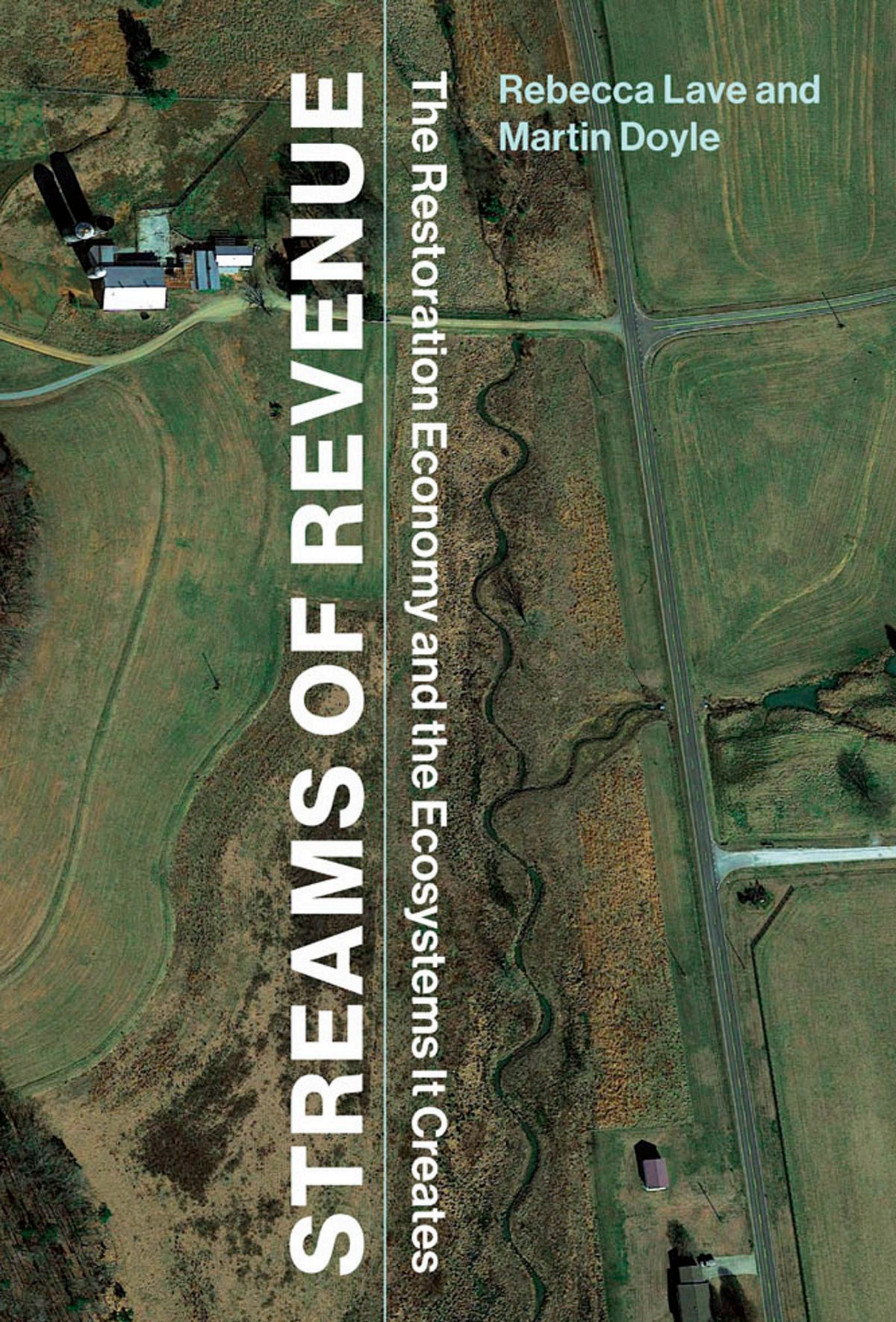

STREAMS OF REVENUE

The Restoration Economy and the Ecosystems It Creates

Rebecca Lave and
Martin Doyle

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Preface

One of the most influential, and perhaps surprising, developments in environmental policy in recent decades is the idea that we can protect the environment from the negative impacts of economic development by making environmental protection itself more economic. The goal is to reduce environmental harm not by preventing it, but by pricing it. Want to build a housing development on a piece of land threaded with streams? With an environmental market in place, you can do that as long as you pay to offset the damage through restoration of comparable streams elsewhere. Or, in an example that may be more familiar, want to keep emitting greenhouse gases? Fine. You just have to buy carbon credits produced by reducing emissions at another site. Starting in the early 1990s, U.S. environmental policy has supplemented command-and-control regulation (thou shalt not) with market-based approaches (thou shalt pay for your harm) in an attempt to improve conservation outcomes. There are now many environmental markets in the United States (and internationally) that are intended to improve conservation outcomes for everything from prairies and streams to woodpeckers and flowering shrubs.

Even in the United States, where capitalism has long been something close to a national religion, this shift toward market-based environmental management raised some eyebrows. There have been heated debates about economic theory, ecological value, and the details of policy. But at this point in time, environmental markets in the United States are more than two decades old and are firmly established. Haphazard, deliberately vague, and patchy policies have been smoothed out and (at least to some extent) standardized. What is not at all clear is whether these markets have actually improved environmental well-being. This book is the first sustained

attempt to find out. Using stream mitigation banking (the market for rivers and streams under Section 404 of the Clean Water Act) as a case, we explain where market-based approaches came from, how they work in practice, and what they do on the ground.

Rivers and streams in the United States could use some help, as they have taken quite a pounding since European settlers arrived. They have been straightened, shortened, and put in pipes underground. They have been dammed, diverted, and cut off from their floodplains. They have been dredged, buried in sediment, and dredged again, and they have been polluted to the point of biological death. Almost anytime there was a choice between the well-being of a stream and human ease, the stream lost.

Efforts to prevent or at least undo harm to streams began in the late 1800s, but only grew legislative teeth in late 1960s and early 1970s. The Clean Water Act, in particular, was spectacularly successful in many ways. As one example, it is now possible to swim in most rivers and streams in the United States without having to take a heavy course of antibiotics afterward. The question is how to get us the rest of the way: how do we prevent further harms to rivers and streams, and even improve their ecological, chemical, and physical character and function? Can a market for streams do what command-and-control legislation has (thus far at least) failed to do?

The answer to the latter question is no, or at least not yet. The idea of allowing much-needed development to harm ecosystems as long as we restore comparable ecosystems elsewhere turns out to be quite hard to operationalize. It is very difficult to ensure equivalence between ecosystems that are harmed and those that are restored. Further, we are not yet able to reliably restore most (perhaps all) ecosystem types; natural systems are highly complex, and we are far from understanding the full scope of that complexity, much less being able to reproduce it. Finally, in addition to being complex, ecosystems are messy, dynamic, and highly interconnected; standardizing them into simple, tradeable commodities in order to create robust markets is certainly doable, but it raises unsettling questions about what, if anything, such simplified versions of ecosystems actually achieve. We thus argue that ecosystem service markets, very much including stream mitigation banking, have not delivered on the conservation goals of their advocates and should be radically reconfigured.

We have written this book with a strong emphasis on clarity and accessibility. We hope it will reach multiple audiences, from those of you studying

to become environmental managers in the public, private, or nonprofit sector to those of you who already do such work. At some point in your careers, it is very likely that you will be asked to help set up an environmental market, to keep an existing one running, or to manage a project that is part of a market. This book has much of what you need to know about where these markets come from and how they work in practice. You will not find heavy theory or science in here, but suggested readings in the endnotes provide entrance points if you want to dive in. We also hope this book will be of interest to river scientists trying to figure out what is going on at their field sites, to ecological and environmental economists who have been central to conceptualizing and critiquing market-based approaches, and to advocacy groups evaluating whether or not to support pricing environmental harms.

The stakes here are high. We humans damage the world around us in many ways. Regulations are intended to limit that damage: to provide a ceiling beyond which environmental degradation should not rise. If market-based approaches cannot build and secure that ceiling, we need to change them.

Acknowledgments

This book was a long time in the making. Our first conversation about mitigation banking (in fact, our first conversation ever) took place by phone in 2006 when Rebecca was a graduate student at UC Berkeley and Martin was an assistant professor at the University of North Carolina.[1] In the thirteen years since, we submitted, resubmitted, resubmitted again, and finally won a grant from the National Science Foundation to fund this work (BCS 1213827), conducted research throughout the United States, wrote multiple articles, gave dozens of talks on environmental markets, switched institutions, and during all of that time were physically in the same room fewer than half a dozen times. Nevertheless, there has been a consistency in idea-sharing that has been unusually productive and delightful, and allowed us to sustain the project over time and space.

Throughout this process, we collaborated with Morgan Robertson, a political ecologist at the University of Wisconsin and one of the most knowledgeable people on the planet on wetland mitigation banking. Though he did not help to write this book, many of the ideas we present here are a product of more than a decade of collaboration and discussion in which he was an integral part.

The social science component of this project was entirely dependent on people's willingness to talk with us. Our human subjects protocol does not allow us to list you by name, but there is no way we could have done this work without you, and we are immensely grateful. Thank you!

We are also grateful to colleagues both inside and outside academia who helped to frame this project and hone its results. At Indiana University (where Rebecca is now), Ilana Gershon, Tom Gieryn, and Eden Medina listened to and reflected on multiple iterations of this work. At the University of North Carolina and at Duke University, Todd BenDor and Emily

Bernhardt were thought partners throughout much of the work. Frank Magilligan and Margaret Palmer have helped us wrangle this sprawling subject into coherence over the years. Although we never formally interviewed them as part of this research, Palmer Hough and Eric Somerville at the EPA provided very useful historical context on the development of mitigation banking, as did Dave Owen. Doug Thompson has been a wealth of information and understanding about the historical roots of restoration in the early twentieth century; we drew heavily on his painstaking and excellent work. David Lansing helped us come to grips with the literature on carbon credits. Most recently, as we were developing the argument in the last section of the conclusion to this book, timely critical feedback from colleagues at the University of Cambridge revealed some important holes in our thinking.

A number of graduate students helped with aspects of this research. Julia Ferguson and David Gordon were part of the initial nationwide survey of stream mitigation banking that helped us pick the states where we focused our work. Curtis Pomilia helped with transcription and Susan Powell tracked down the roots of mitigation in environmental policy. Jai Singh collected much of the geomorphic data in North Carolina and Eric Nost was involved throughout, most particularly with our research in Oregon.

At the MIT Press, Beth Clevenger provided thoughtful feedback and great enthusiasm (and if you've ever written a book, you know how precious the latter bit can be), and the manuscript review process has been simply fantastic.

Rebecca's Acknowledgments

Hooray for my colleagues in the Geography Department at Indiana University for creating such a positive and respectful work environment, and for embracing the unfamiliar in accepting monographs as legit scholarly products. Indiana University, more broadly, has been an unusually supportive institution for me. My community here in Bloomington has been a consistent source of comradery and outrageously good food: Steph, Reynard, Sarah, Tessa, Charles, Sara, Mark, Kylie, Eric, Cristian, Eden, Ilana, David, Maria, and Edgar, among many others. I am so grateful to have landed here given the deep weirdness of the academic job market. I continue to be inspired by my kickass colleagues outside IU. Particular thanks to Julie Guthman, Becky Mansfield, Kendra McSweeney and Wendy Wolford for

helping me navigate the gendered absurdities of academic life, and to Phil Mirowski and Sam Randalls, who were there in the early days of this project, helping me to think better, smarter, and more deeply about the political economy of environmental science.

Sam and Nell make everything better with dumb jokes, thoughtful company, and unfailing encouragement to channel Bone Claw Mother rather than Midwestern Nice Girl.

I am profoundly grateful that unlike my previous book, this one was not steeped in untimely losses, though Ruth Gibson Snyder (1917–2016) is still much missed.

Last thing: working with Martin for nearly fifteen years, particularly the process of cowriting this book, has been an entertaining, thought-provoking, and egalitarian collaboration. I will miss working with you, my friend!

Martin's Acknowledgments

I began talking to regulators and mitigation bankers in North Carolina fifteen years ago, and over that time, their patience in educating me, willingness to take repetitive phone calls, and readiness to review all manner of my writing have been tremendous. Most notable are Adam Riggsbee, John Preyer, George Howard, George Kelly, Todd Tugwell, Steve Martin, and Dave Lekson, among many others. Mike Wicker (U.S. Fish & Wildlife Service) has played a consistent, behind-the-scenes role in steering mitigation banking toward positive results, and in encouraging academics to research the benefits and detriments of banking; streams, rivers, and wetlands in North Carolina have benefitted tremendously from his efforts. Two mitigation bankers deserve particular credit, or blame, for my interest in working on mitigation banking: Don Carr and Bud Needham. I regret that Don passed away before this book was finished; Bud and I lost a guide through the policy swamps of Washington, DC, and a great friend. The restored ecosystem at Timberlake is a fitting tribute to Don's relentless vision of how mitigation banking can leave lasting benefits for ecosystems, and particularly for birds.

Finally, working on this project has required me to read books and think thoughts that are far beyond my normal intellectual universe. I would not have done so had it not been for Rebecca's contagious intellectual enthusiasm.

1 Introduction

Martin Dairy Creek used to be a weed-lined, straight-as-an-arrow ditch, passing through pastures and farms in rural North Carolina. The channel itself was a few feet wide and a couple feet deep, and rarely carried more than an inch or two of water, situated as it was in the headwaters of the watershed. The channel had been straightened decades earlier and its banks had since begun to erode, creating mixtures of wide, raw banks along some reaches and large silty bars on the streambed in others. The constant erosion and deposition of sediment degraded the habitat and made life challenging for any fish or aquatic insects that tried to make a home in this typical rural American waterway.

Then in 2017, bulldozers arrived. Martin Dairy Creek's banks were stripped bare of vegetation to make room for a platoon of big yellow machines that set to work remeandering the creek. The channel was reformed to be shallower and slightly wider, with near-*perfectly* regular meander bends. Small, adolescent trees were planted in carefully spaced sequences and patterns along the creek's banks, each the same height and age. A series of nearly identical riffles were constructed, each with well-sorted, well-placed gravel and cobble. A mostly innocuous, occasionally rambunctious rural creek had been transformed into an elegant, symmetrical work of engineering. Like a road or a bridge, this creek was now very clearly designed and constructed (figure 1.1).

On the opposite side of the planet, in Australia, sits the terrestrial equivalent of this carefully rationalized aquatic system. This particular landscape had previously been a mixture of forest and farmland. Now, however, there are rows upon rows of trees, mainly eucalyptus, but also large uniform expanses of pine trees. Each tree is the same age, having all been planted

Figure 1.1
Aerial image of Martin Dairy Creek, North Carolina. The stream flows from top to bottom, with the portion upstream of the farm road being unrestored—and perfectly straight—while the downstream portion is restored into almost perfectly symmetrical sine wave meander bends.

simultaneously. Each tree is equidistant from its neighbors. This forest did not accumulate over time by natural process, or by piecemeal, uncoordinated decisions of various landowners; like the stream in North Carolina, this Australian forest was planned, designed, and constructed.[1]

There is something not quite natural about these ecosystems and their clean, symmetrical forms. There is no confusing the perfectly proportioned stream with its unruly, unmodified kin, nor the linear rows of trees with an old growth forest (though not all carbon forests are so obviously designed, there are no rules that encourage more natural planting plans). In each case, these ecosystems have been made visually coherent and biophysically distinct from their surroundings. They have pieces that are comparable to other systems—trees, riffles, meander bends—and individually make sense, but are startlingly artificial when combined. They are now strange ecosystems to behold.

Reconfiguring ecosystems to suit human desires is not new. What is newer is that each of these systems was modified under the banner of ecological restoration; they were "restored." Humans intervened in an ecosystem they considered degraded in an attempt to return it to health. And what is really new, only a few decades old, is the rationale for restoring these disparate systems: "the market." Like a rapidly growing number of ecosystems around the world, they were restored to create a novel type of commodity. The buyers of these odd ecosystems, however, were not interested in owning a wiggly creek or a linear forest; in most cases these individuals or organizations never set eyes on the ecosystems they purchased. The buyers of these ecosystems only did so because they were required to participate in a particular environmental market, making them participants in a broader, nascent restoration economy.

Buying and selling ecosystems through environmental markets has been the subject of volumes of research. Such markets have drawn advocates and critics, engaged in debate ranging from appropriate treatment of economic minutiae to whether markets and the burgeoning restoration economy can save us from the impending catastrophe of climate change.

But the debates have largely sidestepped the question of just what kind of landscapes these new markets might produce. Behind every environmental market transaction there is an ecosystem: an actual place whose biophysical conditions are changed when capital changes hands. These ecosystems are the manifestations of environmental markets. These ecosystems—with all

their potential for artificiality and contrived nature—bear the fingerprints of the market's invisible hand; they are the manifestation of the restoration economy.

Selling Nature in Order to Save It

The environmental movement has long worked to protect nature from the most destructive impulses of capitalism. Whether by setting aside protected areas like national parks to be preserved from human disturbance, moderating the use of timber or fisheries to produce sustainable yields, or restoring ecosystems to undo anthropogenic harm, the goal of environmental conservation often has been to force the invisible hand of the market to squeeze the natural world a little less tightly. Now, market forces—channeling capitalism, or bending it at least—are increasingly seen as the best, perhaps only way to save nature.

The idea that traditional forms of environmental regulation are insufficient, and that we should sell nature in order to save it, began gaining traction in the 1980s. It is now firmly, if surprisingly, established in environmental policy circles, promoted by presidential administrations as otherwise distinct as those of Obama and Trump. The notable early successes of the Clean Water Act in improving water quality in places like Cleveland, or of the Endangered Species Act in bringing iconic species such as bald eagles back from the brink of extinction are often dismissed as costly and inefficient. In their place, a broad range of market-based policy approaches have been proposed, from cap and trade to eco-labeling to impact investing. These quite different policy frameworks share a core claim that would have been anathema to most environmentalists even twenty years ago (and still is to many): the path forward is not to protect nature from capitalism, but to tie the two together as tightly as possible. The approaches of major environmental organizations are harbingers of this change: the World Wildlife Fund and The Nature Conservancy (TNC) have major programs now on corporate engagement, environmental markets, and impact investing, with TNC going so far as starting its own investment banking operation—NatureVest.

This is a momentous shift in thinking about the environment, and it has been hotly debated in the United States and internationally. Rather

than refight those battles, this book is centered on a more pragmatic pair of questions:

> What does it take to put market-based approaches into practice? And what are the tangible consequences for ecosystems of doing so?

To answer these questions, we focus on one of the oldest and most robust environmental markets: stream mitigation banking under the Clean Water Act. While seemingly mundane, or even innocuous, stream mitigation banking is often held up as an exemplar for how markets can be created, adapted, and scaled in terms of economic and ecological impact.

Markets for Ecosystem Services

Ecosystem services is a catchall term for the things nature provides society free of charge, such as the crop pollination provided by bees, or wetlands' utility as giant natural water filters. Many environmental markets focus on putting a monetary value on those services, and then creating the conditions that make it possible to sell them. The many varieties of what are referred to as *markets for ecosystem services* (MES) share a common set of claims: (1) growing human needs for housing, food, transportation, employment, and so on, make at least some amount of ongoing environmental damage inevitable, and given that we cannot stop development; (2) the best approach is to stop trying to prevent negative environmental impacts and instead require compensation for them. Imagine, for instance, a proposed factory that would provide much-needed new jobs, but would have the environmental consequence of paving over a wetland if allowed to be built on the proposed site. Instead of insisting that the factory owner find another site, or cease the project altogether, an MES approach would require the owner to quantify the ecosystem services lost through wetland impacts (known as *debits*), and then to buy an equivalent or greater amount of the same ecosystem services (known as *credits*) produced by restoring an equivalent degraded wetland elsewhere. Effectively, MES are commodity markets, although the commodity for sale is not a crop or production input, such as grain or timber, but is instead the service provided by a particular ecosystem.

We describe such markets in detail in chapter 2, but for now the key thing to note is that while calculating debits and offsetting them through

the purchase of credits sounds straightforward, it is remarkably complex in practice. Making a standardized, saleable commodity out of complex, messy, above all *interconnected* ecosystems and their services turns out to be substantially harder than making a commodity out of trees or wheat. For example, how can we be sure that the particularities of the wetland to be restored are equivalent to the unique characteristics of the wetland that would be lost at the proposed factory site? And how do we cope with the myriad uncertainties of whether we can even restore wetlands in general, let alone restore the functions lost from this particular wetland in this particular place?

These are thorny questions. Each market grapples with them in different ways, from the simplified approaches used to trade endangered species habitat to the almost unwieldly complexity of carbon credits (both discussed in more detail in the next chapter). What is perhaps most notable—given the common portrayal of MES as a leap forward in achieving environmental goals—is how little we know about how these projects are put together in practice and what their outcomes actually are. Most pointedly, what kinds of ecosystems do MES produce? To answer that question, this book presents a detailed empirical study of the intertwined physical and social processes at work in a specific ecosystem service market from conception to construction to implementation, moving from ideas of what an ecosystem should be to what actually exists in the ground when a market-based, restored ecosystem is constructed.

Stream Mitigation Banking

The specific market that we examine is for stream ecosystems, the industry, practice, and political economy of which are subsumed under the phrase *stream mitigation banking*. The 1972 Clean Water Act (CWA) was intended to protect the chemical, biological, and physical integrity of the "waters of the United States." A particular part of the CWA—Section 404—requires that anyone physically impacting a water of the United States, including streams, must get permission from the federal government to do so: they must receive a 404 permit. While Congress likely assumed that the regulatory agencies implementing the CWA—the U.S. Army Corps of Engineers (Corps of Engineers) and the Environmental Protection Agency (EPA)—

would deny many permits to prevent harm to these ecosystems, the vast majority of permits have been granted, as the agencies have yielded to the political costs of limiting development, be it new homes, factories, or roads.

Rather than deny permits altogether to protect the nation's freshwater ecosystems, the agencies arrived at a workaround known as the *mitigation sequence*: avoid impacts, reduce impacts, and only then compensate for any unavoidable impacts. In practice, however, it turned out to be far more politically palatable to let developers offset their project's impacts on a stream by restoring a comparable stream elsewhere than to ask them to rework the project to avoid or reduce its impacts altogether. While developers initially did the restoration themselves, a new approach arose in the late 1990s—stream mitigation banking. Under this system, an entrepreneur would speculatively restore an ecosystem and generate a "bank" of stream credits. These credits could then be sold to developers to fulfill the permit requirements set by the regulators—the Corps of Engineers and the EPA. In theory, as more mitigation banks emerged in an area, developers would have multiple bankers competing for their business. This competition could thus create market-like conditions for stream restoration credits.[2]

Over a two-decade period—from 1998 to 2018—the regulations and practice of stream mitigation banking evolved from a series of isolated, bespoke, one-off curiosities to a well-regulated industry and the beginnings of a "restoration economy." The first stream mitigation bank was approved in 1998 in North Carolina. A wide variety of developers subsequently went to the stream market—from shopping mall developers to state highway departments to public utilities and airports—and as a result more than one thousand stream mitigation banks were in operation in forty states as of 2018.[3]

Overview of the Book

Social scientists have studied (and often critiqued) the underlying rationales of market-based environmental management; for their part, biophysical scientists have studied (and, likewise, often critiqued) the underlying assumptions of ecological restoration, most typically by examining the failures of particular projects. That has left unexamined everything in between. What does it take to go from the idea of MES to actual functioning

markets? Just as important, what are the specific environmental consequences of the markets once created? What is actually constructed on the landscape as the end result of an ecosystem service market, and what decisions had to be made along the way in order for it to be built that way? Tracing the path of a particular market allows us to understand the interrelations of policies, science, concepts, personal relationships, engineering, and standards of practice that underlie any environmental regulatory market.

This book is about that path, from start to finish. By tracing the process of creating an ecosystem service market from conceptual beginnings to physical manifestations, we can begin to understand its fingerprint on the landscape. We trace the roots of stream mitigation banking, the challenges of balancing ecological and economic concerns, and the physical consequences of how we have done so to date. The history and evolution of stream mitigation banking are particular, but not unusual; all environmental markets will have a similar genesis, evolution, and implementation, contorting science, policy, and politics to create a market and the commodities for sale within it. Although market-based environmental approaches, including stream mitigation banking, are thus far relatively minor in global economic terms, their potential impacts are deeply consequential: environmental policy shapes the landscapes around us and determines the long-term prospects of vulnerable species, ecosystems, and human communities. As markets have become a preferred regulatory instrument for environmental policy, their actual operation and effect, rather than theoretical underpinnings, becomes critical to society.

The chapters in this book are loosely grouped into three sections. The first (chapters 2, 3, and 4) considers what a market for ecosystem services is and does, and how one was created for streams. The second (chapters 5 and 6) draws on our fifteen years of social and physical fieldwork across several states, but primarily in North Carolina, to explain the various parties involved in making stream mitigation banking function, and how they go about accomplishing this. The final section (chapters 7 and 8) describes what we know about the actual environmental consequences of stream mitigation banking, particularly whether the market that was created delivers on ecological promises and expectations.

More specifically, chapter 2 provides an overview of MES in theory and practice, focusing on the challenges that all ecosystem service markets face

in addressing what we consider to be the two key negotiated elements of any such market: reconciling equivalence and uncertainty. How do MES policy-makers balance the conflicting goals of economic and ecological functionality? How does that vary across different kinds of ecosystem markets, whether carbon markets or habitat for endangered woodpeckers? Chapter 3 introduces readers to the history of stream restoration, and the relevant science and engineering necessary for any ecosystem service market intended to work in streams. The 150-year-old practice of stream restoration has shifted over time from attempting to improve habitat within streams to creating entirely new stream channels. Why did people begin intervening to improve stream ecosystems, and how have those improvement goals changed? Chapter 4 plunges into the history of market-based approaches to environmental management, from the work of John Dales in the 1950s to the incorporation of such approaches into federal policy. How did the idea of selling nature in order to save it gain such momentum, and how was it converted from idea to policy and practice?

Chapter 5 introduces the cast of characters in the stream mitigation banking community, from the federal agency staff members who set up and regulate the mitigation banking market to investors who provide the funding to initiate a bank. How do dynamics among these players influence mitigation policy and practice, and shape how they address concerns about uncertainty and equivalence? Chapter 6 walks through mitigation banking in practice, highlighting the surprising complexity of this seemingly simple trade of debits and credits. Focusing on the history of a particular North Carolina stream mitigation bank, we ask how do bankers, regulators, and the other key actors keep a functional market for stream credits running?

Chapter 7 investigates the physical consequences of how mitigation actors, policies, and practices in North Carolina resolve the tensions between the economic and ecological goals of stream mitigation. Through a detailed set of geomorphic (i.e., physical) surveys of streams in North Carolina, including those restored under the auspices of mitigation banks, we quantify the actual physical imprint of this ecosystem service market on the fluvial landscape (the hydroscape), and thus begin to understand its peculiar biophysical consequences. Finally, in chapter 8 we return to our initial questions about the environmental implications not only of stream mitigation banking, but of MES more broadly. We argue that markets for

ecosystem services have not delivered on the conservation goals of their advocates, and thus need to be radically reconfigured either to strengthen equivalence between destroyed and restored ecosystems, producing narrow but more certain ecological improvements, or to embrace the chaos and dynamism of natural ecosystems, producing far less certain, but potentially much better ecological results.

We turn now to chapter 2, and an overview of the goals and challenges of markets for ecosystem services.

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