

# THE PROBIOTIC PLANET

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Using Life to Manage Life

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TO MAGALI, AMELIE, AND LOUIS  
for foraging, fermentation, and unwavering love and friendship



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# CONTENTS

PREFACE	ix
INTRODUCTION	
Life in the Anthropocene	1
1. The Probiotic Turn: Rewilding and Biome Restoration	25
2. Thinking Like Gaia: The Science of the Probiotic Turn	55
3. Symbiopolitics: Governing through Keystone Species	81
4. Wild Experiments: The Controlled Decontrolling of Ecological Controls	109
5. Geographies of Dysbiosis: The Patchiness of the Probiotic Turn	133
6. Future Pasts: The Temporalities of the Probiotic Turn	161
7. Probiotic Value: Putting Keystone Species to Work	187
CONCLUSIONS	
A Spectrum of Probiotics	213
ACKNOWLEDGMENTS	233
GLOSSARY	237
NOTES	239
BIBLIOGRAPHY	279
INDEX	323



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## PREFACE

THE MANUSCRIPT of *The Probiotic Planet* was completed at the end of 2019 and the book was published at the end of 2020. I write this preface in April 2020 in the midst of the global Covid-19 pandemic. The United Kingdom and many other countries are in lockdown. Universities, schools, and most workplaces are closed. Travel and general mobility are tightly restricted, and citizens are social distancing: keeping apart to try to restrict the spread of the disease. The elderly and the already unwell are dying in greater numbers and a profound economic recession is predicted. A general atmosphere of anxiety, uncertainty, and frustration pervades personal and public discourse.

One on level, it is an unfortunate time to be publishing a book that maps and encourages a probiotic enthusiasm for microbes and other forms of life. We are living through an amplification of the modern, antibiotic approach to managing life. Hands, surfaces, and volumes of air are awash with antimicrobial chemicals, people are panic-buying personal protective equipment to secure their lungs and bodies, and the pressures for distancing and isolation enact boundaries and territories around bodies, homes, and nations. Resources are dedicated to antiviral drugs and vaccines to accelerate the development of immunity. Such a response is understandable, for Covid-19 is a new and lethal pathogen that we must make time to tame and live with.

But as the pandemic hopefully eases and we come to better understand how it emerged and spread, how it was known and experienced, and how such pandemics might be averted in the future, I wager that we might benefit from the types of probiotic thinking and action that are mapped in this book. A probiotic approach involves using life to manage

life; intervening in the ecological dynamics of a system to deliver desired functions and services. Often probiotic approaches use keystone species, or species with disproportionate agency relative to their ecological abundance, to manage ecosystems. Probiotic enthusiasts tend to stress the importance of biological abundance and diversity for delivering the resilience of their target system—from the body to the farm to the nature reserve—and for transforming it to a desired stable state.

Covid-19 is no keystone species. It is a virus, and thus on the margins of the menagerie of forms commonly included in the category of life. As a virus it is also anomalous in its pathogenicity. There is a myriad of viruses, many of which are undescribed, and only a tiny subset is harmful to humans and animals. An even smaller number have the ability to jump species. Covid-19 certainly needs fighting, but it would be a shame if the necessary push for antiviral control results in an amplified fear of nonhuman life and collateral damage to ecological diversity and health.

Probiotic thinkers advocate what Heather Paxson terms a “post-Pasteurian” approach to hygiene and the wider management of non-human life. A post-Pasteurian approach requires a nuanced taxonomy of life-forms and a more selective armory of control methods than the modern antibiotic (or Pasteurian orthodoxy). It retains a vigilant control over specific pathogens, but it also permits the existence of those organisms that restrict the spread of disease and encourages those that deliver desired functions and services. A post-Pasteurian would certainly go after Covid-19, but she would also look at a full range of ecological knowledges and interventions to understand social practices and to enable viral control.

Many people in the urban, Western world live lives cut off from encounters with unruly organisms. We might garden, keep a pet, or ferment, but we are rarely threatened by the vitality of the nonhuman world. With the arrival of Covid-19, many have had to learn how to think like a virus, tuning into the threats posed by a highly mobile infectious agent and adjusting everyday regimes to try to exclude it. Engaged publics are learning about the science of “contact tracing” and its revelations about international, local, and then more intimate domestic movements and infections. Public health officials sketch the viral mobilities enabled by a cough and a sneeze. They encourage us to space ourselves and to choreograph our movements to prevent transmission. We speculate as



to how the virus persists on different surfaces and visualize the microscopic landscapes it inhabits. Anxiously we learn to gauge the temporalities of infection through practices of self-isolation and the experience of illness.

As newly forged microbial citizens, Western publics are developing a degree of ecological awareness that is unprecedented since the advent of antibiotics and the successful eradication of infectious disease. And as with other infectious diseases the ability to dodge the virus and the experience of infection is strongly stratified by socioeconomic status. The virus is laying bare stark inequalities in health care, housing, and economic support.

It is also becoming clear that there is no single way of thinking like a virus, in the same way as there is no single model of probiotic knowledge. As I write, disagreements abound among expert epidemiologists as to the reproduction rate of the virus and its trajectory. Rifts are emerging between deductive mathematical modelers and inductive public health researchers keen to test empirical realities. On the margins of the scientific establishment, maverick figures are advocating off-label and untested antibiotic solutions that find favor among desperate politicians. Covid-19 exposes the powerful strand of anti-Pasteurian expertise and health care that takes issue with mainstream science and medicine. Some populist leaders downplay or deny the etiology and the magnitude of the pandemic to justify business as usual. Alternative experts frame the virus as divine judgment and offer conspiracy theories linking the virus to familiar bogeymen. The internet is awash with retailers peddling alternative cures. In this book I explore how the uncertainties caused by the absence of nonhuman life permit rich epistemic diversity. With Covid-19 we see how the uncertainties and insecurities posed by microbial excess open comparable space for denial, doubt, and debate.

At the time of writing, the ecological drivers of the emergence of Covid-19 are not fully known. One hypothesis links the disease to “wet markets” selling live animals in China and a convoluted multispecies transmission pathway from bat to pangolin to pig to human. Comparable zoonotic diseases like SARS and H5N1 have been linked to the hot spots created by industrial livestock agriculture with its concentration of animal bodies, waste, and antimicrobial chemicals. In either case, it is clear that the intensities and accelerated connections of the

globalized economy and the globalized food system will have played key roles in this pandemic. In disentangling the pathogenesis of Covid-19, it is likely that probiotic thinkers will point to how the novel, simplified, and unstable ecologies of the food system created the ideal “dysbiotic” conditions for disease emergence. They will advocate interventions that de-intensify production to introduce a greater deal of ecological diversity, stability, and control. They may well find that the exuberant application of antibiotic chemicals leaves pathogenic legacies as skin, bodies, and domestic ecologies recover in the aftermath of continued chemical scouring.

The different ways in which nations and citizens are responding to the pandemic scrambles the political and economic orthodoxy in a fashion much more dramatic than in any of the cases I describe in this book. Many of the core functions of modern economies have been suspended. In a fundamental shift in policy after years of austerity, the U.K. government is now providing a basic income and housing the homeless. A furloughed workforce is volunteering in large numbers to care for those in need, and citizens appear carefully in public to applaud a newly discovered category of “key workers”: nurses, carers, supermarket staff, and delivery drivers. This compelling moment of communal solidarity is fragile and conditional. But a crisis precipitated by ecological dysbiosis and nonhuman vitality is making history in ways inexplicable to humanist models of social theory. It remains to be seen whether this newfound recognition in powerful circles of human vulnerability to nonhuman life shifts social relationships and the management of the nonhuman world. Too many microbes are precipitating planetary change, but what new worlds will this pandemic create?

## Introduction

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# LIFE IN THE ANTHROPOCENE

### *The Antibiotic Anthropocene*

In 1983, ecologists working for the Dutch government introduced herds of back-bred cattle and horses into a nature reserve just north of Amsterdam. The animals were left to de-domesticate themselves in the hope that they would restore the naturalistic grazing that had been missing since the rise of modern agriculture. The aim was to simulate the ecological conditions that would have characterized Northern Europe at the end of the last ice age, with the cattle and horses standing in for the extinct aurochs and tarpan. The project was promoted as an act of rewilding, and it has inspired a wider movement for rewilding Europe with large herbivores, predators, and other ecologically significant species.

In 2004, a British immunologist deliberately infected himself with *Necator americanus*, a species of human hookworm. He wanted to explore the old friends hypothesis, which proposes that the rise in autoimmune, allergic, and inflammatory disease in the West is caused by the absence of some microbes with which humans coevolved. Having demonstrated that it was safe to host the worms, which remain common in tropical areas, he began a clinical trial to test their therapeutic potential for training and exercising the human immune system. Popular interest in the human microbiome and this ecoimmunology has inspired a network of DIY helminth users, who raise, share, sell, and host a variety of worms for the purposes of biome restoration.

Rewilding and biome restoration are exemplary of a probiotic turn that is underway in the management of life in some parts of the WEIRD (Western, Educated, Industrialized, Rich, and Democratic) world.<sup>1</sup> I use

the adjective “probiotic” in an expansive sense to describe human interventions that use life to manage life, working with biological and geomorphic processes to deliver forms of human, environmental, and even planetary health.<sup>2</sup> Going probiotic goes well beyond a preference for live yogurt; it links a range of efforts that aim to change the composition of biophysical systems to modulate the rhythms and intensities of their ecological interactions. These projects look for tipping points within these ecologies and manage their dynamics so that they stay within desired boundaries. They control, restore, and enhance the functioning of ecosystems to secure a desired set of systemic properties—in these two cases, biodiversity and immunity.

This book wagers that this probiotic turn can be detected across a range of ecological scales and science and policy domains that are generally conceived in isolation. Further microscale examples include the wider use of probiotic microbes and biotherapeutic organisms (like leeches and maggots), and the adoption of prebiotic diets and lifestyles designed to foster their emergence and survival.<sup>3</sup> It is evidenced in emerging health and hygiene practices that nurture microbial life on the body and in the built environment. These develop targeted approaches that differentiate between good and bad germs and that manage human microbial exposure across the life course.<sup>4</sup> They extend to the long-standing approaches of permaculture, organic farming, and biological pest control.<sup>5</sup> Going probiotic involves the selection and engineering of organisms for bioremediation and waste management, alongside the revived interest in fermentation in food processing.<sup>6</sup> The probiotic interest in rewilding is part of a wider rethinking of the management of biophysical systems, including forms of natural flood management and coastal realignment,<sup>7</sup> localized methods for weather modification,<sup>8</sup> and nature-based, planetary-scale schemes for geoengineering through afforestation, ocean seeding, or solar radiation management.<sup>9</sup>

Advocates position these probiotic innovations as antidotes to the pathologies caused by modern, antibiotic ways of managing life. Like the term “probiotic,” I use “antibiotic” in an expansive sense to mean much more than a class of pharmaceuticals that restricts the growth of specific microbes. Being antibiotic describes systematic efforts to secure the Human through the control of unruly ecologies. It involves efforts to eradicate, control, rationalize, and simplify life that are common

across landscapes, cities, homes, and bodies. It describes the scientific and political developments in the nineteenth and twentieth centuries that led to economic growth, food surpluses, and disease eradication. In going antibiotic, bodies have been purified, cities sanitized, and some natural environments made safe, productive, and orderly. Many human lives have been extended and made better. But in recent decades, scientists and citizens have in many cases considered this antibiotic approach to be excessive; obsessions with purity, division, simplicity, and control lead to blowback and the emergence of new pathologies.<sup>10</sup> Modern modes of managing life and the earth may be disturbing and intensifying natural processes, helping drive the planetary transition into the Anthropocene.

Environmentalists were among the first to flag the pathologies of modern natural resource management.<sup>11</sup> They demonstrated how the rationalization of environmental processes (like reproduction, grazing, predation, flooding, and fire) can undermine the functionality of ecological systems and cause extinctions. Agriculturalists warned that the simplification, standardization, and intensification of modern farming can lead to soil degradation, can cause the death of pollinators, and can create hot spots for disease emergence.<sup>12</sup> Meanwhile, doctors have raised concerns that modern antibiotic drugs, diets, health care, and lifestyles are creating widespread dysbiosis in the collection of microscopic organisms that live in, on, and around the human body known as the human microbiome.<sup>13</sup> Missing microbes might account for recent increases in allergic, inflammatory, and autoimmune diseases.<sup>14</sup> There is great anxiety that the use and abuse of antimicrobial chemicals accelerates the evolution and spread of drug resistance.<sup>15</sup> On a planetary scale, earth systems scientists caution that the earth is approaching critical boundaries as a result of the Anthropocene's great acceleration in fossil fuel consumption.<sup>16</sup> These scientists suggest that the planet is close to tipping out of Holocene conditions and moving into a new state that might become pathological to all but the hardiest forms of life.

These diagnoses of antibiotic blowback offer a profound critique of modern dreams of mastery and progress. They have been met by denial, obfuscation, and deferment, particularly when they threaten the political economic order and lack simple technological solutions. Subsequent popular responses have tended to fall in two opposing directions. One aims for a techno-optimistic amplification of the status quo: one final

effort to achieve our Enlightenment destiny as a God species capable of ecological planetary control.<sup>17</sup> Better technology, better government, and more science and reason will save the day through an accelerationist vision of ecological modernization.<sup>18</sup> The other looks backward, promoting a return to idealized premodern or paleo pasts. We will be taken back to Nature through less technology, less government, and less science and reason. As Bruno Latour observes, seen this way, an otherwise heterogeneous collection of policies and practices consistently array civilization and its futures along a linear development trajectory. We are offered either more of the same or a retreat into history.<sup>19</sup>

While these popular twentieth-century responses to the pathologies of antibiotic ways of managing life certainly inform the probiotic turn, it is also being shaped by more contemporaneous anxieties that call into question some of the certainties of modern and antimodern environmentalism as well as health care. For example, those involved in rewilding must come to terms with how the diagnosis of the Anthropocene undermines the idea of a stable earth—an earth that provides the background to human history and is a source of timeless value. Although this argument predates the political event of the Anthropocene, conservationists have come to realize that there really is no longer a nature to which we can return. Similarly, although on a different scale, the figure of the human as an unraveling holobiont<sup>20</sup>—a multispecies chimera that is kept alive, sane, and rational by its microbes—unsettles the modern idea of health as the absence of microbes and of the Human as a mind in a vat.<sup>21</sup> The probiotic turn is influenced by the more-than-human intellectual zeitgeist catalyzed by the Anthropocene and microbiome, which questions these modern ontological reference points and the “more of the same” or “back to nature” programs they inform.

This zeitgeist is also evidenced in a common challenge, made by prominent advocates of going probiotic, to reductionist scientific epistemologies that model life as adhering to universal and mechanistic laws on which firm predictions can be made. Probiotic approaches that use life to manage life pull at the binary and linear models of resource management that are founded on them.<sup>22</sup> Probiotic thinking must thus grapple with the contemporary “postepistemological” or “posttruth” condition of a world marked by uncertainty and complexity, the slipperiness of which has compounded a growing distrust in science among some publics

and in some parts of politics.<sup>23</sup> The probiotic diagnosis of the false promises of modern ways of managing life, as well as a growing awareness of their inherent pathologies, has weakened the modern settlement between science and politics, and between science and its publics.<sup>24</sup> Here objective and rational scientists generate knowledge outside of society and in advance of politics. Such knowledge is provided to policy makers, who receive it with gratitude and deference, then use it to shape the publics in its image. This has always been a straw man depiction, but the end of Nature and the Human, as well as the loss of certainty, have led to the proliferation of knowledge claims and controversies, the formulation of new modes of expertise, and the proliferation of novel forums in which publics engage (and disengage) with science and technology.<sup>25</sup>

The probiotic turn is happening at a contemporary juncture in which common anxieties about ecological dependency, dysbiosis, and precarity profoundly challenge modern approaches to health and environmental management, animate a range of ecomodernist and reactionary alternatives, and prompt a far-reaching consideration of the futures of progress, prosperity, and multispecies survival. I do not want to overstate my case. The probiotic turn is not an emic category used by the actors whose stories I report; no one talks of going probiotic in such terms. It is not synchronized across policy domains. Some of these practices are novel; others have longer histories. Nor is it occurring everywhere with the same intensity; it has a geography. Many of these practices are marginal and contested; they also differ in important ways. Nonetheless, in this book, I hope to demonstrate that they represent a coherent and important shift in how life is conceived and managed in parts of the WEIRD world.

To be clear from the outset, this book is not a celebration of the triumph of ecological thinking. The probiotic turn is not a panacea for planetary health. No single technological or governmental solution is going to fix the current political and ecological juncture. Nor is there only one way of going probiotic. Instead, in this book, I have two initial aims. The first is to specify the probiotic turn, identifying the common characteristics of probiotic approaches to managing life and providing rich empirical illustration of their practice, history, and variety. The second is to critically analyze the different manifestations of probiotic thought and practice. The probiotic turn has promise, but it requires

close critical differentiation. There are many different ways to go probiotic, each of which has different beneficiaries.

### *What Does It Mean to Go Probiotic?*

The probiotic approach to managing life has six general characteristics; these are composed of a common scientific ontology, mode of biopolitics, approach to knowledge production, relational geography, temporality, and political ecology. These are the respective subjects of chapters 2 to 7, and I will summarize them below. I focus this exposition on the cases of rewilding and biome restoration with which I opened this chapter, and which are my principal empirical reference points.

The probiotic turn is founded on a common scientific conceptual framework in which the world and its constituent parts form a nonlinear but nonetheless self-regulating system—or, better, a system of nested systems. Borrowing from the work Donna Haraway, Bruno Latour, and Isabelle Stengers, I describe this as a Gaian ontology, after the influential work of James Lovelock and Lynn Margulis.<sup>26</sup> Probiotic scientists, thinking like Gaia, are preoccupied with evolutionary and ecological relationships as well as the ways living organisms shape and are shaped by their environments. These scientists think in cycles; they concern themselves with feedback loops with the potential to modulate or amplify ecological change. They focus on questions of symbiosis and symbiogenesis—the reciprocal, coevolutionary relationships and dependencies between life-forms—as well as the ways these configure the structure, intensities, and dynamics of ecologies, climates, and geomorphologies. This science stretches and subverts the neo-Darwinian figure of the bounded human individual, emphasizing both its microbial composition and its planetary entanglements.

In my examples, probiotic science is especially concerned with keystone species—that is, the subset of organisms with disproportionate ecological importance resulting from their location within ecological networks. Some species, like wolves, beavers, or earthworms, are capable of configuring entire landscapes through their effects on the food chain or their ecosystem engineering. In the absence of this engineering, or the top-down regulation performed by their ecological interactions, ecologies tip into degraded and dysfunctional conditions. Ecologists



and immunologists describe dysbiotic human populations marked by missing microbes and a planet haunted by extinct or diminished keystone species as a result of antibiotic modes of managing life. Research attention focuses on mapping the shape or topology of ecological interaction networks, identifying keystone species and tipping points, then designing and testing experiments to revert ecologies to their desired composition and functionality. Here the planet and its component systems adhere to multiple stable states, few of which are provident for human life. Gaia is neither vengeful nor beneficent but rather is agitated and in transition. Humans figure centrally in these novel ecosystems, naturalized as a “hyperkeystone species” capable of both disaster and remedy.<sup>27</sup>

This Gaian ontostory of nested systems shaped by symbiotic relations informs a common set of management practices that are geared toward nurturing and modulating ecological dynamics to secure the delivery of desired ecological functions and services. In chapter 3, I explain how this approach involves the strategic deployment of keystone species within and beyond human bodies, and targeted interventions to create ecological conditions conducive to their flourishing. These mechanisms range across nested scales, from the nature reserves that are the targets of rewilding to the human bodies that are subject to biome restoration. Probiotic governance is targeted at the conduct of individual humans and animals; it also involves interventions into populations of keystone species. However, the ultimate aim is to transform the dynamics of the ecologies with which they are entangled, working from the bodies of animals out to the planetary concentration and circulation of atmospheric gases. In using life to manage life, probiotic governance differs markedly from the command-and-control logics of modern antibiotic approaches to human and environmental health.

Informed by Michel Foucault and those who have further developed his work, I suggest we understand probiotic governance as a novel mode of environmental biopower that works on and through human subjects to modulate the dynamics of socioecological systems.<sup>28</sup> This involves shaping the knowing conduct of human actors through what I term holobiont governmentalities. This concept describes how the scientific figure of the human as a holobiont is enrolled to legitimate new projects and practices of probiotic subject formation that recalibrate

human encounters with animals, microbes and the wider environment. These interventions seek to enable ecological change. Taboo modern elements like dirt, rot, damp, and mess are given salutary probiotic potential. Probiotic governance also involves symbiopolitics (a term I borrow from Stefan Helmreich): the application of keystone species or anthropogenic surrogates to modulate the intensities of symbiotic relationships to deliver ecological functions and services.<sup>29</sup> These two forms of power are discursively and materially connected, but they involve different methods and targets for governmental action. The first targets the self-aware behaviors of the human host; the second focuses on the dynamics of nested ecosystems. Both come to shape the lives of the humans and animals that are governed as and through populations of keystone species. Probiotic governance has similarities with other efforts to institutionalize systems biology—for example, to deliver biosecurity or resilience.<sup>30</sup>

Drawing on Heather Paxson's work on the biopolitics of raw-milk cheese production, I suggest we see the probiotic turn as a post-Pasteurian recalibration, rather than a rejection, of antibiotic management practices.<sup>31</sup> Probiotic governance involves a nuanced differentiation between beneficial and unruly organisms and the "controlled decontrolling of ecological controls" to put them to work.<sup>32</sup> This symbiopolitics requires a different set of knowledge practices to those that predominate modernist science. A Gaian ontology of novel ecosystems offers deeply uncertain and complex foundations on which to legitimate ecological management decisions. There is no singular Nature to which scientists or politicians can make recourse; publics, in all their emergent heterogeneity, can be caught up in the conduct and analysis of any probiotic experiment. In chapter 4, I explore how, in grappling with this reality, probiotic knowledge makers have shuttled between the scientific truth spots of the laboratory and the field site. They have observed natural experiments in which keystone species have gone missing or made their own self-willed return. They have also designed experiments in nature, managing clinical and countryside settings to monitor change and test hypotheses. They have arrived, somewhat uneasily, at a model of real-world (or what Clemens Driessen and I have previously termed "wild") experiments that involve working closely with unruly ecologies and publics.<sup>33</sup>

The diverse scientists involved in these wild experiments dedicate much of their time to mapping ecological interactions and nonlinear

processes.<sup>34</sup> They develop their ways of thinking in cycles, flows, and feedbacks. They refine apparatus for detecting the ecological anachronisms and vacuums left by the absence of coevolved ghost species, and they seek data and models to disclose how ecosystems are wired and rewired by keystone species. But some of these scientists, and the citizens with whom they interact, also seek to hack their focal ecologies, conducting open-ended experiments, sometimes at the edge of the law, to see what happens when keystone species are introduced.<sup>35</sup> They learn to be affected by their subject organisms, developing craft skills and experience to understand novel ecological interactions.<sup>36</sup> This hacking values the epistemic potential of surprises, developing public methods to nurture and apprehend unpredictable and nonanalog ecological dynamics. The probiotic turn is marked by an uneasy constellation of these mapping and hacking practices that generates a lively knowledge politics. Advocates disagree over what the wild is, and how it might be known, valued, and managed.

There are stark and unequal geographies to the probiotic turn in terms of where its science is developed and applied, and in the distribution of its benefits and impacts, which I trace in chapter 5. Going probiotic involves developing mutually beneficial relations with species and processes, many of which (like wolves or helminths) have previously threatened human existence or health, and which have been subject to concerted programs for control or eradication. These keystone species can be understood as pathobionts, or organisms that are not inherently good or bad but whose role is configured by their ecological context. They can be parasites (who depredate their hosts), ghosts (whose absence causes ecological dysbiosis), and mutualists (whose presence benefits their hosts). The possibility of going probiotic with such organisms is strongly configured by political, economic, and ecological relations. The situations in which designed mutualistic (or Mutualism 2.0) relations are feasible have a common geography that is patchy and uneven, and interdependent on relations elsewhere. Probiotic relations are predominantly confined to specific parts of the temperate, white WEIRD world in which life was already tightly controlled and the resources for controlled decontrolling are readily available.

There are parts of the non-WEIRD world that have yet to be made subject to antibiotic ecological relations, where people may live in

preantibiotic and mutualistic relations with keystone species. There is a complex geography here, but these areas tend to be rural, poor, and Black, and they tend to involve traditional or indigenous ecological relationships. But the political-ecological intensities experienced by people and places in many less affluent parts of the world may also tip relations so that keystone species become parasitic, leading to deleterious accumulations, dysbiosis, or even death—for example, in the accumulation of helminth infections among those living in plantation political ecologies. Given the magnitude of antibiotic global management in both the macrobiome and the microbiome, the majority of the world is haunted by some degree of ghostly relations. Dysfunctional, “trophically degraded”<sup>37</sup> ecologies and human “epidemics of absence”<sup>38</sup> are now the norm. But the human experience of this haunting is strongly configured by compounding exposure to other parasites and by their differential ability to access artificial surrogates for missing keystone species, like immunosuppressant drugs or pest-control products. Many people thus experience a doubled dysbiosis of lost old-friend microbes and amplified exposure to (drug-resistant) crowd infections.<sup>39</sup> The possibility of going probiotic is thus largely an elite experience, and one that reflects and is maintained by longer histories of global exchange and exploitation. The probiotic turn cannot be read as a linear universal trend in a progressivist history of world development.

If the probiotic turn has a common, patchy geography, then it also evidences a common temporality. The stories told by advocates of going probiotic are founded on a history that frames the present as a critical inflection point, one occurring at a moment of crisis and engendered by the pathologies of modern, antibiotic approaches to managing life. Probiotic proponents present themselves as seers, visionaries able to look back in time in order to diagnose the problems of the present, dismiss rival contemporaneous solutions, and herald new restorative futures. That is, they offer future pasts.<sup>40</sup> On the one hand, their ecological politics is often profoundly retrospective, advocating rewilding, biome restoration, back-breeding, and de-domestication, for example. They look to past baselines to identify desired ecological conditions. They tell revisionist histories that challenge the linear and triumphalist narratives of Western agriculture and health care, tracing ecological unraveling through the premodern and then modern periods. On the other hand,

such seers are prospecting into the future and are anticipating novel ecologies. They seek functional landscapes that will emerge along unexpected pathways. The quality of these desired future pasts is not directly indexed to the authenticity of historical reenactment. Instead it involves a recalibration of human ecologies and their keystone species. The historical reference points for these future pasts range from the postpaleo to a postpastoral, both of which signal the centrality of agriculture and domestication to contemporary anxieties about when the wild was, and how it was lost. As I trace in chapter 6, this retrospective periodization permits some dark, reactionary, and ecofascist models of going probiotic.

The final common dimension to the probiotic turn is a consistent political economy marked by a drive to value the ecological work done by keystone species in economic terms. This involves a range of discursive, legal, and financial practices that depart from established methods of bestowing value. Certain organisms are afforded higher value by virtue of the types of ecological work they do. Keystone species shift from being pests (like hookworms) or resources (like cattle or beavers) and come to the fore as idealized ecosystem engineers: skilled and well-networked middle managers that coordinate the activities of others in a nonhuman division of labor. They figure as a source of nonhuman intelligence, a model for biomimicry and the creation of artificial surrogates. Keystone species thus become lively commodities involved in ecological work, and exchanged and sold in different economic formations.<sup>41</sup>

This naturalization of nonhuman work involves a range of proprietary practices through which a once open source resource (like abundant worms or beavers) is first turned into common property, then privatized as a source of nonhuman intellectual property. Sometimes keystone species become natural capital; other times, they remain in common. Yet rarely are they permitted to live in an unalienated relationship with their own means of (re)production. This process instigates what Jessica Dempsey terms an “ecological–economic tribunal for life,” one in which the future survival of a species or other ecological component is indexed to its functional utility.<sup>42</sup> But this framing is partial and incomplete, and is resisted by a range of human and nonhuman actors let loose by a “ticklish Gaia.”<sup>43</sup> The nonhuman elements of Gaia proliferate in ways that caution against the hubris of some of the more ambitious dreams of probiotic planetary control.

Taken together, these six dimensions provide us with a first approximation of the common characteristics of going probiotic. They offer a means of distinguishing it from its antibiotic antecedents, and they serve as useful foci for critically differentiating ways of going probiotic; the overview provided above masks a great deal of political and ecological heterogeneity. To lay out the conceptual underpinnings for my analysis of this difference, I must make a detour into social theory.

### *Why Gaia, and Why Now?*

This book is not a traditional work of science studies that reports a history of probiotic ideas or the coproduction of probiotic science and society. It does a bit of both of those things, but it is also interested in the manifestations of the probiotic turn in social theory. It tracks a triangular relationship between probiotic science, its social context, and an emerging body of probiotic social theory. More specifically, one of my aims is to critically examine the convergence between strands of new materialist and environmentalist thinking in the social sciences and the Gaian science associated with the probiotic turn. This convergence comes in several forms. The most prominent comprises the collaborations among social theorists and some of the microbiologists, immunologists, ecologists, and earth systems scientists involved in the probiotic turn. The outcome is an increasingly normative body of ecologized social theory that aims to diagnose and address the problems caused by modern antibiotic modes of biopolitics, or ways of conceiving and managing life.

French anthropologist Bruno Latour has been collaborating and writing with earth systems scientists (and even sought an audience with James Lovelock, the purveyor of the Gaia hypothesis, now a hundred years old).<sup>44</sup> He defends Gaia as scientific framework and has developed and promoted a synoptic version of Gaian thinking in books on how science and politics might be conjoined in the “new climatic regime.”<sup>45</sup> Similarly, feminist science studies scholar Donna Haraway has long admired the work of Lynn Margulis, and has maintained close links with those involved in developing the field of ecological evolutionary developmental biology, to which Margulis’s science gave rise. Haraway promotes Margulis’s science in several of her essays as well as in her collaborations with biologists Scott Gilbert and Margaret McFall-Ngai.<sup>46</sup> Finally,

anthropologist Anna Tsing has collaborated with Haraway and some of these scientists while also working with ecologists central to rewilding, like Jens-Christian Svenning.<sup>47</sup> These transdisciplinary collaborations have been enabled by a series of high-profile and well-resourced research programs that have taken the Anthropocene and the microbiome as generative provocations for new forms of academic, artistic, and literary endeavor.<sup>48</sup>

Reading across this work, we can establish that prominent figures see a turn to Gaian science as a solution to two key challenges that social theory faces in the early years of the twenty-first century. First, Gaian thinking offers a palatable liberal and ecological political ontology—or ontostory<sup>49</sup>—for rematerializing theory after the idealist excesses of the cultural turn. Second, it provides common epistemic ground for rebuilding alliances with the natural sciences after the science wars, and in the face of rising science denialism. I will take these two points in turn. In the aftermath of eugenics, the Holocaust, and the environmental determinism of some colonial scholarship, much Western social theory disavowed materialist accounts of the world that sought explanations for, and justifications of, social patterns in biological, climatological, or geomorphic phenomena. In a now well-told history, influential strands of critical theory presented the social as a realm of signs, symbols, and discourse peopled by disembodied human minds. Culture was separated from nature, and critical attention focused on how the latter was used to construct or naturalize the former.

Special attention was paid to the late twentieth-century rise and influence of neo-Darwinian sociobiology. This depiction of selfish and violent individual actors, struggling to survive and reproduce in a world without top-down regulation, was taken as patriarchal, neoliberal theory parading as biology.<sup>50</sup> In contrast, Haraway, Latour, and others make an alliance with the ontostory of Gaia and of symbiosis because it provides a markedly different model of social and multispecies relations. The postmodern synthesis in biology, which is gradually superseding the modern synthesis of Darwinian natural selection and Mendelian genetics, places greater emphasis on reciprocal and mutualistic interactions, marked by tolerance, dialogue, and communication. We learn of the lateral (rather than vertical) exchange of biological materials, and the environmental context (or niche) of an organism is afforded much more

importance in shaping and regulating behavior.<sup>51</sup> The selfish individual is subsumed within a wider ecology. When coupled with the planetary models of earth systems science, this communitarian, self-regulating model entangles the human in the earth, challenging the reductionism and anthropocentrism of some forms of social Darwinism.<sup>52</sup> As Haraway puts it, “The order is re-knitted: human beings are with and of the earth and the biotic and abiotic powers of this earth are the main story.”<sup>53</sup> It is not hard to see why this science provides an appealing worldview for liberal left academics concerned with social inequality and ecological degradation. It offers Latour grounds to ecologize politics, bringing them “down to Earth” to “face Gaia.”<sup>54</sup> Writing in *Science* with earth system scientist Timothy Lenton, he argues,

Earth has now entered a new epoch called the Anthropocene, and humans are beginning to become aware of the global consequences of their actions. As a result, deliberate self-regulation—from personal action to global geoengineering schemes—is either happening or imminently possible. Making such conscious choices to operate within Gaia constitutes a fundamental new state of Gaia, which we call Gaia 2.0. By emphasizing the agency of life-forms and their ability to set goals, Gaia 2.0 may be an effective framework for fostering global sustainability.<sup>55</sup>

Latour is careful to note that Gaia is not an organized totality with teleology, and is neither vengeful nor providential in its inclinations toward life. But Latour’s return to earth and his investment in an earth systems science framework for global governance are indicative of the rise of a wider “general ecology” among prominent thinkers and political theorists, the ranks of which include new materialist illuminati like Jane Bennett, William Connelly, Timothy Morton, and Cary Wolfe.<sup>56</sup>

For Latour in particular, Gaian thinking also offers new epistemic grounds for social theorists to collaborate with scientists. The potential planetary changes it makes tractable provide a clear imperative for why they should do so. Latour comes to Gaia after a long and distinguished career dedicated to placing science in its social context, tracing the practices, networks, and power games through which specific accounts of the natural world come to prominence. Though he was far less of an idealist than some of his science studies colleagues, his interventions helped critique a powerful political epistemology of natural science (as outside



of society and politics) and revealed its social construction. Latterly, and somewhat remorsefully, Latour has come to observe how such methods are mirrored by those who doubt or deny the science of climate change. Critique, for Latour, “runs out of steam” when it is aligned with these “obscurantist” projects, shorn of any epistemological or materialist grounds.<sup>57</sup>

Going on the offensive (and drawing on both Haraway and Stengers), Latour proposes a new model of “composition” in which social and natural scientists collaborate with each other, and with publics, to develop new forms of knowledge and new models of deliberative democracy. The indeterminacy of Gaia here offers grounds for epistemic pluralism and political action.<sup>58</sup> More concretely, Haraway and Tsing have used Gaian thinking to ground interdisciplinary research programs that foster “arts of living on a damaged planet.”<sup>59</sup> On the basis of long histories of friendship and social interaction, trust and mutual respect, they have worked with natural scientists to develop and refine new “arts of noticing”:<sup>60</sup> knowledge practices that enable the types of composition envisaged by Latour. Tsing describes these as “transdisciplinary mutualisms,”<sup>61</sup> or experiments that cut across the spaces of knowledge production, spanning the field, the laboratory, and the studio, and folding together disparate representational idioms including opera, film, craft, and writing.<sup>62</sup> In keeping with the Anthropocene zeitgeist, Haraway and Tsing also engage with science fiction as a way of bridging epistemic difference.<sup>63</sup>

This rapprochement between critical social theory and science is historically striking and important. It is also politically vital in the context of the problems by which it is propelled. In this book, I share these figures’ enthusiasm for transdisciplinary collaboration while thinking critically about the terms of reengagement and the ends to which such Gaian science might be put.

### *Going Probiotic Otherwise*

The probiotic turn in science, politics, and new materialist theory has been greeted with rather more skepticism by other social theorists, and it is to their criticisms that I now turn because they help identify some of the criteria I will use to differentiate ways of going probiotic. Three issues stand out here: scientism, quietism, and hubris.

Sympathetic critics of the new materialist turn in the social sciences have expressed concern about the epistemic grounds on which some prominent thinkers have engaged with the model ecosystems offered by the Gaian natural sciences. For Heather Paxson and Stefan Helmreich, model ecosystems are “contemporary tools that scientists . . . use to describe desires for exemplary ways of studying human entanglements with nonhuman agencies.”<sup>64</sup> Models do important epistemic work, but they also operate “in a prescriptive sense, as tokens of how organisms and human ecological relations with them *could*, *should*, or *might* be.”<sup>65</sup> Paxson and Helmreich are concerned that new normative desires to ground social and ecological projects in biological science might occlude scientific uncertainty and heterogeneity, thus causing us to lose sight of the practices through which scientific knowledge is generated and legitimated. They caution that some “new materialist tactics often veer toward universalizing metaphysical claims about the nature of ‘matter’ as such and also, at times, take scientific truth claims about the world at face value—a move that we consider a step backward.”<sup>66</sup> In a specific example, they cite a review by Maureen O’Malley of a book by Myra Hird, who develops Margulis’s science toward a microbial ethics, worrying that “by removing from the picture how the science was done as well as the ongoing revisability and contestability of microbiological findings, we are left with the sense that there is a fount of straightforwardly produced and accepted knowledge from which we can drink.”<sup>67</sup>

Bruce Braun voices similar criticisms about the work of Jane Bennett, noting a surprising lack of reflexivity among some new materialists and a tendency toward scientism:

In looking to the natural sciences the (new materialist) literature too often takes “science” to speak in one voice, or in what often amounts to the same thing, draws selectively from the natural sciences in order to find the ideas and concepts it needs, ignoring science’s heterogeneity and side-stepping vibrant internal debate over models and paradigms. . . . There is an irony here, for even as many new materialists propose an ontology that is non-deterministic and non-teleological, they often deploy a very different epistemological position when it comes to the emergence of their ideas, which are viewed as universal rather than particular, and necessary rather than contingent: the world

is marked by indeterminacy and contingency, except when it comes to theories of indeterminacy and contingency!<sup>68</sup>

These criticisms are not directed at Haraway or Latour, whose training in science studies informs more transparent and nuanced accounts of their epistemic alliances with Gaian science.<sup>69</sup> But the risk of scientism serves as a useful warning for the alliance with science I make in the analysis of the probiotic turn that follows—one I hope to address by paying close attention to the practices of probiotic science (chapter 4) as well as the geographical, historical, and political economic contexts in which this knowledge is produced (chapters 5 to 7, respectively).

A second and connected set of criticisms accuses probiotic social theorists and scientists of a political quietism: that an end of critique and alliance with science risks downgrading the role of the theorist to speak truth to power, to challenge the status quo, and to imagine and advocate for transformative alternatives. This case is made most forcefully by a group of geographers and political scientists concerned with what David Chandler terms the “ontopolitics of the Anthropocene”: emerging frameworks of knowledge and governance that fold the uncertain, planetary science of disturbed, or ticklish, earth systems into the management of human and nonhuman life.<sup>70</sup> Chandler, Sara Nelson, Stephanie Wakefield, and others have identified two tendencies in this work.

The first, and most significant, examines the governance of environmental and economic systems that are framed as on the verge of tipping points, where the potential for collapse is folded into the governance of the present in regimes for biosecurity and environmental security. They trace a long history in which policy makers have borrowed concepts from ecology and systems biology to forge a “resilience dispositif”—a powerful mode of adaptive governance, enabled by the Gaian science of resilience thinking, the primary aim of which is to secure the (often unjust and unsustainable) status quo in the face of coming disasters, be they climatic, economic, or microbiological.<sup>71</sup> Here a particular strand of new ecological thinking is understood to naturalize neoliberal modes of social and ecological organization.<sup>72</sup> Chandler and others do not direct their critique at Latour and his compositionalist model; indeed, Latour himself does not make explicit use of resilience as an organizing concept in his high-level reformulation of global governance

for Gaia 2.0. However, but there are commonalities worthy of further investigation.

Second, Chandler and Wakefield identify a contrasting tendency in the ontopolitics of the Anthropocene to affirm life amid the blasted ruins of landscapes destroyed by capitalist modernity.<sup>73</sup> They argue that this genre is best exemplified in the writings of Tsing on the political ecologies of global matsutake mushroom collection and exchange.<sup>74</sup> Tsing's work focuses on ecologies that have already been tipped into novel and degraded political and ecological conditions by colonial and capitalist development. Such ecologies are marked by extinction as well as by the proliferation of undesired forms of life, like pathogens and invasive species. But these ecologies also evidence the precarious, multispecies survival strategies of those living amid the ruins, which sometimes enable socioecological "resurgence"—a term Tsing differentiates from resilience, and that she takes to describe the emergence of desired ecologies and livelihoods.<sup>75</sup> In spite of its critique of neoliberal capitalisms, Chandler and others take issue with this affirmation of ruins. They suggest it too willingly gives up on progress, science, and the possibilities of reworking modernity. It diminishes human potential and struggles to think beyond capitalist economic models.

Out of this critique of resilience and ruins, a range of thinkers has sketched a third model of ontopolitics, one in which a politicized engagement with Gaian science (especially resilience thinking) helps critique the status quo, attending in particular to the political and economic relationships that come to configure the unequal experience of ecological change across a wide range of scales. This work stokes up critique (to rework Latour's metaphor), developing an experimental political ecology that can "transform" the unequal, proprietary, and anthropocentric character of antibiotic modes of managing life.<sup>76</sup> The aim is to find and nurture just and sustainable ways of responding to what Isabelle Stengers calls "the intrusion of Gaia" into social theory: salvaging some of the tools of modernity to build better communal futures along trajectories that are "orthogonal" (after Latour) to popular alternatives of ecological modernization or reactionary retreat.<sup>77</sup> The most vibrant strands of this work are found in novel feminist and eco-Marxist thinking that engages with how the material properties of animals, ecologies, and geophysical systems configure neoliberal capitalism to both enable and constrain alternative futures.<sup>78</sup>

The third and final criticism of the traffic of Gaian thinking into social theory comes from the new materialists, voiced by theorists like Clare Colebrook, Nigel Clark, Elizabeth Povinelli, and Kathryn Yusoff, who are concerned with “geopower” and who write from indigenous, feminist, and postcolonial perspectives.<sup>79</sup> In different ways, they caution that a celebration of symbiosis risks maintaining the anthropocentrism of modern theory as well as its preoccupations with human survival and the management of life. They suggest that the probiotic turn in social theory does not fully acknowledge the “radical asymmetry” of geological processes (we need them much more than they need us), the vast longevity of earth’s history, and the magnitude of disruption that will follow from the now unavoidable end of Holocene conditions.<sup>80</sup> They caution that aspirations for biopolitics (however affirmative or ecological) are hubristic and ill-fated.

Their work develops a much darker, sometimes apocalyptic environmentalism that at the very least provides a necessary corrective to some of the bright green probiotic dreams of the techno-optimist ecomodernists that will be encountered in this book. Often written from the perspective of those on the front line of Anthropocenic antibiotic change, their writings offer profound philosophical and empirical lessons in “learning to die in the Anthropocene,” where learning to die involves less the literal end of life and more a willingness to experiment with alternative modes of becoming otherwise as the planet passes into, and perhaps beyond, the coming disaster.<sup>81</sup> I engage with these ideas throughout my analysis, attending to situations in which the aftermath of antibiotic interventions or the unpredicted outcomes of probiotic experiments give glimpses of alternative—sometimes inhuman—political ecological futures.

Taken together, this body of probiotic social theory, including both its advocates and its skeptics, provides the conceptual tools I use to differentiate and critique the probiotic turn in chapters 4 to 7 of this book. I return to my evaluation of the relationships between Gaian science, contemporary ecological crises, and probiotic social theory in the conclusion. The ways of going probiotic that I suggest hint at the many ways there are of facing Gaia—and the many Gaias that one might face. I focus in particular on how approaches to going probiotic differ with regard to the hoary themes of humanism, progress, and justice. Through

this parsing of probiotic diversity, I evaluate the epistemic and critical potential of a transformative model of Gaian social theory that makes a careful, political, and humble alliance with Gaian science.

### *Methods*

This book makes some rather grand claims, which makes it necessary to provide details about my methods and evidence. The arguments I develop are informed by nearly a decade of empirical research. Some of this I did alone; some I conducted with PhD students, postdoctoral researchers, and colleagues. I am a human geographer by training, but even as a geographer, I deploy a somewhat heterodox methodology and disciplinary praxis. Geography has given me a diverse and generous discipline that tolerates a wide range of empirical interests and epistemic commitments. Being a geographer, I spend nearly as much time conversing and collaborating with natural scientists as I do with social scientists. Teaching geography in an institution dedicated to small group tutorials, I read my colleagues' work and help students make sense of their writings. Although I am not trained as an ecologist or an earth systems scientist, I spend a lot of time around them. My interest in the microbiome has taken me outside of geography and into the companionship of a network of microbiologists. I helped found the Oxford Interdisciplinary Microbiome Project, and I led an interdisciplinary research group exploring the microbiome of the domestic environment. I was taught microbiology by scientific friends and have had to teach it to the publics involved in these research activities. In different ways, these institutional commitments have led me to partially inhabit the worlds of Gaian scientists, who give me space to ask questions, develop hypotheses, and road test some of the ideas in this book. I intend this book to be read as a conversation with this science rather than a distanced critique. There is too much at stake to forego transdisciplinary collaboration.

I have deployed a more formal set of methods for tracing the probiotic turn in science. I read science journals to track general trends, and I have set e-mail alerts to notify me of themes of interest. I follow key scientists and science journalists on social media and read popular science books. Chapter 2 is based on a more systematic reading of the scientific literature on earth systems science and the microbiome, with

specific focus on rewilding and ecoimmunology, the two examples of the probiotic turn that feature most prominently in this book. While I can't claim to fully understand the technical details and methods of these fields, my reading identifies their key ontological principles, concepts, and metaphors. I read this literature guided by existing work in the history of science—especially on the histories of ecology, immunology, and conservation biology—to better understand their precursors and the significance of the trends I trace. I look for disagreement and dissent; I also note the absence of conversations across what would seem to be related domains.

My analysis was further developed through interviews with over fifty microbiologists, immunologists, and ecologists whose work I was reading. I spoke to them on the phone or visited them in their laboratories, offices, and field sites. I asked for clarification of key methods and concepts, gained unpublished insights, and was also able to rehearse my argument of a probiotic turn. Several of my informants were kind enough to demonstrate their research, and I witnessed probiotic science in action in the context of rewilding in situ, in the laboratory, and in clinical experiments with microbes. I developed my understanding of the social worlds and epistemic character of probiotic science by attending several conferences and workshops, sometimes presenting my own work on rewilding and participatory microbiology. In the chapters that follow, I tend to cite these scientists' published papers, but my analysis is strongly shaped by my firsthand conversations and field observations.

However, the probiotic turn is not only a scientific event. Researching its public dimensions required a further set of methods, tailored more explicitly to my case studies, which I discuss in more detail in the following chapter. In both examples, I spent time accessing the popular literature and visual culture of rewilding and biome restoration, following how they were presented and discussed in legacy and social media, and on film. For biome restoration in particular, I joined a set of social media support groups and spent time witnessing the social interactions of advice, support, and conspiracy that characterize this virtual space. Through this virtual ethnography, I was able to identify at least twenty key informants among the DIY communities who are using worms and human feces to treat a range of health conditions. Speaking to further participants and reading their accounts, I learned how to raise a worm colony

at home, and how to know when one's worms are doing well. I spoke to those who organize the online networks that made these microbes widely available, and I traced the legal and regulatory challenges they face in distributing their organisms across a range of national jurisdictions.

Understanding the social dimensions of rewilding took me and my collaborators to a range of field sites and archive locations. Part of the analysis presented in this book draws on work I undertook with Clemens Driessen on the history and politics of rewilding in the Netherlands. Clemens carried out extensive archival research in Germany tracing the back-breeding of Heck cattle. He also conducted interviews with those involved in their contemporary reintroduction for rewilding Europe. I draw on these materials in chapter 6. I also visited several of the best-established examples of rewilding in Germany, the Netherlands, and the United Kingdom, including the Knepp Wildland Project in Sussex and the various beaver reintroduction projects in Devon, Scotland, and Bavaria. I spoke with those leading these projects as well as with various local supporters and opponents. I also sought out examples of self-willed rewilding—like the wild boar in Europe—by soliciting interviews with enthusiasts for their return and reading popular coverage of the legal, political, and economic challenges they pose.

### *A Guide to Reading*

I anticipate that this book will have a range of readers who will come to it with different backgrounds and interests. It uses a diverse range of social and natural scientific terminology, not all of which will be familiar to everyone. I have provided a glossary of key terms at the end of the book. *Probiotic Planet* is designed to be read from start to finish. The book's first part provides an overview of the probiotic turn, and the second offers a critical appraisal. I would encourage everyone to read chapter 1, which provides a detailed overview of rewilding and biome restoration, and which introduces the specific case studies that feature in the chapters that follow. Chapter 1 also provides a more substantial discussion of the differences between an antibiotic and probiotic approach, and it gives more detail on the probiotic turn as it manifests in other domains of knowledge and action, including food, agriculture, and waste and environmental management. This chapter justifies why we might



take rewilding and biome restoration as indicative of wider trends across these other domains. Chapters 2 to 7 then work through the six characteristics of the probiotic turn. Chapter 2 summarizes the common elements of probiotic Gaian science, chapter 3 covers the governance practices this informs, and chapter 4 looks at the knowledge practices from which it is developed. Then chapter 5 maps the unequal geography of the probiotic turn, chapter 6 traces its temporalities, and chapter 7 turns to its political economy. The conclusion returns to the three broad aims of the book and draws out its contributions.

