As the 20th century neared an end, few people—even the most knowledgeable economists and geologists—would have predicted that the United States would become the world’s largest producer of oil and a leading producer of natural gas just over a decade later. This surge in domestic oil and gas production is primarily driven by petroleum (oil and natural gas) resources from unconventional formations—formations that are more difficult and expensive to access than traditional formations. The most lucrative U.S. unconventional formations are shales, which are very densely packed rocks located thousands of feet underground. Shales trap oil and gas tightly within their tiny pores and require hydraulic fracturing if they are to be economically produced.

Due to the perfection of a technique called horizontal drilling combined with new hydraulic fracturing techniques in the late 1990s (techniques that slowly and then rapidly spread around the country over the next two decades), there are so many new oil wells in North Dakota that there are too few pipelines to handle the capacity. Pennsylvania has a long history of oil and gas production, but abundant wells drilled into the Marcellus Shale underlying the state have transformed rural towns as thousands of workers have poured into the area. And the boom is not just a rural one. In Fort Worth, Texas, alone, there are more than 1,800 active natural gas wells and 40 compressor stations.1

The technologies that generated this glut are now largely familiar to the American public, at least in a cursory way. In the late 1990s in Texas, George Mitchell, building upon a long history of research and development in the area, perfected a specific technique called “slick water” hydraulic fracturing. Using this technique, oil and gas companies—which are called “well operators” when they are responsible for directing drilling operations and other site activities—drill a well and then pump large quantities of water and some chemicals down the well to crack open a rock formation around the well. The companies also inject “proppant,” typically sand, to prop open the fractures formed by the pressure of the water. These fractures expose the surface area of rock, in which oil and gas is tightly trapped, thus releasing the oil and gas and allowing it to flow through the rock and into the well. Companies now employ this technique, as well as older fracturing techniques (e.g., “gel” fractures that use less water and more chemicals) in mineral formations around the United States.

It was not slickwater fracturing alone that drove the nationwide surge in oil and gas production that was to follow Mitchell’s success. Before Mitchell’s late-1990s breakthrough, oil and gas operators had begun to horizontally drill oil and gas wells before fracturing them. These companies drilled vertically down into the formation from which oil and gas would be produced and then turned the drill bit to drill horizontally through the target formation—sometimes laterally drilling more than a mile from the vertical wellbore. This, too, exposed more surface area of the rock. Furthermore, operators discovered that hydraulically fracturing the horizontal well bore in stages maintained pressure during each fracture treatment, thus generating better fracture patterns.

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along the well. These operators isolated portions of the horizontal well using equipment called “plugs,” progressively moving laterally through the wellbore and fracturing each portion.

Neither fracturing nor horizontal drilling—the technologies that would later drive rapid growth in U.S. oil and gas production—were new techniques in the late 1990s. Oil and gas companies had used hydraulic fracturing, sometimes called “fracing” or “fracking,” since the 1940s. Slickwater fracturing, though, was a new technique, which used much larger volumes of water than other fracturing methods. And horizontal drilling, although not new, was expensive; oil and gas companies had in some cases been hesitant to use it. As these companies realized growing success using horizontal drilling and hydraulic fracturing in Texas’s Barnett Shale, they transported these techniques elsewhere. It soon became apparent that horizontal drilling and hydraulic fracturing did not just unlock massive quantities of oil and gas in Texas—these techniques were, to a large extent, transferrable to many deep, “unconventional” oil and gas formations once deemed inaccessible and largely uneconomical.

Although the United States has long been an oil and gas producer, its historic production was driven by conventional oil and gas resources. These resources consisted of underground rock “reservoirs” or formations located in “fields” that contained similar geology and had been identified as likely containing economic quantities of oil or gas. Ancient plant matter and other organic materials, as well as layers upon layers of sediment, formed the building blocks of these reservoirs. As sediment continued to cover the organic matter, eventually becoming rock, and heat and pressure built up, this “cooked” the organic matter that sat within rock. Depending on the type of organic matter and the amount of heat to which it was exposed, as well as many other factors, oil, natural gas, or both formed within the rock. Some of the oil and gas migrated upward from the area where it was formed (the “source rock”) into a “reservoir rock,” which contained an adequate seal, such as impervious rock or a salt layer overlying the reservoir rock, to prevent oil and gas from escaping farther upward. As a drill bit pierced a reservoir and began drawing materials from the reservoir, water or gas in the reservoir would expand, thus pushing oil and gas upward through the well. Operators often did not have to physically pump oil and gas out of a well for many years, as the natural “reservoir drive” ensured that oil and gas flowed abundantly. There are still conventional reservoirs in the United States, and there are numerous conventional producing wells. (One well in Pennsylvania has produced continuously for more than 150 years.) But the recent boom in oil and gas production, which has pushed the United States toward the unexpected status of a leading global oil and gas producer, is primarily driven by unconventional resources like shale.

Unconventional oil and gas resources are resources that tend to exist at relatively low densities over very large areas, and they are difficult to access—typically because they are trapped very tightly within underground formations that have low permeability. These resources require special technologies to be developed, and these technologies tend to be much more expensive than conventional drilling technologies. As introduced

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above, the most common unconventional resource in the United States is shale. Other unconventional resources include tight sandstones (which, like shales, have tiny pores and are densely packed) and coalbeds (which contain methane). Minute fractures must be created in these types of rocks to expose enough pore space to release oil and gas; the oil and gas does not naturally flow when someone drills into the rock. And although horizontal drilling, unlike fracturing, is not a necessary component of shale or tight sands production, it can greatly enhance production numbers by exposing more of the formation. The perfection of the combination of horizontal drilling and hydraulic fracturing in Texas’s Barnett Shale spurred drilling and fracturing of shales around the country, from the Marcellus Shale in Pennsylvania, West Virginia, and Ohio; the Fayetteville Shale of Arkansas; Oklahoma’s Woodford Shale; Louisiana’s Haynesville Shale; and North Dakota’s Bakken Shale, among many others.

Up to this point, readers might wonder why, if George Mitchell had built on others’ earlier experiments to perfect the Slickwater fracturing—horizontal drilling combination in the late 1990s, the glut in oil and gas did not emerge until recent years. Indeed, there was still little national discussion of fracturing even as late as 2008, when oil and gas companies were beginning to drill and hydraulically fracture wells in Pennsylvania’s Marcellus Shale. The lag is largely explained by economics. By the early to mid-2000s, gas prices had risen enough to begin to make horizontal drilling and hydraulic fracturing, which can cost millions of dollars per well, economical. Furthermore, it took oil and gas companies some time to fully realize just how important the innovation was and how widely applicable it was. The technique is not universally transferrable—the Monterey Shale in California, for example, does not appear as responsive to slickwater fracturing, leading operators to try other alternatives. Also, initial experiments with fracturing globally have not always been successful. With only slight modifications, however, slickwater fracturing and horizontal drilling can be transferred to vast swaths of U.S. shales and sandstones; it took some time for operators to discover the broad applications of the technique. Production has declined as price has declined, and domestic reserves will not produce large amounts of oil forever. For example, the International Energy Agency projects that investments in and production of U.S. unconventional oil will decline by the 2020s. But these developments have had, and will continue to have, expansive impacts.

As production grows, so, too, do U.S. perceptions of the effects of the boom, and these perceptions often follow very divided paths. Some homeowners and renters with wells in their backyards may experience localized air pollution, spills, and occasionally even “blowouts” that spew fracturing chemicals into the air, and thus express understandable concerns about environmental and health impacts. Certain national environmental groups and some scientists, scholars, and policymakers similarly worry about the negative externalities of oil and gas production, including, for example, habitat and wildlife impacts, the rate of leakage of the powerful greenhouse gas methane, and the threat of abundant fossil fuels displacing investments in renewable energy. Certain social scientists also are increasingly concerned about the impacts of boom and bust cycles of

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5 Golden & Wiseman, supra note 2, at 975, n.110.
development on communities, as well as on the culture of towns that are transformed from agricultural areas to busy industrial centers almost overnight. On the other side of the ledger, many scholars, policymakers, and mineral owners are enthusiastic about the massive amounts of money and jobs created by the boom, the opportunities for increased energy security, and the cheap natural gas prices that are attracting manufacturing back to the United States.

Regardless of one’s view of the oil and gas boom and the positive and negative externality it generates, the surge of U.S. fossil fuel production raises a number of important issues for professionals in all areas—from lawyers to town officials and even accountants. The boom requires that experts who have long practiced in their areas, even within oil and gas law, learn new concepts, and it is opening up new jobs for individuals interested in environmental compliance; tax policy; mineral rights issues and good leasing practices; local, state, regional, and federal governance; and many other issues. This book focuses on the legal aspects of unconventional development, ranging from property rights to environmental compliance and international export policy. In describing the many areas of the law that accompany unconventional development, we focus particularly on shale gas development rather than, for example, coalbed methane drilling and fracturing. Shales are the most widespread unconventional resource in the United States and will continue to drive much of our production.

This book is geared toward lawyers, policymakers, regulators, and students who aspire to work in the many areas that demand experts in the “law of shale gas and tight oil.” But it should serve as a useful resource to anyone working in the area. We introduce shale gas technologies and terminologies to give a background understanding of the field for a range of professionals and students, and we attempt to discuss the legal issues in an accessible manner that nonlawyers can understand.

We begin in Chapter 1 by explaining the purpose of hydraulic fracturing and by exploring various fracturing technologies. For example, we note that oil and gas operators first began fracturing oil-bearing formations in the 1860s by detonating explosives in the subsurface, and that “explosive fracturing” was used regularly up until the mid-1900s, when it was superseded by hydraulic fracturing. We also describe how the oil and gas industry uses various hydraulic fracturing techniques, including fracturing operations in which the fracturing fluid is a viscous gel (gels were the earliest type of hydraulic fracturing fluid, and gel fracturing is still sometimes used); slickwater fracturing, which has been widely deployed in the United States; and finally, other fracturing techniques that might be increasingly used domestically and overseas in situations where neither gel fracturing nor the popular slickwater technique is suitable.

In the following chapter, we turn to property rights—the rights that any oil and gas company must acquire before drilling or fracturing. Chapter 2 specifically explores the law of mineral rights, which involves questions about who owns minerals, what types of minerals are owned, and what fraction of minerals are owned. This chapter also explores one of the most important instruments in the oil and gas law—the lease. Most mineral owners do not have the knowledge, resources, or expertise to drill a well on their own property, and they therefore convey their minerals to an oil and gas operator through an instrument that is called a lease (although that terminology can be misleading). This instrument typically conveys a fee simple determinable or similar interest in property, giving the oil and gas operator the right to access the minerals, explore for and produce minerals and profit from them, and a number of other rights. In return, the mineral owner (often called a “landowner”), receives royalties—a cut of the oil and gas produced
or its value—as well as certain rentals and an upfront bonus for signing the lease. This instrument is thus much broader and sometimes more sophisticated than, say, a lease for an apartment or even a commercial building.

Chapter 2 also explores the common law right of mineral owners and lessees to access the surface to develop minerals, even over the objection of surface owners, and resulting conflicts between mineral owners and surface owners. Although some states through “surface damage acts” have given surface owners the right to receive damages for the use of the property by mineral owners and to negotiate the terms of surface use, the majority have not enacted these types of protections.

Chapter 3 describes the water resources that are essential to developing a well, how oil and gas operators acquire the water rights necessary for hydraulic fracturing, and how states regulate water withdrawals both to protect various water owners’ rights and to achieve broader environmental goals. Some states have updated certain water laws to specifically address water withdrawals for fracturing, but others continue to apply their general water law regimes—which apply to withdrawals for domestic and industrial use, agriculture, and other uses—to hydraulic fracturing.

Chapter 4 begins our long tour of the numerous environmental laws that apply to oil and gas operations. Historically, oil and gas law was more about the conservation of oil and gas than it was about the conservation of the environment. States, the primary regulators of oil and gas development, enacted oil and gas conservation laws that focused on ensuring that as much oil and gas was drawn out of the ground as possible when drilling occurred. For example, they required that wells be spaced a certain distance from each other or limited the amount of oil and gas that could be withdrawn from each well, thus avoiding quick drainage of underground reservoirs that would leave valuable resources trapped behind. More recently, states have used their “police powers” reserved to them under the Constitution—the power to regulate various activities to protect human health, safety, and welfare—and certain powers delegated to them by federal agencies to address the environmental impacts of oil and gas production and associated activities, such as waste disposal. Chapter 4 explores state regulations designed to prevent oil, gas, fracturing fluids, and other substances from leaking out of wells underground, thus protecting water quality. Surface activities can also impact water quality because oil and gas wastes that are stored on the surface of a well site can leak and seep through soil to underground water sources. We discuss the regulation of waste storage and disposal in Chapters 7 and 9.

Chapter 5 continues our discussion of the environmental regulation of oil and gas activities, discussing state and federal regulations that address air pollutants at well sites and beyond well sites, such as natural gas compressor stations and processing facilities. Chapter 6 explores other federal regulations beyond the Clean Air Act that apply to oil and gas operations, and Chapter 7 describes a range of state environmental regulations that extend beyond the protection of underground water resources introduced in Chapter 4. Chapters 8 and 9 focus on two types of state regulation that have recently garnered a great deal of attention: states’ requirements for disclosing the hydraulic fracturing chemicals used at well sites and their regulation of the disposal of wastewater, including the flowback that returns from fractured wells. Chapter 9 focuses on a specific problem that emerges from disposal of wastewater (both flowback and other, larger sources of wastewater from

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oil and gas operations)—the earthquakes that are sometimes caused by disposal wells—and on state efforts to address this issue.

Having discussed federal and state regulation of the environmental impacts of oil and gas development, Chapter 10 moves to the local level, exploring local governments’ similar regulatory efforts. However, many states have prohibited (“preempted”) local governments from regulating many aspects of oil and gas development, and this chapter discusses these cases.

The final chapters of the book turn to broader legal issues associated with shale gas and oil development. Chapter 11 introduces the types of litigation that have arisen as a result of the boom and unique evidentiary issues in litigation that alleges sometimes difficult-to-prove claims, such as the cause of underground water contamination. For example, some parties have attempted to persuade courts to issue Lone Pine orders, which typically require parties raising claims to allege specific injuries and provide at least rudimentary evidentiary support for these claims early in the litigation. Chapter 12 discusses a particularly thorny legal issue that has arisen as a result of horizontal drilling and hydraulic fracturing—whether hydraulically fracturing into another person’s minerals is a trespass—and Chapter 13 explores other specific oil and gas law issues that have arisen as a result of shale gas and oil development. These include, for example, arguments that an oil and gas lease that is silent on issues such as water withdrawal and disposal wells does not authorize an operator to use the water on the property for fracturing or to drill an underground injection disposal well on the property.

Finally, Chapter 14 concludes by shifting our sights overseas, describing the growing push to allow more U.S. oil and gas exports and briefly exploring how other countries have approached shale gas development.

The law of shale oil and gas is a large field, covering everything from property rights issues to complex environmental regulation. We hope that this book will provide a comprehensive yet somewhat easily understandable introduction to this sweeping area of the law. As this book goes to print, the law is still evolving and changing. But the baseline knowledge provided here will equip lawyers, students, judges, and other professionals with a basic understanding of the core legal issues and the likely changes to track as the oil and gas boom continues to mature.