28–29). These men may have shared knowledge on the ways and means of controlling drifting sand. As I explored in Chapter 4, lore surrounding sand drift and dune stabilization may have circulated between different European regions in the early eighteenth century and definitely did thereafter. I believe that this knowledge had also crossed the Atlantic by this time.

In the seventeenth century, scores of English men, women, and children left their homes and migrated to North America, fleeing economic depression, political tyranny, religious purges, and epidemic disease in search of a better life. According to historian David Hackett Fischer (1991, 16, 31, 36), most of the founders of Massachusetts were from eastern England, although almost all English counties were represented. As mentioned in Chapter 3, some of these regions were well-acquainted with sand drift. In Lincolnshire, for instance, fourteenth-century records of the manor of Ingoldmells reveal that locals were acutely aware that cutting the bushes and grasses growing on dunes posed a danger to the community, with the practice thus subject to penalties (Massingberd 1902). Uprooting marram had also been outlawed since the reign of Queen Elizabeth I (Trelawny 1846, 280–281). Moreover, the planting of marram seems to have been common practice in some dune areas from the end of the eighteenth century onwards (Clarke and Rendell 2014, 422). That some of those who crossed the Atlantic would have been familiar with the issue of sand drift can be inferred from the story of Reverend Charles Morton, who lost his position in the Cornish county of Blisland following the restoration of King Charles II. Morton emigrated to America in 1684, where he became the pastor of the church in Charlestown and was recognized as one of the eminent ministers of New England. Years before emigrating, Morton wrote a memoir in which he reflected on ways to develop Cornwall, including a chapter on the use of sea sand as soil fertilizer ("Biographical Memoir of Rev. Charles Morton" 1838). In this essay published in 1675, Morton described the beneficial applications of sea sand in Cornwall, but also mentioned how windblown sand had inundated and destroyed fertile land in England.

Morton also alluded to several English places, including Plymouth, Barnstable, Falmouth, and Truro, which are also locations in Massachusetts and Cape Cod ("The Improvement of Cornwall by Sea Sand…" 1675).

In fact, many of the towns in the New World were named after the English birthplaces of their founders (Fischer 1991, 36). For instance, Agnes Edwards and Shebnah Rich argued that Truro in Cape Cod was named after the Cornish borough of Truro, with Rich noting that many of the settler names could be traced back to Cornwall (Edwards 1918, 145; Rich 1883, 118). Rich also connected the landscape around the American Truro with two areas on the other side of the Atlantic: Perranporth and Perranzabuloe, located just a few miles from Truro, Cornwall. Home to the legend of Saint Pirran, the fifteenth-century pilgrimage site was frequently overwhelmed by the sand over the centuries (Rich 1883, 216, 219). Can we assume that those who named Truro in Cape Cod noted the similarities between its sandy landscape and that of their homeland—one reminiscent of the terrain and folktales of their native Cornwall? According to Allen, in the setting of the colony, "a hierarchy of authority developed, culminating at the level of provincial government, to deal with problems common in old England and now common to New England" (Allen 1981, 7). Were the dunes one such problem, an issue common to both the old and new worlds? We cannot be certain, but such links would certainly explain the measures adopted in Truro by both the settlers and the colonial government to protect the harbor from sand encroachment in the 1700s.

Beachgrass

There is another important element in this story, one immediately familiar to those accustomed to the dunes: beachgrass. As evidenced above, beachgrass was plentiful and covered a large proportion of the sand dunes on Cape Cod. This raises the question of whether this species was native to the peninsula or imported by the settlers as one of the many plant species Europeans introduced to North America. The answer is simple: The beachgrass mentioned in the records was native to America, but the path to discovering it was not.

Having travelled from London to Massachusetts in 1663, John Josselyn (1630–1675) produced a seminal work on the plant life of Maine. Published in 1672, the text identified species that were also common in England, including matweed (Josselyn 1860, 171). Edward Tuckerman (1817–1886), who was responsible for the introduction and notes of Josselyn's book, added that this was likely the English matweed, helm, or *Calamagrostis arenaria*—popular names for the famous *Ammophila arenaria*. English matweed was included in John Gerard's (1545–1612) *Herbal*, published in 1597 and revised by Thomas Johnson in 1633, under the scientific name *Spartum anglicanum*. (Interestingly, the book that I consulted included marginalia next to the drawing of this plant, labeling it *Arundo arenaria*, another name for *Ammophila arenaria*.) Johnson noted that he had seen such a plant on the British shore between Margate and Sandwich in 1632 (Gerard 1633, 42). It is worth noting

that a significant number of those who emigrated from the British Isles to Massachusetts came from this region (Fischer 1991).

At the end of the nineteenth century, F. Lamson-Scribner, an agrostologist for the US Department of Agriculture, noted that marram grass or *Ammophila arenaria* was a common species along the coasts of northern and western Europe and the American Atlantic coast from Virginia northwards. Its value as a sand binder, he continued, had long been recognized in England, Holland, and Cape Cod (Lamson-Scribner 1895, 425–426). However, Lamson-Scribner was wrong: *Ammophila arenaria* is not native to the Atlantic coast or the region of the Great Lakes in North America. But, its congener, the American *Ammophila breviligulata*, is. If experts like Lamson-Scribner (Westgate 1904; Cowles 1899) confused these two plants, it follows that the Europeans settlers may have made this same mistake—wrongly identifying the *Ammophila breviligulata* covering the dunes of Cape Cod as the marram common to the coasts of their homeland. Aware of the sand-binding qualities of English marram, they would have used the American species for dune stabilization, just as their brethren were doing in the British Isles. This means that in the eighteenth and nineteenth centuries, the grass planted on Cape Cod dunes by locals and the military was most probably the native species, not the European one. I could have stopped here, but two questions kept bothering me. First, as *Ammophila arenaria* is now present on the US North Atlantic coastline, including that of Cape Cod (Timm, Smith, and Greenspan 2014), when was the plant introduced? Second, when was the American beachgrass species finally identified?

Unable to find a concrete reference to the introduction of European beachgrass to the North America East Coast, I returned to my sources in the hopes that I might find more on the subject. The oldest references—laws and letters—from the Cape simply refer to "beachgrass." Later, experts like Lamson-Scribner, Gifford, Hitchcock, and Westgate (1895, 1898, 1904a, 1904) discussed *Ammophila arenaria* as a single common species planted to fix dunes on both sides of the Atlantic. This poses a problem: while *Ammophila arenaria* may have been circulating in the US it was not distinguished from *A. breviligulata* and both could have been used. The Global Biodiversity Information Facility (GBIF) is an international network funded by various governments to provide open access to data about all types of life on Earth. This digital tool includes museum specimens collected in the eighteenth and nineteenth centuries as well as species occurrence records.[2] According to the GBIF database, the first vestige of *Ammophila arenaria* in North America was collected in 1872, near the Bass River in New Scotland, Canada. The specimen is preserved at the University of Michigan Herbarium.[3] This institution also has a specimen of *Ammophila arenaria* harvested in Sandy Hook, New Jersey, in 1877.[4] The first reference to the European species in Cape Cod is from Hyannisport, Barnstable, in 1888,[5] the preserved specimen of which is housed at the Missouri Botanical Garden. Interestingly, the Missouri Botanical Garden has another specimen from 1896, with a note reading, "grass used for binding the drifting sand. Cape Cod, MA."[6] Unfortunately, although

these records may seem like a good indicator of the arrival of *Ammophila arenaria* to the US Atlantic coast, it is highly possible that some of these specimens have been catalogued incorrectly. For instance, a specimen found at Lake Michigan in 1881 was initially misidentified as *Ammophila arenaria*, and later corrected to *Ammophila breviligulata.* [7] Similarly, a plant from Monhegan Island, Maine, was catalogued as the European beachgrass species in 1921, only to be recognized as the American congener in 2007. As some of these records include photographs of the specimens, I asked Sally Hacker from the Department of Integrative Biology at the Oregon State University if she could identify the species for me. Sally confirmed that several of the records labeled *A. arenaria* were in fact *A. breviligulata*, including the specimens from Canada (1872), New Jersey (1877), and Michigan (1881). As the specimens collected from Cape Cod did not include photographs, it was not possible to identify them online.

Let us return to poor *A. breviligulata*, long mistaken for its European counterpart. When was the species finally acknowledged? Sifting through natural histories, digital biodiversity libraries, and online plant catalogues, I eventually found the answer: *A. breviligulata* was identified in 1920, when Merritt Lyndon Fernald (1873–1950), an American botanist working at the Gray Herbarium, Harvard University, realized that it was an entirely separate *Ammophila* species. As Fernald explained,

> The common Sand Reed, Psamma, Marram or Beach Grass, which covers the coastal sand dunes from the Straits of Belle Isle to North Carolina and occurs on sandy shores of the St. Lawrence system inland quite to Lake Superior, has been universally identified with *Ammophila arenaria* (L.) Link, the species occurring on the western and southern coasts of Europe. Superficially the two are very similar, although it needs only a glance at good material of typical *A. arenaria*, which occurs from southern Scandinavia to Portugal and Morocco, to see that the spike-like panicle is much shorter than in most of the American plant.
>
> (Fernald 1920, 70)

This issue was solved, but I could not discover when exactly *A. arenaria* was introduced in the American Atlantic coast.

From dunes to forests

In 1893, the State of Massachusetts initiated an extensive reclamation project to halt the threat of sand encroachment to Cape Cod harbor. Supervised by James A. Small, the intervention was considered a success and used as a reference for similar projects in other areas. J.M. Westgate, an assistant in sand-binding work from the US Department of Agriculture, was sent to the Cape to observe the initiative, investigate the causes of the devastation, and assess the measures taken over the years. Westgate's thorough report describes

how the plants were selected, harvested by hand, bundled, and then transported to the area where they were to be replanted. Beachgrass planting was merely the first step of the intervention—the ultimate goal of which was the reforestation of the dunes with trees species. However, not many trees were capable of surviving in the Cape's environment. Indeed, pitch, Austrian and Scotch pine, and Scotch broom were some of the few successful species. The reclamation project also involved the construction of roads in the dune territory and the macadamization of the southward road connecting Provincetown to the rest of the peninsula (Westgate 1904, 30–32). I had the opportunity to see the legacy of these past works in the spring of 2022, as I strolled through the dune forest that covers the Province Lands. A bike trail meanders between the canopy of trees, a patchwork landscape of bush and moss, and the bright white sand—a remarkably different scenario from the monocultural pine forest I had seen in Gascony, France, just a few weeks earlier.

As mentioned in Chapter 5, from the mid-nineteenth century, the afforestation of dunes emerged as a dominant and highly lauded trend in Europe. Despite two centuries of experience with dune stabilization in Cape Cod, North American naturalists, scholars, and experts turned to France, Holland, and Denmark for guidance on sand-binding matters—generally assuming that the stabilization of dunes in the US had been limited and was still in an experimental stage (Baker 1906, 213). George Perkins Marsh, a diplomat and

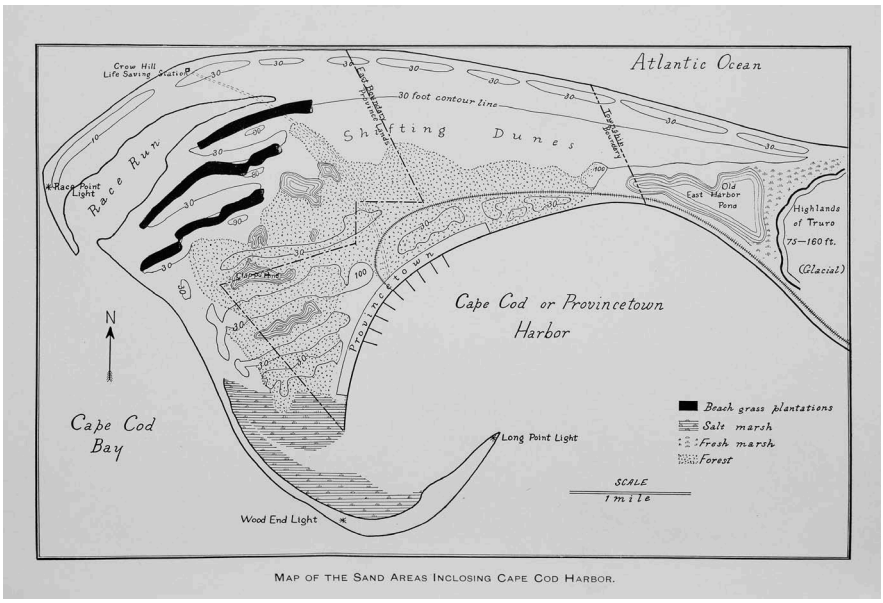

Figure 6.3 Map of the dunes and the sowings with beachgrass in the Province Lands, Cape Cod

Source: Reproduced by Westgate, 1904. Original document held by the Linda Hall Library.

conservationist instrumental in the development of the American environmental movement, argued that the dunes of America posed no great danger because the lands they threatened had a low value. Consequently, there was little interest in spending great sums of money to arrest their movement. In contrast, March noted in 1863, the severity of damage caused by the dunes in Europe had earned the attention of governments and motivated the systematic efforts to bring them under control (Marsh 1907, 552–553). In his seminal work, *The Earth as Modified by Human Action*, Marsh explored the history of dune stabilization in Europe and connected it to the contemporary efforts in his own country. Although he was aware of Cape Cod through Dwight's *Travels*, he did not give the peninsula much notice, believing that measures undertaken during the colonial period had since been abandoned. Recognizing the role of humans as agents of change, Marsh was interested in providing more *noteworthy* examples of the impact of human industry on the dunes so as to illustrate the "history of man's influence on the great features of terrestrial surface" (Marsh 1907, 569, 538; "About George Perkins Marsh" n.d.).

According to historian James Lewis, Marsh's observations on the effects of deforestation and the interconnectedness of vegetation, soil, and water had a marked influence on the work of the first American forestry advocates. As in Europe, Marsh's contemporaries were beginning to recognize the consequences of deforestation. Some recommended the scientific management of the forests, planting of trees, and the rationalized harvesting of timber. Impressed by the first reports on the conditions of US forests and the information compiled by men like Franklin Hough, Charles Sprague Sargent, and Bernhard Fernow, in 1881, US Congress created the Division of Forestry within the Agriculture Department, which had been established in 1862 (Frome 1984; Cox et al. 1985; Hays 2007). The Division of Forest recognized the problem of the sand dunes from an early stage. The Division's third chief was Prussian-born Bernhard Fernow (1851–1923), who had trained at the Forest Academy of Muenden and served in the Prussian Forest Service, before becoming a US citizen (Lewis 2005). Fernow led the Division of Forestry from 1886 to 1898. Clarifying the American forestry problem in a lecture at the National Museum in Washington DC, Fernow mentioned several European examples of tree planting, including the thousands of acres of sand dunes afforested and made productive in France. He also drew attention to the shifting sands on the shores of Lake Michigan and the North American coast, which he attributed to the destruction of forest cover. The reckless exploitation of forests, he argued, had made it necessary to devise methods to fix and restabilize the sands (Fernow 1888).

As there were no forestry schools in the US, the first American foresters—including John Clayton Gifford (1869–1949) and Gifford Pinchot (1898–1910)—studied in Europe. Earning a PhD from the University of Munich, Gifford was the first graduate forester in the US. He worked for the Forestry Service in the US Department of Agriculture between 1903 and 1906, and taught forestry at Cornell University (Tyrrell 2015). Having studied in France and Germany,

Pinchot served as the chief of the US Division of Forestry and then the Forestry Service between 1898 and 1910. Pinchot is considered the founder of professional forestry in the US because he established the Forest Service's administrative structure, the Society of American Foresters, and the Yale School of Forestry (Lewis 2005, 244). Experienced with European sand dune afforestation works and methods, both men were aware of the problems of sand drift on the American coastline (Pichot and Ashe 1897). In fact, Gifford published a paper on the subject comparing some known cases in France, like Soulac, with the shifting dunes in Cape Cod, New Jersey, and North Carolina, where seaside resorts and harbors were being damaged. He argued that the constantly changing coastline could be "rendered practically stable by the application of forestry and engineering skills" (Gifford 1898, 606). Although Gifford mentioned the interventions in Cape Cod, he considered the work in Europe to be the best model for dune reclamation. Praising European governments for actively engaging in forestation, he described the operations in France as the most striking and valuable lesson on the matter (Gifford 1898).

Foresters were not the only ones interested in sand reclamation within the Department of Agriculture. In 1902, Professor A.S. Hitchcock, an agrostologist in charge of cooperative experiments as well as grass and forage plant investigations at the Bureau of Plant Industry, was sent to Europe to study the methods used there. Frequently called upon for advice on the proper means of controlling the sands invading cultivated fields and railroads, the Department of Agriculture wished to learn from the centuries of European experience. Hitchcock visited the Netherlands, Denmark, France, and Germany in order to investigate their dune stabilization techniques and whether they could be applied in the US. His investigation was aided by official and scientific networks, his contacts in Europe—who included a US minister at The Hague, the director of the botanical garden at Copenhagen, and a botanist at the *Jardin des Plantes* in Paris—facilitating his access to certain dune areas (Hitchcock 1904b). Westgate's visit to Cape Cod in 1904 is another example of the Department of Agriculture's growing alarm over the damage to valuable property resulting from dune encroachment.

The papers and reports produced on sand dunes at the turn of the twentieth century suggest that the US was experiencing increasing problems with dunes sweeping inland and encroaching on private property and public infrastructure. In 1890, traveling the Atlantic coastline by sea, the author and journalist John Randolph Spears described how waves of sand at Capes Hatteras and Henlopen were engulfing the Kinnakeet and Chicamicomico settlements as well as the surrounding forest. Echoing the doom and gloom of the European narratives, Spears warned,

> Time will soon come when this simple people must be driven from their homes, pursued by a fate as irresistible as the deluge of old, leaving behind them all the associations of their race, of their customs, and of their occupations.
>
> (Spears 1890, 512)

Pragmatically, like the European populations who had long lived with the dunes, the islanders saw no reason for alarm: when they could no longer withstand it, they told Spears, they would move. Baffled by this response, Spears cast the Native Americans as powerless and resigned to impending ruin, asserting that, "calmly, idly waiting, these people accept their doom" (Spears 1890, 512).

J.P. Bond, a Forestry Assistant who later led an investigation in Cape Hatteras area, described the damage caused by the sand to the village and the remaining forest at Hatteras, examined the viability of a sand fixation project, and proposed measures based on the methods developed in Europe. He considered it feasible, but expensive. In fact, the cost of the project would exceed the intrinsic value of the property it was intended to protect. Nevertheless, noting that the area supported a considerable population, Bond asserted, "These people are entitled to protection by the State" (Pratt 1908, 47). As in the case of many European countries, the US recognized dune stabilization as a state imperative requiring the appointment of specialized public institutions and experts in the name of the greatest good.

At the beginning of the twentieth century, Hitchcock (1904a) identified the most unstable dune areas on the US Atlantic coast as including Cape Cod (Massachusetts), Avalon and Stone Harbor (southern New Jersey), Cape Henlopen (Delaware), Cape Henry (Virginia), Currituck (North Carolina), Isle de Palms (South Carolina), and Tybee Island (Georgia). In 1917, Francis Schleicher, a graduate student at Cornell University, produced a report on the dunes from Maine to Florida, paying particular attention to local sand drift and reclamation projects. While sand drift was still a problem in some places, like Cape Hatteras in North Carolina, other areas were experiencing major changes. Indeed, on a few New Jersey beaches—like Easthampton, Coney Island, and Shinnecock Hills—the dunes had been significantly modified by the building of fashionable summer residences and golf links (Schleicher 1917). Just like the other side of the Atlantic, modernity had arrived on the American shore—the beach fast emerging as a popular leisure space. Of course, this shift in usage gave rise to a slew of new environmental issues. The battle for the shores—against coastal erosion—had begun.

Some examples from Latin America

Although I do not dwell much on this subject, it is worth noting that the trend of dune afforestation—as both a discourse and practice—also extended southwards to countries like Mexico and Argentina. In 1885, Ignacio Ochoa Villagómez, a Mexican agronomist, presented an afforestation plan to the Development Ministry. The plan specifically targeted the *medanos* (dunes) of the port of Veracruz, which were some 50–80 meters high. During the rainy season, the low interdune areas became wetlands, the stagnant water thought to be a breeding ground for diseases and miasmas, which often afflicted foreigners staying in the city. To overcome such problems, Villagómez suggested

adopting Brémontier's method of dune stabilization. Knowing that European species like the *Arundo arenaria* and the maritime pine were ill-suited to the Mexican dunes because of the climate, the agronomist proposed the use of *Arundo nitida*, a native perennial grass, as well as local bushes and trees species (Ochoa Villagómez 1885). Miguel de Quevedo, one of the most prominent promotors of forestry in Mexico, was the first to attempt the afforestation of the dunes of Veracruz. Born in Guadalajara, Mexico, Quevedo was raised and trained as an engineer in Bordeaux and Paris, where he learned about the value of forests for soil conservation and dune stabilization. He returned to Mexico and was appointed Director of Works at the port of Veracruz, a position he held between 1890 and 1893. Although his main task was to build a dyke at the bay, he soon realized that the need to move sand—the workers spending hours of the day clearing the area—was leading to significant delays. The workforce was also being affected by the spread of malaria and yellow fever, diseases transmitted by the mosquitoes that thrived in stagnant waters of the city and port of Veracruz. At the beginning of the twentieth century, Quevedo returned to Europe, visiting colleagues in Berlin, Vienna, and Nancy to discuss the subject of afforestation. On the advice of Lucien Daubrée, chief of the French Forest Service, he travelled to Argelia in North Africa to learn about the French interventions to stabilize the dunes in the region. During this trip, Quevedo collected some of the pine and acacia seeds being used in this intervention and planted them in Mexico. In 1908, Quevedo, with the support of the government, initiated the afforestation of the dunes of Veracruz. In 1909, President Theodore Roosevelt invited Quevedo to participate in an international conference on natural resource conservation in Washington, DC, where he met Gifford Pinchot (Simonian 1999, 92–93, 96–97). A year later, work on the dunes of Veracruz was halted by the outbreak of the Mexican Revolution, an armed popular uprising against the military dictatorship in power. Adriana Guadarrama Sosa, a PhD student at the University of Granada, Spain, is currently writing her thesis on the history of these dunes. She was working alongside me in Lisbon when I wrote this chapter in September 2023. In 2025, Adriana, who is from Veracruz, will present her research on this case and its connections, providing more threads through which to trace and understand the intricate web of history surrounding the dunes.

In Argentina, the moving sands also threatened important agricultural areas. In 1910, the agronomist Pedro Bovet produced a report on the subject, identifying the most problematic areas and providing examples of the solutions applied in France, the US, Russia, Portugal, Sweden, and Chile. His suggested solutions echoed those applied elsewhere: afforesting the dunes, thereby immobilizing the sands while improving the economic value of the land. Most of the cases Bovet mentioned, however, were located inland, with only the dunes on the stretch of coastline in Nechochea, Buenos Aires Province, identified as a menace to the *balnearios* or seaside villages. Although some regions to the south were also being invaded by sand, experts dismissed

these areas as having little value. While Bovet did not see the activity of coastal dunes as cause for alarm, he warned that they might become a problem in the future with the increasing use of the seashore and appearance of new *balnearios*. Echoing the steps taken by other countries, Bovet advocated for the creation of protective legislation and the need to cultivate trained experts to work on dunes and their control (Bovet 1910). According to the geologist Silvia Marcomini, urban development led to the afforestation of some coastal dune areas in Buenos Aires Province several years later. For instance, dune afforestation was undertaken in Cariló from 1918 to 1926, and initiated in Vila Gesell in 1933, Pinamar in 1941, and Valeria del Mar in 1947 (Marcomini et al. 2017). All these examples reflect the spread and circulation of dune stabilization techniques based on European methods along the Atlantic coastline of America. They also illustrate the dissemination of a general discourse that cast the dunes as dangerous wastelands, justifying efforts to improve them through afforestation.

Sand webs

Sand and grass are small things. Yet, as Tom Cohen (2019, 6) reminds us, even small things impact the course of history. Paying heed to the small things can help us fill the gaps in knowledge, providing a richer and subtler understanding of how people in the past read their own world. Attention to small things can also help us explore the connections between bigger events. As I have shown in the previous pages, sand and grass can be linked to larger trends and structures—to migration, colonialism, land use, the exchange of knowledge and species, adaptation, and environmental transformation. Paying attention to overlooked things allows us to perceive the interplay between the natural and human worlds, the small dynamics underpinning greater developments, the complex shifting matrix of values and policies and corresponding institutional and legal frameworks, and the rhythms and cycles of the nonhuman. Indeed, even if things only seem to "intersect and interact in a small pot," they are very much entangled in the wider world (Cohen 2019, 5–6).

Notes

1 The map can be accessed via the following link: www.loc.gov/resource/g3700m.gct00284/?sp=137&r=0.015,0.494,0.35,0.132,0
2 This website is accessible via the following link: www.gbif.org/what-is-gbif
3 The photo of this specimen and related information can be accessed via the following link: www.gbif.org/occurrence/1989546439
4 The photo of this specimen and related information can be accessed via the following link: www.gbif.org/occurrence/1989291146
5 This record is accessible via the following link: www.gbif.org/occurrence/1259775858
6 This record is accessible via the following link: www.gbif.org/occurrence/1258926834
7 This specimen is currently preserved at the Harvard University Herbaria: www.gbif.org/occurrence/1998791521

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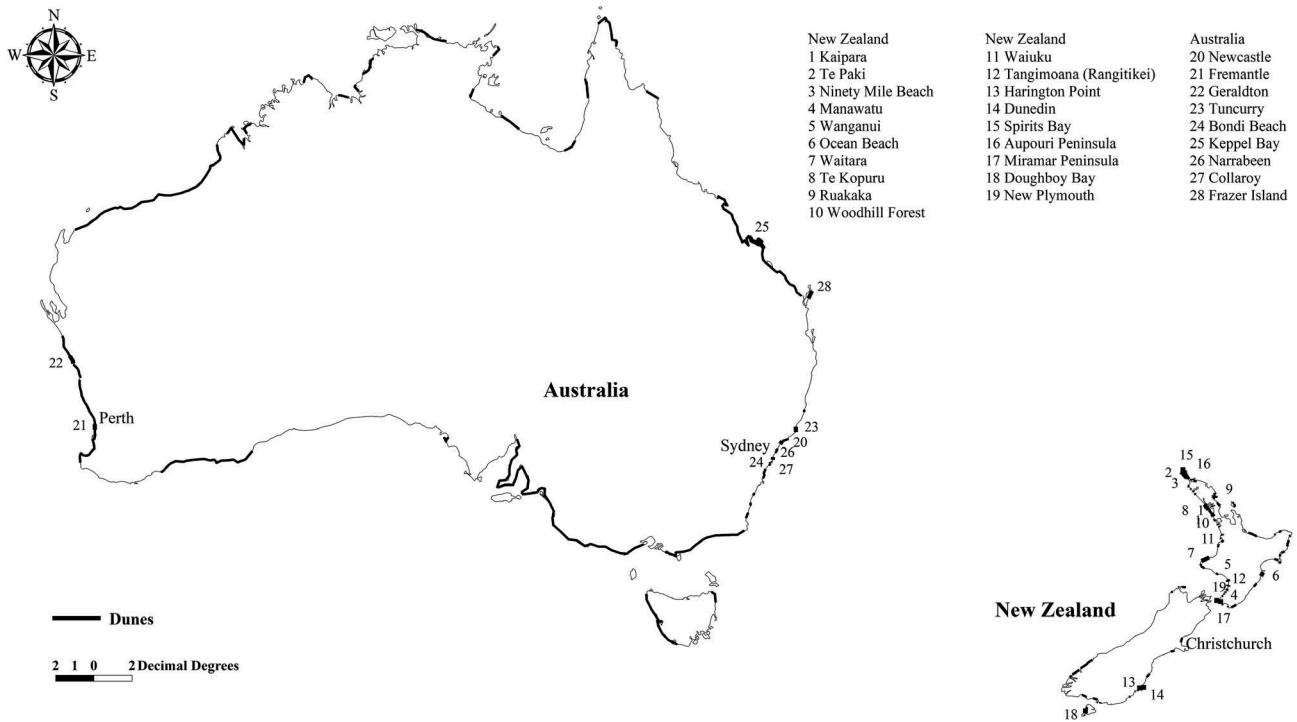

Figure 7.1 Map of Oceania with the location of the regions and places mentioned
Source: Map by D.M.R. Sampath

7 Reaching the Pacific

Serendipity in research

"Mum, there are so many dunes, how do you choose which ones to work on?" my then 14-year-old son asked me during the COVID-19 lockdown. This simple question betrayed a fundamental issue, one that had never crossed my mind: how did I select the dunes that I was researching? Some were chosen because they predominated in the historical sources, quickly evidencing a story that deserved to be told. Others were discovered on my journey as a historian, gifts from those I met along my sandy path. I call these my "serendipitous moments," an idea borrowed from my colleague Isaac Land, who has written about such "lucky encounters" on his Coastal History blog. Such encounters lead to unanticipated discovery or realization, the sorely needed missing piece or clue that points us in the right direction (Land 2014). I have had some of these experiences. For instance, it was not in my plans to attend the 2019 World Congress of Environmental History held in Florianópolis, Brazil, but I ended up doing so after being invited to join a panel on Global Coasts. At the conference, I ran into James Beattie, whose excellent chapter on sand drift in Australia and New Zealand I had read in preparing my presentation. Seizing the opportunity to discuss our interest in sand drift, I walked up to James, who was talking to Ryan Jones at the time. Ryan mentioned the huge expanse of coastal sand dunes located in his home state of Oregon, the same dunes that inspired Frank Herbert's beloved science-fiction novel, *Dune*. Meeting James and Ryan was a stroke of good fortune—not only for the friendships forged, but because it led to my decision to include both New Zealand and the Oregon dunes in my project.

Such serendipity aside, it is worth noting that I have never been to the Pacific. How could I write about an ocean and a coastline that I have not seen? It is important to be familiar with the environment that one is studying. I learned this from Alveirinho Dias, my PhD co-advisor, over cups of coffee: it is necessary to go to places to feel them. I certainly traveled widely to visit many of the dunes described in this book. However, it was not possible to visit all of the beaches included in my research. Moreover, in this time of climate crisis, replacing "in-situ fieldwork with ex-situ fieldwork" is a question

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of integrity, as landscape architect and scholar Rosetta Elkin argued when explaining why she did not feel the need to go to Alaska to study the Alaskan permafrost and at-risk populations (Elkin 2022, 138). In fact, this distance is familiar to historians, who usually work on times, places, and people with which they have no personal contact. Indeed, the subjects of historical research usually no longer exist and if they do, they are not as they once were.

Complex and provisional histories

In this chapter, I offer three distinct histories about the Pacific: New Zealand, the west coast of the United States, and Chile. Australia is often mentioned because of the influence of Australian dune stabilization in neighboring New Zealand. These cases share some obvious connections forged by the experience of empires. These three asymmetrical case studies are also a way of illustrating the overlapped layers and reciprocal relationships that places and environments are made of. Because of the wide geographical scope, the long period covered and the vast amount of information, the biggest challenge lies in tracking and establishing sequential meaningful links between intricate webs. Explaining always entails making choices and simplifying complexity, bringing forward narratives that are neither absolute nor exclusive, but most often porous and with variable outcomes.

European expansion has generally been seen as reckless—the imposition of rule through violence and the exploitation of subjugated peoples and lands. The social and environmental consequences of imperialism notwithstanding, reality is much more complex. Beyond the arrogance of machine-like empires that used their military power and techno-scientific advancements to colonize new lands, hundreds of thousands of ordinary people departed the Old World for their own reasons. Ambition and greed certainly, but also poverty and persecution. The contact with different environments—perceived as unhealthy, infertile, or alien—created anxieties that motivated the use of problem-solving strategies from Europe, responses that had proven effective back home (Beattie 2011, 1–6).

The outcomes of these strategies frequently deviated from expectation. After all, the world is not, as Christa Wirth noted, a self-contained sterile laboratory to which standardized models can be applied and the same results obtained. Diaspora reshaped people, cultures, science and practices, animals and plants—changes wrought through fluid encounters facilitated by contact with polycentric worlds and a multitude of networks. In recent years, "questions of how knowledge, technology, and practices travel and change in different social situations and within asymmetrical power relations […] have replaced obsolete paradigms of 'diffusion' by which science emerged in the West" (Wirth 2019, 115). Tracing the movement of people, practices, and species across oceans and continents is no longer a matter of tracking their routes from origin to destination, but of recognizing the interactive and dynamic processes of dislocation, translation, and negotiation beyond travelling, settling, and adapting to new lands (Castryck 2019, 103). James Beattie,

Edward Melillo, and Emily O'Gorman (2015) developed the concept of eco-cultural networks—that is, the interlinked cultural formulations, material exchanges, and ecological processes—to highlight the transfer of ideas, organisms, and commodities under imperialism, as well as the deep interdependencies between societies and their environments. In this sense, the concept of eco-cultural networks is a useful tool to describe and explain the complexity and contingency of the multidirectional pathways and diffuse exchanges related to the dunes.

New Zealand: Environmental anxiety over sand drift

The stories that I tell in this book are linked to the European dune experience. New Zealand is no exception. Nevertheless, long before the arrival of Europeans to this part of the world, the Māori had built their links with the dune territory and, despite the amount of time that has passed since then, they still remember it. Stories keep this connection alive. In the Northland dunes of Aotearoa (New Zealand), the name the Māori gave their island, human presence dates back to the twelfth to thirteenth century. According to a legend from the Kurahaupo people, Tohe, their chief and ancestor, announced that he was going to visit his daughter by crossing Maungapiko, at Spirits Bay, to Kaipara. This was a long and treacherous journey, and left his family in distress. According to Seitzer and Gasteiger (2000):

> Humankind had only just discovered these islands, and many places and waters lacked names. Tohe bestowed many names as he walked along the west coast from Te Paki to Maunganui Bluff. Most are still in use, such as Te Paki itself, "the place where the weather turned fine," or Te Wharo Oneroa a Tōhē, "the long sands travelled by Tohe" (Ninety Mile Beach).

Centuries later, Tohe's people set up a summertime camp in the dunes of Aupouri to collect and process seafood. Post holes and vestiges of shellfish, fish, and seal bones have been found in the sands. Pigeon remains have also been found, prompting archaeologists from the Department of Conservation in Whangarei to assert that forests covered part of this area in the 1400s (Seitzer and Gasteiger 2000). Carbon dating of charcoal, marine shell, and moa bones place human occupation of the coastal and inland dunes of this area as starting approximately 1000–1500 years BP. Human activities are thought to have contributed to the de-vegetation and destruction of coastal forests, notably by fire (Coster 1989).

Polynesians settled in New Zealand, introducing significant changes to the land. They brought new fauna and flora, used fire to clear areas for food production, felled trees, and collected and hunted plants and animals. Their activities reduced the forest cover by 50 percent (Roche 1990). Indeed, in 1770, Captain James Cook described the Northland coast as a barren region with "nothing but white sand thrown up in low regular hills" (Cook n.d.; Beattie

2011, 181). These practices intensified with the arrival of European settlers in the late eighteenth century. Europeans—predominantly from the British Isles—established their own settlements in coastal areas, clearing forests and vegetation for timber, fuel, and agriculture. They also introduced hoofed animals and rabbits to this environment (Sampath, Beattie, and Freitas, 2023).

The memoir of Murray Gladstone Thomson (1944) provides interesting insights into life on the coast of New Zealand in the nineteenth century. Born in Edinburgh in 1850, as a boy, Thompson emigrated to Dunedin on the South Island. According to Thompson, the territory between the dunes and the wooded hills was known as "the flats" and inhabited by the Māori. The flats were low-lying areas behind the beaches and protected "by an unbroken line of sandhills, clothed with a strong, wiry, brown grass […]. This native grass effectually held the sand against the strongest winds," sheltering the landward areas (Thomson 1944, 43). His description of the transformation of the South Dune Flat is a powerful example of coastal environmental change and the dispossession of Māori land and way of life. In the 1860s, when Murray first visited "the Flat," this was a swamp with several varieties of rushes. It was a wild area that had long served as a hunting ground for the Māori, particularly rich in eel and ducks. The surrounding areas possessed abundant evidence of ancient camping sites, including polished adzes, flint spears, and shaped whalebones. However, the military soon began using the flat for rifle practice, Chinese settlers leased part of it for market gardening, and, in the early 1870s, speculators bought some of the land and subdivided it into lots. Increased settlement saw the construction of buildings, streets, and ditches, as well as the draining of the water. Floods became frequent. As Thompson noted, "it was no uncommon thing for the sea, on the occasion of a high tide backed with a favourable wind, to make inroads into parts of 'the Flat,' where the natural protection, the sandhills, were low lying." Coastal flooding saw seawater invade the streets and houses where the swamp had been. In concluding his observations, Thompson pointed to the differences between European and Māori land use:

> "The Flat" soon became one of the popular and thickly inhabited parts of Dunedin. Surely a great change since the time, and that not so very long ago, when the only light to pierce the darkness would come from the camp-fire of some Māori resting for the night.
>
> (Thomson 1944, 118)

Thompson also reported the gradual disappearance of native grasses covering the dunes since his youth due to human activity. Dune vegetation was destroyed with the growth of villages and farmland, harvesting and clearance of grasses, grazing of cattle, introduction of rabbits, carting of sand, and building of ports, roads, railroads, and telegraph lines. The loss of vegetation cover destabilized the dunes, by enabling strong winds to blow the sand onto nearby land. Thompson was well aware of the consequences of such

destruction, noting that his childhood home in Kelvin Grove, New Zealand, located 400 yards from the beach near Harington Point, had been buried by sand after his family left (Thomson 1944, 43–44, 32). James Beattie's (2011) work on environmental anxieties provides detailed information on sand drift in New Zealand and Australia, with an excellent analysis of the causes and the explanations given at the time. After meeting in Florianópolis, James and I worked with Ruwan Sampath, a coastal dynamics expert, on the matter of dunes in New Zealand, and published a paper (Sampath, Beattie, and Freitas 2023) on the case of the Manawatū-Whanganui dune field.

The problem of sand drift: Looking for solutions

While sand drift episodes gained attention in the 1850s, concern became more widespread from the 1870s, as settlers intensified their activities and expanded their land use (McKelvey 1999, 24–25; Sampath, Beattie, and Freitas 2023). Citing the *Tanaraki Herald*, an 1873 article in the *Wanganui Herald* asserted,

> It is fearful to see the destruction of property near the beach, caused by sand drifting. Acres and acres have been ruined, and the owners are likely to lose more if they do not take steps to prevent the encroachment of the sand.
>
> (*Wanganui Herald* 1873-04-22, 2)

The Māori were also affected by such episodes, with many forced to abandon their crops (Kirk 1873, 54). In addition to damaging farmland, the sand had inundated village streets (*Wanganui Herald*, 1874-11-04, 2). A later article noted that travel was terribly difficult in certain areas:

> [B]arely two miles from the Manawatu Ferry the coach completely stuck fast in the soft sand. All the efforts of the jaded horses were insufficient to extricate it, and all the passengers, including the women and children, had to dismount and remain […] shivering under the flax-bushes in the pitchy darkness.
>
> (*Wanganui Herald*, 1878-04-10, 2)

As Thompson asserted in his memoir, neither he nor others could stand idle in the face of the destruction of their property. Thompson first erected scrub fences to keep the sand from ruining the flats and cottages at the foot of the hills. After discovering the value of marram grass and lupine, in 1897, he obtained three sacks of marram roots from the chairman of the Ocean Beach Domain Board and planted them. Within five years, the grass covered the sandhills, successfully repairing the broken line of the dunes (Thomson 1944, 44–45). "Marram?" I asked myself while reading his memoirs, "the same marram used in Europe?" Indeed, I discovered, Thompson had planted *Ammophila arenaria*.

In both western and eastern Australia, places like Newcastle, Fremantle, and Geraldton were experiencing sand drift episodes—the sand burying properties, roads, and crops—as early as the 1850s, with a variety of efforts made to combat the hazard (Beattie 2011, 182–183). In 1867, William Keene, Inspector of Mines to the Government of New South Wales, wrote to James Coutts Crawford—a farmer, explorer, and scientist from New Zealand—in reply to his inquiries about what was being done in Australia to mitigate sand drift. In Newcastle, Keene wrote, a great deal of money had been spent to fix the sand through the sowing and planting of grasses. However, all such efforts had failed. While bent (marram) grew in abundance, it had failed to fix the sand. He had thus suggested the use of pine, the use of which he had observed in Bordeaux and Bayonne, in France. Keene's opinion notwithstanding, Crawford had faith in the value of grasses as sand binders. As early as 1872, Crawford experimented with growing, dividing, and transplanting *Ammophila arundinacea* (*arenaria*) over a number of acres. The plants took root and stabilized the dunes to some extent, albeit at an extremely slow pace (Crawford 1872; Keene and Crawford 1873). His contemporaries, William Travers and Leonard Cockayne, believed that Crawford was the first to introduce marram grass to New Zealand through his experiments at Miramar Peninsula (Travers 1881; Cockayne 1909). According to Thomas Kirk (1873, 53), who compiled a list of the native and exotic species from Europe, the Americas, India, and Australia that could be used in dune reclamation efforts, marram was already present in other areas of the archipelago. Indeed, Kirk asserted, he had seen the plant growing with great luxuriance on the beach between the town of New Plymouth and Sugar Loaves.

At the Wellington Philosophical Society and Auckland Institute, the educated men of New Zealand discussed issues like dune encroachment and examined the state-of-the-art solutions being applied abroad. Many of these well-informed men had been educated in Europe and had travelled extensively through their careers (McKelvey 1999). They were aware of the French developments in Gascony and the use of marram. Taranaki politician C.D. Whitcombe, for example, maintained correspondence with M.M. Vilmorin Andrieux of Vilmorin-Andrieux & Co., the Parisian trading company responsible for supplying marram and pine seeds for the works carried out in Pas-de-Calais in northern France and elsewhere (Whitcombe 1872). These erudite men were also acquainted with interventions conducted in other parts of world, such as Scotland, Prussia, and Cape Cod. They had read the work of George Perkins Marsh, as well as research on the efforts carried out in Australia at the time (Stewart 1873; Travers 1881; *Wanganui Herald*, 1891-08-15, 4).

As Beattie has noted (2011), Australasian officials and men of science—whose ranks included many German foresters and Scottish doctors—believed that the French model of dune stabilization could be implemented in Australia and New Zealand. In this regard, the account of J.H. Maiden, a member of the Department of Agriculture in New South Wales, on marram in Australia is particularly illuminating. Written in 1895, the account reveals

a vibrant and interconnected discussion on the usage of *Ammophila sp.* in different regions, as well as Maiden's knowledge of interventions in Europe, Cape Cod, and South Africa. Foresters, agronomists, and other experts shared information about the best employment of the plant through personal correspondence, journal articles, and books. They also exchanged seeds and specimens, communicating the results obtained from their introduction to specific areas. For example, in his account, Maiden noted,

> This grass has been extensively planted by the Department at the sand-drift at Newcastle, in conjunction with the Maritime pine (*Pinus maritima*) and the vexed questions of how to deal with this drift, which, in times gone by, has been such a source of expense and anxiety appears to be in fair way to settlement.
>
> (Maiden 1895, 356)

However, as Thompson's memoir indicates, efforts to control sand drifts were not limited to experts and institutions. Local farmers were also attempting to prevent the sands from damaging their land. In some cases, they had support. Thompson, for instance, obtained marram seeds from the Ocean Beach Domain Board, an organization established by the government in 1892 to help Dunedin's municipal council combat the sand hazard (Beattie 2011, 189). Similarly, in Newcastle, Australia, authorities gladly supplied grass to those willing to plant it, thereby facilitating its propagation (Maiden 1895, 355). Others took their own initiative. For example, John Handley, a farmer from Okehu, New Zealand, planted 10 acres of marram, successfully safeguarding his farmland within a year or two. Handley, the local newspaper proclaimed, had set a good example for his fellows (*Wanganui Herald*, 1889-09-06, 2; 1889-06-13, 2). Handley explained that he was having great trouble with sand drift when he heard about the use of *Ammophila* in 1886. He thus had a handful of roots sent to him, which he planted successfully (*Wanganui Herald*, 1891-06-03, 2). As in Cape Cod, it is possible that some of the settlers may have known about *Ammophila arenaria* from its use in European coastal regions. A letter to the *Wanganui Herald* (1888-04-04, 2) from a D. MacDonald gives some support for this hypothesis. The Scot explained that bent grass, that was already growing in Waitara, New Zealand, had proven very useful for fixing the dunes at his hometown of North Uist in the Outer Hebrides. At the end of the nineteenth century, knowledge on sand stabilization was being spread throughout the colony by experts, word-of-mouth, and the local press, with overseas models being adapted to the local context by trial and error (Sampath, Beattie, and Freitas 2023).

Stabilizing the sands: The means and institutions

Private initiative and local commissions were isolated solutions and not enough to bring an end to the problem. Miles of drift sand on lands leased by the New Zealand government for several years proved utterly impossible to

reclaim, endangering the private property in the adjacent areas (*Wanganui Herald*, 1889-06-15, 2). Toward the end of the nineteenth century, residents and councils in the most affected regions of Australia and New Zealand petitioned the colonial legislature for greater land reclamation measures and the means necessary to implement them, including financial assistance and labor. As in several European countries, particularly Britain, there was some debate over whether public money should be used to fund such interventions. According to Beattie (2011, 183–184), although Australasian governments generally avoided interfering in the affairs of individuals and private enterprises, increasing environmental anxiety and frequent inability to solve these issues locally pressured authorities to take action. To this end, legislators passed specific legislation, including the Geraldton Sand-Hills Planting Act (1872) and the Newcastle Sand-Drift Reclamation Act (1886) in Australia. In New Zealand, the Sand-drift Bill of 1903 (consolidated in 1908) empowered the Governor to proclaim sand drift areas on recommendation of local authorities and other interested parties. While local authorities had the power to propose measures, landowners bore the cost of their implementation (Beattie 2011, 191–196). Such acts, however, were ineffective in New Zealand and had no practical consequence beyond representing the formal and official recognition of the problem (McKelvey 1999, 29).

At the beginning of the twentieth century, the Department of Lands was made responsible for the sand problem in New Zealand. However, in the first years, activity was largely limited to collecting reports from regional agents, who provided descriptions of the affected areas. The government also supported research and travel,[1] commissioning the botanist Leonard Cockayne to undertake a scientific survey of the colony's coastal dunes (McKelvey 1999, 30–31). In two reports published in 1909 and 1911, Cockayne analyzed the geology and botany of the coastal dunes and proposed immobilizing them through dune reclamation, noting that the cost would eventually be reimbursed through the commercial value of afforestation. In this respect, Cockayne noted that previous experiences of dealing with sand drift in Europe, the United States, South Africa, and Australia had proven the efficacy of certain measures, including the use of fences and *Ammophila arenaria*. Following French and German authorities on the issue, Cockayne identified afforestation as the final objective, and argued that tree lupine (*Lupinus arboreus*), a tree native to California that grew on the Pacific coastline, was the species best suited to the sands of New Zealand. He believed that lupine, in combination with marram, would stabilize the dunes.

Cockayne estimated that there were over 300,000 acres of worthless dune area in the colony, noting that the land was either Crown, indigenous, or privately owned. This tripartite ownership, he continued, made the application of the Sand-Drift Act extremely difficult, because the various owners could not be compelled to implement or maintain the reclamation. He considered that this was a matter to the state and he thus suggested that the colonial government proceed with caution, emphasizing the need to evaluate

the methods and costs involved to ensure that it was feasible and financially worthwhile. In this respect, Cockayne proposed creating experimental farms to serve as references for further interventions (Cockayne 1911, 43–44, 60–61, 65). Two years later, the Department of Lands and Surveys established two experimental stations at Rangitikei and Waikato Rivers. Although the work slowed down with the outbreak of the First World War (1914–1918), it did not stop and was even expanded to new areas after the war. Those responsible for operations reported recurrent labor difficulties, limited availability of marram in some localities, trespassing of domestic animals, damage caused by rabbits, and periodic outbreak of wildfires. The Department of Lands also lacked the resources necessary to control the areas effectively. In 1919, the Forest Branch of the Department of Lands became the State Forest Service, which continued the experimental operations at Rangitikei Station, later known as Tangimoana. Operations included trialing approaches to constructing foredune fences as well as the planting and sowing of marram and several exotic tree species (McKelvey 1999, 36–39, 47).

Establishing connections

The case study of New Zealand, alongside some indication of the Australian experience, offers an extraordinary example of the intricate eco-cultural networks that enabled the dissemination of European sand-reclamation methods and species across the Pacific world. Reading Beattie's work on environmental anxieties in Australasia alongside the various primary sources—settler memoirs, newspaper articles, reports, as well as intellectual and political deliberations—I was struck by the similarities between the situation in New Zealand and Europe. In fact, the first scattered attempts to control sand drift in New Zealand were almost contemporaneous with the interventions implemented in Portugal and Spain. Australasian sand drift legislation was also passed around the same time as Portuguese laws on the matter. Moreover, the same rhetoric justifying dune stabilization and afforestation was employed in Europe and Australasia. Indeed, the gloomy image of impending catastrophe presented by Whitcombe and his peers at the Wellington Philosophical Society were not very different from the imagery used by Brémontier at the end of the eighteenth century to underscore the urgency of his proposed intervention. The literature and sources also reflect the cultural and intellectual melting pot of colonial Australia and New Zealand at the time. As settlers from different backgrounds moved to the colonies and built new societies, at the cost of violently subjugating and silencing others, they brought with them the informal and formal knowledge gleaned through the private and professional networks of their homelands. Local newspapers, specialized journals, and scientific societies played an important role in the propagation of ideas and concerns about the sands, including the dissemination of knowledge about the interventions in France, the grasses used in Scotland, the afforestation methods practiced in Germany, the troubles in

Cape Cod, the experiments with *Ammophila arenaria* in Cape Town, and the attempts made to implement such measures in Australasia.

That said, while European techniques were widely admired in those circles, they were not copied wholesale (Beattie 2011, 148, 152). Australasian environmental conditions were distinct and any imported procedure had to be adapted to regional particularities. As Cockayne noted, those responsible for the interventions in the dunes had to be aware of the local climate, intensity and direction of the wind, and coarseness of the sand, and use their experience and judgement to adapt the procedures accordingly (Cockayne 1911). Another significant distinction between New Zealand and Australia and much of Europe involved the management of sand drift: influenced by Britain, the Australasian colonies considered the problem a private, rather than state, matter. Consequently, in New Zealand, action was largely limited to the individuals and local bodies. Even after the passing of the Sand-Drift Act, there were no national-level interventions for some time. In contrast, Europe saw the gradual scaling up of interventions under the coordination of state services. However, the prevalence of the phenomenon and the inability of landowners and municipal councils to resolve the situation increasingly forced the colonial governments to take action (Beattie 2011, 184). Based on Cockayne's proposals, New Zealand shifted away from the policy of the metropole. First through the promotion of study and experimentation in the 1910s; later, launching a major dune reclamation scheme under the combined coordination of the Forest Services and Department of Public Works and Lands in the 1920s. As mentioned in a previous chapter, it was only after the creation of the Forest Service in 1919 that dune afforestation in the United Kingdom came under state control, although its activities remained geographically limited and never took on a national character.

The Pacific Coast: Testing and improving methods

Just as the Māori had stories about dunes, so did the Native Americans of the Pacific Northwest. Certainly, the Native American tribe known as the Clatsop, who inhabited the plains near the mouth of the Columbia River in Oregon, had such stories. One story, narrated by Charles Cultee and collected by the anthropologist Franz Boas (1894, vol. 101), explained the origins of the sandy terrain:

> Coyote was coming. He came to Gōdt'a't. There he met a heavy surf. He was afraid that he might be drifted away and went up to the spruce trees. He stayed there a long time. Then he took some sand and threw it upon that surf: "This shall be a prairie and no surf. The future generations shall walk on this prairie." Thus Clatsop became a prairie. The surf became a prairie.

Oral traditions like this reflect how the Native American people perceived and kept a record of how the land changed over time,[2] including coastal

progradation. The territory to the south of the Columbia was characterized by dune ridges, interdunes lakes, and marshes, with sand accretion compelling the tribes to move to keep close to the shore (Deur 2016, vol. 3). The earliest descriptions of the region appear in the 1804 account of the exploratory expedition of Captain Meriwether Lewis and Lieutenant William Clark, who noted the "hummocky nature of the dunes and the extensive grass prairie" (Thwaites 1905, vol. 3). Based on Dana (1849), these dunes extended from the coast to the east with densely wooded ridges on the east side (Rankin 1983, 2). According to Douglas Deur (2016, vol. 11), the Columbia estuary and adjacent coast were the "homeland of thousands of people and one of the most economically and culturally vibrant places in the Northwest." To the south, other coastal tribes—such as the Coos, Lower Umpqua, and Siuslaw—also told stories about the dunes and named some of their villages after the sands, including *Pa-au-wis* (lots of sand) and *Wai-tus* (a white mountain) villages. The latter was located in the area where the city of Florence now stands, and was likely named after the sandhills characteristic of that coastal and riverine environment (Whereat 2010, 18, 240). Don Whereat collected and examined the oral traditions of Native American peoples who lived in the estuaries of the Siuslaw and Umpqua Rivers and Coos Bay, aligning oral history with archaeological evidence and ethnographic data. These tribes lived off fish, shellfish, and game-like marine mammals, birds, and deer—resources they considered a sacred heritage passed down from their ancestors. These areas were subject to advancing dunes and the silting of water bodies, often forcing people to abandon their villages and move elsewhere (Whereat 2010, 26). These Native American communities did not live on the barren beaches open to the ocean, but on the fertile and sheltered shores of estuaries and streams (Komar 1997, 64; Deur 2016, 11).

Like the communities in Cape Cod, Australia, and New Zealand, the activities of the Native Americans of the Pacific Northwest impacted the land: they used fire to clear vegetation and promoted the propagation of specific plants and animals, often to the detriment of others. However, the Euro-American settlers who arrived in Oregon and Washington in the mid-nineteenth century, many of whom were grain and stock farmers, possessed a totally different perspective of land and its uses. They extensively and intensively transformed the terrain to produce crops and graze cattle and exploited the forests for timber. They introduced pervasive and enduring changes. They also brought new diseases to the area, eradicating many of the Native American tribes and their way of life, reducing once thriving populations into small tribes herded onto reservations. Given the mountainous and heavily wooded interior, early settlers preferred the region's coastal zones, such as the grasslands of the Clatsop Plains. Although the stabilized dunes of these areas were not particularly arable, they proved excellent pasturage for livestock (Deur 2016, 87, 102, 104; Bancroft 1888). To the south, a similar process of land occupation and transformation occurred as settlers moved into the territories of the Coos, Umpqua, and Siuslaw tribes, where they proceeded to plow the

land, graze their cattle, fell the forests, and introduce new species. These activities facilitated soil erosion and the siltation of rivers, increasing the littoral sediment budget (Freitas 2021).

The consequences of such pressures on the coastal ecosystems became clear a few decades later. For instance, in 1874, an article published in the *Tri-Weekly Astorian* asserted:

> When Clatsop plains were first settled the sea ridges were covered with wild vegetation, which held the sands in check, but since that time, by excessive pasturage, the grasses have been destroyed, and the sands loosened. The sands, driven by the winds drifted back upon the plains and covered the meadows, till it became necessary to take steps for united efforts towards checking these encroachments. To this end the Town of Clatsop plains was incorporated, but the only plan adopted by the authorities has been to cause each farmer to keep the cattle of the sea ridge in front of his farm, so that the native vegetation may again spread over the sand.
>
> (*Tri-Weekly Astorian* 1874-01-17, 1)

This account is comparable to so many of the stories I have mentioned about other places around the globe, rendering it unnecessary to repeat how the process of sand drift was triggered and exacerbated by the settler use of land. The solution proposed similarly echoed established knowledge, namely, restricting cattle grazing. "But something more might be done, which would not only hasten the work, but make it much better than before," the author noted, pointing out the interventions in France as well as those on the sand dunes of Golden Gate Park in San Francisco, California (*Tri-Weekly Astorian* 1874-01-17, 1).

The Golden Gate Park

Historical sources indicate that San Francisco's Golden Gate Park was the first place where dune stabilization through the planting of trees was attempted on the US Pacific Coast. In an article published in *The Forester*, Frank Lamb, a forester, explained how the park was created to fulfil the demands of the developing city, with the sandhills between the bay and ocean selected as the site for its construction. Stabilization work began in 1869, the preparatory phase comprising the sowing of *Arundo arenaria* (*Ammophila arenaria*). Within two years, the ground was sufficiently stabilized, and arboreal tree species like Monterey pine (*Pinus insignis*), Monterey cypress (*Cupressus macrocarpa*), and acacia (*Acacia latifolia*) were planted. For Lamb, the results proved that the sandy terrain of the Northwest Pacific could be reclaimed profitably, just as it had been in France (Lamb 1898). In another article in *The Forester*, forester John McLaren detailed the initial interventions, his claims differing somewhat from Lamb's account. According to McLaren

(1899), sea bent grass (*Calamagrostis arenaria* or *Ammophila arenaria*) was planted, bush fences were built to protect against the winds, and a variety of trees were planted experimentally, including the Norway maple, tamarix, poplar, maritime pine, Monterey cypress, acacia, and eucalyptus.

Although the reclamation of the sand dunes of San Francisco was hardly a novelty in the US, it was the first intervention on the Pacific and set an example for future interventions on that coastline. The Golden Gate Park represented the beginning of an emerging trend: the recreational use of coastal areas. In the nineteenth century, most dune stabilization works aimed to prevent sand drift, protect harbors and water bodies from siltation, or reinforce the dunes as barriers against coastal flooding. In San Francisco, however, the purpose was different, the interventions transformed a barren tract of sand into an ocean park, demonstrating the multiple potential uses of reclaimed dunes (Westgate 1904, 35; Schleicher 1917, 32). In 1898, Lamb appraised the charm of the Golden Gate Park, noting its swan ponds, the grand boulevard with its bicycle and foot paths, the "merry go round" and athletic fields, as well as the hosting of open-air concerts (Lamb 1898).

Both Lamb and McLaren referred to the *Ammophila sp.* as a key component of the successful stabilization of San Francisco's dunes. This raises the question: Which *Ammophila*? The European one or its American congener? This doubt is compounded by the fact that, as I noted in Chapter 6, experts often confused the two species. In this respect, it is important to note that none of the *Ammophila sp.* is native to the Pacific coast: the *Ammophila breviligulata* is only endemic to the US Atlantic shore. As such, the *Ammophila sp.* used for the reclamation work in San Francisco had to be introduced to the area. In a report on sand-binding grasses, Lamson-Scribner (1895, 427) claimed that the seeds for the cultivation of the marram grass used in San Francisco were obtained from Australia. If the seeds sown in the Golden Gate Park came from Australia, the species introduced to California in the 1860s was the *A. arenaria*, which was already being used in the dunes of Australasia. This argument is supported by Fernald (1920) who, writing on the identification of *A. breviligulata*, indicated that the Old World species was only known on the Pacific coast of the US, where it had been introduced as a sand-binder in previous years.

By this point, exchanges between Europe and the Pacific and within the Pacific world appear to have been commonplace. In a report published in *Proceedings of the Society of American Foresters* in 1915, Frank Kellogg detailed the extensive 15-year dune reclamation works carried out in the region south of Lake Tallawa in Del Norte County, California—an intervention he believed could be replicated in the Siuslaw region of Oregon. Kellogg primarily referenced dune interventions in European countries—including France, Germany, Denmark, and the Netherlands—as well as those in Cape Cod, San Francisco, Australia, and South Africa. According to Kellogg, the stabilization methods used in Del Norte County were a combination of the techniques practiced in these different areas with local adaptations. Based on

the experience of Del Norte County, Kellogg suggested that the intervention in the Siuslaw region should plant Monterey cypress, blue gum (*Eucalyptus globulus*), and *acacia longifolia*. While the first species is native to California, the other two originate from Australia. Kellogg was also acquainted with the use of acacia in New Zealand (Kellogg 1915, 46–47, 49–50, 61–62). Meanwhile, some years earlier, Cockayne had advocated for the planting of tree lupine—a species native to California—on the dunes of New Zealand, after stabilizing them using *Ammophila arenaria*. Interestingly, Kellogg appeared to be much more aware of the experiences and practices of Europe and the Pacific world than those of Cape Cod. These regular exchanges reinforce the hypothesis that the *Ammophila arenaria* was introduced to the US West Coast via the Pacific world. This also explains why the European rather than the American beachgrass species was used in the initial stages of the sand stabilization interventions in California and Oregon.

The Clatsop Experimental Station and other experiences on the Oregon Coast

At the beginning of the twentieth century, several scattered interventions had been implemented on the Oregonian and Californian coasts to prevent dune encroachment. In addition to the projects mentioned above, some private railway companies initiated stabilization works to protect their lines, such as those promoted by Southern Pacific Railway in the county of San Luis Obispo, California, and the Oregon Railway and Navigation Company (OR&N) along the Columbia River (Kellogg 1915, 42). Meanwhile, Lamson-Scribner was immersed in an investigation of the adaptability of various plants, experimenting with their suitability on a grass farm. Initiated in 1898, the project was first backed by OR&N before the Department of Agriculture in Walla Walla, Washington, took over. The experiments were run by A.B. Leckenby, a special agent of the Division of Agrostology, a bureau dedicated to the study of grasses and forage plants. The testing included certain species of grasses for fixing the sands along the Columbia (*Heppner Gazette*, 1899-08-17, 1).

Besides the development of inland railways and roads, shipping was crucial for trade and transport along the US Pacific coast and its extensive maritime routes. As a result of the continuous shifting of the channels and shoaling of the Columbia River, which posed a threat to navigation, in the 1880s, it was necessary to build a jetty on the south side of the river. The extended jetty system was completed by 1917. Although intended to improve the mouth of the river, this major engineering structure propitiated sand accumulation on the adjacent beaches and the rapid progradation of the Clatsop Spit, which, together with the deterioration of the vegetation cover in the region, led to the development of active dunes in the Clatsop Plains (Reckendorf 1998; Deur 2016, 216–217; Rankin 1983, 142–143; Kaminsky et al. 2010). In 1900, the annual report of the Department of Agriculture noted that some military fortifications along the coast were experiencing trouble with sand drift. To address this issue, the Department advocated for experimental trials with

known sand-binder grasses, emphasizing that the situation demanded information supported by practical demonstrations. Indeed, the interest in these sand-binding grasses was so widespread that it even elicited questions from Japan, where the city of Niigata was being threatened by sand blowing (*The Morning Oregonian*, 1900-01-08, 6).

Leckenby, likely seeking to furnish such knowledge, established another experimental station at Gearhart Park in Clatsop County with the aim of identifying grasses best suited to stabilizing coastal dunes. The Gearhart Park project resulted from a partnership between the state and government department and the Astoria Progressive Commercial Association. A local landowner had given license to use his land on the shoreline on the expectation that the findings would facilitate dune reclamation efforts both on his property and elsewhere (*The Morning Oregonian*, 1900-10-08, 3). The Clatsop Station supplied plants and seeds to other US regions, including Cape Cod. According to Westgate, in 1901, experiments using sand sedge (*Carex macrocephala*) and seaside bluegrass (*Poe macrantha*) revealed that while these plants were efficient sand binders on the Pacific coast, they were ineffective at the Cape (Westgate 1904, 30). In 1903, A.V. Stubenrauch, a horticulturalist at the University of California, created a grass nursery at Fort Stevens military reservation in Clatsop Spit to supply plants like *Ammophila arenaria* to the sand stabilization efforts around gun emplacements (Deur 2016, 215).

Meanwhile, to the south, the drifting sands were choking the harbors of Coos Bay and the Umpqua and Siuslaw Rivers. Between 1910 and 1916, the Forest Service sowed the seeds of several tree species used successfully in Europe, testing their suitability for afforesting dunes once the sand had been stabilized by grasses (*The Sunday Oregonian*, 1910-05-08, 69; Reckendorf et al. 1985, 462). The Southern Pacific Railroad company contributed to this effort by providing labor to aid the planting of grasses on the north side of Coos Bay, where the railroad ran parallel to the dunes (*The Sunday Oregonian*, 1916-05-28, 12). Over the following decades, different state and private entities continued to implement and direct interventions—the Bureau of Plant Industry cooperating with the Navy and Commerce Departments, Oregon State Highway Department, and Southern Pacific Railroad to secure infrastructure and assets (Schwendiman 1977, 282).

The Warrenton Dune Demonstration Project

The problem of drifting sand only worsened as the twentieth century progressed, threatening forts, military reservations, roads, and private property, and, more worryingly, affecting the navigation and commerce of the Columbia River estuary (Bennett 1942). Thus, the local residents and officials of Clatsop County requested assistance from the Soil Conservation Service, who subsequently cooperated with the Civilian Conservation Corps, an organization created to provide jobs during the Great Depression, to launch the Warrenton Dune Demonstration Project in 1935, a major sand stabilization

program that ran from the mouth of the Columbia River to the city of Gearhart (Soil Conservation Service 1940a; Reckendorf et al. 1985).

The Warrenton camp was located within the city limits of Warrenton, a mile and a half from the beach. A plant nursery was set up in Astoria to produce the beachgrass, scrubs, and trees that would be used in the stabilization works (Penwell 1936c; Reckendorf et al. 1985). While most of the dune area belonged to the state and county, part of it was privately owned. This issue was exacerbated by the fact that ownership was not always clear, with a large number of absent landowners or tax arrears. While the issue of private land ownership was being solved, work was initiated on state and county lands (Penwell 1935, Oct. 4). Operations required the collaboration of several public agencies, each with different jurisdictions and competencies. Entities involved in the Warrenton Project included Clatsop County, the State of Oregon National Guard, the US Army, the US Army Corps of Engineers, the US Forest Service, the State of Oregon Extension Service, and the US Biological Service. According to Merritt Penwell, the Camp Superintendent, the Corps of Engineers and Forest Service were contacted because much of the area under their jurisdiction in the Coos Bay and the Siuslaw National Forest was covered by European beachgrass,[3] the harvesting of which the Warrenton Project required until its own nursery could supply demand (Penwell 1936a, Aug. 14).

The issue of private property became an increasingly thorny one. Some years prior, tracts of land along the beach had been purchased in land speculation schemes, the investors subsequently losing interest due to the land being inundated by sand. Despite abandoning the land, these investors—scattered across the US—still owned it. Thus, although the county legally confiscated as much of the area as possible on the basis of tax arrears, this was a slow process (Steele 1935, Nov. 15). Meanwhile, proprietors who could be identified were contacted and asked to cooperate with the project by signing an agreement with the Soil Conservation Service. For instance, Stella Beaman, who lived in Portland, was informed that the Soil Conservation Service would finance and provide the labor and materials required to build a fence along her land and sow grasses to stabilize the dunes. In exchange, Mrs. Beaman would have to agree that she would not use the land in any way that might hinder the intervention for a period of five years (Penwell 1936b, Aug. 22).

Sand control measures were based on Paul Gerhardt's (1900) handbook on German dune culture and adapted to local conditions. The project thus followed practices long established in Europe, namely, the erection of fences to build a foredune, planting of sand-binding grasses to fix the sand, and continuous building of dunes to act as wind breaks. To this end, test plots were established in specific areas representing different environmental conditions, with the results of these tests used to develop the control strategies best adapted to the different sites. For instance, some of the beach areas were completely denuded, such as Hammond Beach to the south of the Columbia south jetty, whereas others had secondary dunes with some vegetation cover and infrastructure, including golf courses (North Gerhart), and houses on the

top or in front of the dunes (South Gerhart). In some places, the interventions were planned in cooperation with landowners or the local mayor (Soil Conservation Service 1936).

Over the years, thorough reports detailed aspects related to the procedures, labor, species used, and results. Evaluating the project in 1938, W.T. McLaughlin asserted that many of the practices implemented had been ineffective and may even have exacerbated the situation. This outcome was not entirely unpredictable, he argued:

> [After all,] control work at Warrenton was undertaken with very little immediate precedent and it was necessary to determine methods and test techniques as the work progressed. Even with information concerning control practices in other parts of the world available, it was necessary to determine how far these principles could be applied with the unusual edaphic and climatic conditions existant in the Warrenton area.
>
> (McLaughlin 1938)

This is an interesting position considering that sand stabilization experiments had been conducted elsewhere in the world and the US for more than a century. Indeed, on the Pacific Coast alone, such interventions had been promoted by public agencies since the end of the nineteenth century, especially by the Forest Service and Department of Agriculture, where McLaughlin worked.

The Warrenton project promoted the formation of artificial foredunes stabilized by the planting of European beachgrass, some American beachgrass, and a little American dunegrass (*Elymus mollis*), the latter the only species native to the Pacific Coast. According to the information collected, American beachgrass was being tested at Clatsop. Although it appeared "to be fully equal to the European beach grass," experts requested an additional year of observation before they could provide conclusive evidence of the merits of either species for dune stabilization. They also reported that American dunegrass was more slow growing than the *Ammophila sp.* Meanwhile, for secondary dune stabilization, the Warrenton project planted legumes, such as seashore lupine (*Lupinus littoralis*), seashore bluegrass (*Poa macrantha*), beach pea (*Lathyrus maritimus*), and red fescue (*Festuca rubra, var. californica*) (Soil Conservation Service 1939; Reckendorf et al. 1985). This stage was followed by the planting of trees, including Scotch broom, various pines, native crabapple, willow, poplar, and alder (Soil Conservation Service 1940b). Writing in the 1940s, McLaughlin and Brown (1942, 27) noted that although European beachgrass was the main species used in the first stages, American beachgrass tested on the Clatsop Plains was found to be equal or superior to its congener. They also noted that *Ammophila breviligulata* was only available as planting stock at Warrenton, indicating that the propagation of the species was still relatively limited and the plant had yet to spread throughout the Northwest Pacific region.

According to Frank Reckendorf, the Warrenton project completed initial stabilization work in 1941. Thereafter, responsibility for the administration and maintenance of operations was placed under the Warrenton Dune Soil Conservation District, a landowners' association recognized by the State of Oregon. The Warrenton project determined the methods and procedures that would be followed in the Pacific coast for the next 50 years, including the use of the European beachgrass "as the principal pioneer species for establishing grass cover on sand dunes from the Strait of Juan de Fuca at the Canadian border south to Los Angeles, California" (Reckendorf et al. 1985, 268). Many interventions benefited from the Warrenton project, including that implemented by the Soil Conservation Services near the city of Florence to fix the dunes that were threatening houses, railway lines, Highway 101, and Siuslaw port. Frank Herbert's visit to the site of operations in 1957 inspired him to write *Dune*. Indeed, the amazing story behind this seminal science fiction novel spurred me to produce one of my favorite articles, in which I combined fiction, history, science, and dunes to think critically about the Anthropocene (Freitas 2021).

Chile: Imported practices, local species

At the beginning of the twentieth century, the Chilean agronomist Ernesto Maldonado (1907) prepared a report for his supervisor at the Water and Forest Section of the Ministry of Industry on the coastal dunes of Cartajena and San Antonio in the province of Santiago, Central Chile. A former Spanish colony, Chile declared independence in 1818, following a period of intermittent warfare that extended until 1826 between the colonial power and the independent Government Junta of Chile founded in 1810. During the colonial period, the Spanish established a land system in the Chilean central region based on large properties for cattle ranching known as "*las haciendas*." These properties were later transformed into crop farms, particularly in the mid-nineteenth century, when the Californian and Australian gold rushes create significant demand for grain exports to those booming markets (Biblioteca Nacional de Chile 2023). A 1923 survey described the rich *haciendas* in San Antonio as primarily focused on grain, cattle, and timber (eucalyptus and pine) production (Valenzuela 1923).

Maldonado had been sent to Cartajena and San Antonio to evaluate the progress of afforestation works, discovering that they had been delayed due to the lack of materials and the loss of many of the trees during transport. The problem on this coast was similar to the others I have described: dune sand was being blown inland and covering the adjacent agricultural fields. According to Maldonado, much of the village of San Antonio, founded by fisherman in 1790, was buried in a landslide in 1906. As he explained, an earthquake dislodged the large sandhill that towered over the settlement, sending a massive wave of sand toward the village, where it buried houses, the school, and a warehouse, claiming many lives in the process. Indeed, the

volume of sand was so great that many of the bodies were never recovered. Following the example of other countries, the Chilean government decided to fix the dunes of Cartajena and San Antonio using the methods applied in France, Spain, Portugal, and Germany (Maldonado 1907).

However, the interventions in Cartajena and San Antonio were not the first attempts at dune stabilization in Chile, the earlier stabilization of the Chanco sands in the nineteenth century predating these state efforts. Located in the province of Maule, south of Santiago, Chanco was an old Indigenous fishing hamlet settled by the Spanish in the eighteenth century. In 1849, the population moved to higher ground to escape the drifting sands invading the initial settlement (Patron 1924, 183). By the end of the century, the new village comprised 2,300 inhabitants, their homes and farmlands spread across a fertile river valley. However, this thriving community and their houses, animals, and crops were also threatened by the encroaching sands. Stabilization efforts were initiated by Federico Albert Faupp (1867–1928), a German biologist who began his career at the Botanical Museum of Berlin before the Chilean President José Manuel Balmaceda hired him to teach at the Pedagogical Institute and collaborate with the Museum of National History. Albert arrived in Santiago in 1889. Ten years later, while Director of Zoology and Botany Departments of the Ministry of Industry, Albert was tasked with investigating the problem of the *arenas volantes* and developing an afforestation plan to solve it (Biblioteca Nacional de Chile 2022). In 1906, the service run by Albert was renamed the Water and Forest Section, the same department Ernesto Maldonado worked for (Albert 1906).

In preparing his report on the coastal dunes of Chile and their advancement inland, Albert traveled to the coast, compared maps, and interviewed locals, listening to their stories and views. In the case of Chanco, where the encroaching sand had already covered more than 12 houses, Albert concluded that the movement of the dunes had started approximately 70 years earlier. Although some had taken measures to prevent the destruction of their land, without the concerted efforts and cooperation of their neighbors, individual enterprises were condemned to failure. In terms of the methods implemented by locals, Albert noted the use of branches as windbreaks, the planting of grasses like the native *ratonera* (*Hierochloa utriculata*) and trees, as well as the covering of small areas of the dunes with organic matter, notably guano or straw. As a botanist trained in Germany, Albert was perfectly aware of the techniques and species used in Europe. However, he strongly believed that measures should be adapted to local climatic and soil conditions, noting that observation of the natural vegetation of the dunes evidenced the best indigenous plants to protect them. Albert provided an extensive list of the plant species, mostly native, that could be used to cover the sand and safeguard it from wind erosion. In addition to a scientific description of these species, he noted the unique aspects of each plant, including their uses as a source of food, medicine, or as a raw material—reflecting a broad and accurate understanding of many of their local uses. Indeed, although he proposed the usual

methods of sand stabilization, such as the erection of fences, Federico Albert championed the use of indigenous grasses to achieve dune fixing, namely, the planting of *doca* or iceplant (Mesembryanthemum) in beach areas to prevent the sand moving inland. Although he admitted that *Ammophila arenaria* might prove better suited to protecting the fields adjacent to dunes than *ratonera*, he did not use it in Chanco (Albert 1900, 134, 184–185). Rather, Albert installed fences and planted *ratonera* to create a stable barrier between the sand near the settlement and the large extension of dunes beyond. He then planted a mix of indigenous and exotic trees—including *Populus alba, Populus nigra, Sambucus Australis*, eucalyptus, casuarinas, and cypress—and indigenous brush like *Salix Humboldtu* and *Cestrum parqui*. Near the shore, he established *doca* plantations to trap the sand coming from the beach.

Concluding his report, Albert listed the areas of Chile most at risk of being inundated by sand in the near future. The forecast was pessimistic, the country facing imminent disaster unless it moved to action. Like his predecessors and contemporaries around the world, Federico Albert argued for the need to protect land from sand drift for the sake of future generations. The main enterprise, that is, interventions in the most at risk areas, was a task for the government. However, Albert noted, the littoral area was too big for the state to handle alone, and private sector involvement was necessary for the success of sand control efforts. In this regard, he suggested that the government should help private sector initiatives by providing accessible knowledge and guidelines. "We can do the same as the states of Europe and North America, yet the major practical effort should be a private one," Albert concluded, "let's join and work together to prevent ruin from happening" (Albert 1900, 185).

Visiting the Chanco area in 1908, Maldonado declared that the initial operations had been successful because a forested tract of land now acted as a barrier against the sands. Reporting to his superior, Federico Albert, he recommended the extension of the operations over a larger area. Maldonado proposed the creation of a foredune to control the sands from the sea, noting that the influx of such sediment threatened the existing protective tree-belt and all the future works. He also noted the need to improve on certain aspects, including the use of timber and branches for the fences and cover, which were expensive and difficult to source locally. Another concern involved watering the young trees during the dry season. As the planted area increased in size, so water collection systems would have to be installed. In Chile, the dune stabilization program was primarily established by the government and put into practice by public agencies. Nevertheless, Maldonado agreed with his chief that it would be important to promote private initiative in such matters. While many landowners threatened by the sands were interested in taking their own measures, Maldonado believed that such actions should be authorized and supported by the Water and Forest Section, which could provide guidance and plant material from the state nurseries (Maldonado 1908).

Final thoughts

In a beautiful piece on the art of writing, historian Greg Dening casts the establishing of links and building of bridges between different regions, people, and species as a dance of the eye and mind, a multiple cross-referenced process of what one sees and reads and the interconnections the brains establishes therefrom. This involves some degree of risk: with different experiences and knowledge, others will invariably think of other possible links. Our job, Dening notes, is to persuade—after all, with no closure to the stories we tell, there is always another slant to what we have narrated (Dening 2002, 6). Many historians have written about the Pacific. I do not include myself in this group, as I am very much an outsider to this environment. My only claim to this new world is through the stories of the people and species that colonized the sands in different times and spaces. There is an enormous amount of information about sand drift and stabilization in Australia, New Zealand, the US West Coast, and Chile, enough to fill countless books. In this chapter, I sought to explain how the subject emerged as a problem and was addressed in each country, noting how measures were based on those of Europe, but also influenced by the contacts within the Pacific region, with some important local adaptations, particularly in terms of the plants used.

Ammophila arenaria once again figures as a protagonist. In this chapter, I argue that its introduction in California was made via the Pacific world, imported from Australia, rather than the US Atlantic coast, where it is not clear when it may have arrived from Europe. From the American Atlantic coast certainly came the American beachgrass tested at Warrenton camp in the 1930s. Today, *Ammophila arenaria* is also present on the dunes of Chile, where it was introduced in the 1950s (Popay 2015). Interestingly, in contrast to other cases, Federico Albert, the German botanist trained in Europe who was responsible for the first major works in Chile, preferred using local sand-binding plants in his experiments in Chanco. He also advocated for state–private collaboration to eliminate the dune threat, knowing perfectly well that he was proposing something different from the model adopted in the US and Europe.

To conclude, I would like to highlight that the reasons for dune afforestation—emphasized by the discourses beyond such interventions—were remarkably similar in all three cases. The human protagonists of these narratives stressed the menace of the dunes and urgent need to prevent impending destruction by taking the lead and actively controlling the sand to protect future generations. This mindset transcended different regions around the world. Although they all saw immediate goals and benefits, their ultimate objective lay in the future.

Notes

1 In 1914, the Department of Lands supported the research tour of R.G. Robinson, superintendent of the South Island nursery, to Hawaii, Canada, USA, Edinburgh, London, Bordeaux, Biarritz, Bayonne, and San Sebastian. The beginning of the First World War ruined Robinson's plans, requiring him to flee to London, his working notes lost during the escape (McKelvey 1999, 37).

2 During a fieldtrip to Boston Harbour in March 2023, I had the opportunity of listening to Faries Gray, Sagamore of the Massachusetts Tribe at Ponkapoag, tell some of his tribe's stories about a time, approximately 3,000 years ago, when the sea level was lower and the islands of the Boston harbour were hills his people used as temporary camps during the fishing season.
3 In the records of the Warrenton project European beachgrass is usually referred to as Holland grass. Images available at the Library of Congress: https://loc.gov/pictures/resource/fsa.8b27858/, https://loc.gov/pictures/resource/fsa.8b27867/

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Figure 8.1 Map of Africa with the location of the regions and places mentioned
Source: Map by D.M.R. Sampath

8 The sands of the Indian Ocean

Travelling in Mozambique

In the first two weeks of February 2023, I journeyed to southern Mozambique with colleagues from the Universities of Algarve, Portugal, and Eduardo Mondlane, Mozambique, in search of beaches, casuarina, and archaeological sites. Traveling by plane, car, and boat, we visited Maputo, Beira, Bilene Beach, and some rural areas in Machanga 100 kilometers inland from Nova Mambone in the estuary of the Save River. We had some mishaps along the way—a flat tyre, storms and torrential downpours, urban flooding, electricity outages, and water shortages. I had never been in Mozambique before. I was immediately reminded of a line from a character from a Mia Couto's (2007) novel, who says that the heart is like a beach. For sure, the heart of the Mozambican people is as big and open as their coast. I kept remembering this quote in Bilene, as I watched the colorful array of men, women, and children traverse the beach path every morning in their daily routines—the women dressed in beautiful *capulanas*, their faces bright with smiles as greetings of "*bom dia*!" echoed along the shore.

In the capital of Maputo, I spent several days at the National Archives, gathering information to complete what I had already collected in Portugal, particularly the reports of the colonial forestry service and local work on the dunes. I wished to broaden my experience and knowledge of Mozambique as a singular case, hoping to grasp other possible ways of seeing the sand—a less Eurocentric view if you will. I wanted to explore the complexity and contingency of the multidirectional histories, some provisional and ephemeral, that can be told of dunes in Mozambique, where the Portuguese introduced the practice of sand afforestation in the twentieth century to protect the city of Beira, stabilize the mouth of the Limpopo River, and safeguard the country's lighthouses. I was also looking to know more about the legacy of these works and the present situation of the coastal dunes. This journey to Mozambique showed me that travel and writing are identical insofar as they define a course, connect places and stories, widen perspectives, and contribute to the interweaving of narratives, facts, and memories of lived worlds—giving voice not only to the when and why of human life, but also to the where of landscapes (Ghosh 2021).

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While the northern coastline of Mozambique is characterized by sandy beaches and low dunes, the stretch from the Bazaruto Archipelago southwards is marked by high parabolic dunes. From Inhaca Island, near Maputo, these dunes form an elevated sandy ridge that runs almost parallel to the coastline until the province of KwaZulu-Natal in South Africa. The dunes are divided into vegetated and immobile inland paleodunes, which were created during the last Holocene transgression, and transgressive coastal dune fields that shelter back lakes and lagoons, forming extensive barrier lagoon systems (Louro 2005; Miguel and Castro 2018; Massinga and Hatton 1997; Tinley 1971). This vast coastal region can be approached from a general or specific perspective. As a historian, I prefer the second option. In this chapter, I bring some intricate stories about dunes, grasses, and trees, mainly from beaches in southern Mozambique, but also South Africa.

Beira, the liquid city

Years ago, I was conducting research at the Portuguese *Torre do Tombo* National Archives when I came across letters mentioning Beira's troubles with the ocean. I quickly realized the value of Beira as a case study and the uniqueness of the Mozambican situation overall. The history of Beira is located in the Portuguese colonization of central Mozambique toward the end of the nineteenth century, with the city's creation and development shaped by Portugal's political and strategic need to control the territory, its resources, and its people. At the time, the African king, Gungunhana, was expanding his influence in the region and pressuring the local population, who looked to the Portuguese for protection. The Portuguese had been familiar with the area of the mouth of the Púnguè River since the early sixteenth century. However, in 1882, the report of Paiva de Andrade, the soldier and explorer, underscored the importance of this territory, suggesting the installation of a military command to control the valley region. In this respect, Paiva de Andrade recommended establishing safe communication between the inland areas and the sea by constructing a railroad, exploring the commercial potential of a port on the right bank of the mouth of the river, and creating a company to administer such a vast domain.

A military outpost was subsequently established in Ponta Chiveve (Beira), in 1887. The following year, the *Companhia of Moçambique* (Mozambique Company) was formed to administer the port and the territory between the Zambezi and Save rivers. In 1892, the head office of the Mozambique Company was strategically installed on the left bank of the Chiveve River, a tributary of the Púnguè, near the sea and close to what would be the terminal point of the projected railway line between Beira and Manica, which was inaugurated in 1899. As early as 1892, the Company was aware that the urban growth of the village in such a marshy and unstable terrain, one permanently threatened by the sea and riverine waters, depended on the construction of protective barriers and landfills. The Company thus financed a

series of sanitary measures and engineering works to create favorable conditions for urban expansion and to attract foreign investment (Roque 2012; Lobato 1983; Amaral 1969). Efforts to protect the area notwithstanding, Beira was at risk from the outset. Indeed, the wetland delta in which it was established was highly dynamic and vulnerable to erosion, sedimentation, and periodic flooding due to high precipitation and tropical cyclones. This vulnerability was exacerbated by the progressive destruction of the mangrove forest, which the Portuguese exploited for building materials and firewood. Like the dunes, the mangrove forest acted as a natural barrier against climate and sea hazards (Massuanganhe et al. 2015).

Housed at the *Torre do Tombo*, the correspondence between the Governor of the Territory of the Mozambique Company and various Portuguese and foreign institutions and interlocutors paints a detailed picture of the threat of coastal erosion to Beira. Exchanged between 1915 and 1935, these letters mention the dunes and the attempts made by the local authorities to stabilize them. In a missive dated January 7, 1915, Governor J. Pery de Lind (1915-01-07) complained to the company's delegate in Lisbon that the tree seeds purchased in 1913 had never arrived, resulting in wasted time and money and the issue of the dunes remaining unresolved. In a letter sent two days earlier, Joaquim Granger (1915-01-05), chief of the Public Work Service in Mozambique, explained that the initial plan was to use the seeds to install a tree nursery in Beira and later transplant the trees to the dunes. In fact, the 250 kilograms of seeds sent from Europe had not been lost, but allocated to other services through administrative error. Nonetheless, committed to solving the problem of the dunes, the Public Work Service reinstated the initial plan. In this respect, Granger proposed that, in addition to the trees, the utility of a grass species used in South Africa should be tested. Granger noted that the grass could be used while they waited for the pines and casuarinas to reach maturity. Granger identified the grass as "marros," "beachgrass," or "*Ammophila arundunacea*," a species sold in the Cape by Stark & Co. Of course, Granger was proposing the use of *Ammophila arenaria* in Beira. The recommendation had come from the interim director of Agriculture, E.H. Heron (1915-01-14), who was establishing a tree nursery at Ponta Gea using pine and cypress seeds obtained from Vilmorin, Andriex & Co., the famous French company mentioned in previous chapters (Queriol 1915-05-24).

In Beira, dune afforestation was intended to stabilize and reinforce the dunes in order to protect the city and Macuti lighthouse, erected in 1904, from coastal erosion. There is no further information about these first experiments with tree planting or even whether marram was ever used in the stabilization process. However, 20 years later, the city was still threatened by coastal erosion, the waves during equinoctial tides or storms reaching the dunes and endangering the casuarinas growing on them ("Letter from the Governor of the Territory…" 1935). This indicates that the pines and cypress probably failed to thrive, while the casuarinas flourished. Recounting the memories of his childhood in the 1960s, the historian and writer João Paulo

Borges Coelho (2017, 13, 17) described Beira as a liquid city, where day after day the waves diligently ate away at the sand and licked the roots of the casuarinas. During my visit, I saw these Australian trees bordering the coast, providing shade to beachgoers enjoying the tranquility of a warm afternoon by the Indian Ocean. Beira is truly special. Indeed, it is where I first set foot on the sands of Mozambique.

The coastal sands and trees of South Africa

Sands, grasses, and trees linked the Atlantic, the Indian, and the Pacific worlds. The first reference I found on marram grass in Beira historical sources said the plant could be bought at Cape Colony. Just like countries in Europe, the Americas, and Australasia, in the nineteenth century, the Cape Colony began to experience problems with sand drift. Southern Africa has markedly few forest areas, with grassland and savanna—ecosystems prone to and dependent on fire for their ecological processes and diversity—constituting the largest biomes in the region. European colonists created a new biotic regime by introducing livestock and new plants, pests, and diseases, and destroying the shrub-dominated indigenous flora in their constant search for timber and firewood, agricultural production, and stock farming (Bennett and Kruger 2015, 22–23, 26; Beinart 1984). Around the 1830s, the steady exploitation of shrub and grass vegetation for thatch and firewood resulted in the dunes encroaching onto the road between Cape Town and the town of Eerste River. Consequently, in 1845, sand stabilization work was initiated under the coordination of the Central Roads Board. Various grasses and tree species were planted during this intervention, as well as several others on the western and eastern coastline during the nineteenth and twentieth centuries (Avis 1992). Some were species native to Europe and Australia, including *Pinus pinaster*, various acacia, *Casuarina equisetifolia*, and, of course, *Ammophila arenaria*. According to the ecologist Anthony Mark Avis, the French method of dune fixing was adopted by the body responsible for the stabilization program, a duty which fell under the Cape forestry department from 1875 onwards[1] (Avis 1992, 235–237; Lubke 2022).

Interestingly, the first trained forester in the Cape was Comte Médéric de Vasselot de Régné, a French forest officer who was trained at the National School of Forestry (*École Nationale des Eaux et Forests*) in Nancy and participated in the sand afforestation works in Gascony. In 1881, he was appointed head of the newly created forest department within the Cape Agriculture Ministry, where he introduced several forest management procedures. He hired a number of foresters to work under his direction, including Thomas Sim (1909), who had Scottish botanical training and was later responsible for a survey of the Mozambican forests, as well as Joseph Storr Lister. Born in the Cape Colony, Joseph Storr Lister (b. Uitenhage, 1852–d. Cape Town, 1927) worked in India as assistant forester under the conservator of forests of the Punjab region as well as several Himalayan forest stations.

Lister also spent some time in Britain, before being assigned to the post of superintendent of the Cape Flats in 1875, where he undertook the task of reclaiming the dunes by planting trees and spreading city refuse to stabilize and fertilize the sands for afforestation (Plug 2020b). Appointed Conservator of Forests for the Eastern Conservancy, Lister was responsible for coordinating the sand stabilization works to protect the harbor of Port Elizabeth. At the beginning of the twentieth century, he became Chief Conservator of Forests of the Cape Colony (Plug 2020b; Bennett and Kruger 2015, 41).

According to Anthony Avis, marram grass was first planted in 1876 and used on a wide scale after 1896 (Avis 1992, 235–237). Based on an article published in the *Indian Forester* in 1895, marram was introduced to the Cape Town Botanical Gardens by Professor Peter MacOwan, who obtained seeds from Lincolnshire, England, and later planted on the dunes of the Cape Flats by Joseph Storr Lister. Peter MacOwan (b. Hull, United Kingdom, 1830–Uitenhage, South Africa, 1909) was a British chemist interested in botany who emigrated to the Cape Colony in the 1860s. He organized an extensive private *herbarium* and created the South African Botanical Exchange Society, sending local specimens to his correspondents abroad and receiving plants from North America, Australia, and Europe in return. In 1881, MacOwan became the director of the Botanical Gardens in Cape Town (Plug 2020c). There are some discrepancies between historical sources regarding the origin of the *Ammophila arenaria* and the time of its introduction to the Cape Colony. For instance, the marram used on the dunes of the Eerste River was sourced from the well-known Parisian house, Vilmorin & Co, in 1892 (Maiden 1895, 354–355). Nonetheless, marram importation likely occurred sometime between the 1870s and early 1880s. It is possible that it arrived through various agents and at different times—this would explain the discrepancies—as seed exchanges primarily occurred through private, rather than institutional, networks (Bennett and Kruger 2015, 29).

In 2015, Ruth Morgan presented a lecture at the Rachel Carson Center, Munich, where we were both fellows at the time, regarding the shared ecologies of the British Empire across the Indian Ocean. In her presentation, which is available online, Ruth explained how India, Australia, and South Africa served as testing grounds for European and each other's plants and practices, as well as for the exchange of experts, knowledge, and species (Morgan 2015). I saw much of what Ruth discussed in my own research on dune afforestation. Certainly, the example of afforestation at the Cape corresponds with Ruth's description, as well as previous work by Richard Grove (1995) and William Beinart (Beinart and Middleton 2004) on the mobility of imperial officials, who often served in more than one colony. Similarly, botanists and foresters in different outposts maintained correspondence, keeping one another informed of experimental findings (Morgan 2015). Casuarinas and acacias are another good example of such exchanges, with these Australian trees widely disseminated across the colonies of the Southern hemisphere due to their ability to survive in difficult terrains like coastal sand dunes. I have referred to

the use of acacias and casuarinas in Mozambique and South Africa, but they were also planted in India, on the shore near Bulsar in the Surat district (Wallinger 1895; "No Title" 1897). These cases are proof of the existence of an intricate web within wider imperial eco-cultural networks, one expanding beyond the metropole and colonies of the British Empire to form linkages with other empires and regions across the Indian, Atlantic, and Pacific Oceans.

This was hardly novel, connectedness across and beyond the Indian Ocean world has existed for millennia (Castryck 2019, 102). As ethno-botanical, archaeological, and written sources show, long before the arrival of the Europeans, there were secular exchanges between East Africa and Persia, Arabia, India, and China linked to the trade of slaves, gold, ivory, and timber. Such exchange networks were responsible for the introduction of numerous Asian plants to this part of Africa, including bananas, coconuts, cane, and some rice species (Rita-Ferreira 1975; Macamo 2006; Departamento de Arqueologia e Antropologia 1980). European empires built and expanded on these rich and prosperous networks. Indeed, it was these preexisting intercontinental and transregional, social and commercial networks, largely controlled by Muslim merchants, that the Portuguese sought to control when they arrived on the coast of East Africa (Roque 2017).

Stabilizing the Mozambican dunes

Lighthouses and the Limpopo River

When the Portuguese arrived in Mozambique in the sixteenth century, they constructed fortresses, villages, and farms at specific points along the coastline, often disregarding ancient indigenous rights and uses. Indeed, the coast was inhabited long before the arrival of the Portuguese. However, living in such a dynamic environment, subject to constant geomorphological changes and flooding, required settlement patterns characterized by cycles of occupation and retreat. For instance, archeologists have discovered several shell midden sites in the dunes of Bilene, Chongoene, and Xai-Xai on the coast immediately to the south and north of the Limpopo River, suggesting the exploitation of coastal resources by farming communities following a "pattern of temporary settlement corresponding to periodical visits to the coast from inland villages" (Morais 1988, 85). While local people had established a strategy of mobility based on ancestral knowledge of the territory, European newcomers lacked such wisdom and payed the price of building permanent structures in areas prone to erosion and siltation. Such was the case of settlements like the fortress and village of Sofala established at the mouth of the Save River in 1505, and the city of Beira, which were both located in dynamic deltaic wetlands (Roque 2016). This does not mean that the coastal areas were wild or devoid of human activity. African farmers, herders, fishermen, and traders contributed to the transformation of these landscapes before and after the arrival of the Portuguese. However, settlements were sparse and

strategically located in regions with a combination of several resources. For example, in Chibuene, located on the sandy dune coast south of Vilanculos, people lived off the land and sea, practicing subsistence farming, foraging, and the harvesting of shellfish. The numerous freshwater lakes in the area probably influenced the long-term occupation of Chibuene, as did the nearby Govuro River, an important transport route between the coast and the hinterland. Archaeological work has revealed two main phases of occupation: the first, between the sixth to eighth and fourteenth to fifteenth centuries, was characterized by dispersed settlement over a larger area; while the second phase, between 1450 and 1700, was defined by the concentration of the previously dispersed settlement and a higher population near the coast. Archaeological evidence demonstrates the connections between inland areas, Chibuene, Bazaruto Island, and Asian ports. The social-ecological history of a coastal site like Chibuene suggests that there was a highly flexible use of resources and mix of maritime, agricultural, pastoral, and regional and transoceanic trading activities amid alternating periods of intense occupation and marked decline (Ekblom 2004, 3, 15, 19, 97–99).

Portuguese occupation on the coast intensified over time, particularly from the nineteenth century. In the aftermath of the Conference of Berlin of 1885, which regulated European access to Africa and required imperial nations to implement direct control over their overseas territories, Portugal felt pressured to strengthen its position by promoting colonial development in an effort to secure their dominion while increasing revenue. Based on European ideas at the time, colonial rule was justified by its civilizing purpose and supported by an association between science, technology, and progress. Railways, harbors, and the telegraph became the anchors of the imperial takeover, boosting the circulation of people, commodities, and information. Imperialism and colonialism imposed European techno-scientific rationality on the people, polities, and environments of Africa (Diogo and Amaral 2012)—a Eurocentric mentality that dismissed local wisdom and tradition as superstition and savagery and regarded nature as a commodity.

In the early decades of the twentieth century, shipping was crucial to Portugal's plans for its colonies, as all trade and transport was made by sea. To guarantee the safe navigation of the Mozambican coastline and ports, the Portuguese built several lighthouses—often in high dune areas exposed to the strong maritime winds. The mobility of the dunes posed a significant threat to these structures. For instance, in 1918, the lighthouse on Inhaca Island, which shelters Maputo Bay, was in urgent need of repair. It needed new windows to prevent the sand from entering the building, while the lighthouse keeper's lodgings were almost entirely buried by sands (Sousa 1918). Built in 1894, the lighthouse was responsible for guiding ships to the port of Lourenço Marques (present-day Maputo). Several years later, the lighthouse of Ponta Caldeira faced the opposite problem when the wind blew away the sand at the base of the building, exposing its foundation and placing it at risk. Windblown sand frequently invaded surrounding staff houses, tormenting inhabitants and

making life almost unbearable in these areas. Such complaints were common to other lighthouses, including Timbué, Bazaruto, and Závora (Cardoso 1932, 1948).

In addition to endangering the lighthouses, the drifting sands of the dunes along the Limpopo River were silting its mouth, obstructing the flow of the river. According to John Aylmer Balfour, the resulting riverine floods submerged the valley and significantly jeopardized plans to establish a major agricultural scheme along the river banks. The Portuguese colonial government had appointed the British-born engineer and former Director of Irrigation in Ceylon (present-day Sri Lanka) to survey the irrigation potential of the Limpopo valley. Balfour subsequently concluded that the best way to alleviate the issue was to create an open bar to facilitate the flow of water during flooding—a solution requiring the stabilization of the sands at the mouth of the river. Accordingly, in June 1920, the colonial government passed an ordinance to fix the Limpopo dunes, with the Portuguese forester Fernando Belo initiating the work in September that year (Cardoso 1939, 1954).

The Mozambican Forest Service

As in Portugal, the Forest Service was responsible for the afforestation of the dunes in Mozambique. Created by Governor General Freire de Andrade in 1920, the Mozambican Forest Service was a subunit of the Department of Agriculture, which had been established in 1908, with the technical support of Otis Warren Barrett, an American expert on tropical agriculture. Barrett, who had previously worked for the US Department of Agriculture, became the first Director of Agriculture in Mozambique (McCook 2009, 504). At the time, Freire de Andrade invited the Conservator of Forests for Natal, Thomas Sim, a Scottish botanist trained at Kew and Harvard Botanical Gardens, to inspect the colony and determine its forest and flora resources (Sim 1909; Plug 2020a). These two initiatives must be understood in the context of the colonial aim to develop the Mozambican economy, an endeavor requiring the evaluation of the colony's natural assets and establishment of the institutional tools necessary to explore its potentialities. However, these objectives were hindered by a number of obstacles. In this regard, the reports produced and letters exchanged between those stationed in Mozambique and their superiors in Portugal indicate that the Mozambican Forest Service struggled to fulfill its mandate from the outset—lacking the staff and means necessary and severely constrained by an agricultural department with conflicting interests.

The Portuguese forester Fernando de Almeida Belo (1887–1927) was the first to work for the Forest Service, albeit for a brief period of just three years. In 1920, Belo was on his way to India, where he was supposed to take a post in the Portuguese Forest Service in Goa, when the Director of the Department of Agriculture, Oliveira Ferraz, convinced him to remain in Mozambique during his stopover at Lourenço Marques. Belo personally oversaw the afforestation of the dunes at the mouth of the Limpopo River. In 1923, he

went back to Portugal for health reasons and never returned ("Homenagem a Um Pioneiro" 1967). His position was difficult to fill, with few experts interested in going to Africa—the living and working conditions considered too harsh and the reimbursement too low. Indeed, struggling to fill intermediate positions in the Forest Service, it took the Department of Agriculture about two years to replace Belo ("Telegrams" 1923). It was only in 1926 that Raúl da Silva Guardado (1894–1942), Head of the Forest Service in Angola, transferred to Lourenço Marques to continue Belo's work ("Telegrams" 1925). Some years later, after visiting the South African provinces of the Transvaal and Natal, Guardado presented a report on the situation of the Mozambican Forest Service, emphasizing the dire lack of personnel compared to the metropolis and even Angola. In Portugal, where most forest areas were privately controlled, the state had 20 foresters, 30 forest technicians, and 400 guards. Meanwhile, despite being nine times the size of Portugal, Mozambique, where all forests were under the state control, only had one forester, one middle-rank forest technician, and three guards. Meanwhile, Angola had 5 foresters, 11 forest technicians, and 105 guards (60 Africans and 45 Europeans). The Forest Service in Angola also had more administrative and financial autonomy than its Mozambican counterpart, as well as a newly created Technical Division for the Fixing of the Dunes.[2] Guardado, elevated to Interim Director of Agriculture and responsible for the Forest Service since 1927, begged for similar measures in Mozambique, noting that his diminished staff and insufficient funding prohibited him from fulfilling his mandate (Guardado 1928a, 1928b).

Guardado returned to Portugal in 1930. Appointed in 1931, Guardado's replacement, Júlio Gardé Alfaro Cardoso remained in the position longer than his predecessors. Indeed, working for the Mozambican Forest Services until roughly 1954, Cardoso had the time and stability to fulfill his duties that his predecessors did not (Freitas et al. 2024). All three foresters—Belo, Guardado, and Cardoso—were trained at the Institute of Agronomy, Lisbon, in the 1910s. As mentioned in Chapter 5, by this point, dune afforestation was already well developed in Portugal, the interventions of the Forest Service in the littoral areas of the metropolis since the late nineteenth century ensuring an excellent base of theoretical and practical knowledge regarding the best methods for fixing coastal dunes. As such, the three foresters had the necessary know-how to carry out stabilization interventions on the dunes of Mozambique, as evidenced by Guardado's (1928c) instructions on the matter in an agricultural local journal. Thus, these men served as key agents in the implementation of the operations at the Limpopo and the lighthouses. That said, despite implementing established practices learnt in the metropole, they proceeded independently from central services, operating on a trial-and-error basis due to local environmental conditions requiring different approaches. Such adaptations typically involved the plant species used and the planting procedures adopted.

The Limpopo dunes

As noted, under the coordination of Belo, the first large-scale dune interventions in Mozambique were implemented at the mouth of the Limpopo River in 1920. Works began on the left bank of the river and along the beach, with Belo directing the construction of a foredune based on the European method utilizing grasses and fences. According to Cardoso (1954), the foredune was constructed fairly quickly, with a primary dune reaching some 15 meters in height produced within just two years. On the leeward side, another set of fences was installed and local sand-binding plants like *Ipomea biloba, Eragrostis sp.*, and *Canavalia rosea* were planted. Later, casuarinas (*Casuarina equisetifolia*) and coconut trees were introduced, the former proving particularly well-suited to these sands—flourishing despite the poor soil and strong salty winds. Several years later, Guardado tested other tree species, including eucalyptus and pine as well as native *Afzelia quanzenis, Trichilia emetica*, and *Minusops caffra*; only the local species were able to survive to the harsh dry environment.

Between the 1930s and 1950s, Cardoso conducted several experiments to improve and increase afforestation efforts, continuing with the afforestation of the left bank and initiating a new operation on the right. To stabilize the river banks, he set up wooden poles to promote the growth of mangroves, which would protect the margins from erosion while stabilizing the sand. He also made changes to the distances and type of fences erected to create the foredune. In this respect, Cardoso was determined to establish more effective and economic procedures. For instance, because irrigation was not possible, it was necessary to find other ways to protect the casuarina trees from soil dryness in the initial planting stage. To this end, his predecessor, Guardado, had used the basket method, whereby the young plants were grown in grass baskets and later planted with these containers, which the locals called *cherrumes*. Considering this method overly complicated and expensive, Cardoso discovered an alternative: rather than a basket, the roots of the young trees were wrapped in a wad of river mud called *matope*. When transplanted from the nursery to the dunes, the *matope* would provide the rich organic matter necessary to feed the plant and preserve the required level of soil humidity, increasing its chances of survival. It is unclear whether the Portuguese learnt this method from the local population, and I found nothing in the archives to clarify this matter. Nevertheless, of the 1.5 million trees planted, only about a million thrived over the years due to drought and storms. The casuarina, considered the species best suited to the conditions of the coasts of southern Africa, was also used in South Africa and Angola. Nevertheless, as casuarina wood had low commercial value, the foresters working in Mozambique also introduced other species, including the *chanfuta* (*Afzelia quanzenis*), a native species that was slow growing but commercially valuable (Cardoso 1954; Guardado 1928c). In the Limpopo region, maintenance and replanting works continued until the end of the 1960s (Fonseca 1968).

Protecting the lighthouses

In addition to the work at the mouth of the Limpopo River, dune stabilization interventions were implemented around the lighthouses built to ensure the safety of coastal navigation. These operations were coordinated and supervised by the Forest Service, which had the necessary technical expertise, and funded by the Lighthouse Section of the Maritime Department. Writing in 1948, Cardoso (1948) explained that most of Mozambique's sandy coastline did not present a threat to human activity, even in areas with dunes over 200 meters in height. The majority of dunes were relatively stable, with primary dunes matted with endemic pioneer vegetation and secondary dunes blanketed with a largely continuous strip of coastal forest extending from Bazaruto to Ponta do Ouro (Massinga and Hatton 1997). Even mobile dunes seldom presented a danger, simply because there were no nearby settlements or agriculture. Only the dunes near certain lighthouses posed a problem and had to be fixed: namely, from north to south, the lighthouses of Uifundo, Ponta Caldeira, Timbué, Bazaruto, Barra Falsa, Barra do Inhambane, Závora, Boa Paz, Monte Belo, Inhaca, and Ponta de Ouro. As the Ponta de Ouro lighthouse was located on the border, with part of the dunes in South African territory, the Mozambique Forest Service had to obtain permission before proceeding with afforestation efforts. Without continuing the intervention across the border, the entire initiative would have failed—the winds simply continuing to inundate the lighthouse with sand (Cardoso 1948). This case is a good illustration of the fact that nature—wind and sand—has no respect for political boundaries, frequently resulting in common transnational issues. The method used to fix the dunes around the lighthouses was fairly similar to that implemented along the shores of the Limpopo River, namely, the construction of an artificial foredune by erecting fences and after planting casuarinas. However, where the interventions on the Limpopo River used a combination of grass and bush cover to stabilize the sands before planting trees, those near the lighthouses only used bush cover.

Bilene Beach

In the 1950s, a new reason for dune afforestation emerged in São Martinho de Bilene, part of a series of coastal lagoon systems extending from Inhambane to Ponta do Ouro. Of these, the Bilene or Uembje Lagoon is the only natural saltwater lagoon connected to the Indian Ocean (Balidy et al. 2008). In the 1950s, the lagoon, known for its charming white sands and crystal calm waters, became a popular tourist destination among those looking for a place to rest or go fishing. However, this paradise was threatened by the mobile dunes of the sand barrier that separates the lagoon from the ocean, with the windblown sand silting up the shallow estuarine system. Accordingly, the Forest Service planted casuarinas—a move regarded not only as a necessity to safeguard the lagoon, but enhance the area's beauty, the green of the trees thought to complement the deep blue of the Indian Ocean waters ("Um

Trecho da Praia de S. Martinho de Bilene" 1955). With coastal tourism flourishing in Mozambique, local administrators fully supported such endeavors, anticipating a return on their investment. For example, convinced of the need to foster tourism, the Governor of the District of Gaza strongly promoted the growth of Bilene, which had a small airport, a road accessible throughout the year, a 90-bedroom hotel, and 100 private homes. Other infrastructure was in development, including two hotels, a post and telephone office, railway services, and a water supply. The purpose was to attract both national and international visitors, offering an alternative to South African beaches, which were considered unsafe due to frequent shark attacks (Ruas 1960). During this period, the Forest Service maintained the regular planting of casuarinas in coastal areas, noting the need to protect the dunes from the winds on the beaches of Závora, Pomene, Tofo, Barra Falsa, Bazaruto, the mouth of the Limpopo River, and Bilene. Were such interventions motivated by a concern to defend lighthouses or tourist destinations? The report does not say (Fonseca 1968).

There is something missing from most of the history of dune afforestation in Mozambique: *Ammophila arenaria*. Was marram not used in such operations? Did the Portuguese not introduce this famed plant in their East African colony? They did. The use of marram was proposed in the case of Beira at the

Figure 8.2 Casuarina and other vegetation at Bilene beach, Mozambique, 2022
Source: Photo by J.F. Freitas

beginning of the twentieth century, although it is unclear whether it was actually planted. Nevertheless, marram was tested on the Limpopo dunes years later (Cardoso 1948, 7). As several photos published in the *Gazeta do Agricultor* show, it was also planted on the beach of Costa do Sol in Lourenço Marques (Costa 1955). However, *Ammophila arenaria* does not appear to have thrived in the coastal conditions of Mozambique, with *Casuarina equisetifolia* being the main agent in the dune stabilization and afforestation efforts in this region.

The long road ahead: Changes and continuities

Apart from visiting the archives, I wanted to go to Mozambique to find out more about the legacy of the dune afforestation schemes. I felt that reading the historical sources and recent environmental reports did not give me a true understanding of what had happened to these artificial forests. Some coastal areas have undergone major changes since independence in 1975 and the civil war (1977–1992) that displaced millions of people, driving them from villages in the interior to the coast. Travelling to Mozambique provided an opportunity to link the past—the dust of the official written records, and a Eurocentric view—with the present, one shaped by the lived traditions that have survived over time.

Arriving in Beira at midday on a sunny day, I immediately saw a stretch of casuarina trees between the asphalt and the sandy beach from Ponta Gea to the Macuti lighthouse. This old regiment of trees guarding the shoreline replaced in some places the indigenous mangroves, signaling the emergence of the liquid city. The casuarina is a silent sentinel, watching the tide day by day draw closer to the houses and roads of Beira, one of the cities most vulnerable to sea level rise in Africa. I cannot say much about the current situation of the casuarina plantations elsewhere along the coast of Mozambique, except for Bilene. After spending the night at a hotel on the interior side of the lagoon, my colleagues and I crossed it by boat to explore the dune barrier system that keeps the ocean at bay. It was Ana Gomes, the team's geo-biologist, who pointed out the casuarina surrounding the lagoon: a beautiful swathe of green between the blue waters and skies. On the seaside, the primary dunes are covered with casuarina trees, which extend almost into the Indian Ocean. I felt privileged to walk barefoot on the beach separating the waters from the forested dunes I had read so much about. Were these the trees planted under Portuguese rule? Probably not, but they were definitely the legacy of the afforestation program established in the 1950s, and of those that followed.

The planting of casuarinas on the coastline continued after independence, promoted by the national government and integrated into a major reforestation program. Fernando Costa, a technician working for the Mozambican Forest Service in the 1980s, reported afforestation efforts were still being carried out by the Forest Service, particularly in places like Tofo, Bilene, Limpopo, and Ponta do Ouro, where the dune forest had disappeared due to

human consumption and negligence (Costa 1985). As Hatton, Voabil, and Manjate (1996, 110) have noted, "Small-scale farming on land derived from slash-and-burn agriculture is common throughout coastal Mozambique." Used to grow maize, cassava, beans, and groundnuts, this farming system—known as *machambas*—involves cultivating land for a period of three or four years before preparing a new crop area, sometimes by clearing the dune forest (Costa 1985; Hatton, Voabil, and Manjate 1996). During the civil war, the arrival of millions of refugees placed significant pressure on coastal resources, which were quickly depleted. The growth of urban centers and industry along the coast significantly exacerbated the destruction of woodlands and mangroves, with urban and industrial expansion leading to increasing competition for space and demand for timber (Louro 2005, 18; Ministério da Agricultura 2006, 10, 15).

Mozambique's coastal forests—a complex matrix of several floristic communities and diversified ecosystems (including mangrove, dune forest, and miombo woodlands)—have been severely affected by human pressures in recent decades. Extending more or less continuously along the coast from Ponta do Ouro to Bazaruto, the dune forests are interspersed with a mosaic of agricultural fields, scattered settlements, and orchards of exotic species like coconut, cashew, and mango trees (Kanji et al. n.d.). Located on the paleodunes, these forests are mainly comprised of indigenous species—a marked contrast to the artificial casuarina forests planted on the primary dunes closest to the sea. In the 1990s, the resources provided by these variegate coastal environments of "forests, edaphic grasslands, mangroves, freshwater lakes and rivers, inter-tidal zones and littoral waters" were the economic mainstay of local communities (Hatton, Voabil, and Manjate 1996, 110). Small-scale agriculture and artisanal fishery are still the most important source of food and employment for Mozambique's coastal population—some two thirds of the country's population (Pereira et al. 2014, v). In recent years, tourism has to be added to the list of activities contributing to the income of households. Nevertheless, for these populations, coastal forests still offer important subsistence resources in terms of food (e.g., fruits, tubers, mushrooms, honey, and game), medicinal plants, gums, resins, shade, timber, firewood, charcoal, and underground freshwater (Balidy and Jacinta 2011; Albano 2004). Coastal forests also have social and religious value. As ancestral burial sites known as *gwendzelo*, [3] some forests are considered sacred and used for community ceremonies. Similarly, others serve as family holy areas known as *phahlelo*, which are important sites for special occasions (Albano 2004). As such, these forests—the trees and the sandy soil in which they are rooted—are not just ecosystems to be used or preserved, but living entities with histories and stories rooted in non-material vestiges that we cannot objectify (Elkin 2022, 48, 93).

The stories of dune reclamation in Mozambique and South Africa, which share many connections in terms of environments, people, practices, and plants, have much in common with others that I have told in previous chapters. These stories illustrate how the perceived low value of the sandscapes, determined by utilitarian purposes, economic necessity, and aesthetic ideas,

led the colonial states to intervene to control sand movement in strategic areas. These stories can easily be read as declension narratives of colonial resource exploitation and landscape transformation. However, to see these initiatives only in this light is to focus solely on linear outcomes, ignoring the multiple actors—including nature—and factors that contributed to the processes of environmental change (Kreike 2013). Dunes and coastal forests were an integral part of the thriving Indian Ocean world and its global networks. The role of scientists and colonial employees has been pointed out in promoting the transfer of knowledge and species—so important as drivers of change—between colonies, and between the metropolis and the colonies (Grove 1995). But, many important exchanges—facilitated by Muslim traders and local communities—predated the arrival of the Europeans in the Indian Ocean, long before a naturally and historically integrated space (Castryck 2019, 102). The case of Mozambique also challenges the general idea of the monolithic nature of the colonial rule (Grove, 1995, 7). In fact, despite its absolute authority over forest matters, the Portuguese state never had total control over these resources. The vastness of Mozambique's territory and the lack of personnel and funds—a recurring complaint of colonial administrations—meant that the Forest Service's ability to act and manage depended heavily on heterogeneous interests (e.g., agriculture versus forestry) and on the goodwill and effective cooperation of its few European and more numerous local staff. In the meantime, colonial institutions and personnel were "porous and plural," open to new influences (Beinart 2000, 293), and not necessarily following metropolitan standards. According to Ruy de Araújo Ribeiro (1959), the foresters working in the colony considered that their colleagues in Portugal did not have knowledge of tropical environments and indigenous African species, so their scientific expertise and coordination was not suited to local specificities. Portuguese foresters working in Mozambique, although implementing European and northern models, had to adapt methods and species to local environmental conditions, as their peers did in America and Australasia, and in this way developing practices—such as the use of the *cherrumes* and *matope*—that had no counterpart in Portugal. To read these stories only as declension narratives of colonial resource exploitation is also to fail to recognize that environmental change is not a singular outcome, but offers variable results, as there are no closed histories; dunes and coastal forests are ongoing entities.

Notes

1 According to Bennett and Kruger (2015, 39), the government entity responsible for public forestry in South Africa was frequently modified and renamed toward the end of the nineteenth century. Therefore, I use the generic "forest department" to refer to this entity.

2 In Angola, the Technical Division for Fixing the Dunes was established by Decree no. 590 of June 30, 1927. This division was solely dedicated to protecting the villages of Porto Alexandre (present-day Tombwa) and Baía dos Tigres, two

Portuguese settlements with strategic economic value due to their possessing abundant fishing resources and harbors. While interesting, I have excluded these cases because they pertain to sand drift from inland deserts rather than coastal dunes (Alves 1930; Almeida 1961; Moreira 1965).

3 *Gwendzelo* and *phahlelo* are terms used in the southern Mozambique, with different terms employed in the northern part of the country. These differences are due to the different languages spoken across Mozambique.

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9 Contested practices, unstable environments

One-size-fits-all?

Countries around the world adopted similar dune stabilization and afforestation measures to solve a common problem: the transgressive behavior of coastal dunes. But was this solution really suitable for everyone and everywhere? At the time of its implementation, afforestation was heralded as a great achievement, evidencing a nation's capacity to conquer and improve nature and secure the livelihoods of its people. However, my narrative would be incomplete if it failed to acknowledge local or alternative perspectives and dissonant voices (Soto Laveaga 2018). It is also necessary to draw attention to the unanticipated social and ecological consequences of some of these interventions, many of which only emerged several decades later.

In general, dune afforestation introduced radical changes to "traditional lifeworlds," a concept that Inese Sture borrowed from Cole Harris (1991) to describe the existence of those who created the *aizjomi* landscape, a Latvian cultural dune scenery. The notion of traditional lifeworlds refers to a time when people lived according to an established order of things, that is, a framework that gave meaning and imposed limits on individual actions (Sture 2012, 428). Before the emergence of foresters and other state agents, dunes were what Tim Ingold (1993) defined as "taskscapes," resourceful places integrated in the everyday dwelling activities of the local population, experienced through bodily practices, and rooted in well-known natural and social rhythms. The sands were living environments, exploited by people who were aware of their dynamic processes and how to cope with their fluid nature. These people were able to benefit from the poor soil of the dunes using ancient knowledge embedded in their shared collective existence (Sture 2012). As such, the imposed transformation of the dune landscape into forests was often a disruptive experience for those who depended on its resources. Nevertheless, stressing only this side of the story can be just as biased as focusing on the advantages of afforestation. Reality offered a wide range of possible combinations.

Once again, *Ammophila arenaria* is a pivotal part of the narrative. A vibrant agent of connection and driver of change, the use of this plant had

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some major unintended outcomes. As an effective means of stabilizing active dunes, European marram was widely disseminated as a semidomesticated species. However, it went feral and became invasive in some areas (Kreike 2013, 14–15). While other species were introduced with the goal of stabilizing and afforesting dunes—including pine, tree lupine, casuarina, and eucalyptus—none had the historical importance of the *Ammophila sp.* This chapter is dedicated to analyzing the social and environmental impacts of dune stabilization and shows that the transformations that occurred were not linear or singular processes of degradation or improvement.

Contested practices: The social impacts of dune afforestation

A glorified project

In the years that follow the afforestation of the dunes of Gascony, politicians, official reports, and the press glorified and appraised it as the triumph of the enlightened French state. Indeed, these impassioned speeches asserted the measure had brought prosperity and health to a barren marginal territory, vanquishing the threat of the sands and eliminating its miasmas (Temple 2011, 16–18). Afforestation had also strengthened the presence of the state in a region where it had hitherto been fairly tenuous.

According to historian Jacques Sargos, in 1810, the Commission of the Dunes declared that the dunes had been abandoned by their proprietors, the noblemen having fled with the outbreak of the French Revolution in 1789. As these territories had since been afforested by the government, the commissioners surmised, they constituted national property. However, many nobles returned after the Bourbon Restoration in 1814, and reclaimed their properties—the once bleak areas now forested and considerably more valuable. Many of the disputes ended up in court, where the state and property heirs spent decades fighting over ownership of the land (Sargos 1998, 280–282; Caillosse 2015, 343–344). Indeed, in 1924, Bernard Saint-Jours was still arguing that Nicolas Brémontier and the French State had exaggerated the risk of the mobile dunes, portraying them as a terrible danger to justify the usurpation of privately owned property. In this regard, Saint-Jours was rejecting the arguments of those who based the state's right to the dunes on the Ordinance of 1681, the Decree of 1790, and the Law of 1792, which stipulated that land along the coast or covered by the "flux and reflux of the sea" was public domain, as was the mobile or empty lands. Saint-Jours argued that the Commission of the Dunes only had the authority to rule the plantation, and had no right to the land that was privately owned by individuals or communities (Saint-Jours 1924, 3, 24, 26–27, 66). According to Sargos, while Saint-Jours went too far in denying the mobility of the dunes, he was not wrong in surmising that mainstream discourses inflated the threat of the sands to serve various interests and propel careers. As Sargos noted, the "State used the fixation of the dunes to substantially increase its domains"

(Sargos 1998, 282–283). The protracted dispute between the state, local authorities, landowners, and inhabitants over the dunes was largely one over power and control of resources (Labatut 2009). National and local political, economic, and social interests were involved in the conflict, which gradually evolved in response to the dynamic mutations of French politics, the national economy, emergence of new mentalities, local concerns, and a transfigured territory, which was turned into a prosperous forest and seaside tourist attraction. In the second half of the nineteenth century, most of the Landes was privatized so that its forests could be exploited for commercial use. Only a small area was retained by the state: a narrow band of trees along the coast (Temple 2011), where the dunes are still active and need to be controlled by a protective forest with no commercial value.

Early descriptions of coastal territories in France, Denmark, the United Kingdom, Spain, and Portugal portrayed these regions as the fringes and backwaters of the nation (Temple 2011, 19). The low patrimonial value of the coastal sands, particularly where active dunes made the landscape too unstable to live near, explains the sparse population density of many of these areas as well as the relative lack of concern regarding property rights. The poor agricultural potential of the sandy soils meant they were often considered common land for collective use. This was the case of many of the Portuguese dune fields. For instance, an 1897 technical report addressing the need to afforest these areas revealed that most of the dunes belonged to the local parishes and municipalities, some to the state, and the remaining few to private individuals. According to the foresters responsible for the survey, both the local authorities and population recognized the urgency of fixing the sands and were willing to cooperate. The few who were reluctant, the report noted, could be expropriated (Borges et al. 1897). However, in the nineteenth century, the question of property limited interventions to territories under direct state control. The Portuguese governments eventually overcame this obstacle by consolidating their legal and administrative power over the nation's land, citizens, and local authorities (Melo 2017), a process facilitated by the widespread recognition of the benefits of dune afforestation. In fact, over the years, some municipalities or communities took the initiative of planting pines on their lands or requested the Forest Service to do so (Rei 1924; Direcção Geral dos Serviços Florestais 1939, 1940).

In Spain, the project to fix the dunes of the Golfo de Rosas, on the Mediterranean coast, similarly encountered difficulties related to the question of property ownership of the beachfront and inland areas. The former area, the *ingeniero de montes*, Javier de Ferrer y de Lloret noted, had only two small private farms. Thus, by expropriating the two farms per the law of public utility, the beachfront area could be included in maritime public domain and considered state property. However, the inland area—where most of the vineyards and olive groves were abandoned or ruined by the sand—had several proprietors and represented a more complex situation. Recognizing the urgent need for action and the long-lasting difficulties of expropriating land,

de Lloret advised that the works commence on public ground. He believed that a solution to the problem would be found in due course, and afforestation extended to other territories as necessary. In this regard, de Lloret proposed that the state take over areas where ownership was unknown and the communal lands in the vicinity, expropriate certain enclaves, and invite private individuals to afforest their own domains (Ferrer y de Lloret 1895, 30–39, 69–71). Following the reorganization of the Forest Service in 1901, the Spanish state bought several dune areas in the Guadalquivir-Huelva region in order to afforest them (Ojeda Rivera et al. 1993, 87). Comparing the legal and administrative apparatus established in Portugal, Spain, France, and Italy, Cristina Joanaz de Melo concluded that these central governments used afforestation to strengthen their reach and authority, a process that often led to tension and conflict with local populations and administrations. Certainly, people were seldom interested in having an external power impose changes to their secular and frequently self-organized lifeworlds. Meanwhile, local administrations did not want to lose influence and autonomy over socio-economic resources vital to their populations (Melo 2017, 43, 138–139).

As explored in a previous chapter, the question of the ownership of the dunes did not emerge as a significant issue in the United Kingdom. Until the twentieth century, landlords were responsible for afforestation. Unlike other countries, the problem of sand drift was not considered a state matter. Interestingly, this was not necessarily the case in British colonies or former territories. On the other side of the Atlantic, the Massachusetts government retained the ownership of the "province lands" in Cape Cod to ensure the protection of the harbor from the drifting sands. For state agent J.M. Westgate, private possession posed a risk insofar as these lands could be "subject [ed] to possible shortsighted policies leading to immediate profit" causing negative impacts (Westgate 1904, 34; Chase et al. 1893, 28). In New Zealand, Leonard Cockayne also pointed out that practices conducted by private individuals who knew nothing about reclamation methods could have damaging consequences on adjacent properties. He believed that the work involved was too great to be done by individuals, and that dune stabilization was a task for the state, as had been demonstrated the world over. In his inventory of New Zealand dunes, Cockayne classified the ownership of the dunes under three categories: those held by the Crown, those classified as Māori territory under the Native Land Act (1865), and those owned by private individuals or entities. Of these, those held by the Crown posed the greatest threat. However, Cockayne added, although "Native" lands lacked value and had little use—in European terms—the active dunes in these areas still posed a danger. He thus argued that should the state adopt a national dune reclamation scheme, it should considerer extending authority over the dune areas in Māori territory (Cockayne 1911, 65).

While geographically distant, these different views have much in common: in addition to presenting the same solution to a similar problem, they also proposed and justified dispossession (Grove 1995, 15). In some cases,

afforestation and dune stabilization was strategically used to confiscate land from local people. Broadly speaking, there was not much difference between the subjugation and dismantling of the secular homelands of the Māori and the traditional lifeworlds of the peasants of Landes. As one French deputy noted, the transformation of Gascony was the "*peaceful conquest* of an *interior colony*" (quoted in Temple 2011, 16–17; italics added for emphasis). Perhaps the distinction between the two lay in the degree of violence and disruption.

The end of "the manner by which we… are on the earth"[1]

Recalling his long years working for the Portuguese Forest Service, Alberto Rei praised this institution's dedication to the welfare of a docile and hard-working people, worthy of help. In doing so, Rei noted how the populations threatened by the sands readily accepted the protective action of the state. However, his reports also reveal the existence of tensions and conflicts, including locals less pliable and "docile" than others. These "rogue people," Rei admitted, saw little merit in turning the sands into forest and rebuked the attempts to do so (Rei 1924, 1940).

Contrary to the claims of the Forest Service, the dunes were not sterile, marginal, or empty areas, at least not for those who depended on their resources. As mentioned in a previous chapter, within the traditional agricultural systems predominant at the time, dunes played a fundamental role in supplementing meagre household incomes. This was transversal to most of the dune areas of coastal Europe, as were the frictions generated by the denial of the secular rights of the populations to the dunes' resources. Where the sands belonged to a lord, the peasants often paid for their use, that is, for permission to graze their cattle, cut the grass, or collect firewood (Péret 2019; Jelles 1968). In other places, where the dunes were the property of the parish or municipality, they were considered common land and freely available. In Portugal, the 1897 report produced, along with the information on property rights, a list of the uses and traditions connected to the dunes. In the north of the country, locals used them to dry their fishing nets and seaweed. Meanwhile, in the central region, the lack of roads meant people traversed the sands as they moved from their beach shacks—known as *palheiros*—to their houses and crop fields inland. Here too, locals allowed their cattle to graze on the dune vegetation and harvested marram for fodder. In the dunes of the semi-industrialized area of the Aveiro lagoon, a few short railway lines transported merchandise, and the vegetation was used to box the still famous *Vista Alegre* tableware, the factory located on the edge of the watershed (Borges et al. 1897). While these dunes were not occupied, they were not deserted either. They were lived spaces with meaningful purpose and utility.

The need of different local resources to support unstable domestic economies included the exploitation of some of the existing dune pine forests, which the Forest Service sought to protect as they planted new ones. The people of

Coimbrão, near Leiria, believed that they had an ancestral right to the use of the pine forests of Urso and Pedrogão, as well as the adjacent common lands for grazing. In 1873, they requested that the Forest Service take this into account in planning the afforestation project in the area, that is, that their rights to the forest be recognized and maintained. Investigating the matter, the Forest Service determined that these practices had gradually destroyed the existing woodlands and created open fields. Indeed, the Urso and Pedrogão forests had been significantly reduced in size due to overexploitation, the consequent destabilization of the sands endangering the local population (Alarcão 1873). Suffice to say, the foresters were not inclined to comply with the request of the Coimbrão community.

The enduring issue of rights is important to understand the opposition to sand afforestation efforts. When pressured by their own parishes and municipalities to allow the afforestation of their communal lands, many people only agreed to do so if their ancient ways of life were recognized and accepted. They wanted to secure their continued use of the land or forest for grazing and collecting firewood (Cravidão 1985). However, many of these practices would no longer be possible on the reclaimed dunes, as some of these activities were not compatible with the planting of marram and growing of trees. This means that they were banned by the Forest Service, which also restricted access to the newly forested areas. Foresters often saw local populations, the same people they were trying to help, as agents of destruction. As such, guards were posted to protect the plantations and fines set to discourage trespassers and abuse (Rei 1924; Direcção Geral dos Serviços Florestais 1939). This made for an uneasy relationship between parties, exacerbating tensions around the dunes and forests.

Unsurprisingly, there was widespread resistance to the external control of their land, resources, and ways of life by local populations. According to Sargos, the true challenge of afforesting the dunes was never the method or the means to do it, but the rights of use (Sargos 1998, 275). In the region of Gascony, where large-scale dune intervention began, disputes over the control of the sands lasted for decades. One of the first to propose the fixing of the sands in the eighteenth century, de Villiers was well aware of the trouble that the question of the rights to pasturage on the dunes and exploitation of the forest by the communities would raise. However, he considered that such rights were subordinate to the *bien public* or common good. Evoking *la place de l'raison* and the authority of a *government éclairé*, that is, the rational use of the land and the superior power of an Enlighted governance, de Villiers justified state intervention by arguing that the ancient rights were not as important as avoiding the damage caused by the sands and "civilizing" that part of the country (Villiers 1779). Contemporaneous French narratives evidence conflicting thoughts on this matter, particularly overt in the arguments of intellectual elites who accused any who opposed afforestation efforts as uncivilized and obstacles to the "progress" of the Landes. Arguments that clashed with those of who resisted change and the imposition of new ways of

life, in a time that had as its backdrop the tensions and turmoil that followed the French Revolution.

Documents housed in the archives of Bordeaux provide detailed evidence of such antagonism, particularly from the Forest Service's point of view, which reported regularly on the abuses inflicted by locals. This bias is not surprising—these are, after all, official documents. In some places, populations took to quasi-guerrilla warfare against the Forest Service, vandalizing freshly sowed areas, pulling up the young pines, unleashing their herds on the plants, as well as threatening the forest workers and refusing to sell them food. Consequently, the plantations were typically protected by the *garde des semis* or "police of the sowings," who were appointed to watch over the works and prevent them from being harmed (Caillosse 2015, 354–356). Such popular resistance actions were often supported by local gentry and authorities, who had no desire for the state or its agents to interfere in the running of their land and intrude on domestic affairs (Sargos 1998, 279–280; Buffault 1897, 132–133).

At the end of the nineteenth century, 88,000 hectares of forest covered the coast and the inland area of Gascony—representing the complete metamorphosis of the regional ecosystems. Indeed, the wetlands were dried, the dunes were stable and covered with trees, and the beach had been restrained by an artificial littoral dune, a barrier protecting the forests from the sea (Sargos 1998, 283). This engineered landscape also signaled the end of a way of being in the world. Those who inhabited the area had to change as well, afforestation forcing them to adapt the lifeworlds developed over the centuries (Sture 2012) to new rhythms and demands. The spread of the pine forest disrupted the local agro-pastoral economy. "Enriching well-off landowners," Temple (2011) argued, "forestation was ruinous for the small property owners, sharecroppers, agricultural labourers and, above all, shepherds or *pasteurs* who depended on the communal moors." Subsistence agriculture was replaced by intensive forest production, marked by frictions between different groups and interests, the Forest Service, local elites, workers, and shepherds (Temple 2011, 19–20). The success of the afforestation scheme made the dune areas much more valuable. Proprietors and municipalities reclaimed part of such national domain through litigation and, over the years, the forest passed—by court order or sale—into private hands (Buffault 1910; Temple 2011).

Those who toiled in the sands

The social impacts of the dunes work are a complex issue. The tensions and conflicts resulting from the top-down implementation of afforestation by the state are just one side of the story. Certainly the most well-known one, I must say, with many authors discussing the issue. It is thus necessary to tell some lesser-known stories that are specific to particular regions.

The *Archives Départementales de la Gironde*, Bordeaux, have a great amount of information about the daily operations and routines of the afforestation procedures, including the list of those who carried out the actual

sowing of seeds and planting of trees and those appointed to guard these efforts. Certainly, much of the correspondence between Jean Peyjehan and Nicolas Brémontier during the experimental years concerned labor, materials, tasks, and costs. Peyjehan's list of wages from 1791 provides some interesting insights: during the period reported, 30–50 people—mostly men, but some women and children—were employed to work on the dunes five to six days a week. The foremen were paid 25 *sous* per day, while men were paid 20, young men 15, women 14, and children 6 *sous* per day. A few of the workers were related, with "father," "son," or "sister" (i.e., *Genon pére, Genon fils, Marie Daugey, sa soeur*) noted next to some of the names ("État de la dépense…" 1791). A list produced by the Bridge and Road Services in 1817 indicates that 50 people worked in the dunes of Arcachon between January and February that year. Employed to repair the covers and fences, most of the workers were women, who received 0.75 *centimes* a day, while men received 1.50 *francs*. A few were paid just 0.60 *centimes* a day, possibly indicating that they were younger. As before, many were family, with their kinship identified next to the names ("État des ouvrages exécutés et dépenses…" 1817). The 1791 and 1817 wages reported in these documents align with those presented by Caillosse (2015, 347) based on other sources.

According to Pierre Buffault (1897, 132), the General Supervisor of the Forest Service, in the first years, all the activities was carried out on a daily or piecework basis. Around 1814, a contractor was given responsibility for cutting and transporting the branches needed to cover the seeds and plants, while wage laborers continued sowing seeds and laying down vegetation covers. From 1817 onwards, companies were hired to carry out the tasks—now well established and defined—as economically and regularly as possible. Buffault vividly described the operations and the people involved therein as follows:

> On the dune, a long series of workers unfurled with their backs to the sea. In the front row were the women, most of them young, separated by men, whose job was to consolidate the carpet of brush they were spreading out. They had taken-off their excess clothing, because the sun, from which nothing sheltered them, was ardent. They were all browned from the sea breeze and the sun. The women used their pruning hooks to shape and fan the branches thrown by the children behind them, then arranged the branches on the sand like roof tiles. Their male colleagues weighed down the branches and threw shovelfuls of sand on top to hold them in place. In front or behind passed the sower, who cast the seeds. Among the workers came and went the foreman, who gave orders and greetings in a few words of the *patois* dialect, and the supervisor watching the execution of the tasks. From time to time, trudging across the sand, teams of oxen or packhorses arrived. They carried overflowing loads of brush harvested in distant places. The drivers, helped by the children, laid the bundles down in heaps, while the supervisor, weighing the bundles, proceeded to collect them. Afterwards, the animals and people went back to fetch new

> loads. In the evening, the whole group headed off to the canteen, a thatched and planked hut, shelter for the night, to find supper and a good night's rest after an exhausting working day.
>
> (Buffault 1897, 132–133; my own informal translation from French)

Indeed, the state's afforestation achievements were underpinned by the harsh reality of men, women, and children performing backbreaking manual labor in a difficult terrain under a brutal sun. In general, the laborers and guards were recruited from the surrounding communities, although there were not always enough laborers to meet demand. After all, locals had other duties, including toiling in the fields and the saltpans. Work on the dunes was secondary, another job among their various complementary activities (Caillosse 2015, 347, 356).

In Portugal, the 1897 report also provided information on the availability of labor in the various dune areas, evidencing that some had an abundance of human resources, while others did not. This was largely related to whether locals had any alternatives, with a high rate of emigration in some regions and better paying jobs in others. Here too, men and women worked side by side and women were paid less. According to the report, men earned 280–300 *réis* a day, while women only received 140–180 *réis* (Borges et al. 1897). Another account on the afforestation of the dunes of Mira and Cantanhade in central Portugal revealed a reality similar to that of Gascony. These dune areas were typically poor territories, with agriculture and fishing the main economic activities. These areas seldom had any relevant industries or trade, lacking the roads necessary for the circulation of people and merchandise. Therefore, working for the Forest Service offered coastal populations the opportunity for another source of income, something for which there was particular demand amid crises like the Second World War (1939–1945). Indeed, although Portugal was not directly involved in the conflict, it suffered its devastating economic consequences. Unemployment was high in many regions and the Forest Service's provision of hundreds of jobs helped with this problem (Direcção Geral dos Serviços Florestais 1940). This was similarly highlighted by Rei, who noted the thousands of men, women, and children employed in afforestation works over the years. He also underscored the importance of the money distributed among the communities to pay for the materials, transports, and working animals (Rei 1940). In addition to trees, the Forest Service also built or facilitated the construction of roads and railways and installed telegraph and telephone lines, accelerating the development of these peripheries (Direcção Geral dos Serviços Florestais 1939; Rei 1940) and their integration into wider circuits (e.g., administration, communication, transports, tourism) of the national economy. Afforestation and associated measures helped promote the modernization of these territories at a time when the seaside was becoming increasingly associated with elites and leisure.

Like Portugal, several other countries—notably the United Kingdom, the United States, and New Zealand—associated the benefits of dune stabilization with the opportunity to combat unemployment. In the United Kingdom, one of the main tasks of the British Coastal Erosion Royal Commission, appointed in 1906, was to evaluate whether afforestation was a desirable means of increasing employment during periods of crisis ("The Coast Erosion Commission" 1911). The Commission concluded that forest work offered striking advantages in terms of providing employment during winter and periods of trade or industry depression (Royal Commission on Coastal Erosion 1909, 12). In the US, some cases of dune stabilization were associated with employment campaigns. For instance, in the aftermath of the storms that struck the coast of North Carolina in 1932 and 1933, a development program supported by Franklin Roosevelt's New Deal initiative and implemented in the Outer Banks and Hatteras Island included dune building and reforestation. Federal agencies like the Emergency Relief Administration—Transient Bureau, Works Progress Administration, and Civilian Conservation Corps (CCC) set up working camps on Roanoke Island and Cape Hatteras, as part of the erosion control project that would lead to the formation of the Cape Hatteras National Seashore (Senter 2003):

> By the time the project ended in 1941, workers had built over three million feet of sand fencing, planted 142 million square feet of dune grasses, grown and planted over two and a half million trees and shrubs, and radically altered the Outer Banks landscape from Ocracoke village to the Virginia border.
>
> (Senter 2003, 349, based on Stratton and Hollowell 1941, 88–89)

Founded by President Roosevelt in 1933, the CCC was an "unprecedented experiment in federal work relief" (Speakman 2006) intended to provide jobs for young men struggling with the consequences of the Great Depression. In exchange for food, clothing, shelter, medical care, and educational opportunities, CCC enrollees were employed in natural resource preservation activities, including tree planting, erosion mitigation, road construction, and dune stabilization (Speakman 2006; Cole Jr. 2010). The CCC was also involved in the Warrenton project at Clatsop Plains, Oregon, under the direction of the Soil Conservation Service (Reckendorf et al. 1985), where they sought to match "brain and muscle against the endless force of tide and sand" (Soil Conservation Service 1940).

Meanwhile, in New Zealand, the Great Depression hit the country's factories and business, leaving thousands of people without a job. To minimize the social impacts of this economic crisis, the government created a relief scheme administered by the Public Works Department, which employed men in intensive manual labor. "What could be more labour intensive," McKelvey (1999, 41) asked, "than planting marram?" In 1932, operations commenced in Te Kopuru, Ninety Mile Beach, Ruakaka, Woodhill, Waiuku, and

Tangimoana, with the workers housed in tents around the intervention sites. The conditions were bad and the duties arduous. In the beginning, a lack of transport meant that the men had to walk from the camps to the dunes and carry bundles of marram from the nurseries in stretchers or in their arms. Unsurprisingly, "the planters were unenthusiastic" (McKelvey, 1999, 42). After several years, the marram was established enough, and tasks shifted to include the sowing of tree lupine and later radiata pine, macrocarpa, or *Eucalyptus botryoides*. Although work and wages improved over the course of the 1940s, the increase of job opportunities following the Second World War resulted in labor shortages. In 1951, the New Zealand government awarded the task of dune stabilization and afforestation to the Forest Service (McKelvey 1999, 41–46), which implemented several large-scale afforestation schemes in a bid to increase the commercial forest areas behind the protective coastal ones. Personnel primarily comprised young men housed in camps consisting of single men's huts and a cookhouse for meals. Higher ranked staff, such as supervisors and mechanics, lived with their families in government houses in small villages, built at some distance from the single men's barracks. Over time, many of the operations, including the planting of marram, were mechanized, overcoming the problem of labor shortages and significantly reducing the costs of implementing and maintaining the interventions (McKelvey 1999, 50–52; Sampath, Beattie, and Freitas 2023).

Perhaps more interestingly, there were some attempts to use penal labor for dune stabilization and afforestation. In this regard, Benedict Taylor has examined the case of the Tuncurry Afforestation Camp, in New South Wales, Australia, which operated from 1913 to 1938. The first prison afforestation camp was actually established in Waiotapu, New Zealand, in 1901, but this camp was located inland and not related to dune stabilization. Characterized by barren shifting sandhills, Tuncurry was identified as a suitable site for reclamation following the successful example of the French Landes. Inspired by his visit to Waiotapu, the New South Wales Minister for Justice proposed that something similar be implemented in the state. The Director of Forestry, troubled by a shortage of labor, suggested that the experiment be applied to forest work. The prisoners, most of whom were urban burglars, were primarily tasked with clearing and burning the native vegetation, planting pine, and maintaining the plantations. The experiment was underpinned by ideas of social and ecological redemption and rehabilitation: wasted lives transformed into productive members of society; wastelands turned into productive areas (Taylor 2008).

Similarly, in Mozambique, the Portuguese used penal labor in coastal dune afforestation schemes. However, the historical sources offered no moralizing discourse of salvation: penal labor was simply cheap and available. In the 1930s, intervention in the dunes surrounding lighthouses mainly employed local African men (Cardoso 1932). According to a 1939 report, African labor was divided into four categories: hired hands, volunteers, tax defaulters, and prisoners. Hired employees received monthly wages of 120 *escudos* and food (maize flour, groundnuts, and salt), and were supplied with transport to the

dune fields. However, many of these men ran away, taking advantage of the government transport to areas near the Transvaal border of South Africa. For instance, of the 427 men hired by the Forest Services in 1939, 142 absconded. In the Limpopo dunes, all 726 employees were categorized as volunteers, that is, people who had actively sought work. There were no complaints about their labor. They received variable sums of money and food as reimbursement, but seldom chose to remain because payments were frequently delayed by more than 15–20 days. Those who had defaulted on their tax were given the opportunity to work off their debt to the state by providing labor on public projects instead of going to jail. These were paid 100 *escudos*. As an alternative, the Police Department supplied penal labor, mostly urban delinquents with reduced sentences (one to four months). Prisoners were paid and fed, but received significantly less than the other workers (45 *escudos*) (Cardoso 1939). In 1944, the agricultural and forestry stations had about 1,295 employees, of whom 860 were volunteers and 139 were prisoners serving sentences ("Colónia de Moçambique…" 1946). There is scant information about these men besides operational details. But, the reports also show that there was friction between the African laborers and Portuguese staff, who described the workers as unable to cope with their tasks and prone to running away or absenteeism. This is not surprising, since many of the African laborers were forced to serve in the afforestation schemes, which were known to involve carrying out difficult tasks in adverse environmental conditions.

I found little in the archives in Lisbon and Maputo regarding the impact of dune afforestation interventions on the local Mozambican communities. This is not to say that such information does not exist, merely that I was unable to find or access it. It may well be that the voices of these groups are not represented in these archives. It is also possible that these sandy coastal areas were sparsely populated, the interventions thus having relatively little impact on the lives of those nearby. Meanwhile, in addition to upsetting human lifeworlds, afforestation disrupted ecosystems and triggered major environmental challenges.

Unexpected results: Unstable environments

The effectiveness of the European native *Ammophila arenaria* as a sand-binding species was responsible for its introduction to temperate climatic zones around the world. These zones are located in the middle latitudes, that is, between 23.5° and 66.5° latitude on both sides of the equator. In North America, European beachgrass spread along the west coast from Los Angeles to Queen Charlotte Islands in Canada, while the native *Ammophila breviligulata* prevailed on the east coast from eastern Canada to South Carolina, reaching the Pacific coast in the 1930s. *Ammophila arenaria* also took root in South Africa, Australia, Tasmania, New Zealand, and the Falkland Islands (Wiedemann and Pickart 2004). Intentionally introduced to these new environments, the alien *Ammophila sp.* thrived and spread rapidly, impacting coastal sand dune ecosystems and dynamics (Doody 2013, 177). But, while

the *Ammophila breviligulata* is an invasive species only on the northwest coast of the American continent, its European congener became far more widespread and troublesome, particularly on the Pacific coast of the United States and in Australia and New Zealand.

Broadly speaking, marram emerged as a "major threat to native foreshore plants and animals" by outcompeting many of the existing plant species that animals depended on for food and habitat (Doody 2013, 180; Hesp and Hilton 2013). The invasive marram also caused major changes to the landscape by altering the geomorphology of the dunes and reducing the continuous supply of sand from the beach to the backdunes, facilitating the growth of vegetation across the open dune fields. I have authored and coauthored several papers detailing the introduction and dissemination of marram in Oregon and New Zealand, as well as the impact of this invasive species and approaches to managing it (Sampath, Beattie, and Freitas 2023; Sampath, Freitas, and Dias 2022; Freitas 2021). Nevertheless, there is still a wealth of material to parse in terms of tracing the connections between the regions I have been discussing.

In Oregon, the introduction of the *Ammophila sp.* led to the development of foredunes, "tall ridges of sand parallel to the shoreline, which intercept wind-driven sand delivery to the backdune" (Hacker et al. 2012, 140; Hesp 1989). Reaching up to 15 meters in height, these foredunes serve as barriers against the waves, wind, and sand. This was the outcome nineteenth century foresters sought to achieve in the first phase of operations, which involved planting marram to facilitate the development of a foredune to protect the pine plantations on the leeward area. These foredunes can be considered a form of environmental infrastructure insofar as they were built or transformed to deliver critical services for humans (Carse 2012). However, the construction of such infrastructure set in motion some unexpected biophysical feedbacks and caused significant changes to ecosystems. Before the arrival of the *Ammophila sp.*, the dunes of Oregon "consisted of small hillocks of sand […] sparsely colonized by native plants including the native beach grass *Elymus mollis*" (Hacker et al. 2012, 140; Cooper 1958). The development of the foredunes interrupted the natural dynamics of the coastal sand dune system by decreasing the disturbance of the backdunes, which caused a rapid plant succession that contributed to the formation of wetlands and scrub habitat, preventing the movements of the sand and leading to the decline of unique plants, animals, lichen, and fungi species (Hacker et al. 2012; Zarnetseke et al. 2015; Wiedemann and Pickart 2004). Over the course of several years, there was a shift in the colors and dimensions of the landscape, as open sand was immobilized and supplanted by wetlands, woodlands, or dense mats of gray-green vegetation (Restoring the Oregon's Dunes 2018).

Similarly, in New Zealand, *Ammophila arenaria* spread rapidly and outcompeted native plants (Hesp and Hilton 2013, 68). The geomorphology of the dunes was also affected, with the appearance of foredunes as well as dune types that had once been fairly uncommon or unheard of in the region. In

Doughboy Bay, for instance, the pre-marram landscape of transgressive dunes and blowouts was replaced by stable and vegetated dunes protected by marram-created linear foredunes (Hesp and Hilton 2013, 79). These marram-created dunes are normally steeper and higher than those vegetated with indigenous foredune species like *Desmoschoenus spiralis* and *Spinifex sericeus* (Hilton, Duncan, and Jul 2005, 176; Esler 1970). In their national survey of the extension of active dunelands in New Zealand, Mike Hilton and his colleagues (Hilton, Macauley, and Henderson 2000) pointed out that, in 1911, Cockayne had estimated the country had around 129,000 hectares of dunes dominated by native sand-binding plant species—a significantly larger area than the 52,000 hectares Newsome (1987) identified in the late 1980s. Meanwhile, Hilton et al. found that in the mid-1990s, this area had reduced further to just 39,000 hectares. According to them, marram had made significant impacts on the east and south coasts of South Island and west coast of the North Island. They concluded their survey by asserting that:

> [Many] of the remaining active dunelands are small remnants of previously much larger areas. Many of these fragments are of national significance, despite their area, in that they contain threatened or localized plants. There are now relatively few dunelands that contain the sequence of semi-vegetated, unstable dunes to stable, vegetated dunes described by Cockayne.
>
> (Hilton, Macauley, and Henderson 2000, 23)

Like the west coast of the US, in New Zealand marram became an unwelcome invasive species that needs to be eradicated. Indeed, marram's effectiveness in stabilizing the sand—the rationale behind its utilization and dissemination until mid-twentieth century—led to it nowadays being considered an environmental threat. What changed in the meantime? I examine this issue in greater detail in the following chapters.

Ammophila arenaria, however, did not emerge as an invasive species in all of the regions to which it was introduced in the nineteenth century. In South Africa, for example, where the Department of Forestry planted marram extensively on the mobile dunes of the Cape Province, a recent study noted that "marram does not occur except where it was planted, and at many sites simply disappears. Where it is still present at those sites it is never dominant but forms a natural part of the dune system," with no evidence of spread to other areas. As marram is not invasive in the Cape, it is still used to stabilize dunes and has recognized socioeconomic benefits (Lubke 2022, 13). Similarly, although introduced by the Portuguese, marram did not thrive in Mozambique, with no mention of the plant in descriptions of the vegetation cover on the Mozambican dunes today (Louro 2005).

Moreover, marram was not the only exotic species used in dune stabilization. Several tree species—including pine, casuarina, and acacia—were widely disseminated and impacted native environments. In Mozambique, the Australian *Casuarina equisitifolia* planted by the Portuguese can still be seen in

Figure 9.1 In spite of all the efforts to control them, dunes are still the best example of unstable environments: Dune of Sabiaguaba, Ceará, Brazil, encroaching on the road

Source: Photo by Davis Pereira de Paula

Bilene and Beira. Although not considered a problem, its introduction transformed Mozambican ecosystems and habitats (Louro 2005). The changes wrought by the introduction of an exotic species can be considered negative or positive depending on the place and the consequences of its presence. In Senegal, for instance, the casuarina contributed to significantly increasing forest floor organic matter. As part of a development program funded by the Food and Agricultural Organization of the United Nations, Canada, and the US, casuarinas were planted in Senegal from the late 1940s in order to stabilize the active dunes and protect the adjacent agricultural fields. In the 1990s, casuarinas were seen as providing important benefits to the region, including improved soil fertility for agricultural crop production as well as wood fiber and firewood (Maily and Margolis 1992). In contrast, in Brazil, the *Casuarina equisetifolia* present in Pernambuco e Bahia coastal forests is considered an invasive species (Zenni and Ziller 2011). In a recent analysis of the dispersion strategy of the casuarina in the dunes of Cumbuco, researchers from the University of Ceará found that between 2004 and 2018, the species had expanded from the initial plantation area of 110 hectares to 140 hectares (Neto, Ricardo, and Melo 2020). Meanwhile, in the US context, Wheeler et al. described

Casuarina spp. as one of the most severe threats to coastal ecosystems—their rapid colonization of open sandy habitats resulting in the significant decline of native species. In addition to facilitating sand loss and erosion, the infestation of casuarina on Florida's beaches has interfered with the nesting of sea turtles, crocodiles, and the swallow-tailed kite (Wheeler et al. 2011).

At the beginning of the 1990s, the botanist Anthony Avis, working in South Africa, identified the adverse consequences of the introduction of three Australian acacia species as part of dune stabilization efforts. According to him, the *Acacia cyclops, longifolia*, and *saligna* have strong competitive abilities, and thus represent a danger to native species. They typically form stands of dense impenetrable shrubs or trees, eliminating other species and creating a kind of ecological desert. In addition, Avis noted, these alien species increased the periodicity of fires due to their highly inflammable foliage, draining of soil water resources, and the erosion caused by the lack of an understory (Avis 1992, 244). The *Acacia longifolia* introduced in the south of Brazil and Uruguay in the mid-twentieth century for dune stabilization in Florian'opolis and Cabo Polonio, respectively, is similarly considered an invasive species (Vicente et al. 2020). This acacia is also present on the dunes of Argentina, as are eucalyptus and pine, associated with the afforestation programs of the second half of the twentieth century to stabilize the dunes and facilitate their posterior urbanization. According to Cintia Celsi, although the acacia is not considered invasive in Buenos Aires Province, it is well established and its dense foliage hinders the survival of plants living on the lower stratus (Celsi 2016).

Pines have also altered the ecology and dynamic processes of coastal regions. As a result of the large-scale planting of Black pines (*Pinus thunbergii*) in South Korea after the Second World War, 95 percent of coastal dunes in the region are now covered with these trees. Similarly planted in Japan, these protective forests were created to safeguard villages and fields from strong winds and drifting sand. However, the pines have also contributed to the decline of native plant and animal life, facilitated the intrusion of terrestrial plants, and altered the soil of the dunes. Moreover, in 2010, typhoon Kompasu revealed that the pines were not an effective coastal defense against erosion, as the dunes where they stood were severely damaged, whereas those matted with grasses were intact or only slightly affected. The forest also interfered with wind patterns, diminishing their velocity and changing their direction, impacting the supply of sand to the dunes and making them more vulnerable to coastal erosion (Choi, Kim, and Jung 2013; Kim, Choi, and Jung 2014).

Curiously, one of the clearest examples of the issues inherent to large-scale dune afforestation using pine is the place where such initiatives began: Gascony. The intensively managed environment of this entirely human-made forest "proved to be a profoundly uncertain landscape, marred of social division, ecological degradation and economic instability. Labour strikes, fires, fluctuation in global markets and, increasingly, the intensification of storms attributed to climate change have periodically disrupted the forest production" (Temple 2011, 14). As Temple has pointed out, the environment of the Landes has become

unstable, the monoculture of pine making it highly vulnerable to fire, disease, plague, and soil depletion. Production and its revenues are subject to variations and crises of international markets and the global economy. Socially, private ownership has fostered tensions and disputes between landowners and workers, local associations, and the state, accelerating the depopulation of this rural area.

Final thoughts

The cases presented in this chapter question "the self-fashioning of Europeans as the superior re-creators of colonial environments." While Europeans have intendedly transformed and exploited "non-European nature and natural resources," it is worth emphasizing that changes often occurred because they lost control of the transfers they had initiated (Kirchberger 2020, 20). Dune stabilization involving plant species and knowledge exchange between different regions can be addressed from the point of view of the unpredictability and miscalculation of applying a "one-size-fits-all" solution. However, considering only this perspective is limited, as there are multiple approaches and stories about sand fixing. As Sujit Sivasundaram has suggested, the transfer of scientific concepts and living species cannot be seen as a simple import-export mechanism. Local adaptations involved difficult balances between ecological, political, social, and cultural circumstances (Sivasundaram 2010; Holzl and Oosthoek 2018, 369), and frequently had different outcomes. The stories told here about dunes have a time and a place, they cannot be dissociated from some general historical trends, namely the processes governing the emergence of the modern nation-state, bureaucratization, imperialism, and the understanding of nature in terms of its usefulness to society (Holzl and Oosthoek 2018, 370, 382). Nevertheless, each duneland has its own history, one shaped by interactions that result in unique characteristics, outcomes and baselines, particular trajectories of change, and plural ongoing (sub)processes (Kreike 2013, 40–43). As such, these dune histories have not ended, but are still unfolding, posing new management challenges as ever-changing natural and human drivers force them to continue to evolve and adapt.

Note

1 Extract from Vincent Vycinas (1969, 15) quoted by Sture (2012, 429).

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10 Dunes as a destination

Beach fever

At the end of July, those who can escape the city and head to a beach on the west or south coasts of Portugal for the summer holidays. The seaside is associated with leisure and fun, as well as therapeutic benefits like relaxation. For most people, this is a natural connection, one that has always existed, as if humans are inherently attracted to the sea and its margins. However, this feeling and fascination with the coast is culturally constructed and relatively new historically speaking.

It is impossible to talk about the history of the beach without mentioning Alain Corbin's (1994) seminal work, *The Lure of the Sea and the Discovery of the Seaside in the Western World*, which examines the shifting attitudes toward the sea and seaside from the mid-1700s. This extraordinary book describes how the European elites rediscovered the littoral, long considered a marginal area associated both geographically and ideologically with the fringes of the nations and society. Indeed, both the original French title and its Portuguese translation point to the view of the littoral as the *territoire du vide*—that is, an empty territory—before it was transformed into the playground of the elites and became a crowded touristic destination in the twentieth century. Another great historian, John Gillis, wrote of the "unprecedented surge to the sea" over the last century, with half of the world's population now living near the ocean in packed coastal cities. This phenomenon is common around the world, as if continents have been, Gillis asserted, "turned inside out." This physical migration to the shore, "one of the greatest in human history," has made us all "creatures of the edge." This process, Gillis argued, involved a "cultural reorientation of vast significance" (Gillis 2012, 1). Coasts are now part of the popular imagination, albeit some more than others. Certainly, the tropical beaches of places like Tahiti and the Bahamas or those of California and Florida have been made famous by Hollywood films and television shows, the pictures and videos posted by social media influencers travelling to these paradises, and the advertising campaigns of the tourism industry, which has made millions from the allure of the sea, sand, and sun. This rush to the coast, Elsa Devienne (2021) noted in respect to Los Angeles, initiated a process of beach

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modernization, with the massive urbanization of maritime fronts to house and amuse the new coastal dwellers, transforming this territory into a complex urban sociocultural and environmental hybrid space.

This shift in the perception of the beach also had consequences for the dunes. Rather than a wasteland and potential threat, dunes gained new appreciation, ecologically and aesthetically valued for their peculiar characteristics and fluid nature. Indeed, the once feared shifting sandhills are now the beloved wild dunes. How this change came about is the subject of this chapter.

Inventing the beach

The collective awakening of beach desire

From the end of the eighteenth century, progress in the medical-scientific field led to a better understanding of the functioning of the human body, identification of the microorganisms responsible for the transmission of disease, and the discovery of treatments for previously incurable ailments. This knowledge resulted in greater concern for personal health, particularly among elites. In this respect, daily life in industrial cities—pervaded by smoke, filth, crowds, and disease—and the weakness attributed to material comfort and *otium* were increasingly linked to fears of physical decline and vulnerability to infection (Pereira and Pita 1993). It was in this context that the desire for the beach emerged, with the sea increasingly regarded as a therapeutic imperative for a community keen to recover their vital energy (Corbin 1994). In 1752, the English physician Richard Russell (1752) published a book about his experiences in treating certain diseases with seawater. Although there were earlier works, Russell's studies are considered forerunners in the field of marine hydrotherapy, which quickly spread throughout Europe and was prescribed for all kinds of ailments. Clinicians believed that the body and spirit could be revitalized and cured by the fresh air, iodized emanations of seaweed, absorption of salts, terror produced by the crashing of the waves, shock caused by immersion in cold water, and walks and exercise practiced by the sea (Corbin 1994; Freitas 2011).

The use of the coast for therapeutic purposes represented a rapprochement to this territory, one connected to a new way of perceiving it, which was often associated with small elite circles, namely, the royal family and aristocracy. As a reference for the rest of society, elites had the ability to create and disseminate new habits, that is, to establish fashions and trends. Their presence in certain localities to enjoy the sea was fundamental in defining a novel set of perceptions and emotions related to the maritime environment. The seasonal migration of the elite to the coast was responsible for the introduction of civility and other markers of civilization to this peripheral area, making it a particularly desirable place insofar as going to the beach became a form of social distinction. Appropriated by these exclusive circles, the coast was transformed into a public space characterized by specific rituals, practices,

and codes of behavior. In the 1720s and 1730s, the first signs of elite sea bathing appeared in the British coastal areas of Brighton, Margate, Weymouth, and Scarborough, where this new trend led to new forms of settling (Borsay 2008). The promenade—where Elites walked along the beach or cliffs to see the sea and to be seen by society—connected sociability and urbanization, as well as the famous piers, walkways, jetties, and maritime avenues that would follow.

Over the years, coastal villages developed across the continent, including Dieppe and Bologne-sur-Mer in France, Ostend in Belgium, Scheveningen in the Netherlands, Biarritz and San Sebastian in Spain, Cascais in Portugal, and Heiligendamm, Norderney, and Wyk in Germany. Identified as seaside resorts or urban areas organized around a beach and defined by a specific urban layout, some of these villages had once been small fishing hamlets, ports, or extensions of nearby cities and were adapted to their new functions, while others were built *ex nihilo* according to a plan (Clairay 2008). In general, they had a particular combination of facilities, namely, bathhouses, hotels, casinos, public gardens, sports fields, the famous promenade, and a railway station. The expansion of the railways in Europe was closely linked to the proliferation and popularization of seaside resorts from the end of the nineteenth century (Puyau 2008). At this point, the therapeutic reputation of the beach was gradually replaced by an appreciation for it as a place of leisure. The coast subsequently became a destination rather than a passage area (Gillis 2012, 144–145).

A perfect example of this renewed coastal reality is Soulac-sur-Mer, born on the dunes where Soulac had been before it was abandoned by the population, who moved to Jeune-Soulac, located a few kilometers to the east, after the sands buried the Basilica of Notre-Dame-de-la-fin-des-Terres. Soulac-sur-Mer emerged in response to the new bathing fashion, advertising the benefits of its sea and healthy pine air—a renaissance only possible because of the fixation of the mobile sands initiated by Nicolas Brémontier. The symbol of this phoenix-like transformation was the church itself, which was excavated from the dunes and recovered at the end of the nineteenth century (Caillosse 2015, 358–359). In the same way, nearby Arcachon became a summer and winter destination, a place where the sea breeze and the scent of the pine forest combined to create a therapeutic atmosphere ideal for those suffering from lung problems. According to the newspaper *La Ilustración Española y Americana*, the village was a paradise made by nature and man, where the Spanish royal family spent time, in 1779, visiting the observatory, attending concerts, sailing in the bay, and visiting their friends in villas overlooking the sea (Rodriguez Correa 1879).

The new beach paradigm soon spread to other parts of the world. Upper- and middle-class North Americans were also looking to escape the bustling cities and seek novel places and experiences. The Cape Cod Rail Road extended to Hyannis in 1858, and Provincetown in 1873, putting the tip of the Cape within easy reach of Boston. According to John Cumbler, seeing an

opportunity, developers began building hotels and inns and buying tracts of land and selling it in smaller parcels. Meanwhile, local families converted their homes into boarding houses and served meals to tourists. However, the biggest change came with the rise of the automobile, which made travelling easier and less expensive for families. Tourism drove the local economy after 1920, with the traditional fishing activities and workplaces transformed and adapted to the fit the image of the Cape as a vacation destination (Cumbler 2013, 219–223). On the Northwest Coast, in Oregon, "summer people," as Paul Komar called them, began coming to the beach as early as the 1860s, first by boat or wagon, and later by railroad (Komar 1997, 69). In 1905, a Portland newspaper ran an article with the headline "Oregon and Washington resorts attract crowds of tourists," noting that each incoming train brought growing numbers of this transient population to Long Beach and Clatsop Beach (*The Sunday Oregonian*, 1905-08-27, 31). However, the most popular beach in the US at this time was Atlantic City, located on a barrier island off New Jersey. Dubbed the "queen of resorts," Atlantic City was built from scratch in the 1850s by a group of investors who recognized the potential growth opportunities of that coast once it was connected to the mainland by rail. Atlantic City was first sold as a health resort for Philadelphians who viewed a trip to the beach as a necessity, rather than a luxury. Over the years, city leaders and hotel owners improved the area, eliminating the mosquito-infested marshes, removing bushes, and building wooden plank walkways to facilitate access to the sea. This walkway eventually became the famous Boardwalk of Atlantic City, a symbol of the city's identity and its attempt to control the coastal environment (Simon 2006).

This desire for the beach extended almost everywhere under the influence of European and North American ideas and practices. According to Caroline Ford, in Sydney, day trips to the beach began in the 1850s, visitors enjoying picnics and walks along the shore as they took advantage of the fresh, clean sea air. By the early twentieth century, Sydneysiders were diving into the surf in great number, convinced of the healing qualities of such activity (Ford 2014, 13). In the nineteenth century, Bondi Beach—now the most famous beach in Australia—was a pastoral area, a 200-acre estate covered with large dunes where cattle rumbled. Like other beaches, it was only accessible by boat or through bush tracks running parallel to the coast, visitors forced to wade through large dune areas, swamps, and creeks. In the early 1900s, the shifting sands were a problem for Bondi beachgoers, prompting the government to erect fences and plant marram. However, this only partially solved the problem, with the sandhills still regarded as a nuisance and obstacle to development and progress in the 1920s. Therefore, as in other places, in the wake of the Great Depression, the government used unemployed labor to remove the dunes. However, at that time, rather than simply taming nature, improvement works involved reshaping the coastal landscape to create something new, pleasant, and luxurious. Indeed, the Bondi Beautification scheme aimed to transform the barren sandy stretch of shore into a modern and iconic beach (Ford 2014, 26, 30, 125–132).

In Brazil, the beach phenomenon was similarly introduced by the elite as an element of social differentiation based on the supposed virtues and superiority of the European civilization. Linked to therapeutic concerns, the modern practice of sea bathing emerged in Rio de Janeiro, Fortaleza, and Recife toward the end of the nineteenth century. Known as the capital of the *Sertão* or "the arid interior," Fortaleza had generally ignored the ocean, with its main economic resources—cotton and cattle—produced in the hinterland. That said, the port of Fortaleza was an open door to Europe, through which luxury goods and fashions were imported. From the beginning of the twentieth century, the upper class—imitating external models—slowly moved toward the coast, disseminating the practice of sea bathing to the rest of the population (Dantas 2019).

The beach as a site of leisure and business

The democratization of access to the coast from the mid-twentieth century was facilitated by a series of demographic, social, and technological factors connected to the postwar economic boom. Of these, the most important were population growth, the development of air transport, the proliferation of private automobiles, the increase in workers' purchasing power and social benefits (e.g., paid vacations), and the change in professional structures, namely, the growth of the tertiary sector, to which the majority of tourists belonged. Meanwhile, the widespread rural exodus contributed to the littoralization of society, concentrated in large urban agglomerations on the littoral. The desire of an increasing number of people to use the beach as a place for recreation led to the growth and transformation of coastal settlements and the intensification of the occupation of the seafront, resulting in enormous urban pressures on such areas (Freitas 2011; Ford 2014).

The postwar period saw a tourism boom driven by the trendiness of the "sun and sea" and discovery of southern Europe's beaches by those from northern and central Europe. In Spain, for example, tourism became a mass phenomenon from the 1950s onwards, fostered by the Francoist government, which actively supported the development of regions like Catalonia and the Balearics and Canary Islands in order to facilitate economic recovery after the civil war. Following its neighbor's example, Portugal began promoting tourism in Algarve, underscoring its Mediterranean climate and landscape. The expansion of air travel was essential in this respect. Indeed, the inauguration of Faro airport in 1965 enabled the integration of the province into the international tourist circuit, bringing it closer to the centers of these networks—the United Kingdom and Germany—where most visitors came from (Freitas and Dias 2019).

In Australia, Sydney's southern suburbs, dune areas, and scrublands were the home to Aboriginal residents. From the 1930s to the 1950s, the southern and northern areas of the city saw weekend, vacation, and more permanent camps scattered on public and private property along the shore. For some,

camping was a necessity rather than a choice, but many appreciated this kind of life while vacationing near the sea. Over time some camps were transformed into more permanent structures, but the majority were removed to make way for the establishment of open spaces and amenities, such as golf courses, surf clubs, parking lots, and houses. According to Caroline Ford, a number of cultural changes and developments played a role in this process. The rise in the use of the automobile after the Second World War, for example, allowed Sydneysiders to leave the city and travel to more distant beaches. As people flocked to the shore, coastal housing and apartment blocks with a sea view sprang up along the beachfront. Suddenly, Ford added, "the coast was no longer marked by empty spaces" (Ford 2014, 108).

In the US, Atlantic City experienced its glory days in the 1930s and 1940s, when its Boardwalk offered an artificial and surreal world of neon colors, bright lights, and dizzying sounds—a third nature serving as a frontier between the mighty ocean and human civilization. However, by the 1950s, the Boardwalk had lost its appeal and was in decline. By the 1960s, Miami Beach had become the leading beachfront attraction. Atlantic City "offered less of the kind of nature" that suburban Americans wanted at that time, the majority preferring to stay in their air-conditioned homes with their pools or visit some place more exotic like Florida or the Caribbean (Simon 2006, 18). Meanwhile, the Pacific coast was also going through significant changes. As Elsa Devienne has shown in respect to California's beaches, between the 1930s and 1960s, there was a general political, economic, and scientific consensus to modernize the coast, which was undergoing unprecedented economic development at the time. Private coastal stretches were acquired for public use, beach access was improved, modern infrastructure was built, and hard engineering structures were erected to protect against coastal erosion, profoundly altering the landscape of Los Angeles. However, from mid-twentieth century, ideas began to change and environmental groups and concerned citizens started protesting against the "Miamization" of California's beaches, suggesting more appropriate and smaller-scale urbanism instead (Devienne 2021). While unique, the histories of these beaches share several common features, from their discovery by the upper- and middle-classes to their appropriation and transformation by mass tourism. They also illustrate different timeframes. As the first beaches to be converted to leisure lost their charm and popularity to rival resorts, others sought to replace them in a cascading effect. This phenomenon globalized coastal tourism, as travel agents and consumers searched for the next exclusive, unspoiled, and exotic beach for the people tired of urbanized and crowded coasts. This was the case with the beaches of southern Europe as well as those in the tropical south.

In Brazil, for example, the construction of Avenida Beira-Mar along Fortaleza's seafront in the 1960s evidenced the city's decision to embrace the ocean and modernity. The avenue expelled the last "unwelcome" inhabitants from the coast—mainly the few stubborn fishermen who remained—and accelerated the transfer of social clubs, houses, and commerce to the adjacent

areas, completing the transformation of the city's beachfront (Paula 2012). According to the Brazilian geographer Eustógio Dantas (2019), until the 1980s, beach tourism in Brazil was typically a local and national practice. Unlike other regions of the tropical South, Brazil had yet to join the mass tourism flows promoted by European and North American travel agencies, a phenomenon that contributed greatly to the touristification and urbanization of so many coastal areas. For instance, international tourism in the Caribbean had grown since the mid-nineteenth century as interest in exotic destinations increased, commodifying the sea, sun, and sand of the tropics. Brochures from the 1940s and 1960s proclaimed that Barbados was the Riviera of the Caribbean, a land of eternal sunshine where it was always summer (Carey 2011). In Brazil, this process occurred much later, when the state federal governments were given greater legal authority to implement local development policies. Consequently, northeastern states like Ceará invested in the modernization of their coastal cities, building airports, roads, and other major infrastructure to attract external investment and international touristic flows. With the international real estate boom, the relation with the beach changed from a civilizational model to an economic one (Dantas 2019). Consequently, the two-story houses of the former elites were replaced by the skyscrapers that now characterize the maritime front of Fortaleza, blocking the afternoon sun for those enjoying the stretch of sand, that is the last remnant of the great dunefield that once existed there.

Figure 10.1 Skyscrapers on the beach. Fortaleza, Brazil, 2016
Source: Photo by J.G. Freitas

It is noteworthy that earlier dune interventions also played an important role in this coastal urbanization process insofar as they contributed to the new attractiveness of the coast. The forestation of dunes and the draining of marshes and dune slacks, which were associated with miasma and disease, was seen as a positive enterprise, matter of public health, and an improvement to coastal areas, making them safer and more civilized. This was the case for Costa da Caparica. Located to the south of Lisbon, this beach became the most sought-after destination for the inhabitants of the Portuguese capital following the stabilization of its dunes and drainage of the wetlands (Palma, Dias, and Freitas 2021). In the Gulf of Cadiz, Spain, the coastal forests resulting from dune stabilization interventions were seen as adding value to the region, promoting its tourist potential insofar as they were important and aesthetically pleasing "natural spaces" (Ojeda Rivera et al. 1993). In Sydney's Bondi Beach, sand fixing, levelling, and removal was a precursor to the beautification of the shore and set the basis for its modernization (Ford 2014). Similarly, Frank Reckendorf has argued that dune stabilization and foredune creation in Oregon were an important factor in the economic growth of the area as it promoted private resort and residential development in the stabilized zones and facilitated the provision of road access to and near the beaches (Reckendorf et al. 1985, 267; Reckendorf 1998, 435). Similarly, in Cape Cod, the solving of the dune problem helped convert the "low wind-stunted plants and sparsely covered dune" into a major tourist attraction (Zak and Brendakis 1963).

The consequences of urbanizing the coast

In *The Human Shore*, Gillis argued, as I do in this book and elsewhere (Freitas and Dias 2017; Freitas, Bastos, and Dias 2018), that "the first to occupy the beach and build residences facing the sea were upper- and middle-class inlanders convinced of the therapeutic quality of the sea air and water." Fisherfolk were fluid communities, always on the move as they followed the unpredictable migrations of their prey. When they settled on the coast, they usually did so in sheltered areas or by keeping a distance from the sea itself (Gillis 2012, 115). As Paul Komer has pointed out, this means that "all the development we see today on coasts—homes, shops, roads, bridges—has come about within the last 100–150 years" (Komar 1997, 69). This building in such an unstable environment—which past coastal communities had for so long avoided—has had consequences, and one of the most serious is the problem of coastal erosion.

Until the mid-nineteenth century, New Jersey's barrier islands were only accessible by boat. This changed rapidly with the building of bridges connecting the islands to the mainland. The rows of sandhills near the ocean and the salt marshes behind them were not suited for streets and housing because they were too high and irregular or too low to drain. Therefore, the developers graded the land level by cutting down the dunes and used the surplus material to raise the terrain where necessary. They then sold the oceanfront

lots for the highest price because they were the most valuable (Smith et al. 1930, 10–11). However, a major issue soon began to worry developers, individuals, and communities: sea encroachment was threatening the infrastructures. As Engle noted in 1922:

> The erosions are still in progress and unless checked will not only result in further loss of physical property but discourage investment of capital in seashore property. Thus it is of prime importance to protect this valuable contribution to the State's growth.
>
> (Engle 1922, 5)

The case of the New Jersey shore is one of many. In Portugal, the villages of Espinho and Furadouro on the west coast are emblematic of how human occupation has drastically altered the environment and exacerbated coastal erosion. Seasonally inhabited by fisherfolk since the end of the eighteenth century, coastal erosion only emerged as a problem when they became seaside resorts, the fishermen's mobile wooden shacks replaced by hotels, chalets, cafes, rental houses, and meeting places to host and entertain the elite. From the end of the nineteenth century and throughout the twentieth century, the sea destroyed what had been built on the beach, including the churches. As a plethora of written and iconographic evidence shows, in the process of transforming Espinho and Furadouro into tourist destinations, the extensive dunefields were levelled, dug, mined, and built (Freitas and Dias 2017).

Australia also provides several good examples of the link between beach settlement and coastal problems. According to Mike Danaher, in the early twentieth century, the well-established dune system of Yeppoon Main Beach in Keppel Bay was destabilized by campers and visitors who came down to the coast and traversed the dunes in order to reach the sea. This destabilization ultimately caused the sand to drift inland, troubling the city residents, who complained about the nuisance. Meanwhile, between 1910 and 1930, several recreational structures were built on the beach and large amounts of sand were removed from the dunes. In the late 1930s, a stone seawall was constructed and the dunes were levelled as part of an improvement program to protect the buildings between the beach and the dunes, provide for better access to the ocean, and create a grassy area for picnics. In addition, between 1965 and 1972, tons of cubic meters of sand, which was considered an infinite resource, were removed and transported for construction and reclamation purposes. Consequently, by the 1990s, there was no beach at Yeppoon Main Beach during high tide, as the sea flooded the existing beach up to the new seawall built after the passage of Cyclone Davis in 1976 (Danaher 2005). Meanwhile, the suburbs of Sydney also faced the threat of coastal erosion. In Narrabeen-Collaroy, beachfronts were divided right to the edge of the sand. As Ford explained, the vegetated dunes were progressively transformed into a suburban landscape vulnerable to sea encroachment. In 1944 and 1945, winter storms undermined the foundations of several buildings in Collaroy,

while washing away others. According to the *Sydney Morning Herald*, "Roaring over the beach, the waves were in some instances breaking over the floors of the houses, tearing doors from their hinges, and swirling around house furniture. The near portion of two cottages, undermined by the surf, collapsed" (*The Sydney Morning Herald* 1945-06-13, 1).

Similar examples can be found in Brazil. In Fortaleza, in the nineteenth century, the harbor and the industrial areas, warehouses and workers' quarters, as well as the railroads and the access roads were located in the high beach and dunes. These were marginal zones considered unsuitable to the upper- and middle-classes because of their industrial functions and busyness. However, with the transfer of the harbor infrastructure from the more central Iracema Beach to the peripheral region of Mucuripe in the 1930s, urban occupation on the coast was reorganized. The city increasingly embraced its beaches and moved closer to them, sprawling over the dunefield that bordered the seashore. The construction of the new harbor and its access roads as well as the workers' homes around resulted in the further destruction of the dunes and vegetation. Moreover, the jetties erected to prevent the siltation of the new harbor affected the flow of sediment that nourished Fortaleza's beaches, which were already being deprived of their sand exchange with the dunes due to urbanization. Consequently, from the 1930s onwards, Iracema Beach and others faced serious problems with coastal erosion. With the severity of this issue only increasing since the 1950s, several groynes were built along the maritime front of Fortaleza in an effort to protect the adjacent buildings (Paula 2012).

Recognizing the value of dunes

As a new paradigm appeared and coasts underwent dramatic transformations into profitable sites of recreation, coastal land once considered worthless became prized real estate. However, amid this change, some natural processes, such as erosion, turned the ocean into a predatory beast (Quinn 1977, 12; Ford 2014, 257). Marchand (2010, 6) defined coastal erosion as "the process of wearing away material from a coastal profile due to an imbalance in the supply and export of material" in a given section. Coastal erosion is typically caused by high winds, waves, and tides as well as storm surges, and results in the retreat of the coastline. Beaches are always moving—gaining and losing sand—because they are part of a dynamic system. However, "when we build motels, pavilions, boardwalks, and even whole towns on the edge of the ocean," we fail to "recognize any real estate as movable" (Kaufman and Pilkey 1979, 13). This is when problems begin.

When coastal erosion emerged as a serious threath toward the end of the nineteenth century, scientific knowledge of coastal dynamics was relatively basic and the first attempts to deal with the issue were based on trial and error. Along the US Atlantic coast, private individuals and local communities spent millions of dollars on infrastructure to prevent it, frequently

exacerbating and extending the problem to adjacent areas (Quinn 1977, 12–14). As Mary Louise Quinn argued, people soon realized that individual scattered efforts would not be able to deal with the situation and that an organized response was needed. As early as the 1920s, the New Jersey State Board of Commerce and Navigation appointed a special group known as the Engineering Advisory Board on Coastal Erosion, which worked with the US Army Corps of Engineers to gather information on coastal changes, conduct beach surveys, analyze the problem, and propose solutions. Meanwhile, universities and other research groups—such as the Committee on Shoreline Studies under the Division of Geology and Geography of the National Research Council in Washington, DC—sought to expand the empirical knowledge at the basis of shoreline protection engineering practices. In 1926, the American Shore and Beach Preservation Association was founded to promote the economic development and preservation of the coasts (Quinn 1977). However, the game-changer in coastal science during this period was the Beach Erosion Board (BEB), a central agency comprising a seven-member board of experts and staff organized under the US Army Corps of Engineers. Founded in 1930, the BEB operated until 1963, when it was replaced by the Coastal Engineering Research Center. The BEB was responsible for a number of field studies as well as expanding basic data on waves, winds, tides, beach profiles, sand samples, and groynes in an effort to innovate ways to prevent erosion and contribute to the development of coastal engineering, which was still in its infancy. The BEB also cooperated with state agencies, universities, and research institutes, including the Scripps Institution of Oceanography, the University of California, Berkeley, and New York University. From 1947, the BEB published a bulletin to disseminate information on coastal matters and participated in international meetings and overseas consultations as part of a strategy to expand the results of its work (Quinn 1977).

The growing interest in coastal processes led to the advancement of scientific knowledge on these issues and the identification and recognition of the relationship between littoral cells, sand budgets, sand sources and sinks, alongshore/offshore/onshore sand transport, sand properties, the impact of dam construction on the reduction of sand delivered to the coast, and how hard coastal structures trap the littoral drift of sand (Wiegel and Saville Jr. 1996). Of course, the US was not the only nation conducting research and making progress in this area. In the 1960s, coastal studies proliferated in many parts of the world in response to the socioeconomic concerns raised by erosion. In Australia, for example, local universities were at the vanguard of beach morphodynamics research, led by a new generation of locally based coastal scientists and engineers (Ford 2014, 264–265). The 15 papers comprising the *History and Heritage of Coastal Engineering* (Kraus 1996) show how many individuals and institutions across different countries—including the Netherlands, Denmark, France, Germany, Great Britain, Canada, Portugal, Spain, and Mexico—contributed to the development of coastal science and engineering in the twentieth century.

This is not to say that there was no understanding of coastal dynamics until the mid-twentieth century. Indeed, what I have described in previous chapters regarding the empirical wisdom of coastal populations is an example of how much was known about coastal systems since earlier periods, long before twentieth-century efforts. In many different parts of the world, people knew how to deal with the threat of the sea and the sand, usually by avoiding it or by adopting coping strategies, such as living in sheltered areas. Certainly, the men of science who tried to stabilize the sands in the eighteenth century, including Brémontier and his contemporaries, had a pretty good idea of how the dunes were formed, why they moved, and the importance of vegetation in this process. Similarly, the experts of the British Royal Commission on Coastal Erosion appointed in 1906, as well as all of those they interviewed, were aware of the trapping effect of hard engineering structures built on beaches and their negative effects on the nearby shore. The reports of the New Jersey Board of Commerce and Navigation published between 1922 and 1930 provide a clear summary of what was known about erosive processes and beach defense at the time. These reports show that engineers, scientists, and authorities had a perfect understanding of the relationship between settlement, dune destruction, and the exacerbation of coastal erosion and its damaging effects on infrastructures. As noted in the 1930 report:

> [O]ne of the first activities of the men who build upon these beaches is to level down the sand dunes, the finest and most beautiful moulded barrier that nature can erect short of rock upheavals. In general, we can safely accept the prediction that troubles from erosion begin with the lowering of these sand dunes. […]
>
> Nature's best protection during fluctuations has been depleted. Furthermore, any erosion or overflow by the high storm tides now become a serious matter, for here are beautiful dwellings right on the beach within range of these high seas […].
>
> (Smith et al. 1930, 7, 11)

While experts recognized the consequences of losing the dunes, they were largely resigned to such destruction as inevitable. There was simply no room for dunes in Atlantic City or Miami Beach. For instance, those responsible for the mentioned report asserted, "As between a row of sand dunes—beautiful and helpful as they are in resisting the forces of littoral attack—and a number of palatial hotels of one to five million dollars, any locality will choose the hotels" (Smith et al. 1930, 22). Simply put, hotels were worth more than the dunes, so the dunes were destroyed to make space for the building of hotels. This choice was made easier by the provision of a "solution" for potential coastal erosion. "As a consolation for the loss of the sand dunes," Smith, Jenkinson, and Saunders explained, "the valuations of the hotels and the rest of the community will support the cost of effective sea protection structures" (Smith et al. 1930, 22).

As such, the destruction of the dunes was not only due to economic interests and a general lack of knowledge about these landforms, but also to an overreliance on hard engineering structures to solve any consequences. There are a number of examples evidencing this widespread mindset, one that endures to this day. Let us consider two cases from Portugal. Although regularly damaged by sea overwash and severe coastal erosion, urban growth continued throughout the twentieth century in the localities of Furadouro and Espinho sheltered by a increasing number of groynes. This raises the obvious question: did people and government not realize the pitfalls of building in such an exposed area? Historical data shows that they did, but continued doing it anyway. In the 1950s, a technical report by the Urban Services of Aveiro, the district capital, clearly opposed the construction of an *esplanada*—a promenade with a balcony parallel to the beach—in Furadouro. The report was ignored by the Tourism Commission and dismissed as "inconvenient," because it went against the prevailing trend of developing and improving seaside villages. Despite the project was doomed to failure, the esplanada was constructed, the village seafront was levelled and the dunes razed. And, as the report had predicted, in 1958, the structure was destroyed by the sea. In 1960, a wall of stones was erected on the beach to protect the rebuilt esplanada from the waves (Freitas and Dias 2017).

There was a time when hard engineering structures built perpendicular (e.g., groynes and jetties) or parallel (e.g., seawalls and revetments) to the shore were seen as the solution to coastal erosion and thus widely adopted. The purpose of such structures was to trap the sand in the littoral drift or absorb the energy of the breaking waves. By the 1920s and 1930s, these hard engineering structures were widespread along the US coast, especially in New Jersey, to the point that they hampered the recreational use of the beach in some places (Quinn 1977, 79). Indeed, some areas became so armored by different generations of groynes that they looked like hedgehogs from the air, a phenomenon that came to be known as "New Jersization." However, it soon became evident that these rigid structures reduced the ability of beaches to respond to changes in the dynamic equilibrium of which they were part. In a natural system, the erosion of one beach supplies sand to the next beach downdrift and so on. By trapping sand on one beach, groynes and jetties retain the sediment needed further down the coast, starving nearby beaches of sand and exacerbating coastal erosion in these areas. On shorelines protected by seawalls, which were often used to replace the function of dunes before they were destroyed, the beachfronts were steadily eroded and buildings invariably endangered by the encroaching sea. In fact, seawalls aggravate erosion: as the waves strike the seawall, their energy is reflected and intensified, and the receding waves take more sand with them, ultimately undermining the structures and leaving the beach without sediments (Kaufman and Pilkey 1979).

In the decades after the Second World War, technology improved and knowledge progressed. The US Army Corps of Engineers, responsible for most of the big coastal protection projects, recognized that hard engineering

structures were actually exacerbating the problem they were supposed to solve (Hall 1952). They realized that interventions would be more efficient if they worked with the natural forces, rather than against them. In this respect, Quinn (1977, 79) asserted,

> This line of thought places emphasis on the beach itself and on that vital commodity, sand. It was found that beaches were more effective as dissipaters of wave energy than fixed structures. Additionally, beaches were also more desirable from the aesthetic as well as recreational point of view than unsightly walls of stones or cement.

From the late 1940s onwards, the US Army Corps of Engineers moved away from traditional hard engineering structures and progressively adopted a "soft" approach to coastal erosion. "Beach nourishment" is now one of the most commonly used techniques, and involves the periodic addition of a certain amount of sand in the depleted system, thereby compensating for the sand gradually lost to the waves (Quinn 1977).

Significantly, experts realized that beaches and dunes constitute a single sand-sharing system, which means that the circulation of the sand is fundamental to maintaining its equilibrium and ensuring its recovery after extreme events. Simply put, to preserve the beaches, it was essential to protect and restore the dunes. Therefore, it made sense to promote their formation and enlargement by accelerating natural processes. A BEB technical memorandum (no. 101) published in 1957 details the formation and stabilization of dunes with vegetation. The author of this report was perfectly aware that this type of intervention had been implemented in Europe for several centuries, as well as in Cape Cod, Oregon, and the Outer Banks of North Carolina in the US. However, the author argued, there was insufficient knowledge on these earlier interventions and their outcomes, particularly those carried out in the US. The technical memorandum also detailed projects being implemented at the time, namely, those in the Outer Banks, Long Island in New York, as well as Jupiter Island, Jacksonville, and Panama City in Florida (Davis 1957). As I explore in the next chapter, the methods used in these works were almost the same as those used long before. Here, I wish to emphasize that although the methods were quite similar, the reason for these interventions was completely different. Dunes were no longer enemies, but allies. They were not being fought, but taken care of. They were not being eliminated, but rehabilitated. The dunes were valued for what they offered: protection.

Of course, this was not the only reason why beaches and dunes gained appreciation. Indeed, they were starting to be seen as a "priceless scenic and scientific resource for which there [was] no substitute." There was also increasing awareness of the threat to this shared natural heritage with the disappearance of undeveloped seashores. No one expected that beach use would cease, but some believed that certain areas should be preserved through the establishment of permanent protection. To this end, the US National Park

Service organized a coastal survey to determine which areas were still pristine and deserving of preservation. The report gives some idea of what was most valued on the coast at the time: rich and diverse plant and animal life, spectacular dunes, forests and freshwater lakes, isolation, remoteness, and historic value. The National Park Service subsequently recommended that some of the identified stretches be acquired and managed by the federal government for conservation, research, and public recreation purposes ("Our Vanishing Shoreline" 1955).

Despite the century-long history of the conservation movement in the US, coastal preservation did not receive much attention before the mid-twentieth century. This changed with the new interest in coastal areas, the rapid pace of their transformation, and the imminent lack of public spaces for recreation as ocean fronts were purchased and fenced off by wealthy private individuals. According to Jackie Mullen, "the Park Service used fears of development as the main driver to pass legislation that promoted recreational development" and the preservation of ecological diversity and wilderness (Mullen 2015, 11). In view of Mullen's thorough account of the creation of US coastal parks, it is unnecessary to detail the politics and negotiation processes involved in such effort. That said, the approval of the seashore conservation was difficult to secure due to differences in land use, the increasing worth of coastal property, and national and local interests. For instance, although authorized in 1937, the Cape Hatteras National Seashore was only officially established in 1953. The fact that much of the land was publicly owned greatly facilitated this process. Meanwhile, Cape Cod National Shoreline was established by President John F. Kennedy in 1961. While the elites who had bought homes on the Cape were afraid of losing their property to the park, they were more fearful of massive tourism ruining their quiet piece of paradise (Mullen 2015). Nevertheless, the intent behind the park's establishment was to preserve the Cape Cod experience and its unique dune landscape "for the public at large, and not just for a privileged few" (Finch 1993, 17).

The Oregon Dunes, Mullen explained, were a different matter entirely. In Oregon, the Park Service's proposal to turn the dunes into a national seashore was rejected by the Forest Service and timber industry, which were held in high esteem in the region. This created a divide between the two agencies, which had different views on land appropriation for conservation and resource-extractive activities. Ultimately, the Oregon Dunes were converted into a National Recreation Area in 1972, and placed under the management of the Forest Service (Mullen 2015). The primary purpose was to "provide for the public outdoor recreation use and enjoyment of certain ocean shorelines, dunes, forested areas, fresh water lakes, and recreation facilities by present and future generations" and ensure the "conservation of scenic, scientific, historic and other values" of these lands, a third of which were covered in active open coastal sand dunes of a size found nowhere else ("Final Environmental Statement. Oregon Dunes National Recreation Area" 1977, 4, 8).

The US was not the only country to designate extensive dune and coastal forest areas as national reserves or parks. In the United Kingdom, for

example, the Kenfig Dunes have been a Site of Special Scientific Interest since 1953, and became a National Nature Reserve in 1989, while the dunes of Holkham Estate were designated a National Nature Reserve in 1967. In Spain, the National Park of Doñana, known for its spectacular dunes, was created in 1969. A year later, the French government designated the Landes of Gascony as a Regional Nature Park. In Portugal, the Natural Reserve of the Dunes of S. Jacinto was created in 1979. Moreover, the coastal forests planted on the Portuguese dunes in the nineteenth and twentieth century are considered national forests and managed by the Institute for Nature Conservation and Forests. In Australia, the landscape of sandy beaches, dunes, dune lakes, and rainforests of Frazer Island form part of the Great Sandy National Park, which has been protected since 1992. In addition to their enormous ecological value, these areas have recognized touristic and cultural value. For instance, created in 2007, Denmark's Thy National Park encompasses a vast expanse of dune, heathland, and woodlands considered a symbolic landscape deeply linked to national identity (Knudsen and Greer 2008).

Tatajuba: Dunes, lakes, coconut trees, and discord

In Europe and the United States, dune conservation is an important and relatively consensual issue. Various agencies and entities contribute to the preservation of the coastal landscape by managing conflicting uses, enforcing conservation laws, and overseeing nature rights. Society in general is committed to supporting such efforts, as the ecological, aesthetic, and recreational value of the dunes is widely recognized. However, the relationship between people and dunes can be very different in other parts of the world. Nature conservation issues are rather complex and problematic when local communities are highly depended on resources for their livelihoods.

One of the things I like about travelling and getting to know people and cultures is the opportunity to learn other views about matters that I thought were broadly accepted. In November 2022, I travelled to Brazil with Mihaela Tudor, who was writing her PhD in geography on the dunes of Portugal and Brazil, to meet my colleague and friend Davis Pereira de Paula, a professor at the State University of Ceará, Fortaleza. Davis acted as our guide when we visited the National Park of Jericoacoara (Jeri), which was created in 2002, from the former Environmental Protected Area of Jericoacoara established in 1984. The park protects the unique landscape of beaches, dunes, mangroves, and dune lakes that characterize the region. Situated between the ocean and the dunes, the village of Jeri has become one of the most famous vacation destinations in Brazil. With its extraordinary beaches, warm climate, sandy streets, and boutique hotels, Jeri is incredibly popular among both domestic and international tourists.[1] Jeri is also known for its remoteness, as it can only be accessed by car via the beach or the authorized 4x4 vehicles that circulate the park, crossing the dunes as they transport residents and tourists from the main village of Jijoca to Jeri. These vehicles and buggies are also used for

dune tours, a much sought after recreational activity in this region. While in Jeri, Davis, Mihaela, and I rented one of the 4x4s for a "scientific tour," with Davis taking us to the places where he and his students often conduct fieldwork. I must admit that I had never seen anything quite like those dunes. The view from their peaks was breathtaking, the beauty of the endless open sand difficult to describe. Only a poem or song could capture the different emotions the scenery inspired, and I'm no poet.

On our day trip to the dunes, we visit Tatajuba, a community located next to Jeri, but outside the national park. "Tatajuba is the old Jeri," the residents say. Tatajuba is what Jeri used to be, before the invasion of hotels, restaurants, shops, and crowds (Coriolano and Mendes 2009). However, Tatajuba is in danger of becoming a new Jeri, with an increasing number of international investment groups and private individuals buying land nearby. Tatajuba's coast is a postcard: a paradise of ocean, dunes, coconut trees, and coastal lakes. The village, which can only be reached by boat ride or the trek of 4x4 vehicles across the dunes, is dotted with humble dwellings and a few pousadas run by foreigners, who also promote kitesurfing, the main attraction of this remote place.

At the beginning of the twentieth century, fisherfolk from Camocim and their families settled and developed the small community of old Tatajuba. But, sometime between the 1950s and 1980s, "the dunes came" ("*Aí foi que as dunas chegou*"), forcing the population to move as their houses were invaded by the sand (Santos 2011, 106). The literature and testimonies of the inhabitants suggest that this occurred gradually, rather than as a singular or sudden event.[2] Like the old stories of the villages lost to the dunes in Europe in the early modern period, in the twentieth century, the church of Tatajuba was buried by the sand. Villagers took the image of the local patron saint with them as they left to found a new community. In fact, the disappearance of old Tatabuja resulted in the creation of four new places: Nova Tatajuba (or Tatajuba), Vila Nova, São Francisco, and Baixa da Tatajuba. By 2011, these communities had a sum total of approximately 1,000 inhabitants, who made their livelihoods from artisanal fishing of fish, shrimp, and crab, as well as subsistence farming of sweet potatoes, beans, and cassava. To prevent disaster, the villagers have installed wooden fences around their houses and planted trees to provide protection from the wind and sand.

The dunes, actors in this narrative, are constantly shifting. In a few decades, these sands may force the people of Tatajuba to move again. According to geographer Jeovah Meireles (Assis 2012), in such a dynamic environment, sustainability necessarily involves mobility. Local people know this. For them, the dunes are no ordinary sandhills, but enchanted places, connected with fantastical stories of treasures and princesses, a lost ship and their forebears. In fact, every inhabitant of Tatajuba seems to have a different relationship with the "*duna encantada*" (the enchanted dune), that expresses the intimate respect they all share with the surrounding landscape. Locals value the dunes and beaches, not as commodities, but because they make up their world (Júnior 2006). Locals also know that the dunes and beaches are what bring

Figure 10.2 Living on and with the dunes. Tatajuba, Brazil, 2022
Source: Photo by J.G. Freitas

people to the area. The dunes and beaches are the reason tourists "pass by" as they travel from Camocim to Jeri by buggy, buying coconut water and handicrafts from inhabitants en route.

As we travelled through the dunefield, we saw many areas marked as lots—bare sand with a few sticks and fences signaling the boundaries of private property. Dunes in Brazil are publicly owned and cannot be bought or sold. However, Davis told us, "Tatajuba is far… peripheral… and things like this happen." Although tourism is an alluring prospect for these low-income communities, many inhabitants are wary of the kind of tourism they see in Jeri and are fighting to maintain control over the land and its uses. In addition to resisting the sale of their surroundings, people are working collectively to promote a community-based, sustainable, and locally run tourism industry. However, the population are up against international corporations and global interests, and not all members of the community are on the same side. Indeed, since the 1990s, Tatajuba has fought companies claiming to have bought these coastal lands. The dispute remains ongoing, with part of the community trying to turn the area into an environmental reserve to prevent its urbanization, while others are swayed by the opportunity for jobs and the benefits offered by big companies. Such discord is dividing people and eroding their long-established solidarity (Santos 2011).

Thinking out loud from afar

After the visit to Jeri and Tatajuba, Mihaela and I presented our work to geography graduate and postgraduate students at the State University of Ceará. Our presentations were followed by a lively discussion, as the students wanted to hear more about coastal policy and management in Portugal and how it compared to Brazil. The most challenging comment, however, came from a colleague, Edilson Pereira Júnior, the director of the postgraduate program. Edilson noted that I had emphasized conservation and protection of dunes in my presentation, but Brazilian focus, he said, was still on extractivism, production, and the economic use of resources. He gave the example of the increasing number of aeolian energy parks being installed in the dunes. Although Brazilian law protects the dunes for their ecological importance, this argument has yet to be generalized in practice. The dunes are still commonly considered empty land to be improved or a raw material to be used. Edilson's statement took the discussion in a different direction. Suddenly, the students were very interested in how we saw the relationship between the population of Jeri and the dunes, as their touristic use is often in conflict with the park's purpose of protecting them.

Those who work in Jeri are humble people, they transport tourists in vans, serve them in shops, cook for them, and clean their hotel rooms. These people lead a hard life: they live far away from Jeri, which is too expensive, wake up early, travel long distances, and work in the heat, to provide services to wealthy tourists. In the 4x4 vans, the local people talked, sometimes to each other, sometimes to us, knowing that we were outsiders. "This used to be a lagoon, now it's dried up." "That dune over there was very small, look how it's grown, it's going to come up here to the road and the path will have to be changed again." "If I could rent a bigger room, make it nicer, it would be good for business, the customers like it." "I'm right there on the main street; I work in a shop. My daughter is with my mother; I can't bring her." In the restaurant at Lagoa da Torta, where we stopped for lunch, the boy who attended us told us that he goes to school in Tatajuba. Tourism allows him to earn some money, everyone there works in the tourism sector. They also go fishing, with the fish not sold to tourists distributed among the community. The boy also explained that while Tatabuja had no problems with sand, the houses in nearby Moreias were being invaded by the dunes. For local people, the dunes are not leisure and entertainment or even valuable ecosystems; they are their livelihood, their uncertain ground, the landscape they see every morning. The dunes are neither novel nor dazzling; they are a mundane part of their routine. For numerous families, the beach and the dunes are their breadwinner, allowing them to put food on the table. Should they be prevented from using the dunes so that these can be protected? It's a hard choice to make.

It is clear, however, that if the locals abuse these resources, they will kill the goose that lays the golden egg. The intense flow of buggies and 4x4 vehicles, the irregular building, the garbage left behind, are impacting the landscape

(Coriolano and Mendes 2009, 104), affecting dune migration, facilitating wind erosion, contributing to the silting of the lakes, and damaging the local ecosystems. As a consequence of tourist activities, the dunes are migrating toward Jeri, the sand already covering parts of the buildings and streets of the village (Meireles 2014, 147–152). The pressure is enormous over there. Just think of the situation in Tatajuba: what will become of this beach if everything is sold and developed? Like everyone else, the residents of Tatajuba also dream of and want more. They want a better life for themselves and their children. Selling the dunes could give them that. After all, what is a dune but a pile of sand? Would anyone hesitate to trade a handful of nothing for their life's dreams? However, in this case, the sand is worth gold. The locals know this. But they are divided. Some just want to sell the lands and get a better life. Others understand that the dunes have greater value if they remain in their hands, offered to tourists in small doses as a coveted, unique experience. These are the ones that are fighting against foreign companies and against the end of their traditional lifeworld. They are aware that if the dunes are sold to and owned by foreigners, they will lose what makes them special—the stories, heritage, and kinship with the people of Tatajuba. If all this is lost, the dunes will be just sand, or worse, another degraded urbanized coastline.

Many of the topics covered in this book seem far away in time. Something from the past. But others have a strong connection to the present. The purpose of going to Brazil was to see and hear about dunes today. My work there was to understand how the dunes fit into people's daily lives. Being on the ground, feeling the complexity of the problems, putting myself in people's shoes, I found that I had no bright answer or solution to give the students. It is much easier to read about such issues in books and take a stand from a distance. As discussed in this chapter, dunes have come a long way since the days when they were just wastelands. Their discovery turned them into valuable assets, but it also brought with it wicked problems, with tourism representing yet another takeover of the coastline or an enduring facet of colonialism. Dunes as a destination can mean either their destruction through intensive use and urbanization, or their preservation as unique ecosystems. Often, both attitudes co-exist in tense conflict in the same places.

Notes

1 On March 15, 1987, the *Washington Post* published a story by Cal Fussman about Jeri entitled, "Beauty and the Beach."
2 Different papers report different dates. For instance, Assis (2012) points to the 1970s, while Santos (2011) refers to the 1950s. The testimony of a local woman available online mentions that the event happed between the 1970s and 1980s: https://maracatublog.wordpress.com/2009/11/20/velha-tatajuba-a-vila-soterrada/

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11 Vanishing coasts

The elephant in the room

Have you ever heard the expression, "the elephant in the room"? It is based on a Russian fable by Ivan Andreevich Krylov called "The Inquisitive Man," about a meeting between two friends. One mentions the wonderful things he had seen on a recent visit to the museum, especially the various small birds and tiny insects. "But did you see the elephant?" his friend asks (Ralston 1871, 43). The man had not. He had noticed all the little creatures, but not the biggest one in the room. Today, the expression is used to mean that there are certain sensitive issues that people are aware of but prefer not to acknowledge. When I first read the fable, I could not help but wonder whether dune rehabilitation is the elephant in the room of present-day coastal management. Is it possible that we are focusing on palliative solutions to avoid addressing the larger problem?

According to the latest Intergovernmental Panel on Climate Change (IPCC) report, "unavoidable sea level rise" over the next centuries will result in the flooding of "coastal and low-lying cities and regions," severely impacting ecosystems, people, and infrastructure (IPCC 2023, 15). Since the end of the twentieth century, coastal protection has become a critical issue. Recognized for their multi-functional relevance as wildlife habitat and protection against erosion, flooding, and storm damage, sand dunes are a common design feature in land reclamation and climate change adaptation projects. For instance, a combination of dykes and dunes has been used to support the low-lying cities of the Netherlands, a country that has pioneered coastal defense solutions (United Nations 2021, 191, 61). Thus, since the 1990s, the European Union (EU) has allocated a significant amount of funds to restore sand dunes and ensure the resilience of Europe's coastal areas ("Strengthening Europe's Sand Dunes" 2021). As noted in the previous chapter, in less than a century, dunes have gone from feared to protected landscapes. In fact, since June 25, 2021, there is even a World Sand Dune Day, an initiative by the Sands of LIFE and Dynamic Dunescapes projects, organizations dedicated to the safeguarding of dunes in England and Wales.

In the twenty-first century, greener forms of coastal protection that use the adaptive capacity of natural systems, such as dunes, wetlands, and mangroves,

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have been complementing or replacing hard engineering structures. According to the EcoShape network, which is connected to a mega-nourishment project called Sand Motor, a pilot scheme that was implemented on the Delfland Coast of the Province of South Holland, soft approaches or "building with nature" solutions are a new philosophy in hydraulic engineering centered on harnessing the forces of nature for the benefit of nature, economy, and society. This philosophy is rooted in broader evolution in infrastructural works over the past decade, with advances in this field allowing to assert that "we want more […], we know more […], we can do more." Accordingly, it is possible "to create opportunities for development of a new nature, up and above what is required for mitigation or compensation." In other words, the purpose of coastal intervention has shifted from "doing less bad" to "doing good," by using "nature development as a starting point for sustainable coastal strengthening" (EcoShape n.d.a). This includes, for instance, designing a new dune landscape where there used to be a dune system in the past or enhancing dune dynamics to activate stabilized dune systems for flood safety, ecology, and/or recreation (EcoShape n.d.b). This seems like a good thing, no? So what is the elephant in the room? What are we not seeing?

Coastal dune management in the present

Building with nature for coastal protection

In recent decades, dunes have been viewed as ecosystem service providers and managed accordingly. Coastal protection remains one of their most valued services, especially in developed coasts, where beach nourishment and dune rehabilitation are preferred to hard engineering structures in safeguarding human assets on the shore.

Dunes provide protection, but they do not work as sand walls. After all, "nature does not build solid walls against the sea." Dunes are "warehouses and distributors of sand," as Kaufman and Pilkey (1979, 110) have noted; they are born of a dynamic equilibrium and move according to it. As explained before, coastal systems are constantly adapting to various geomorphologic and oceanographic factors operating on different time and space scales. Dunes, especially foredunes, are part of a sand-sharing system that includes the beach and offshore bars, which actively exchange sand with each other. When affected by short-term perturbations, like storms, these coastal landforms normally return to their pre-disturbance condition through a morphodynamic adjustment. Put simply, during a storm, sand is transferred from the dunes to the beach and offshore bars, which help dissipate the energy of the waves, reducing their impact on the beach. The sand subsequently returns to the beach and is blown back into the dunes, where it is stored for the next event (Nicholls et al. 2007, 318; Psuty and Ofiara 2002, 189). However, human-induced pressures can alter this equilibrium. Urbanization, land reclamation, the drainage of coastal wetlands, deforestation, sand mining,

and hard engineering structures (e.g., dams, channels, and groynes) modify currents and wave patterns as well as sediment erosion, transport, and deposition, altering the morphological evolution of sandy coasts. Human-induced drivers together with the effects of climate change and rising sea levels contribute to the exceeding of critical thresholds, accelerating processes of coastal land loss or inundation (Nicholls et al. 2007, 318–320, 331, 333). In 2004, the EUROSION group, commissioned by the EU Directorate General Environment to provide quantified information on coastal erosion in Europe, estimated that the area lost or severely impacted by this natural process was around 15 square kilometers per year (EUROSION 2004, 2). Around the world, sea encroachment and the destruction of coastal systems buffer areas are already affecting biodiversity, freshwater resources, agriculture and forestry, fisheries and aquaculture, recreation, tourism, and settlements.

To maintain the existing *status quo*, huge beach nourishment and dune rehabilitation projects have been undertaken. The most emblematic of these is the Delfland Sand Motor initiative, implemented between 2011 and 2016, with the aim of mitigating coastal erosion and creating a recreation area. According to Deltares, the Dutch knowledge institute behind the project, while traditional operations involve something like 2–5 million cubic meters of sediment with a lifespan of five years, the Sand Motor injected some 21.5 million cubic meters of sand into the system with an expected lifespan of up to 20 years. To achieve this, "trailing suction hopper dredgers picked up sand 10 kilometers off the coast and deposited it nearshore," creating a peninsula extending 1 kilometer into the sea and 2 kilometers alongshore. As such, Deltares declared, "Sand Motor is a great example of Building with Nature" (Deltares n.d.b). Similarly, foredunes of varying sizes and forms are being built and managed according to human needs. On the coast of New Jersey, for instance, local communities and the state have promoted dune enhancement based on engineering models providing standardized instructions on the placement, height, and slope the dunes require in order to offer optimal protection according to the specific conditions of each area (Psuty and Ofiara 2002). These dunes are constructed using modern machinery like earthmoving equipment (e.g. bulldozers) to deposit and reshape sediment, often with a dune-dyke form to optimize flood protection (Nordstrom and Jackson 2013, 21). In addition, a combination of other methods is used to increase aeolian sand accretion, including sand fences and vegetation planting. In many places, the process of dune-building is often solely based on these latter methods.

Referred to as a "nature-based solution," dune building is often presented as an innovation of scientific and developed society. This idea is reinforced by descriptions of artificial dunes as engineered structures or design features in reference to their potential as technologies for climate change adaptation (Linham and Nicholls 2010, 31; Elko et al. 2016, 2). However, reading the instructions for the placement of the fences or the plantings presented in the Beach Erosion Board Memorandum No. 101 (Davis 1957) or in more recent technical assessments (e.g. NSW Department of Land and Water Conservation 2001), there are clear similarities between twentieth and twenty-first

Figure 11.1 Marram plantings to reinforce the foredune at Lacanau Ocean, France, 2022
Source: Photo by J.G. Freitas

centuries procedures and early initiatives to stabilize the dunes of Europe, the Americas, and Oceania in the nineteenth century. Many of the same topics are still being discussed, such as whether to build fences parallel to shore or in zigzag configurations, install single or double rows, and the best location and materials to use, as well as which species of grass to plant and when. Despite the extraordinary amount of science and technology introduced into coastal transformation and management in recent years, the old measures of sand-trapping fences and sand-binding plants—including the *Ammophila sp.*—remain in use, largely because they are a simple and cost-effective solution. That said, past interventions implemented prior to the mid-twentieth century are seldom mentioned. Indeed, from long-standing community practices to the trial-and-error achievements of early foresters, centuries of experience of sand stabilization are hardly ever acknowledged. For instance, while Karl Nordstrom recognized that fences were used in the Netherlands and Germany since the fifteenth century, he connected the existing guidelines for building dunes to experiments conducted in the 1960s and 1970s (Nordstrom 2008, 50, 59). There is clearly a gap between current and pre-twentieth century knowledge, despite basic procedures having remained almost the same since the exploits of Nicolas Brémontier and his predecessors whose wisdom and practices he adopted as his own.

In the past, people were forbidden from harvesting the marram growing on the dunes that protected the lands from sea flooding. In this respect, modern science has confirmed what has long been known empirically: vegetation cover plays an important role in dune maintenance and its resilience to marine storm erosion. Vegetation contributes to sediment retention by acting as a buffer against wind power and by trapping sand with its root network. Plants alter the composition of sediment by adding organic matter to the soil, increasing "grain-to-grain cohesion" and transforming "a dune from a collection of individual grains to a larger mass of grains, bound together," thereby strengthening resistance to erosion (Feagin et al. 2015, 205–206). The level of protection offered is also related to the mass of the dunes, so that "any increase in dune height directly enhances its flood-defence capacity." Large volumes of sand in the littoral "help to slow landward retreat during periods of sea level rise" (Jackson et al. 2019, 6). In the past, populations planted marram to fix and reinforce the dunes. This is still a practice today; as mentioned above, foredune recovery projects usually include vegetation planting. And some communities still use the same strategy to secure their land from coastal erosion. For example, in 2016, the inhabitants of the Maharees Peninsula, Ireland, created the Maharees Conservation Association[1] after several particularly stormy winters damaged the dunes protecting their livelihoods. This local association promotes campaigns to replant marram and fence the dunes to avoid animal and human trampling.[2] Other examples of community-based marram grass planting include those carried out by several schools in Ireland as well as that by the Nature Conservancy at St. Peters Harbor Nature Reserve in Canada.[3]

Restoring dune dynamics

Recovering dunes for coastal protection is not the only approach to dune management nowadays. Since the end of the twentieth century, there has been a global trend toward dune stabilization, defined as "a loss in bare sand area and/or an increase in vegetation" (Gao, Kennedy, and Konlechner 2020, 3). A variety of factors are responsible for this phenomenon: the decline of agriculture, livestock grazing, and marram cutting; increased urbanization, industrialization, and infrastructure construction; dune stabilization interventions, like marram planting and afforestation; and decreased sediment supply to the beaches due to flood control mechanisms, sand mining, and coastal engineering structures that alter the littoral drift. Climate is also an important factor in the dune stabilization process. The end of the Little Ice Age and the beginning of the Current Warm Period in the 1850s led to a decrease in storminess, changes in rainfall and wind power, and an increase in atmospheric temperature, carbon dioxide, and nitrogen levels. These changes contributed to the greening of the dunes, with the growth and spread of grass and scrub covering other forms of vegetation and bare sand areas, reducing dune mobility (Gao, Kennedy, and Konlechner 2020; Jackson et al. 2019; Doody 2013, 212; Provoost, Jones, and Edmonson 2011).

Grass and scrub encroachment on open grasslands and heath is seen as a major environmental problem in some regions, as large mobile dune systems are disappearing. Coastal inland dunes depend on the input of sediment from the foredune and on the active role of vegetation. The natural succession of vegetation the further dunes lie from the sea follows a sequence of grass, scrub, and woodland. Each area has its endemic species, creating a mosaic of habitats that support diverse animal life (Doody 2013, 13–15). The mobility of coastal inland dunes is part of this natural process and plays a fundamental role in conserving its biodiversity. As long as the landscape is subject to the passing of new dunes, vegetation pioneer stages—in which plant species' growth is stimulated by sand burial—are continuously replenished. As Arens et al. have noted, "When the system is stabilized, processes might still be active, but on a smaller scale." The current trend for dune stabilization indicates that many dunes are covered with the same climax vegetation, dominated by shrubs (Arens et al. 2013, 110, 116). This phenomenon is affecting specialist plants and animals that depend on bare and sparsely vegetated dunes, "eventually leading to the loss of nature conservation values" (Doody 2013, 122). According to Patrick Doody, the combined impacts of human activities in Europe contributed to a decline of dune areas from 707,000 hectares in the 1900s to 530,000 hectares in 2000, with only 45 percent of these considered to be in a "natural" state (Doody 2013, 54).

Restoration is "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed," with the intention of contributing to its recovery in terms of functional processes, species composition, community structure, and resistance to disturbance (Martínez, Hesp, and Gallego-Fernández 2013b, 6). This is a broad concept. Indeed, as Martinez et al. have noted, the way in which it has been applied to dunes is closely related to the concerns that justify the implementation of the restoration projects, which are usually case-specific. That said, ecological values related to biodiversity have been the main target of most of these projects in accordance with international agreements on nature conservation. In this sense, several European and national directives have been launched for the conservation of wild fauna and flora based on lists of mammal, bird, reptile, amphibian, and plant species selected for their rareness, endemism, and rate of decline. These directives primarily establish the protection of species by safeguarding their habitats through the creation of specific instruments and frameworks, such as the Special Areas of Conservation, which is included in the Natura 2000 network (Heslenfeld, Jungerius, and Klijn 2008, 338–339, 345).

In northwestern European countries where stabilized dunes have become a problem—including the Netherlands, Belgium, and the United Kingdom in particular—management approaches focus on remedial actions that consist of destabilizing dunes in order to restore and maintain ecosystems and habitats considered important for nature conservation. These actions range from mowing, turf-stripping, topsoil inversion or deep ploughing, burning, and herbicide application to the removal of unwanted or alien species, such as sea

buckthorn (*Hippophae rhamnoides*), blackthorn (*Prunus vulgaris*), and European gorse (*Ulex europaeus*). Invasive species are removed mechanically or manually using bulldozers and volunteer labor. The management or reintroduction of livestock grazing is another highly valued technique for reducing biomass and eliminating scrub and other undesirable plants. Animals also contribute to soil disturbance, which helps increase sand mobility. Studies and experiments have been conducted to test the suitability and effectiveness of different livestock (e.g., cattle, sheep, donkeys, and rabbits) to each particular site. The management of people is also relevant, with recreational access to the dunes in some areas only possible via walkways and limited by zoning (e.g., establishing parking lots); while, in others, trampling by people is not only allowed but promoted as it helps reduce the stabilizing vegetation (Doody 2013, 212–226).

Woodlands are the last stage of the dune vegetation succession sequence, but they are almost non-existent due to overexploitation over the centuries. In many places, they were replaced by human-made forests. However, in recent decades, the large tree plantation schemes of the past, which were installed to control the drifting sands, have been recognized as harmful and intrusive to coastal dune systems. The trees standing on the top of the dunes reduce wind power and decrease sediment transport from the beach to the dunes, contributing to dune sand depletion and making the dunes more vulnerable to storm erosion. Trees also trap the sand with their roots, preventing beach–dune sand transfer and interfering with natural system dynamics. In some areas, tree removal began decades ago. For instance, in the United Kingdom, the felling of the frontal woodlands on the Sefton coast, a Special Area of Conservation, was initiated in 1992. Similarly, the exotic conifers growing on the west coast of the Jutland peninsula were cleared in order to restore open dunes areas. This initiative was funded by the LIFE Programme, the EU funding instrument for environment and climate action, within the context of the application of the Habitats Directive (Council Directive 92/42/EEC). Similar initiatives have taken place in the Curonian Spit, Lithuania, and the Netherlands (Doody 2013, 17, 226–231).

The idea of restoring dune dynamics is not unique to Europe. For instance, in Oregon and in New Zealand, it has become a priority for many dune managers and local communities. In both places, the main objective is to eliminate the invasive marram grass and reestablish the previously existing species and landforms, because *Ammophila arenaria* in New Zealand and *A. arenaria* and *A. breviligulata* in Oregon have changed the morphology and ecology of dunes. As one restoration proponent noted of the situation in Oregon, "Where once the wind-driven sand kept the landscape, and the vegetation, in constant flux, the movement had stopped or slowed, and permanent wetlands and woodlands were taking place of what had once been open sand" (Restoring the Oregon's Dunes 2018, 19).

As noted in Chapter 9 on the creation of unstable environments, the introduction of marram upset the local balance of wind, sand, plants, and animals,

threatening the life that flourished in those dunes. In Oregon, native species like the pink sand verbena and seashore bluegrass, which evolved in the specific ecological community of those sands, have been replaced by alien species of Scot's broom and gorse. The decline of these native plants endangers endemic beetles, butterflies, birds, and other animals. Meanwhile, opportunistic species, like crows, opossums, and coyotes, are moving into the new environment of dense scrubland created by the invasive grass. In 2014, a group of local people and entities founded the Oregon Dunes Restoration Collaborative, a cooperative organization dedicated to halting this process and preventing the disappearance of the open sand. This community-based organization chose several critical areas that still had the features of a functional ecosystem and invested in their preservation. In order to restore the shifting dunes and their unique wildlife, the organization focused on eliminating and controlling marram grass through prescribed fire, hand-pulling, herbicide, and bulldozing (Restoring the Oregon's Dunes 2018).

Meanwhile, at the beginning of the twenty-first century, New Zealand's active dunes were estimated to have declined by some 69.8 percent since Cockayne's 1911 report (Hilton, Macauley, and Henderson 2000). As in Oregon, the spread of marram grass caused significant changes to dune ecosystems and the loss of habitats for native plants and animals. Thus, the main purpose of contemporary interventions is to "re-establish the pre-disturbed dune and indigenous vegetation cover" or "restore the dynamic potential of a transgressive dune system" (Hesp and Hilton 2013, 68–69). At Oakura and East End beaches, for instance, the profile of the foredunes was reshaped into a more natural form by bringing in more sand, modelling them with bulldozers, erecting fences, and planting native species like pī ngao (*Ficinia spiralis*) and spinifex. Meanwhile, in Doughboy Bay, Stewart Island, the Department of Conservation eradicated marram using herbicides in order to recover the "transgressive dunes, blowouts and, parabolic [that] characterized the surface of the pre-marram barrier" and protect the few remaining populations of *Gunnera hamiltonii*, one of New Zealand's rarest native plants (Hesp and Hilton 2013, 79). Here too, community-placed groups, as Coast Care, play a prominent role in such efforts.[4]

Competing interests in dune management

Managing dunes for coastal protection or to restore open sand and native species raises some difficult issues due to conflicting interests. Although sand movement is important for ecosystem rejuvenation and biodiversity, it can be troublesome in terms of the dune's potential capacity to guard against sea flooding. In other words, the geomorphological rehabilitation of foredunes can clash with the ecological restoration of the leeward dune fields. In addition, concepts like "alien" or "native" species and perceptions of "good" and "bad" nature also influence dune management and fuel lively debate on the subject.

The building of foredunes with the purpose of coastal protection is rarely a case of restoration. According to Nordstrom and Jackson (2013, 18), the primary aim of these interventions is to create a barrier against sea hazards and not necessarily to rehabilitate their other functions and species communities. Norbert Psuty and Tanya Silveira (2008, 38–39) have described the intervention in foredunes as mainly a question of sediment budget manipulation, determined by local constraints and purposes. Vegetation is a fundamental part of the process, but the conservation of plants and animals is seldom an explicit goal (Hilton, Macauley, and Henderson 2000, 7). Compared with transgressive dunes, coastal dunes covered by vegetation have more potential to retain fresh sand from the beach, promoting foredune vertical and seaward growth. Both vegetation and dune crest elevation make dunes more resilient to marine storm erosion and thus to coastline retreat, which is particularly valuable in a time of rising sea levels. In fact, it is believed that the current trend of dune vegetation growth, that some view as a negative situation, can be an "unidentified geomorphic feedback of the system," which can help regulate the coastline response to sea level rise by reinforcing its "physical buffering potential" (Jackson et al. 2019, 6).

For a long time, foredunes were reinforced or created—typically through the large-scale planting of marram—to reduce the amount of sand blown from the beach to the leeward dunes. However, since the end of the twentieth century, mobile bare sand has been valued for both ecological and recreation purposes (e.g., Dune du Pilat in France and the Oregon Dunes National Recreation Area), such that the remobilization of the sand to create active dunes has emerged as a prominent management option. Indeed, the rejuvenation of sand dunes is the objective of projects like the Dynamic Dunescapes and the Sands of LIFE in England and Wales, respectively. According to the Sands of LIFE[5] initiative website, "Healthy dunes have plenty of bare sand and are constantly in motion." In North Holland, several schemes have experimented with removing foredune vegetation in order to release large amounts of sand to blow inland and feed the leeward system. As Arens et al. have highlighted, the "breakdown of the foredune and remobilization of sand is considered to be the engine for large-scale dune mobility" (Arens et al. 2013, 120). From this perspective, human agency is considered determinant in reverting the stabilization process, as without proper management, coastal dunes will continue to deteriorate, affecting biological diversity (Doody 2013, 293, 295).

However, there is little consensus on this matter. For instance, there is divided opinion on the removal of the old forestry plantations. Although coastal forests planted in the nineteenth century may not have the biodiversity of natural ecosystems, they have become the home of a large number of plants and animals and support several emblematic species, such as the Red Squirrel of the forests of Newborough Warren in Wales. Here, a local grassroots movement known as the Newborough Forest Protection Group emerged in response to the proposed felling of the trees and mechanical remobilization of the sand to create niche habitats, the group questioning the conservation

interpretation of the authorities promoting such actions.[6] In 2018, foresters, nature conservationists, and the public were still bitterly divided over whether "dune slacks and mobile sand habitat trumps the commercial value of conifer plantations" and the cultural and recreational heritage associated with the forest. Such tensions were further heightened "when talk [turned] to the return of an open dune landscape" (Dyke 2020, 40–41). The proposed removal of forestry plantations is complicated by their national, economic, and cultural significance. In Portugal, coastal forests are important public assets managed by state institutions (Rego 2001). In Denmark, some forests are recognized as unique heritage landscapes associated with local history and identity (Knudsen and Greer 2008). In New Zealand, the "sand forests" are valued for environmental, recreational, cultural, and military purposes (McKelvey 1999, 153). As such, in many countries, the clearing of such national symbols or assets is unthinkable.

Suffice to say, initiatives to reverse the process of dune stabilization promoted by many scientists and organizations and supported by EU funds have received mixed responses. Arguments against such actions point to the intensive and extensive human intervention required to remobilize the sands, including the use of heavy equipment, burning, and herbicides to significantly alter the landscape to favor certain landforms and species, usually to the detriment of others. Those who oppose the deliberate destabilization of dunes emphasize that biodiversity in natural systems is the outcome of the interaction between many abiotic and biotic factors that change over time. Trying to prevent this—the evolution of the system—to maintain a certain *status quo* "can turn coastal dune management into expensive habitat engineering" (Delgado-Fernandez, Davidson-Arnott, and Hesp 2019, 6), particularly when that is not "compatible with modern climate conditions" (Cooper and Jackson 2021, 5). Moreover, some argue that these interventions can endanger the system as a whole. As noted, vegetation, particularly on the foredunes, is important to enhance dune resilience to coastal erosion. Rejecting what they call "dune gardening," Andrew Cooper and Derek Jackson have argued that dunes should be left alone, with the exception of invasive species removal, and be allowed to evolve at their own pace. In this respect, they proposed that dune conservation be based on the protection of existing systems from further development and reducing the human stressors (Cooper and Jackson 2021, 5).

The removal of exotic species seems to be a less controversial practice, but this measure has pros and cons. In fact, while people behind Restoring Oregon Dunes describe the *Ammophila arenaria* as an "infamous" plant due to "its ability to spread" and become a dune invader (Restoring the Oregon's Dunes 2018), scientists point to its sand trapping efficiency, its impact on the form of the foredune, and how this influences foredune ability to protect coastlines from sea hazards (Zarnetseke et al. 2015). Indeed, while an invasive species can be a threat to biodiversity and reduce the ecosystem services associated with native species, it can also offer valuable benefits to local communities. For instance, the removal of the *Ammophila sp.* on the Oregon

coast to preserve endemic plants and birds may jeopardize the stabilized foredune system, which protects the human development that has sprung up in the last decades due to the security offered by this system (Biel et al. 2017; Reckendorf 1998).

In the 1990s, New Zealand was estimated to have approximately 200,000 hectares of backdunes covered with "stands of pine, pasture grasses, gorse and other exotic plants," 55,000 hectares of which were commercial radiata pine forests (McKelvey 1999, 148). Meanwhile, marram, which played a vital role in the creation of these valuable artificial forests, has been likened to a plague. The fight against alien species like marram is not unanimous, with many questioning whether vilifying such species might be counterproductive, suggesting that conservation and management efforts should be more pragmatic on a fast-changing planet where entirely new ecosystems are emerging (Davis et al. 2011). In this context, some argue that returning to a "better" historical state is frequently impractical or even impossible. According to Mark Davis et al., organisms should be assessed based on their environmental impact rather than their origin. In other words, their function should be considered more relevant than whether they are native or alien (Davis et al. 2011). From an environmental history perspective, William Beinart reminds us that depending on place, context, and timeframe, the same plant can be "a useful weed, or a damaging invader" (Beinart 2014, 2, 8), which is exactly the case of *Ammophila arenaria*.

Rabbits are another example of this conflict. Alien to the Northern European dunes, over the centuries, rabbits were either prized for their meat and fur or hated and persecuted for the damage they caused to agriculture, and often blamed for sand drift. Today, rabbits play a role in nature conservation, as they help control the vegetation growing in the dunes. Michael Vina, Ruwan Sampath, and I wrote an article about sand and rabbits in the United Kingdom (Vina, Sampath, and Freitas, 2024), in which we discuss the many lives of rabbits and plants as they assume different statuses according to changeable normative categories. According to Davis et al., biota should not be classified based on "cultural standards of belonging, citizenship, fair play," but managed according to the priorities of and benefits to biodiversity, human health, ecological services, and economies (Davis et al. 2011). However, these priorities and benefits are sociocultural categories as well. As Friederike Gesing (2016, 237) has noted, the importance of keeping ecosystem and species functions is based on their specific usefulness to someone and some end—a human end, of course. Moreover, in the case of New Zealand, among other regions, the discussion on native versus alien species is often associated with the legacies of colonialism and the idea that precolonial nature was pristine before the arrival of imperial species and landscapes. As Gesing argued, there is an "internal contradiction in the discourse, with native plants framed as perfectly adapted, yet at the same time threatened." A contradiction present in the debate surrounding marram, with the plant described as stabilizing dunes but in a wrong, less natural, way, to justify the use of native

plants like pīngao and spinifex, as "a matter of re-establishing and protecting the distinctive Aotearoa New Zealand quality of the coastal landscape" (Gesing 2016, 245).

These different approaches are often connected with ideas of "useful" and "useless" things and "good" and "bad" nature, but there is no "good" or "bad" in nature. The perception that stable dunes are bad and dynamic dunes are good or healthier are just different points of view. Both stable and dynamic dunes are part of the dune system (Delgado-Fernandez, Davidson-Arnott, and Hesp 2019). As Beinart has suggested, it is necessary to "introduce a social and cultural dimension into debates about biodiversity" (Beinart 2014, 22) and landscape management. Because biodiversity and landscape conservation are seldom ever simply about nature. Restoration practices aim to establish ways of moving from the "existing state" to the "desired state" (Doody 2013, 201), but what is this desired state? What is the baseline "desired state" for a dune landscape that has been shaped and reshaped by millennia of climate change and used intensively by humans? The idea of restoring open grassland or heath or even bare sand is often an attempt to "return" to a landscape that was not natural in the first place, but the consequence of intensive grazing by domesticated stock and marram harvesting, among other factors. Where is the ecological fidelity that should be at the core of restoration when "successive layers of human context" (Nordstrom 2008, 12) are an integral part of the system being restored? Similarly, why should a previous layer be more desired or "better" than the existing one? Whole ecosystems are being manipulated in favor of "human perceptions of value" (Delgado-Fernandez, Davidson-Arnott, and Hesp 2019, 7), as humans act to protect their time-bound interests. The subjectivity of these practices should be recognized, as should the way in which they translate an "ongoing self-reflection" (Gesing 2016, 271) of what humans think or imagine nature ought to be.

The concept of building with nature as a new means of safeguarding coastal areas must also be viewed through a critical lens. Nature-based approaches are a growing fashionable business, with enterprises and consortiums presenting them as the ultimate "solution," proposing their large-scale application or selling them as a product guaranteeing safety and quality of life (Deltares n.d.a). Per the webpage of Deltares, the organization responsible for the Sand Motor project,

> We see nature-based solutions as a major component in the infrastructure of the future: they are sustainable, adaptive and resilient. They provide an appropriate response to the additional challenges that our infrastructures will have to cope with in the years ahead.
>
> (Deltares n.d.a)

However, enhancing nature or using it as green infrastructure does not mean working for nature's sake, but harnessing its forces for human well-being. This is still manipulating the system and tailoring it to stakeholder needs.

Sometimes, these claims even infer that it is possible to produce "better natures" (Gesing 2016, 25), or easily replace—following standard guidelines—those that are disappearing, by driving physical and natural processes and optimizing the "use of ecosystem services to achieve new functionality, sustainability and new opportunities for nature" (EcoShape n.d.a). The problem is that such ideas can give the impression that there is nothing wrong with destroying what can be rebuilt. Nature has become a blurred thing, difficult to distinguish from human agency, easily integrated "within the planning, design, construction and operation of engineered projects to serve a wide range or purposes" (Bridges et al. 2018, 5).

If nature can build dunes, why can't we?

In some sectors, there is a belief that coastal landscapes "can be constructed through human engineering" (Bridges et al. 2018, 6). Indeed, the enthusiasm of some about dunes as a natural defense casts them as the global green panacea against sea level rise. This reminds me of a line from my friend Carlos Augusto Ribeiro, a plastics artist: "*contra a maré cremos, crianças, que basta edificar mais cubos e muralhas de areia*"—which loosely translated means, "As children, we believe building more sand walls will stop the tides" (Ribeiro 2011, 119). The point is that humans do not build nature as nature. As Martinez et al. have noted, "independently of how effective the restoration actions were, what we have learned from numerous restoration projects [and history, I must add] at dune sites is that we cannot fully compensate for the ecological functioning of natural processes" (Martínez, Hesp, and Gallego-Fernández 2013a, 334). Moreover, rebuilding, rehabilitating or restoring is not always possible. Coastal resilience is defined as "the inherent ability of the coast to accommodate changes induced by sea level rise, extreme events and occasional human impacts, whilst maintaining the functions fulfilled by the coastal system in the longer term" (EUROSION 2004, 28). In this respect, coastal resilience depends on two main factors: sand and space. More specifically, coastal resilience requires a sediment supply able to keep a positive balance between accretion and erosion, and space because, as the sea rises and the beach retreats, dunes move inland to escape the waves and avoid scarping and overwashing. If dunes cannot migrate they will not survive (Psuty and Ofiara 2002, 190, 216). Simply put, no sand, no space, no dunes. Dunes have a finite capacity.

Since the beginning of the twenty-first century, when EU countries realized that coastal erosion was a major threat and that the cost of protection would be economically unsustainable in the long run, they have invested in coastal resilience by maintaining a favorable sediment status through beach nourishment within specific coastal stretches and diverting development from risk areas (EUROSION 2004). The problem is that "time is running out for sand." Indeed, due to unsustainable exploitation, sand is being removed from natural systems faster than it can be replaced, leading to a global shortage

that is driving up its value and fueling illegal extraction and sand wars (Bendixen et al. 2019). As the journalist Vince Beiser (2018) explained, sand is the world's most overlooked commodity. Although most people do not realize it, sand is a key component of modern civilization from the manufacture of concrete, glass, silicon chips, and fiber-optic cables to land reclamation projects and beach nourishment operations. The extraction of sand from rivers, beaches, and seafloors causes river and shoreline erosion and other major environmental impacts. It is still unclear what the global sand budget is (Torres et al. 2017), but we are betting heavily on sand to protect human development from future coastal hazards. This is a risk given the relative scarcity of this highly sought-after resource and because its extraction has long-term negative impacts on interconnected environmental and socioeconomic systems.

Space is also a troubling issue. In my presentations, I often display photos of Fortaleza, Brazil, or Nazaré, Portugal. These photos show the same three items: the ocean, the beach, and the buildings behind it. "Notice," I tell my audience, "how the only thing standing between us and the sea is a thin line of sand. Do you see that the beach–dune system has no way to move, how cities and infrastructures built too close to the shore block their escape route?" The issue of space is compounded by the fact that the amount of protection provided by the dunes is proportional to their volume and mass, as "higher and wider dunes will provide more buffering than lower and narrower dunes." Having buildings right next to the ocean does not leave room for extensive dune fields (Psuty and Ofiara 2002). As Stephen Mosley has noted, coastal cities and communities—which represent a huge part of the world's urban areas and population—are now on the frontline of rising sea levels and extreme weather events (Mosley 2014, 520). This means that the pressure on natural coastal systems is enormous, but so is the pressure in preserving them to protect people and infrastructure.

Maintaining dunes in developed areas for coastal protection, especially when the sand supply is low and space is restricted, means that humans have to act as permanent keepers of such built landscapes. In Europe, as in the US and other wealthy countries, nature management is politically and socially accepted and citizens are willing to pay for a "product" that offers protection, safe drinking water, recreational areas, and economic revenues (Meulen, Bakker, and Houston 2004). This willingness also includes paying for programs to restore dunes and control exotic species with the goal of conserving rare and endangered species and enhancing wilderness areas (Martínez, Maun, and Psuty 2004). It is widely believed that the economic value of the ecosystem services provided by coastal dunes and their benefits for society are maximized if the beach–dune system is well preserved (Pérez-Maqueo et al. 2013, 298). However, this situation does not reflect global reality.

In the Global South many densely populated coastal areas suffer from the same problems as western developed shores, with large cities menaced by severe sea erosion. A recent study on the socioeconomic impacts of coastal flooding over the twenty-first century points out that developing countries in

South Asia, Southeast Asia, East Asia, and West Africa are the ones where more people will be affected and more damage is expected due to low levels of coastal defense, large populations, and wide flooded areas. The implementation of additional adaptation measures using structural solutions can improve this scenario (Kirezci et al. 2023), but this has costs and not all can pay them. In these and other countries, the issue is not about building dunes as buffer areas or restoring their dynamic properties, but about preventing their destruction. Preventionist strategies are underpinned by the logic that, in the future, it will not be necessary to invest in costly interventions—for which there will be no money—to repair what could have been saved. However, as mentioned before, it is extremely complicated to talk about conservation values in places where people struggle to secure basic subsistence. For example, in Mozambique, 80 percent of the population gets their household fuel (firewood and charcoal), food, medicine, construction materials, and timber from the country's forests. Between 2003 and 2013, the highest rate of deforestation was recorded in the littoral due to agriculture expansion, wood exploitation, uncontrolled burning, and the increase of urban areas and infrastructure. Population growth, urbanization, food production, illegal felling, and mining are considered the biggest threats to Mozambique's forests and dunes (Conselho de Ministros 2020).

This does not mean that nature conservation is not a priority in poorer and developing nations. Mozambique, for example, has several marine protected areas and dunes are protected by law. The problem is the difficulty of applying existing legal frameworks and the prevalence of many unregulated practices. As the *Mozambique Marine Ecosystem Review* has contended, the country faces a dilemma—one not unique to Mozambique—of how to support development and improve the well-being of large, low-income populations living in precarious conditions without destroying the future viability of ecosystems (Pereira et al. 2014, 7). My colleague, the Mozambican geographer Inês Raimundo, conducted interviews with the people of Xai-Xai. In their statements, coastal inhabitants were aware of the environmental consequences of cutting down trees, including how such actions would affect rainfall and bring drought. However, they added, "we are hungry and we need to do something" (Raimundo 2021, 294). In addition to the local population exploiting resources for subsistence, these areas are being impacted by the mega industrial projects proposed or implemented on the coast. Such projects include titanium mining in the dunes of Moma (Nampula) and port construction, like that of Techobanine, which have affected Maputo Special Reserve and Ponta do Ouro Partial Marine Reserve. According to the *Mozambique Marine Ecosystem Review*, the primary problems with these large-scale operations, which are often backed by foreign capital and powerful companies, involve the lack of baseline data to assess their impacts and determine environmental planning, the institutional weakness to ensure monitoring and compensatory measures, and the violation of local communities' land rights (Pereira et al. 2014, 97–98, 100).

In Brazil, such large schemes similarly pose a threat to ecosystems and populations. I have mentioned in Chapter 10 the particular case of Tatajuba.

The Brazilian geographer António Meireles, who has studied this phenomenon, described the harmful impact of international tourism projects invading coastal areas, displacing fisherfolk and indigenous communities from their lands, and destroying their traditional ways of life and culture in order to build huge seaside resorts with five-star hotels, condos, and golf courses. Meireles argued that as long as ecosystem services are treated as commodities with an economic value, their intangible richness will always be undervalued due to the socio-environmental complexities involved. In a world dominated by the global financial market, it is extremely difficult to perceive the value of the ancestral, symbolic, and cultural bonds associated with beaches, dunes, lagoons, and mangroves for traditional and indigenous communities, or their relevance for food and resource security (Meireles 2014, 326).

In Brazil, Mozambique, and many other places, including Europe and the US, environmental issues are deeply linked with social (in)justice—that is, with the marginalization of demographic groups perceived as having less worth and rights than others—and the degradation of ecosystems based on utilitarian views determined by the dominant economic system, which has significant direct or indirect influence with varying degrees of transparency on political decision-making (Solomonian and Di Ruggiero 2021). As Alveirinho Dias told me 20 years ago when we started working together, coastal management is not so much about controlling natural processes as it is about managing people and conflicting perceptions, uses, practices, and expectations.

Final thoughts

What is the elephant in the room when it comes to dunes and coastal management today? Well, there are several elephants; the situation something of a Gordian knot of different subjects. Through the book and this chapter, I have touched on some of these pressing but relatively overlooked issues. I resume them here. First, there is the complexity of natural systems and the cascading effects of human interventions, with their unforeseen long-term consequences. The perfect example of what Ian Hodder (2012) calls the "unruliness of things," these consequences often constitute or create entirely new problems. Second, the cost of the never-ending cycle of the maintenance work of envirotechnical infrastructure, as people invest considerable amounts of labor and technology to sustain certain environments and get caught up in the process of constantly amending them to ensure their existence in the way that they need ecosystems to be (Hodder, 2012, 87, 85–86, 98). Third, the goals and outcomes of human interventions change as the world itself changes. Political and economic shifts, distinct perceptions and ideas, different technologies and knowledge constantly forge new ways of thinking and living on the coast and in relation to the dunes. They foster transformations that leave long-term legacies. Fourth, soft infrastructure can contribute to increased social risks and vulnerabilities by adopting lock-in solutions that give populations a false sense of security, just like hard engineering solutions did before. Soft and hard

structures do not solve the problem of coastal erosion; they only buy us time. Fifth, green infrastructure can also feed the arrogant belief that humans can create better natures than nature itself and that they can repeatedly destroy and restore it without consequence. This highly technocratic view, in particular, can have terrible consequences for some parts of the world, where the issue is not to build better or repair nature, but avoid damaging the existing environment altogether. Finally, the overreliance on green structures overlooks the fact that ecosystem-based adaptation measures will lose their effectiveness as ecosystems reach their own thresholds (IPCC 2023, 18). In the case of dune systems, sand and space are two big ifs, as the former is becoming scarce and the latter is almost non-existent on developed coasts already suffering from sea encroachment.

Notes

1 A video on the Maharees dunes is available via the following link: www.maharees conservation.com/about-maharees/sand-dunes.html
2 See www.mahareesconservation.com
3 More information on these initiatives is available at https://pulchra-schools.eu/2022/05/18/marram-grass-coastal-resilience-and-implementing-nature-based-solutions-in-portmarnock-ireland/ and www.natureconservancy.ca/en/where-we-work/prince-edward-island/events/st-peters-marram-planting.html
4 For more information, see: www.coastalrestorationtrust.org.nz/
5 The website is accessible via the following link: https://naturalresources.wales/SandsofLIFE?lang=en
6 Their website is accessible via the following link: www.savenewboroughforest.org.uk/

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12 Connecting the dots

Toward an open future

In the prologue, I questioned the relevance of examining something perceived as having no consequence, like sand dunes. Dunes are intriguing environments that catch people's attention and imagination. Strange and unusual things have this power. Dunes are perfect for laying the groundwork to talk about coastal areas and the world around this liminal space between land and sea. Global society moved to the littoral during the twentieth century and may soon have to leave as the waters rise. As Melody Jue (2021) has noted of seaweed, dunes are repositories of information and actors and mediums of connection. They mediate between the beach and the archive, as they move from sand materialities to concepts inscribed on paper. By analyzing the dunes that are trapped between pages, activating their potential as stored data, and discovering the reasons for their passage from the beach to some legal text or report at a given moment, the paper dunes of the archives can be read and restored to their original socio-historical contexts and environmental conditions. They provide snapshots of specific periods of life in a particular beach milieu that, when placed in sequence, enable the reconstruction of long-term relationships between people and the coastal environment that extend well beyond the ocean's edge.

Reading the dunes

Oral traditions and legends about dunes are common throughout the world. Some, such as those of the Māori, Native Americans, and Danish fisherfolk, have an ecological basis and provide explanations for their formation, mobility, or vegetation. Most, however, portray the sandhills as fearsome landscapes, pointing to a troubled period when the drifting sands menaced infrastructures and livelihoods. Archaeological and archival evidence support these stories. By cross-referencing scientific data and historical information, it is possible to perceive the occurrence of these slow disasters on different parts of the European coast due to a combination of the climatic conditions of the Little Ice Age and human activities that fueled wind erosion and set the dunes in motion. Other places in the world experienced similar problems. Although

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I was unable to find detailed information, there were sand drift events in both China and Japan in roughly the same time period. In North America and Oceania, sand drift troubles appear to be connected to the arrival of the European settlers.

Contrary to a later view popularized in erudite circles at the end of the eighteenth century, communities were not powerless against the shifting sands. In fact, the populations who settled near, but not on, the coast considered them important complementary territories, where they grazed cattle and collected grasses and wood. Unwritten rules and customs, many of which were posteriorly incorporated into law, indicate the existence of local traditional ecological knowledge, which recommended maintaining and protecting the vegetation cover of the dunes and promoted the planting of marram as the best way to prevent sand drift and reinforce dunes as coastal defenses. When it was not possible to stop the encroaching sand, moving villages and people away from the danger was another common strategy. In fact, one of the most interesting things I observed over the course of my research was how different communities across Europe, seemingly without contact with one another, developed similar coping practices to live with such a dynamic environment.

The idea that dunes were nothing more than barren land was introduced and disseminated by outsiders that did not know the reality of coastal regions. At the end of the eighteenth century, this view was widely spread through learned networks, scientific academies, and books. Describing the sandhills as a terrible threat, erudite men developed these arguments as the basis of the subsequent war against the dunes. Across Europe, they discussed and tested the possibility of stabilizing the moving sand using grasses and trees, including Johan Ulrich Røhl and Erik Viborg in Denmark, J.D. Titius in Poland, Johannes le Francq van Berkhey in Holland, Friedrich August Ludwig von Burgsdorf in Germany, Nicolas Brémontier in France, and José Bonifácio de Andrada e Silva in Portugal. These men did not found new knowledge; rather, they used the ancient strategies of the local populations. Nicolas Brémontier became famous for codifying these oral empirical practices, creating a manual of instructions that others would successfully follow in the decades to come. However, his greatest achievement was to persuade and gain the support of the French administration, setting in motion the large-scale reclamation of the sandy lands of Gascony.

Dune stabilization, in association with modern forestry, "emerged closely intertwined with the modern state as a political and economic entity, as a war state, as a fiscal state, as a welfare state" (Holzl and Oosthoek 2018, 382). The looming image of the sandy wastelands and the dangers of sand drift provided the right excuse for state intervention and dune afforestation. In France, Spain, and Portugal, the cases I examined more closely, dune stabilization throughout the nineteenth and twentieth centuries was driven by the needs of emerging centralized states and administrations, which sought to control people, territories, and resources. Under the premise of fixing the sands, these interventions allowed centralized states to extend their rule over peripheral

coastal areas. Official national histories described this as a fairly consensual process due to its well-known and propagandized benefits, but the reality was much more complicated and harsh. Top-down afforestation initiatives imposed state control on territories with ancestral rights and uses, causing considerable distress to communities and raising new environmental concerns. In several regions, restrictions on the communal use of lands often led to long and sometimes violent clashes. Local populations initially resisted such appropriation, but later, unable to stop the process, became part of it as voluntary or forced labor. Dune stabilization and afforestation extended over more than a century, but they remain socially and ecologically unfinished, troubling tasks.

The practice of sand stabilization spread outside Europe via imperial webs. Indeed, while the times and circumstances differ from one region to another, Cape Cod, Oregon, Chile, South Africa, Australia, New Zealand, Brazil, and Mozambique share many similarities. The arrival of European settlers in these regions, the building of cities on the coast, and the introduction of new agricultural practices—including cattle in areas where no such animals had existed before—and intensive woodland clearing led to the destruction of the grasses and trees covering the dunes. Through their actions, Europeans created an environmental problem that would affect both settler and indigenous populations: namely, sand drift. Meanwhile, some of the newcomers, familiar with the phenomenon in their homeland, introduced a solution they knew to be effective: the planting of marram or *Ammophila arenaria* to fix the sand.

As I followed the dunes from Europe to other continents, I was fascinated by several findings, which I wish to highlight here. First, the similarities between the livelihoods of indigenous peoples and the traditional practices of some European coastal populations, who shared a cautionary principle that led them to avoid living in dangerous places. Their way of life translated what the authors of *Afectividad Ambiental* describe as "*saber vivendo, saber estando*" or the art of inhabiting a familiar territory (Giraldo and Toro 2020, 91). In Portugal, there is a saying, "*a par do rio nem olival nem casario*," which means that one should not build anything permanent near the river (or ocean) because what the water reaches, it takes away ("*onde o rio achega, o rio leva*"). Second, the co-existence of debates and practices related to sand stabilization in different areas of the globe. The problem of sand drift in Cape Cod at the end of the eighteenth century coincided with the occurrence of the same trouble on the other side of the Atlantic, while the discussions and experiments made to stop it in South Africa, Australia, and New Zealand occurred in parallel with those in several European countries in the late nineteenth century. The intricate webs of the empires were fundamental to the circulation of people, knowledge, and species across the Atlantic, Indian, and Pacific oceans. However, these movements were not entirely organized or controlled by imperial entities or personnel; much was due to individuals exchanging information and seeds or carrying books and plants in their luggage. Third, national paths depended on many specific and diverse contexts, but in most countries—with the exception of the United Kingdom, which

considered dune stabilization and afforestation a private sector matter—the state took responsibility for stopping the moving sands and creating wealth in these outer regions through the planting of forests. The newly created national Forest Service and staff training were key in the process. In the case of Mozambique, sand afforestation occurred from the 1930s onwards, not to protect farms and people, but to save lighthouses. In addition to occurring later, Mozambican interventions relied on an exotic tree species, the casuarina, rather than the planting of marram grass.

Ammophila arenaria, the common marram or European beachgrass native to Europe and North Africa and valued for its ability to trap sediments, was once considered the most effective way to stabilize dunes. It was so successful at this task that in some regions outside its endemic geographical area, it actually changed the nature of the dunes, affecting their form and ecology, which had an impact on local flora and fauna. Marram is currently considered invasive in the US, Canada, Argentina, Chile, the Falkland Islands, Australia, and New Zealand. In some of these countries, the efforts to eradicate it are as great as those to plant it more than a century ago. Ideas regarding the usefulness of *Ammophila arenaria* have evolved since its adoption as a "one-size-fits-all" solution. Dunes are no longer thought of in the same way either. The discovery of the beach as a therapeutic site, rapid littoralization and growth of urban areas and activities in the twentieth century, and rise of the "sea, sand, and sun" beach tourism industry have contributed to the progressive destruction of dunes. At the same time, the relevance and contribution of dunes to the equilibrium of the coastal system was perceived. Scientific developments and environmental concerns led to the recognition of the importance of dunes as ecosystem services providers.

Today, dunes are highly valued, often protected by law, and rehabilitated when necessary. This does not mean that the history of the dunes is complete or that it has a happy ending. This shift in perspective is merely the tip of the iceberg. In the past, dunes were exploited by local people and appreciated as coastal protection in areas subject to recurrent sea flooding. They were also misunderstood and considered a nuisance by those who looked at the beach and saw nothing but barren sand and empty land. The image of the dunes was somehow simpler back then. Now it is considerably more ramified. Dunes are valued and protected in some countries, largely those more developed economically with intensively urbanized coastlines. These countries are interested in preserving what is left of their "natural" landscapes and have the financial resources and citizen support to invest millions in beach nourishment and dune reconstruction. These nature-based solutions are now widely regarded as a panacea for coastal protection problems in many parts of the world. However, there are two main issues to consider: the lack of sand and the lack of space. Massive amounts of sand are being removed from natural systems to build the modern world. Meanwhile, the space needed for beaches to evolve naturally was lost as this modern world was built on or next to the shore. The combination of these factors prevents the dunes from working as

sediment reservoirs and moving inland to get away from the rising sea, thereby compromising their ability to act as buffer areas.

While dunes are valued, there is no consensus on how to manage them. Scientists and coastal authorities are divided between sometimes conflicting approaches and options: while some proclaim the importance of maintaining vegetated dunes for coastal protection, others point to the need to keep sand bare in order to promote the biodiversity of the dune environment. I do not have the training required to scientifically evaluate proposals to remove planted forests and exotic vegetation and disturb foredunes to reactivate sand movement, or judge the discussions about what is "good" and "bad" nature and "healthy" or "moribund" natural systems. Nonetheless, as a historian who has closely examined the relationship between people and dunes, I have to say that these management approaches do not seem overly different from the past goal of afforesting dunes in terms of giving them some kind of "utility." We may have different ideas regarding the value of dunes, but we are still trying to shape them based on notions of how we think they should be or can be used.

The conservationist view of dunes held by some is not shared by all. Even where dunes are protected ecosystems, there are other interests—mainly economic—that see them as valuable assets for commercial exploitation. The pressure of real estate on coastal systems is significant in the northern hemisphere, and even more so in some regions of the southern areas. In Brazil, the untamed sands of Ceará, where many indigenous and traditional communities still survive on artisanal fishing and subsistence agriculture, are being sold to international corporations interested in constructing tourist resorts. Wind energy companies are building turbines on the Brazilian coast for the production of clean energy, negatively impacting the dunes. Sand mining and tourism are also problematic in Mozambique. Despite the existence of laws to safeguard coastal environments, these laws are difficult to enforce. Moreover, the populations of Mozambique, as well as many in Brazil and other parts of the world, still depend on the basic resources they collect from the dunes and coastal woodlands for their daily survival, as well as the services they provide to tourists, like the buggy rides in the Jericoacoara Natural Park or staffing the hotels of the Bilene Lagoon.

The various uses and management approaches to dunes, including their conservation, are underpinned by a view of nature as a provider of critical services. Just like with rivers, forests, and wetlands, dunes are steered by human practices to perform specific functions (Carse 2012). These natural elements are thought of and used as infrastructure insofar as they are part of socio-technical systems assembled to secure human values and needs. However, the association of dunes with infrastructure, technology, and engineering can be misleading. Histories about science and technology frequently note the unanticipated outcomes of some experiments, things often taking on a life of their own and becoming subversive agents of change. The unforeseen consequences of the intentional transfer and introduction of marram between and within different parts of the world, fueled by European imperialism, is a

good example of how easily humans lose control of their initiatives and create entirely new problems (Bennett 2020; Kirchberger 2020). The previous generations, as I often read in notes and reports, made decisions with us in mind. They justified many of their actions with the purpose of doing something useful and leaving a better world for their descendants. Instead, many of these actions left us with a heavy burden. Today, we use the same utilitarian arguments to justify the management of ecosystems, often supported by the deceptive conviction that we have better science and technology and can thus do more than our predecessors. When I come across this type of thinking, I remember a line from Olga Tokarczuk's (2019) novel, *Drive Your Plow Over the Bones of the Dead*, in which she questions who divided the world into useless and useful things, pointing out that we all recognize the importance of useful things, but who knows the benefits of the useless. This is a powerful statement, and one that applies perfectly to the case of the dunes. Despised at the end of the nineteenth century, treasured at the beginning of the twenty-first, who knows how dunes will be viewed in the future.

Dunes as an opportunity for creative dissent

Reading the sources, following the little bits of information across physical and digital archives, talking to people, visiting places, I gained some understanding over the dust and chaos of all these scattered, fragmented elements and events. Through them, I could see "the multiplicity of ever-changing factors that influence outcomes, creating systems that are unpredictably complex" (Isenberg 2014, 136–137). The rich and variegated histories I tell about dunes are not narratives of success or failure, dunes are chaotic environments for a human mind. They obey certain rules and order, just not human order and rules. So I write mostly about the attempts to domesticate them, their multivalent lives, interconnected with the lives of others, and the need to understand and accept their dynamism and pluri-directional trajectories. While trying to show such multiplicity, I also have to deal with the fact that "we all want the human experience to make sense" (McNeill 1976, 4). Our individual and collective pursuit of meaning leads us to tell and retell stories and histories, attempting to make sense of things, justify them, and give them a reason and purpose, even when there are none, to feel that we have power over them. This reminds me of Jorge Luis Borges' story about Tlon, a fictional labyrinthine world built by humans to replace the real world. Tlon is a maze, where people get lost. However, because it was devised by humans, it can be deciphered by humans. They thus prefer it to the real world, which is ruled by inhuman laws that they do not control. Borges subsequently concludes, "The world will be Tlon" (Borges 1962, 16). Is this not what the Anthropocene is—an attempt to build a world within a world that humans can master? The belief in the possibility of fixing the dunes and stabilizing the coast is an outcome of the idea of our ability to dominate nature. But, dunes have proven quite unruly. In the process of keeping the dunes as we think they should be, we are the ones who were trapped to continue to repair the problems we created.

Telling stories of dunes is one way to describe the Anthropocene, as they represent our hopes and expectations in relation to the coast and the failure to impose our will on such a wild environment. Our human-built world, which Borges called Tlon, is like the sand that keeps slipping through our fingers, no matter how hard we try to hold it. However, the purpose of my narratives is not to inspire despair, but to present other ways of seeing and thinking about the coastal environment. I wish to draw attention to other possible solutions, ones that have been tried and tested by centuries of lived experience. We look for answers in numbers and computer models that offer and project different possible scenarios for the future, but we can also expand our repertoire of alternatives by exploring the opportunities for dissent within our inherited stories. Alternatives that do not break the world by expertise or divide between humans and nonhumans, that are not abstract or theoretical possibilities, but concrete measures informed by a deeply-rooted knowledge of how to inhabit and be on the coast.

There is no such thing as zero risk at the shore. The idea that it was safe to live in such a dynamic territory was an illusion, if not delusion, of the twentieth century (Sauzeau 2011, 7). We cannot change this, even with the advances of modern technology, but we can deal with it as a society by cultivating resilient and empowered communities. In the process, we must stop treating people as stakeholders, assessing beings and things for their market value, and managing impacts as trade-offs. We have to stop trying to fix nature and start fixing ourselves (Knight 2019, 6; Gesing 2016, 219).

Thinking like a dune

As early as the 1970s, Wallace Kaufman and Orrin Pilkey (1979, 219) noted a conceptual divide in approaches to coastal issues, namely, *erosion* and *migration*. Although these concepts are applied to the same phenomenon, they represent two different views. Where erosion is associated with the "irreparable loss of vital land" that must be prevented, migration underscores the need for the beach to move in order to survive, accepting such dynamism. In the last decades, hard and soft management strategies have been used to deal with coastal variability, trying to stop it completely or allow some movement with the objective of safeguarding the infrastructure and ways of life on the shoreline. Both solutions require a great deal of human intervention and maintenance and not all countries and communities have the resources to implement and sustain such large-scale investments. Thinking long-term, continuing to bet on temporary engineering solutions to resist major forces such as frequent storms and centennial sea level rise is simply not viable. Given the complexity of natural processes and human societies there is no clear one-size-fits-all solution, but long-lasting sustainability is key (Feagin et al. 2015, 7). In this sense, other possibilities have to be explored. Sometimes, the answer to complex questions lies in "what gives the illusion of being simple," because simple solutions are often those that have been practiced since time immemorial (Todd

and Kanngieser 2020, 2). Migration, as Kaufman and Pilkey (1979, 220) remind us, "is itself a survival mechanism," in fact, one of the most basic human and nonhuman strategies in response to larger forces. As historians like Georgina Endfield, Greg Bankoff, and Tim Soens have shown, past populations were remarkably resilient to environmental disturbance as they developed adaptive and transformative capacities that allowed them to absorb impacts and adapt to new circumstances. Dismantling and relocating livelihoods to higher ground (Soens 2018, 145, 154) or inland is one of the oldest solutions for safeguarding against flood waters and shifting sands.

Managed retreat is supported by many scientists and accepted by indigenous and traditional communities that have always lived with nature's variability features (Gesing 2016, 139). It was historically practiced by coastal populations as an adaptation strategy, and was not considered defeat, as it is today, especially by Western societies. In the past, low-tech communities avoided danger by staying away from disaster-prone areas, such as coasts and riverbanks. However, in the twentieth century, populations—shielded by their faith in technological and engineering improvements and the ability to predict and prevent hazards—moved closer to the shore, exposing themselves to greater risk. The wealth concentrated on the coast, the investments made by the state and the private sector, and the relevance of the economic activities that take place at the edge of the ocean feed into an overly optimistic view about recovery and propel the stubborn need to return to normalcy after disaster. Christof Mauch (2014) used the term "phoenix syndrome" to describe the continuous cycle of reconstruction after destruction underpinned by the idea of not allowing defeat by natural forces, but rallying against such threats again and again. In the long run, this obstinance incurs far greater losses and costs than accepting that it is time to leave some disaster-prone areas and move somewhere safer. In this regard, Rosetta Elkin defined retreat as the adoption of "habitation patterns that meaningfully engage processes of landscape," that is, recognizing the landscape as a multilayered habitat produced by multispecies activities and shaped by different events, which means making room for other things to happen, including change. In her book, Rosetta, with whom I share many views, provides several examples of how resettling does not have to be an involuntary forced process, but a collective decision to move away from risk and build news ways of living on the landscape, with a heightened sense of responsibility and respect for the land that is left behind. In this way, retreat is not a surrender, but an "amendatory practice" (Elkin 2022, 4–5, 10–11). If we think in terms of the co-evolution of coasts and humanity, it makes sense that both migrate together to survive the rising seas. Thinking like a dune means moving as one.

The history of the dunes is far from complete; there is still time for people to participate in shaping their legacy. As Frank Rose (2011) has noted, "People want to be immersed. They want to get involved in a story, to carve out a role for themselves, to make it their own." From the residents who plant marram on the dunes of Maharees, Ireland, to the Coastal Care volunteers

who remove marram from the dunes of New Zealand, the efforts of local communities to protect their coasts are driven by such desires, their actions empowering them. According to Stocker and Kennedy (2011, 108), "Fully engaged communities create healthy places and long term futures characterized by creative synergies among cultural, social, ecological and economic imperatives, and by openness to ongoing dialogue among different perspectives." Different solutions need to be tested going forward, with a focus on place-based strategies and small-scale actions able to establish self-regulating systems that require relatively little intervention (Jones, Rooney, and Rhymes 2021, 16) and are adapted to local aims and contexts. We need all the science we can get to meet the challenges, but most of all we need people. People are empowered when they feel that their role is important. Caring and giving attention through small gestures is not a matter of sentimentality, but of nurturing hope.

In this book, I have tried to show that dunes are not only geoforms and ecologies, but cultural artifacts moulded by their relationship with humans. A relationship that has been beautifully captured in stories, films, poems, music, paintings. Emotion, Mexican author Ermilo Abreu Gómez (2023, 46) notes, is also a way of penetrating into the truth of things. Writers have adopted the dunes as unique scenarios, sources of inspiration, and even passionate characters in their own right. I have mentioned Hans-Christian Anderson's *A Story from the Sand Dunes*, Aquilino Ribeiro's *Batalha sem fim*, Kobo Abe's *Woman in the Dunes*, and, of course, Frank Herbert's *Dune*. Dunes have also inspired poets like Eugénio de Andrade, David Mourão-Ferreira, Sophia de Mello Breyner, and Robert Frost, and songwriters—the sandhills captured in the lyrics of songs like "Cover Your Eyes" by Karine Polwart, "Dunes" by the Alabama Shakes, "At the River" by Groove Armada, and "Dunas" by GNR.[1] They feature in art, painted by Jan Van Goyen, Piet Mondrian, Van Gogh, Henry Ossawa Tanner, Ieva Baklane, and Marta Zamarska.[2] They have dedicated museums like the UCCA Dune Art Museum, a subterranean building located under a sand dune on the Aranya Gold Coast Community in China, or the Tottori Sand Dunes Park and Museum in Japan. These are just some examples that illustrate the plural lives of the sandhills. Dunes as history, literature, and art challenge us to think beyond the environmental narrative of chaos and devastation that seems to characterize the Anthropocene. They help us believe in the importance of the small, overlooked things by reminding us that even in dark and tumultuous times, there is beauty and hope. That people do not only destroy. They build, dream, laugh, dance, love, and work for good.

Notes

1 The songs are available here: www.youtube.com/watch?v=ELeZmPDdFPE, www.youtube.com/watch?v=AI6nIJ-anYQ, www.youtube.com/watch?v=rKF46Z9cwNE, www.youtube.com/watch?v=m-uztVX6QFQ, and www.youtube.com/watch?v=4BUJwI8-d88

2 Some paintings are available here: www.saatchiart.com/paintings/dunes/feature

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