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Pore Space Property

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PORE SPACE PROPERTY

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Abstract

Through modern technology we can use the void pore space of underground rock formations for a growing number of socially beneficial purposes. These run the gamut from unconventional oil and gas production to climate change mitigation. The common law of property and tort, however, has struggled to keep up with advancing technology in this area. Significant questions remain about the nature of property rights in pore space. Of particular interest are the limits, if any, on an owner's right to use pore space for beneficial purposes when it extends beneath the land of another. For example, may A *hydraulically fracture an oil well on her property if the fractures extend beneath* B*'s land? May* C *store anthropogenic carbon dioxide for climate change mitigation in a common reservoir that extends beneath the land of* D*,* E*,* F*, and* G *if they do not consent? If so, what, if any, compensation does* C *owe to the others? These and similar scenarios pose urgent questions for a wide range of landowners, industries, environmental interests, courts, and policymakers across the nation.*

This Article searches for answers to these pressing questions in the doctrinal histories of similar common pool natural resources. The Article reviews the development of common law rights in water and oil and gas to synthesize lessons for shaping the content and limits of rights in pore space. Then, applying these lessons to the current state of pore space rights, the Article explains that rights in pore space are established by a default rule of prior use and are absolute, subject to little, if any, limitation. As demand for the resource continues to grow, however, owners, and, ultimately, courts will likely search for ways to limit the absolute extent of pore space rights to avoid a tragedy of the pore space commons.

In searching for doctrinal mechanisms to make pore space rights limited, or correlative, the Article predicts that courts will be tempted to choose between establishing limits by strict, formalist rules of proportionality (which favor certainty), on the one hand, and

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instrumentalist, utilitarian standards of reasonable use (which favor development of the resource), on the other. This Article identifies an underexplored doctrine from oil and gas law that would define the limits of pore space rights without resort to purely instrumentalist or formalist doctrines. The "fair-opportunity doctrine" articulated here would permit an owner to use any quantity of pore space anywhere in a common reservoir, so long as it does not interfere with the lawful existing operations of other owners or deprive other owners of a fair opportunity to either participate in the proposed operations or conduct like operations from their respective land.

I. INTRODUCTION

The Earth's subsurface is comprised in large part of geologic reservoirs—porous and permeable interconnected rock structures—that stretch beyond the boundaries of any single tract of land.[1] By virtue of their porosity, common reservoirs can contain a number of natural resources like water or hydrocarbons. Properly considered, the pore space—the rock's capacity to store fluids—is itself a useful natural resource for its ability to receive and hold diverse substances, ranging from hazardous wastes and anthropogenic carbon dioxide to potential energy generated by renewable sources.[2] In addition to storage and disposal of fluids, pore space is used in the production of hydrocarbons by conventional and unconventional means, including enhanced recovery, horizontal drilling, and hydraulic fracturing. Use of pore space for these and various other purposes is largely unregulated, leaving the task of governing competing uses of interconnected pore space to common law doctrines of property and tort.[3]

As technology enables more, and more intensive, use of subsurface pore space, the task of developing our doctrines governing ownership and use of pore space grows more urgent. The amount of pore space available for existing and future commercial and environmental purposes will grow scarcer over time. In fact, pore space is already beginning to appear scarce in states experiencing high levels of oil and gas development. In these states, fights over use of pore space, and efforts to limit injection of oil and gas wastes to avoid environmental externalities like induced earthquakes, are increasingly common.[4] The urgency to define property rights in the subsurface is further compounded by pressing desires to use pore space to mitigate greenhouse gas emissions. Though climate mitigation techniques like carbon

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[1] *See infra* Part II.A.

[2] *See infra* Part II.A. It has been said that the pore space might be considered a "renewable" resource in the sense that it can be filled, emptied, and refilled over time for various purposes. Tara K. Righetti, *Correlative Rights and Limited Common Property in the Pore Space: A Response to the Challenge of Trespass in Carbon Capture and Sequestration*, 47 ENV'T L. REP. NEWS & ANALYSIS. 10420, 10428 (2017).

[3] *See infra* Part II.D.

[4] *See infra* Part V.A.2.

dioxide capture and storage are potentially economically viable, the lack of clarity regarding subsurface property rights has helped stymie large-scale implementation.[5]

Clear answers to the legal questions surrounding ownership and use of pore space is urgently needed. These legal questions have two dimensions. The first dimension asks which party holds the initial entitlement to pore space under any given parcel of real property as between the owner of the surface estate and the owner of a severed mineral estate. The first dimension—who holds the bundle of sticks in the pore space—has been addressed elsewhere[6] and is settled in several states, with the majority placing the initial entitlement in the owner of the surface estate.[7]

This Article addresses the second dimension of pore space property, which asks about the extent of the initial entitlement to possess and use the pore space. This dimension is concerned with the rights and duties included in the pore space bundle of sticks. Here, the legal doctrine and theory remain underdeveloped. I have argued elsewhere that the property interest in subsurface reservoirs is a nonpossessory use right, the extent of which is defined under common law nuisance doctrine.[8] Other writers have characterized the pore space as a form of semicommon property, and have proposed defining the limits of the property interest either based on utilitarian standards,[9] or strictly in proportion to the size of each owner's land holdings in the common reservoir.[10]

Legal reasoning, and thus the law, often proceeds by analogy. This was true in the development of oil and gas law, in which early courts sought to analogize oil and gas to other, better understood natural resources like water and wild animals.[11]

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[5] Joseph A. Schremmer, *Getting Past Possession: Subsurface Property Disputes as Nuisances*, 95 WASH. L. REV. 315, 323–24 (2020).

[6] *See generally* Owen L. Anderson, *Geologic CO_2 Sequestration: Who Owns the Pore Space?*, 9 WYO. L. REV. 97 (2009).

[7] *See* Righetti, *supra* note 2, at 10426–27 (surveying how courts and legislatures have allocated pore space rights to the surface or severed mineral estate). The Texas Supreme Court in Lightning Oil Co. v. Anadarko E&P Onshore LLC upheld the trial court's assertion in 2017 that the subsurface pore space and all non-mineral structures underground are the property of the surface estate owner, and that the mineral owner owns only a "fair chance" to produce any minerals that may exist within the subsurface pore space and structures. Lightning Oil Co. v. Anadarko E&P Onshore LLC, 520 S.W. 3d 39, 46–48 (Tex. 2017).

[8] Schremmer, *supra* note 5, at 315–20.

[9] *See infra* Part III.D.2.(b)(i)–(iii) (discussing the theories of reservoir rights of Professors Eugene Kuntz, David Pierce, and Owen Anderson).

[10] *See infra* Part III.D.2.(a) (discussing the strict-proportional theory of reservoir rights of Professor Summers) and Part V.C.2 (discussing Professor Righetti's application of a strict-proportional theory to use of pore space for carbon storage).

[11] For example, in an 1897 case involving a dispute over the defendant's right to use enhanced stimulation techniques—in this case "shooting" a natural gas well with nitroglycerin—to produce a common reservoir, the Indiana Supreme Court analogized natural gas to both water and wild animals (or *ferae naturae*). People's Gas Co. v. Tyner, 31 N.E. 59, 60 (Ind. 1897). While the animal and water analogies have received significant

Likewise, in fashioning a set of common law doctrines to govern property rights in pore space, jurists should consider analogies to other forms of common pool natural resources. The goal of this Article is to do just that—draw lessons from the development of the law governing ownership and use of similar natural resources and apply those lessons to the nascent development of the law of pore space property rights. Specifically, this Article attempts to construct a doctrine of pore space property rights based on principles that emerged in the development of other common pool natural resources: surface waters, groundwater, and oil and gas.

The "fair-opportunity doctrine" ultimately articulated here defines pore space rights based on certain aspects of these principles without relying on either utilitarian considerations or a strict rule of proportionality. Under the fair-opportunity doctrine, any owner of pore space rights in a common reservoir may use any amount of pore space located anywhere within the reservoir, provided that it does not interfere with existing pore space activities, or deprive other owners a fair opportunity to either conduct like uses of the reservoir or participate in the interfering use. For example, if *A* wishes to use the pore space capacity of a common reservoir, which also underlies *B*'s land, for a carbon dioxide storage facility without *B*'s consent, *A* may do so under the doctrine, provided that the operations do not (1) interfere with *B*'s existing use of the reservoir without compensating *B*, or (2) deprive *B* of the fair opportunity to (a) use the reservoir for similar purposes or (b) participate in *A*'s operations on fair terms.

It will aid the later discussion to address the analogy I am drawing between pore space and water and oil and gas resources, because the similarities may not be obvious at first blush. Water and oil and gas are extracted *from* pore space, whereas the pore space itself serves as a conduit or storage tank for receiving injected substances. Pore space, unlike water and hydrocarbons, is fixed in place and cannot itself transgress property boundaries. These differences are overwhelmed, however, by the similarities.[12] Like water and oil and gas, pore space is a finite, depleting, and rivalrous resource. One owner's use of a cubic inch of common pore space diminishes the unused pore space available to other common owners by one cubic inch, just as extraction of a cubic foot of natural gas from a reservoir diminishes the gas available to other owners in the reservoir by one cubic foot. Moreover, pore space is interconnected, and it is impossible to perfectly exclude a part of the pore space in a reservoir from the effects of activities conducted in other parts. The effects of using pore space under one tract of land thus tend to spill over into pore space under adjoining tracts. This, too, is similar to common pools of water and oil and gas, in which extraction from one part of the pool necessarily "spills over" and drains other parts.

This Article proceeds by identifying pore space as a common pool resource analogous to water and hydrocarbons. It then surveys the development of rights in

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criticism for decades, they are defensible in principle. For a thorough defense, *see generally* Rance L. Croft, *Of Reservoir Hogs and Pelt Fiction: Defending the Ferae Naturae Analogy Between Petroleum and Wildlife*, 44 EMORY L. J. 697 (1995).

[12] The similarities are further addressed *infra* in Parts I.A–C.

those resources to synthesize lessons about the development of rights in common property in general. The Article ultimately applies those lessons to articulate a fair-opportunity doctrine of pore space property.

Part II begins by describing the physical characteristics of pore space in common, interconnected subsurface reservoirs. Based on these physical characteristics, Part II identifies pore space as a common pool resource and a form of limited-common, or semicommon, property (like water and oil and gas). Like all common pool resources, when unregulated, pore space is susceptible to overexploitation by common owners who can externalize the costs of their overuse to their fellow common owners—a recipe for a classic tragedy of the commons.[13] Part II demonstrates that statutory conservation schemes aimed at conserving certain resources like oil and gas from wasteful overproduction generally do not cover the use of pore space itself. This statutory void leaves pore space unregulated except by an undeveloped body of common law.

Part III considers three models of common law regulation of semicommon property: riparian waters, groundwater, and oil and gas. The discussion sketches the development and evolution of rights in these resources over time, focusing on doctrinal changes as well as changes in the physical and economic conditions of the resource. The discussion highlights similarities across all three models, which are explored further in Part IV.

Part IV synthesizes key lessons from the three models. The first lesson is that rights in semicommon resources shift from absolute to relative in response to shifts in the resource's physical and economic conditions over time. These shifts occur in roughly three stages. In the first stage, rights in the resource are generally based on an absolute rule that either forbids any disturbance of the resource or permits any use of the resource regardless of resulting disturbance. In riparian rights, this stage was reflected in the doctrines of natural flow and ancient use.[14] In groundwater and oil and gas rights, it took shape in the rule of capture.[15]

As demand for the resource grows, however, the absolute rule tends to cause either over- or under-exploitation of the resource, and the attendant problems of waste and high transaction costs eventually overwhelm the absolute rule's efficiencies. This leads to a second stage of development, in which rights come to be viewed as limited by reciprocal duties of reasonable or proportional use, and, therefore, as relative (or "correlative") rights in the Langdellian classification.[16] The doctrinal mechanism for relativizing rights is usually furnished by a rule of

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[13] *See* Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968) (coining the phrase for the concept of overexploitation of a commons by commoners unconstrained by rules or norms of governance).

[14] *See infra* Part III.B.1.

[15] For groundwater, *see* Part III.C.1, and for oil and gas, *see* Part III.D.1.

[16] In Professor Christopher Columbus Langdell's well-known classification, legal rights are either "absolute" or "relative." Robert G. Bone, *Normative Theory and Legal Doctrine in American Nuisance Law: 1850 to 1920*, 59 S. CAL. L. REV. 1101, 1118 (1986).

reasonable use or correlative rights, both of which loosely enable informal group control over the resource.

However, when resource scarcity becomes extreme, and especially when the resource is nonrenewable and depletable, rights tend to again take an absolute form. In this third stage of development, rights, while absolute, are more limited in scope than in the first stage. This third stage occurred in Western water law with adoption of the prior appropriation doctrine, and in oil and gas law with the passage of statutory conservation regimes. Yet, in both cases, courts and legislatures again chipped away at the absolutism of rights in times of severe permanent depletion of the resource.[17] Thus, as detailed in Part III, rights in semicommon resources move in an accordion-like fashion from absolute to relative in response to resource conditions.

The second lesson from the models is that the move to relative rights is accomplished through the application of tort law, specifically nuisance doctrine. Rights in resources are most often relativized by application of rules of reasonable use or correlative rights. Like nuisance doctrine, such rules define the limits of the right to use commonly owned property. Nuisance thus emerges as the tort for protecting relative property rights. The content of nuisance doctrine, and therefore of relative rights, depends on philosophical choices about how to define property rights. This choice is the subject of the third lesson from the semicommon property models.

The third lesson examines the alternative theoretical bases for defining the extent of limited property rights. An instrumentalist theory of property rights balances the utilities of owners' clashing uses of the resource through a standard of reasonableness in an effort to achieve maximal efficiency in each case. A formalist theory, on the other hand, fashions a formal definition of relative rights ex ante, usually based on strict proportionality, which is applied with minimum reference to utilitarian considerations. The discussion of the third lesson examines the tradeoff between maximizing development of the resource in each individual case under an instrumentalist model and promoting certainty in property under a formalist model.

Part V applies the lessons synthesized in Part IV to the development of pore space rights. The discussion begins by locating the current state of pore space property doctrine in an initial absolute stage of development, in which property rights are nearly absolute and determined by a principle of first use. To avoid, as much as possible, a tragic waste of pore space capacity by overuse, Part V describes the need for pore space property rights to become limited and relative. Having established the need to relativize pore space rights, Part V then addresses advantages and disadvantages of doing so under an instrumentalist reasonable use standard and a formalist rule of strict proportionality.

Finally, Part V attempts to synthesize a definition of relative pore space rights that is neither strictly utilitarian nor strictly proportional. This definition, which I call the "fair-opportunity doctrine," is based on the principle that all owners of common pore space are entitled to the fair opportunity to utilize the pore space

[17] *See* Part IV.A.

capacity of a reservoir. Derived principally from oil and gas correlative rights doctrine, the fair-opportunity doctrine states that an owner in a common reservoir may use any quantity of pore space anywhere in the reservoir, so long as it does not interfere with the lawful existing operations of other owners, or deprive other owners of a fair opportunity to either conduct like operations from their respective land or participate in the proposed operations.

Part VI briefly concludes by summarizing the key lessons from the models of semicommon property and the contours of the fair-opportunity doctrine.

II. THE UNREGULATED PORE SPACE SEMICOMMONS

A. Physical Background

The subsurface of land is comprised of layered, widely distributed formations of rock (the crust) on top of a highly dense mantle, floating on a flexible, molten core. Human activity, including mining and drilling for water and hydrocarbons, occurs only in the crust.[18] Temperature and pressure increase with depth, such that rock formations in the crust are under varying amounts of pressure.[19] Not all rock formations in the crust are absolutely solid. Sedimentary rock contains void "pore" spaces occupied by oil, natural gas, freshwater, or brine.

The volume of pore space within a given rock formation is its "porosity."[20] Porosity can be thought of as the rock's capacity for fluid storage. The degree to which a rock's pore spaces are interconnected is its "permeability."[21] Rock formations that are sufficiently porous and permeable to contain and transmit fluid resources like water,[22] oil, and natural gas are called "reservoirs."[23] Broadly

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[18] John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 994 (2008).

[19] *Id.* at 993–95.

[20] "Porosity" refers to the pore spaces, or openings in a rock that are not occupied by the solid framework of the rock material. It can be thought of as the rock's capacity for storage. The entire porosity is always completely occupied by fluid, either oil, gas, or water. Seldon B. Graham Jr., *Fair Share or Fair Game—Great Principle, Good Technology—But Pitfalls in Practice*, 8 NAT. RES. LAW. 61, 72 (1975) (citing to S.E. BUCKLEY, ED., PETROLEUM CONSERVATION 50 (Am. Inst. Mining & Metallurgical Eng'rs, 1951)); S.J. PIRSON, OIL RESERVOIR ENGINEERING 30 (2d ed. 1958).

[21] Itzchak E. Kornfeld, *Geology, The Marcellus Shale, Experts, & Dispute Resolution*, 116 W. VA. L. REV. 865, 884 (2014).

[22] Reservoirs containing groundwater are called "aquifers." *See* THOMAS C. WINTER, JUDSON W. HARVEY, O. LEHN FRANKE, & WILLIAM M. ALLEY, GROUND WATER AND SURFACE WATER: A SINGLE RESOURCE, U.S. GEOLOGICAL SURVEY CIRCULAR 1139 (1999), https://pubs.usgs.gov/circ/1998/1139/report.pdf [https://perma.cc/7K2X-S3RL].

[23] HOWARD R. WILLIAMS & CHARLES J. MEYERS, MANUAL OF OIL & GAS TERMS 831 (7th ed. 1987).

speaking, then, each reservoir consists of four parts: (1) solid rock strata, (2) pore space, (3) fluid minerals and water within the pore space, and (4) natural pressure.[24]

B. Pore Space as a Common Pool

Under the *ad coelum* doctrine, rights to produce fluids from, or inject fluids into, the pore space of a reservoir initially lie with each owner of land overlying the reservoir.[25] The borders of reservoirs, however, generally transcend the legal boundaries of land ownership such that reservoirs are owned by numerous landowners. Although reservoirs are legally segmented into individual parcels of ownership, they are physically interconnected. Changes in pressure caused in any separately owned part of a reservoir inherently affect pressures throughout the entire reservoir. For example, assume *A* were to drill a producing oil well from the surface of her property into the underlying Mississippi Lime formation, a known oil and gas reservoir. *A*'s wellbore would become a pressure sink capable of draining pressure and fluids (like oil and connate water) from throughout the reservoir, including the portions underlying *A*'s land and that of her neighbor *B*.

If, instead of production, *A* were to use the well to inject produced water, hazardous waste, carbon dioxide, or the like, the wellbore would pressurize the Mississippi Lime formation and drive pressure and fluids laterally from the wellbore into pore space under *A*'s and *B*'s land. Thus, *A* cannot use her portion of the Mississippi Lime without diminishing the portion available to *B*. For this reason, the Mississippi Lime, like all pressure-connected reservoirs, is "rivalrous," "depletable," or "subtractable."[26]

By virtue of this inherent interconnectedness, and the difficulty in demarcating, monitoring, and enforcing boundary lines beneath the surface, property interests in the subsurface are also nonexcludable.[27] Landowners with rights in a common reservoir are entitled to *use* the reservoir, even parts of it beyond their own tract, but not to exclusively *possess* any portion of it.[28] Property in subsurface resources are

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[24] *See* David Edward Pierce, *Coordinated Reservoir Development—An Alternative to the Rule of Capture for the Ownership and Development of Oil and Gas*, 4 J. ENERGY L. & POL'Y 1, 50 (1983).

[25] *See* David E. Pierce, *Employing a Reservoir Community Analysis to Define and Marshall Correlative Rights in the Oil and Gas Reservoir*, 76 LA. L. REV. 787, 789–90 (2016) [hereinafter Pierce, *Reservoir Community Analysis*].

[26] *See* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 32–33 (1990) (referring to such resources as "subtractable.").

[27] Schremmer, *supra* note 5, at 340–42; *see also* Tyler Cowen, *Public Goods*, LIBR. ECON. & LIBERTY, https://www.econlib.org/library/Enc/PublicGoods.html [https://perma.cc/C4ZN-RYKB] (last visited June 30, 2020) (noting that "'[n]onexcludability' means that the cost of keeping nonpayers from enjoying the benefits of the good . . . is prohibitive.").

[28] *See* Schremmer, *supra* note 5, at 375–76.

more like a usufruct[29] than a fee simple in land. In the above example, *B* would have no right to exclude *A* from using her portion of the Mississippi Lime, even though it may indirectly drain fluids from, or inject fluids into, the Mississippi Lime as it underlies *B*'s land. *B* would generally have only an action for damages if *A*'s use of the Mississippi Lime were to interfere with *B*'s existing legal use of the formation. Encroachments by one owner into the subsurface of a neighbor's land are therefore nuisances, as opposed to trespasses.[30]

Common reservoirs qualify as a type of "common-pool resource."[31] As with all common pool resources, consumption of a common reservoir of oil and gas, water, or pore space by one owner necessarily diminishes the overall corpus of the reservoir available to the other owners. Allowing unbounded consumption incentivizes each owner to use as much of the reservoir's pore space or contents as quickly as possible. Rapid overuse dissipates the natural pressure that energizes the reservoir and diminishes its ultimate productive capacity to the disadvantage of the other reservoir owners and the public. This is an underground version of the "tragedy of the commons."[32]

On the other hand, totally prohibiting use of the resource by any and all owners renders it valueless, both to the owners and the public. It turns out that the intermediate position is best—the total value of a reservoir to all owners, as well as the public, is maximized by allowing limited consumption by each owner. Coordination and cooperation, rather than competition, are necessary to maximize the reservoir's ultimate value for production, storage, or both.[33]

C. Pore Space as Limited Common or Semicommon Property

In legal terms, the foregoing characteristics mean that reservoirs, or more precisely the fluids and pore space within them, are a form of commons. The

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[29] *See* David E. Pierce, *Resolving Intra-Reservoir Horizontal Drilling Conflicts Using a Reservoir Community Analysis*, 90 N.D. L. REV. 249, 250–51 (2014) [hereinafter Pierce, *Intra-Reservoir Horizontal Drilling*] (discussing how "[i]n many ways the usufructuary nature of water is similar to use of a reservoir to maximize removal of oil and gas. No single owner 'owns' the geophysical system where the oil and gas reside, but they all seek to use it to recover the oil and gas within.").

[30] Schremmer, *supra* note 5, at 375–76.

[31] *See* OSTROM, *supra* note 26, at 30 (defining "common-pool resource[s].").

[32] David E. Pierce, *Carol Rose Comes to the Oil Patch: Modern Property Analysis Applied to Modern Reservoir Problems*, 19 PENN. ST. ENV'T. L. REV. 241, 249–50 (2011) [hereinafter Pierce, *Modern Property Analysis*] (citing Carol M. Rose, *Expanding the Choices for the Global Commons: Comparing Newfangled Tradable Allowance Schemes to Old-Fashioned Common Property Regimes*, 10 DUKE ENV'T. L. & POL'Y F. 45, 49 (1999)).

[33] *See generally* OSTROM, *supra* note 26, at 29–57 (discussing theoretical approaches to self-governance of common pool resources).

commons is limited, however, to the owners of land above the reservoir.[34] Modern commentators, led by Professor Carol Rose, have studied common property regimes for resources held by a discrete number of owners rather than the public at large. Variously termed "limited common property" by Rose and "semicommon property" by others, including Professor Henry Smith,[35] the theory generally holds that rights in semicommon property are nonexclusive and relative among the common owners, but absolute and exclusive as to the rest of the world. In other words, the property interest is partly private and partly common.[36] In a series of influential articles, Professor David Pierce has identified oil and gas reservoirs as a form of limited common property.[37] Pierce conceives of a common reservoir as a community of owners whose "members[hip]" in the reservoir "community" is determined by virtue of owning a tract of surface land overlying the reservoir.[38]

Rose describes "limited common property" as "property on the outside, contract (or norms) on the inside . . . ."[39] The norms or consensual agreements that develop on the "inside" among common owners to manage and allocate rights to use the property[40] are essential to managing common pool problems and avoiding a

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[34] *See* Ohio Oil Co. v. Indiana, 177 U.S. 190, 209 (1900) (stating that rights to produce from a common reservoir are "vested only in the owners" of an interest in the surface of land overlying the reservoir).

[35] In this Article, I will use "semicommon" and "limited common" interchangeably to refer to such types of property.

[36] *See generally, e.g.*, Carol Rose, *The Comedy of the Commons: Custom, Commerce, & Inherently Public Property*, 53 U. CHI. L. REV. 711, 719–20 (1986) [hereinafter Rose, *Comedy of the Commons*] (discussing property as involving elements of both private and public ownership); Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J. LEGAL STUD. 131, 131 (2000) (discussing how property rights are "a mix of common and private rights . . .").

[37] *See, e.g.*, Pierce, *Reservoir Community Analysis, supra* note 25, at 788–89 (discussing the relationship between various landowners for mineral rights); Pierce, *Intra-Reservoir Horizontal Drilling, supra* note 29, at 260 (noting that "'ownership' is correlative"); Pierce, *Modern Property Analysis, supra* note 32, at 252 (highlighting the article's goal to "clarify and elaborate property entitlements" in a community context); David E. Pierce, *Developing a Correlative Rights Doctrine to Accommodate Development of Oil & Gas in Arkansas*, 68 ARK. L. REV. 407, 407–08 (2015) [hereinafter Pierce, *Correlative Rights Doctrine*] (describing the article's focus on a community oriented approach to mineral rights).

[38] Pierce, *Intra-Reservoir Horizontal Drilling, supra* note 29, at 250 (citing JOHN S. LOWE ET AL., CASES & MATERIALS ON OIL & GAS LAW 21 (6th ed. 2013)).

[39] Carol M. Rose, *The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems*, 83 MINN. L. REV. 129, 177 (1998) [hereinafter Rose, *Several Futures of Property*].

[40] Carol M. Rose, *Given-ness and Gift: Property and the Quest for Environmental Ethics*, 24 ENV'T. L. 1, 26–27 (1994) (noting that common property is often "enforced" internally by "customs and norms").

tragedy of the commons.[41] Because limited common property is often held by close-knit groups,[42] norms of reciprocity are quick to develop, and contractual arrangements are relatively low-cost to negotiate and implement. For example, in the early days of commercial oil development in the United States, norms and contractual arrangements commonly coalesced among developers to coordinate production of the reservoir.[43]

There may be many reasons these kinds of ad hoc arrangements are less common in the modern oil patch, including the growth of the industry and appreciation of transaction costs involved in striking bargains with all interested owners. The most significant reason may be the proliferation of techniques for production, injection, and storage in common reservoirs, leading to disputes that are more diverse and complex than the reservoir problems encountered in earlier times.[44] The presence of numerous players and technical complexity increases transaction costs and depresses the likelihood of consensual solutions to problems of reservoir and pore space use.[45]

D. The Regulatory Void

In the absence of custom or contract to govern production and use of limited common property by common owners, state actors often step into the breach. Per Rose, while the governance of common goods "may be solved by collective agreements among the owners of the resources, such agreements are costly and, particularly where a large number of parties must be involved, private collective action is not always possible . . . . Thus a governmental body might be the most useful manager where many persons desire access to or control over a given property . . . ."[46]

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[41] Pierce, *Modern Property Analysis, supra* note 32, at 249 (citing Carol M. Rose, *Expanding the Choices for the Global Commons: Comparing Newfangled Tradable Allowance Schemes to Old-Fashioned Common Property Regimes*, 10 DUKE ENV'T. L. & POL'Y F. 45, 49 (1999)).

[42] Robert C. Ellickson, *Property in Land*, 102 YALE L.J. 1,315, 1,320 (1993) (discussing property "regimes" adopted by "close-knit groups," which can develop efficient internal rules of governance by virtue of their closeness).

[43] *See* TERENCE DAINTITH, FINDERS KEEPERS? HOW THE LAW OF CAPTURE SHAPED THE WORLD OIL INDUSTRY 67–71 (2010) (describing ad hoc contractual arrangements among owners in common oil fields).

[44] For a survey of the variety of modern-day subsurface use disputes, *see* Schremmer, *supra* note 5, at 342–73; Owen L. Anderson, *Subsurface "Trespass": A Man's Subsurface Is Not His Castle*, 49 WASHBURN L.J. 247, 255–81 (2010).

[45] Thomas W. Merrill, *Trespass, Nuisance and the Costs of Determining Property Rights*, 14 J. LEGAL. STUD. 13, 22 (1985).

[46] Rose, *Comedy of the Commons, supra* note 36, at 719–20; *see also* Keith B. Hall, *Hydraulic Fracturing: If Fractures Cross Property Lines Is There an Actionable Subsurface Trespass?*, 54 NAT. RES. J. 361, 372–75 (2014) (demonstrating that governmental regulation

During the twentieth-century, state-specific administrative regulation indeed filled the gap in regulation of extraction hydrocarbons,[47] and to some extent groundwater,[48] from common reservoirs. These statutory and regulatory conservation schemes are limited in their scope, however, and generally do not regulate use of pore space for waste storage, carbon dioxide sequestration, or unconventional hydrocarbon production techniques. No regulatory scheme systematically regulates common owners' use of pore space itself,[49] as they do for the extraction of substances contained within the pore space. The dearth of statutory regulation leaves many open questions. How much of the pore space volume may *A* occupy for carbon dioxide sequestration within a reservoir stretching under land owned by *B*, *C*, *D*, *E*, and *F*? What, if any, compensation might *A* owe to the others for occupying too much?

Moreover, statutory conservation laws largely do not address disputes occasioned when uses of pore space extend into neighboring property, or when multiple conflicting pore space uses clash. Administrative agencies are generally not empowered to adjudicate subsurface property rights or determine tort liability for encroachments caused by, for example, waste disposal and storage, hydraulic fracturing, gas storage, or horizontal drilling.[50] What's more, no overarching administrative regime exists to coordinate conflicts between subsurface activities governed under separate regulations. What happens, for example, when one common owner's saltwater injection operation (regulated through the Underground Injection Control Program[51]) interferes with another owner's oil production operation (regulated under state-specific conservation regulations[52])? In unconventional resource plays, where the use of modern production technologies like horizontal drilling and hydraulic fracturing is necessary, intra-reservoir disputes

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is likely necessary to manage the conservation of limited common property in oil and gas reservoirs).

[47] *See infra* Part III.D.2.(a).

[48] *See infra* Part III.C.4.

[49] Several states have adopted statutory schemes for permitting and measurement for aquifer storage and recovery (ASR) that may be said to regulate the use of pore space for storage of usable water indirectly. *See, e.g.*, COLO. REV. STAT. ANN. § 37-90-9107.6 (West 2020) (requiring application for ASR); TEX. WATER CODE ANN. §§ 27.151–157 (West 2020) (authorizing ASR).

[50] *See* R. Lee Gresham & Owen L. Anderson, *Legal and Commercial Models for Pore-Space Access and Use for Geologic CO_2 Sequestration*, 72 U. PITT. L. REV. 701, 734–42 (2011) (stating, "[a]s with title issues, regulatory bodies have no general authority to authorize trespasses or other torts," and reviewing cases elaborating on this statement).

[51] 42 U.S.C. §§ 300f–300j-27 (West 2020).

[52] *See, e.g.*, Cassinos v. Union Oil Co. of Cal., 18 Cal. Rptr. 2d 574, 576–78 (Cal. Ct. App. 1993) (involving the plaintiff's claims of trespass arising from interference with oil production caused by the defendant's neighboring saltwater disposal operation); Tidewater Oil Co. v. Jackson, 320 F.2d 157, 160 (10th Cir. 1963), *abrogated by* Fransen v. Conoco, Inc., 64 F.3d 1481 (10th Cir. 1995) (same).

that fall outside the scope of existing conservation regulation are increasingly common.[53]

Many statutory schemes address certain reservoir-scale activities on a piecemeal basis through compulsory pooling or unitization of interests. Compulsory schemes effectively coordinate property rights to accomplish certain kinds of pore space uses, such as secondary and enhanced recovery, to avoid property disputes and holdouts among reservoir owners.[54] However, even where administrative law authorizes the creation of units for certain reservoir activities, such unitization does not preclude the holder of a non-unitized interest from suing the unit for violating its common law property rights at the unit's boundaries.[55]

Hence, the use of pore space in common reservoirs is largely unregulated. Where use of common pool resources is not governed by custom, contract, or state regulation, the task falls to the common law of property and tort to define rights and resolve disputes after they happen. Since norm, contract, and regulation of pore space is lacking, common law principles play a major role in defining and defending pore space property rights. Yet, the common law has not developed a robust scheme of pore space property rights.[56] Subsurface property disputes, such as encroachments caused by waste disposal, secondary and enhanced recovery, natural gas storage, hydraulic fracturing, and horizontal drilling, often appear to be decided on an ad hoc basis.[57]

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[53] *See* Pierce, *Modern Property Analysis, supra* note 32, at 264 (noting how "[a]bsent regulation, the common law of acceptable conduct within the reservoir will be defined by what is currently viewed as prudent operating practices"). For recent litigation arising over hydraulic fracturing and horizontal drilling operations, *see, e.g.*, Coastal Oil & Gas Co. v. Garza Energy, Tr., 268 S.W. 3d 1 (Tex. 2008) (concerning hydraulic fracturing); Stone v. Chesapeake Appalachia, LLC, No. 5:12-CV-102, 2013 WL 2097397 (N.D. W. Va. Apr. 10, 2013) (concerning hydraulic fracturing); Briggs v. Sw. Energy Prod. Co., 184 A.3d 153 (Pa. Super. Ct. 2018) (concerning hydraulic fracturing), *vacated and remanded by* Briggs v. Sw. Energy Prod. Co., 224 A.3d 334 (Pa. 2020); Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 520 S.W.3d 39 (Tex. 2017) (concerning horizontal drilling).

[54] *See, e.g.*, WYO. STAT. ANN. § 34-1-152 (West 2020) ("The ownership of all pore space in all strata below the surface lands and waters of this state is declared to be vested in the several owners of the surface above the strata."). For example, Wyoming's statutory scheme for carbon storage provides for unitization and entitles "all owners within the unit . . . to share proportionately in the economic benefits generated by the sequestration activities." Righetti, *supra* note 2, at 10436.

[55] *Id.* at 10437.

[56] *See* Pierce, *Modern Property Analysis, supra* note 32, at 249 (noting that "correlative rights" as a concept arose "at the turn of the century and has been somewhat of a sleeping right since . . ."); *see* 1 KUNTZ, OIL AND GAS LAW § 4.3 (noting that "the elements which are included within the collective term 'correlative rights' have not been judicially classified or analyzed . . ."). *See, e.g.*, Pierce, *Correlative Rights Doctrine, supra* note 37, at 407 (noting that "Arkansas lacks a comprehensive, common law correlative rights analysis for oil and gas").

[57] *See* Schremmer, *supra* note 5, at 318–19.

Courts tend to privilege subsurface invasions from liability when they result from an activity deemed societally beneficial and do not cause actual damages to the plaintiff.[58] Only landowners who have previously established uses of reservoir pore space are entitled to damages for interference with those established uses. Accordingly, pore space rights are governed by a default principle of first occupation, akin to an inverse rule of capture, in which prior use vests an absolute right to continue the use free from interference.[59]

As the following discussion details, semicommon property rights often start as absolute rights established on a principle of first possession, and then develop into relative rights limited by a principle of reasonable or proportional use. The following discussion traces the development of three forms of semicommon property in other common pool natural resources (i.e., resources that are rivalrous and nonexcludable) to derive lessons for refining the property rights regime for pore space.

III. MODELS OF SEMICOMMON PROPERTY

A. General Principles of Semicommon Property Doctrine

This Part sketches the trajectory of common law regulation of three forms of semicommon property in natural resources: riparian waters, groundwater, and oil and gas. The development of each of these areas roughly proceeds in three stages. In the first stage, a common owner's rights in the semicommon property are absolute. These absolute rights entitle the owner either to absolute freedom from disturbance of the resource, or to absolutely use the resource regardless of the effects on other owners. As demand for the resource grows and competition for the resource starts to involve large numbers of parties, the absolute rule starts to produce inefficient and wasteful results, leading to modification through the common law process and a second stage of development.

In the second stage, the extent of rights in the semicommon property is limited by doctrine prohibiting disproportionate or unreasonable use of the resource. In this manner, rights in the resource transform from being absolute to being relative (or "correlative"). Where, however, the resource is critically scarce and permanently depletable, rights tend to revert back to being absolute and precisely defined. In this third stage, rights are absolute but limited in ways the initial stage rights are not. Yet, even in this stage, rights sometimes undergo relativization as conditions of scarcity and depletion lead courts and legislatures to permit reasonable impairment of the otherwise absolute right.

Describing rights in property as relative implies an obligation on each owner to limit their use of the property. The contours of the limiting principle differ across

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[58] *See* Anderson, *supra* note 44, at 271, 255–81 (surveying cases and noting that liability lies only where the invasion interferes with an existing or "foreseeable" use by the plaintiff of the subsurface).

[59] *See infra* Part V.A.1 (describing the current state of pore space property rights in the case law).

types of property and periods of time. Some limiting principles require proportional use, in which each owner's use of the pool is stinted to a determinate amount. Others limit use based on a number of case-specific facts intended to strike a maximally efficient balance of competing interests under a standard of reasonableness. As will be seen, choosing between formalist proportionality rules and instrumentalist reasonableness standards to define rights animates the management of semicommon property.

B. Riparian Waters

The common law of water rights provides a robust model for the development of semicommon property in which rights move from absolute to relative and, sometimes, back again. The form of water most closely analogous to pore space is groundwater, which is water contained in the pore space of subsurface aquifers. Nonetheless, the common law of riparian waters also furnishes a paradigm of semicommon property rights, and warrants discussion here.

1. Post-Medieval Water Rights Begin as Absolute Under Natural Flow and Ancient Use Doctrines

As Professor Joshua Getzler observed in his authoritative *A History of Water Rights at Common Law*, the medieval English law of water rights was more procedural than substantive, and was "subsumed within various categories of action dealing with the wrong of nuisance," and eventually trespass on the case.[60] In the fifteenth- and sixteenth-centuries, however, the substantive property law principle took root that riparian owners had a right to enjoy the flow of a stream undisturbed, and thus could contest any use of the stream that disturbed its "natural flow."[61] The only exception from this natural flow doctrine was for disturbances that resulted from an activity that had existed for such a substantial period that it effectively entitled the user to a prescriptive right to use the stream in that fashion.[62] Under this so-called "ancient use" doctrine, water uses established since "time immemorial" were absolute and entitled to continue without interference. The doctrine did not protect mere occupancy; uses that were old but not sufficiently ancient to establish a prescriptive right enjoyed no protection from interference and would be liable for interfering with an ancient use.[63]

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[60] JOSHUA GETZLER, A HISTORY OF WATER RIGHTS AT COMMON LAW 52, 100 (2004); *see also* T.E. Lauer, *The Common Law Background of the Riparian Doctrine*, 28 MO. L. REV. 60, 82 (1963) (noting the preoccupation of the law during this time with matters of pleading rather than of substance).

[61] GETZLER, *supra* note 60, at 117.

[62] Lauer, *supra* note 60, at 84–85.

[63] *Id.* at 84.

2. The Rise of Occupancy as the Basis of Water Rights—Blackstone and Sic Utere Tuo

Starting around the seventeenth-century, the basis of water rights began to shift from prescription by ancient use to mere occupancy or appropriation. This transformation was part of a larger trend toward a view of property rights as reciprocal or "correlative."[64] The famous 1610 nuisance case *William Aldred's Case*,[65] contributed to correlativity theory the important maxim, "*sic utere tuo ut alienum non laedas*," or "so use your own property as not to harm that of another."[66] There, Benton was held liable for nuisance for operating a hog sty so as to interfere with Aldred's residence. Lorde Coke cast Aldred's right to use his property in the established manner without interference "in terms of natural necessity rather than prescription."[67] In other words, Aldred was entitled to protection from interference based merely on the fact of his prior use or occupancy, and Benton was liable for causing harm to it by subsequent use of his own property.

Following *Aldred's Case*, *sic utere tuo* became the foundation of the water rights doctrine that would largely supplant natural flow and ancient use—Blackstone's prior appropriation doctrine. Blackstone wrote his famous *Commentaries* during a time, in the later eighteenth-century, when competition for streams to generate waterpower had "vastly intensified."[68] With the increasing application of waterpower to ever more industrial uses, disputes over the use of common watercourses became more frequent and began to involve more parties.[69] Under these conditions, the stability previously furnished by the natural flow doctrine began to collapse.[70]

Against this backdrop, Blackstone argued that water rights were acquired by establishing a prior use, or "occupancy," of water rather than by proving an ancient use.[71] In Blackstone's system, once established by appropriation, a water right was coextensive with the appropriative use.[72] Further, by application of *sic utere tuo*, subsequent competing uses of the watercourse were permitted only to the extent they

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[64] Theorizing rights as "correlative" was seen as a way for courts to compromise competing absolute rights without eroding the natural law theory underpinning property law. GETZLER, *supra* note 60, at 122; *see also* Jeff L. Lewin, *Boomer and the American Law of Nuisance: Past, Present, and Future*, 54 ALB. L. REV. 189, 207–208 (1990) (discussing the rise of correlative conceptions of property rights in nineteenth century nuisance law).

[65] Aldred's Case (1610), 77 Eng. Rep. 816, 9 Co. Rep. 57 b.

[66] *Id.* at 821.

[67] GETZLER, *supra* note 60, at 123.

[68] Carol M. Rose, *Energy and Efficiency in the Realignment of Common-Law Water Rights*, 19 J. LEGAL STUD. 261, 273 (1990) [hereinafter Rose, *Common-Law Water Rights*].

[69] *See id.*

[70] *Id.*

[71] GETZLER, *supra* note 60, at 154.

[72] *See* Lauer, *supra* note 60, at 97–98.

did not interfere with a prior use.[73] Thus, Blackstone's application of *sic utere tuo* was strict and formalistic; any interference with an owner's prior appropriation of water was actionable. As Blackstone illustrated, "[t]hus if *A* builds a mill upon the river Wye, *B* may not subsequently take water from the Wye above *A*'s mill in such quantities as to interfere with the operation thereof."[74]

Water law in nineteenth-century Britain and eastern states in the United States came to reflect much of Blackstone's prior appropriation doctrine.[75] More broadly, *sic utere tuo* remained the starting point for analyzing nuisances and water-use disputes through the nineteenth- and early twentieth-centuries. Despite its long reign, the maxim was incomplete as a model of property rights. The difficulty in applying *sic utere tuo* is in determining what constitutes *laedas* or harm. As Professor Jeremiah Smith observed in 1917,

> If by *laedas* be meant damage, the maximum [sic] is untrue as a legal proposition; since the legal exercise of a right is often accompanied with the infliction of positive harm upon another. If by *laedas* be meant injury in the literal sense of an unlawful act (*in* and *jus*), an act in violation of another's legal right, then the maxim is a mere truism or identical proposition. It does not tell us what is a legal right or what constitutes a violation of a legal right.[76]

Sic utere tuo depends on an initial determination of the plaintiff's right that is allegedly interfered with; it does not itself define those rights.[77] Like Lord Coke in *Aldred's Case*, Blackstone resolved the distinction by conflating interference and legal injury, such that any and all interferences with a prior use of water were actionable. Some seventeenth- and eighteenth-century courts, however, exercised policy discretion in defining the extent of plaintiffs' rights. These courts would permit interferences by acts that produced social good, in an attempt to balance the

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[73] GETZLER, *supra* note 60, at 186.

[74] Lauer, *supra* note 60, at 97.

[75] *See, e.g.*, Hatch v. Dwight, 18 Mass. (17 Tyng) 289, 296–97 (1821) (declaring that "the owner of a mill site, who first occupies it by erecting a dam, and mill, [had the] right to water sufficient to work [the mill], . . . ; notwithstanding he may, by his occupation, render useless the privilege of any [owners] above or below him upon the same stream").

[76] Jeremiah Smith, *Reasonable Use of One's Own Property as a Justification for Damage to a Neighbor*, 17 COLUM. L. REV. 383, 389 (1917) (footnotes removed). For the same reason, Justice Holmes lumped *sic utere tuo* together with *alienum non laedas* as "hollow deductions from empty general propositions." Oliver Wendell Holmes, *Privilege, Malice, and Intent*, 8 HARV. L. REV. 1, 3 (1894).

[77] *See* Fontainebleau Hotel Corp. v. Forty-Five Twenty-Five, Inc., 114 So. 2d 357, 359 (Fla. Dist. Ct. App. 1959) ("This maxim does not mean that one must never use his own property in such a way as to do any injury to his neighbor. It means only that one must use his property so as not to injure the lawful *rights* of another.") (emphasis added) (citations omitted).

interests of competing property owners and of the public.[78] Such implicitly utilitarian applications of *sic utere tuo* continued into the nineteenth-century.[79]

3. Rights Fully Relativize Under Reasonable Use Doctrine

Sic utere tuo took on an explicitly utilitarian character in American riparian rights doctrine. Starting in the early nineteenth-century, Blackstone's prior appropriation doctrine began to yield to a new, American riparian doctrine based on the principle of "reasonable use."[80] Under the reasonable use doctrine, "riparian owners had limited[,] but more or less equal[,] rights to use [a common] stream," and "could cause some inconvenience to other owners" without liability.[81] The turn to reasonable use began in the New York courts.[82] In *Platt v. Johnson*, for example, New York's Supreme Court construed *sic utere tuo* to permit an upstream mill to occasionally deny water to downstream users.[83] Getzler characterizes this holding as "a radical recasting of the seventeenth-century English use of *sic utere tuo* expressed in *Aldred's Case*."[84]

The turning point for the broad adoption of the reasonable use doctrine was Justice Story's opinion in the 1827 federal case, *Tyler v. Wilkinson*.[85] *Tyler* involved a complex dispute among several mill owners on the Pawtucket River.[86] Writing for the Court, Justice Story stated that the stream's flow was owned equally by all riparian owners, and, somewhat ambiguously, that there was no right to diminish the water or disturb the flow for other owners except by "a reasonable use," which in turn meant a productive purpose.[87] In this way, Story manipulated the meaning of *laedas* (legally actionable harm) to exclude damage caused by another's productive use of the stream. Story explained that, in determining whether an interfering use is

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[78] *See* GETZLER, *supra* note 60, at 126 ("It has been argued that seventeenth-century nuisance law gave the courts a policy discretion to manipulate the *sic utere tuo* standard and so strike a social balance between useful modes of land use, leading eventually to highly malleable fault and negligence standards for torts to land.").

[79] *See* Lewin, *supra* note 64, at 201–02 ("For dynamic theorists, *sic utere tuo* was secondary to the right of property owners to make productive use of their property. These theorists restricted the scope of the *sic utere tuo* doctrine 'by narrowly interpreting the word '*laedas*'' to mean not 'injury' but 'legal injury.' Legal injury could only result from a legal wrong, an unlawful act. If the defendant had the legal right to make a particular use of his property, then the damage inflicted on the plaintiff was *damnum absque injuria,* or damage without legal wrong or legal injury.").

[80] Lauer, *supra* note 60, at 61–62.

[81] Rose, *Common-Law Water Rights, supra* note 68, at 282–84.

[82] *Id.* (citing Palmer v. Mulligan, 3 Cai. Cas. 307 (N.Y. Sup. Ct. 1805)).

[83] Platt v. Johnson, 15 Johns. 213, 218–20 (N.Y. Sup. Ct. 1818).

[84] GETZLER, *supra* note 60, at 273.

[85] Tyler v. Wilkinson, 24 F. Cas. 472, 473–74 (C.C.D.R.I. 1827) (No. 14312).

[86] Rose, *Common-Law Water Rights, supra* note 68, at 285–86 (discussing the details of the dispute).

[87] GETZLER, *supra* note 60, at 274–76.

reasonable, the law makes "reasonable reference to public convenience and general good . . . ."[88] Morton Horwitz famously argued that Story's overtly utilitarian reasonable use standard "became almost immediately an open-ended formula through which common law judges could implement their own conceptions of desirable social policy."[89]

Over time, individual jurisdictions adopted particularized criteria for reasonableness, such as rules precluding inter-basin transfers of water,[90] and rules granting priority among incommensurable uses of water for domestic, agricultural, and industrial purposes (with the typical rule preferring domestic uses over all others).[91] Many of these modifications are reflected in the Restatement (Second) of Torts. Section 850A describes the relevant considerations in determining reasonableness, which includes, among others, the purpose, economic and social values of the use, the suitability of the use to the body of water, the extent of the harm the use causes, and the practicality of avoiding the harm by adjusting the method of use or amount of use by the proprietors.[92] Riparian cases are thus "often resolved by the use of principles similar to the law of nuisance."[93]

Commentators are divided in explaining the shift from absolute rights under natural flow doctrine to relative rights under reasonable use. In *The Transformation of American Law*, Horwitz contends the absolute conception of property led to "anticompetitive results" that burdened economic growth.[94] Other commentators have also noted that natural flow doctrine "discouraged the development and use of water."[95] In Horwitz's account, the shift to a more relaxed doctrine of reasonable use purposely subsidized capitalist developers by allowing them to inflict injury on weaker members of society without liability, so long as they did so with due care.[96]

Carol Rose, on the other hand, takes the view that the absolute regime seemed to function efficiently when water-use disputes involved few—usually only two—parties. But, as increased water use led to interruptions of flow and pollution from

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[88] *Tyler*, 24 F. Cas. at 474–75.

[89] MORTON J. HORWITZ, THE TRANSFORMATION OF AMERICAN LAW, 1780–1860, 39 (1977).

[90] City of Canton v. Shock, 63 N.E. 600, 603–04 (Ohio 1902) (noting a riparian has no right to transfer water to persons outside of the basin).

[91] *See, e.g.*, Evans v. Merriweather, 4 Ill. (3 Scam.) 492, 495–96 (1842) (prioritizing use of riparian waters for "natural wants" like drinking, household purposes, and water for cattle, over "artificial wants" such as irrigation and manufacturing purposes).

[92] RESTATEMENT (SECOND) OF TORTS § 850A (AM. L. INST. 1979).

[93] A. DAN TARLOCK, JAMES N. CORBRIDGE JR., DAVID H. GETCHES, REED D. BENSON, & SARAH F. BATES, WATER RESOURCE MANAGEMENT: A CASEBOOK IN LAW AND PUBLIC POLICY 133 (6th ed. 2009).

[94] HORWITZ, *supra* note 89, at 101–02, 34–35.

[95] Lauer, *supra* note 60, at 84.

[96] HORWITZ, *supra* note 89, at 102 (noting that "courts began to strike a balance between competing land uses, freeing many economically desirable but injurious activities from legal liability if they were exercised with due care").

upstream sources that implicated large numbers of downstream claimants, the doctrine turned toward reasonable use. Reasonable use doctrine, argues Rose, distributed rights to use water more widely, thus avoiding many of the transaction costs that made dispute resolution involving large numbers of claimants difficult.[97]

4. Absolute Rights Based on Prior Appropriation Rise Again in the West

While reasonable use doctrine was taking hold in the East, miners in western American states were developing an informal water rights regime based on prior appropriation principles similar to Blackstone's.[98] Modern prior appropriation initially arose as custom in California mining camps, where miners lacked ownership rights in the land and could not claim riparian rights as such.[99] The custom eventually came to be adopted as doctrine by courts in western states, which preferred it to reasonable use.[100] As Carol Rose chronicles, "in the West . . . scarcity and the need for careful husbanding of water resources drove water law beyond riparianism's vague correlative rights, and into the more expensive but also more effective appropriation regime of individual property rights in water."[101] Prior appropriation was eventually formalized by western legislatures through adoption of state administrative structures to allocate, monitor, and coordinate trading of appropriative rights.[102]

Professor Rose posits that the return to stricter, more absolute water rights in western states was the result of higher levels of scarcity and the predominant use of water for consumption (usually irrigation) rather than power generation, as in the East. Water used for irrigation, for example, is mostly consumptive, and thus poses a zero-sum game for potential users—where *A*'s irrigation leaves less for *B*. Water used for instream power generation, as by a mill, on the other hand, is not consumptive in this sense, but is more like a "renewable" resource.[103] Higher levels of scarcity justified the higher administrative costs associated with allocating strict property rights under prior appropriation.

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[97] *See* Rose, *Common-Law Water Rights, supra* note 68, at 282.

[98] The doctrine has roots in English common law's notion of occupancy to establish water rights based on first possession, and is similar to Blackstone's prior appropriation theory. *See* Mark T. Kanazawa, *Efficiency in Western Water Law: The Development of the California Doctrine*, *1850–1911*, 27 J. LEGAL STUD. 159, 166 (1998).

[99] Reed D. Benson, *A Few Ironies of Western Water Law*, 6 WYO. L. REV. 331, 333 (2006).

[100] Burke W. Griggs, *Beyond Drought: Water Rights in the Age of Permanent Depletion*, 62 U. KAN. L. REV. 1,363, 1,271–72 (2014); *see, e.g.*, Coffin v. The Left Hand Ditch Co., 6 Colo. 443, 443–44 (1882) (explicitly adopting prior appropriation doctrine and rejecting riparianism).

[101] Rose, *Common-Law Water Rights, supra* note 68, at 265.

[102] *See, e.g.*, N.M. STAT. ANN. §§ 72-1-1–-2 (2020).

[103] Rose, *Common-Law Water Rights, supra* note 68, at 290–92.

Moreover, prior appropriation functions more efficiently in times of drought than reasonable use. Appropriative rights are prioritized based on the time of first appropriation. Senior rights in the priority chain are entitled to full satisfaction of their appropriative right before any junior interest may partake. In times of severe drought, when there is insufficient water to satisfy the needs of all claimants, at least senior rights holders are nonetheless able to make beneficial use of what little water remains. In contrast, under reasonable use, riparian rights holders must share the shortage, such that none of them may have enough water for crops, and the little water they did apply would go to waste.[104] Prior appropriation doctrine thus allocates water use rights more efficiently in drought conditions, which are more common in the arid West than in the East.

As a doctrine of western water law, prior appropriation's greatest challenges have arisen in allocating rights to groundwater resources, which, unlike surface waters, are largely nonrenewable and depletable. As such, the details of the doctrine are outlined more fully in the below discussion of groundwater rights.[105]

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To summarize the development of riparian water rights after the medieval period, the period began with an absolutist view of rights in a watercourse under which riparians were categorically protected from disturbance, except by ancient uses, which were themselves categorically protected from disturbance. Later, mere occupancy supplanted prescription as the basis for water rights as seventeenth-century courts essentially rendered all rights incidental to land, including riparian rights, relative in theory under the maxim *sic utere tuo*. At first, under Blackstone's prior appropriation doctrine, water rights established by a prior use were deemed nearly absolute even under *sic utere tuo*. However, English and American courts in the eighteenth and nineteenth centuries gradually allowed social concerns to weigh in their determinations of property rights under the maxim. In the American West, however, where water is scarcer than in the East and its use was mostly consumptive, rights again hardened to become absolute under modern prior appropriation doctrine. These broad themes, as seen below, are echoed in the development of groundwater rights.

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[104] *See* Griggs, *supra* note 100, at 1302; *see also* Burke W. Griggs, *Water: Practical Challenges and Legal Rights to Acquire and Recycle Water for Hydraulic Fracturing*, 56 ROCKY MTN. MIN. L. FOUND. J. 69, 84–85 (2019) [hereinafter Griggs, *Water for Hydraulic Fracturing*] (describing prior appropriation doctrine).

[105] *See infra* Part III.C.4.

C. Groundwater[106]

1. Acton v. Blundell *and Absolute Ownership*

For much of history, underground waters received significantly less attention as a matter of local custom and judicial decisions than riparian waters. Modern groundwater law started to develop in earnest only in the mid-nineteenth century,[107] with the leading case of *Acton v. Blundell*.[108] The plaintiff sued after the defendant's mining operations cut off the underground stream that drove the machinery in the plaintiff's cotton mills. In denying the plaintiff relief, the court declined to consider rights in groundwater as relative or limited by any version of *sic utere tuo*.[109] On the contrary, *Acton* held that a landowner is privileged to make any use of waters beneath its *ad coelum*-defined tract of land, regardless of whether it interferes with another's ability to use the same waters.[110] *Acton* essentially adopted a rule of capture for groundwater.

In declining to apply *sic utere tuo*, *Acton* gave considerable weight to the fact that subterranean waters are unseen and their natural flows and courses unknown. The court expressed doubt about its ability to determine the necessary facts to adjudicate an alleged interference with producing groundwater wells.[111] Other contemporaneous courts likewise eschewed a relative rights rule because it would entail significant problems of proof and other administrative impracticalities.[112]

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[106] For a discussion of the different categories of underground waters, *see* Joseph W. Dellapenna, *A Primer on Groundwater Law*, 49 IDAHO L. REV. 265, 265–66 (2013). For present purposes, I will use "groundwater" to refer generally to sources of underground water.

[107] For an early account of groundwater rights, *see generally* Henry Budd, *The Law of Subterranean Waters*, AM. L. REG. 237 (1891).

[108] Acton v. Blundell (1843) 152 Eng. Rep. 1223; 12 M. & W. 324.

[109] Budd, *supra* note 107, at 238–39.

[110] *Acton*, 152 Eng. Rep. at 1,234–35; 353–54,5 (quoting the Digest [39.3.1.12] (Marcellus)).

[111] *Acton*, 152 Eng. Rep. at 1,223; 324; *see also* Dellapenna, *supra* note 106, at 271–72 n. 49 (noting that *Acton* admitted non-liability was the only possible rule for groundwater interference due to the lack of understanding about the nature of groundwater).

[112] *See, e.g.*, Frazier v. Brown, 12 Ohio St. 294, 311 (1861), *overruled by* Cline v. Am. Aggregates Corp., 474 N.E.2d 324 (1984) ("Because the existence, origin, movement and course of such waters, and the causes which govern and direct their movements, are so secret, occult and concealed, that an attempt to administer any set of legal rules in respect to them would be involved in hopeless uncertainty, and would be, therefore, practically impossible."); Chatfield v. Wilson, 28 Vt. 49, 54 (1855) ("But we think the law governing running streams is not applicable to underground water, and that no light can be obtained from the law of surface streams; and if it is to be established that there are *correlative* rights existing, between adjoining proprietors of land, to the use of water percolating the earth, an entire new chapter in the law will be necessary to define what these rights are, and to put them on some tangible and practical ground, that the rules concerning them may be applied

In England, *Acton v. Blundell*'s absolute rule of capture doctrine became the rule, though judges quickly expressed dissatisfaction. In the 1857 case of *Chasemore v. Richards*, for example, Coleridge, J., dissenting, opined that the rights of adjoining landowners in percolating waters should be governed by *sic utere tuo* rather than *Acton*.[113] In America, *Acton* was widely adopted initially, particularly in eastern states, which Horwitz attributes to nineteenth-century American judges' laissez-faire ideologies and general desire to promote economic development.[114]

Even so, New Hampshire courts early on suggested that the right of a landowner to appropriate subterranean waters is limited by the corresponding right of his neighbor. Only five years after *Acton*, the New Hampshire Supreme Court adopted a rule of reasonable use for groundwater, highly similar to *Tyler v. Wilkinson*'s rule for surface waters.[115] New Hampshire law thus illustrates that the move from the first stage of absolute rights to a second stage of relative rights need not occur over generations.

2. Rights Become Limited Under Stress of Scarcity and Depletion—The Groundwater Revolution

Many states that initially followed *Acton* subsequently limited its reach doctrinally or legislatively.[116] The rule proved problematic as technological innovations in the mid-twentieth century sharply increased demand for groundwater. These innovations included the high-pressure centrifugal pump, capable of drawing water at greater rates and from greater depths;[117] rural electrification, which made pumping for groundwater financially attractive;[118] and inexpensive irrigation pipe,

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to common use. But from the very nature of the case, this seems impracticable.") (emphasis in original).

[113] Chasemore v. Richards (1857) 157 Eng. Rep. 71; 2 Hurlst. & N. 186, 195–96 (Coleridge, J., dissenting).

[114] HORWITZ, *supra* note 89, at 105–08.

[115] *Subterranean and Percolating Waters; Springs; Wells*, 55 A.L.R. 1385, I.b.2.(b).(1) (1928) (citing Bassett v. Salisbury Mfg. Co., 43 N.H. 569, 82 Am. Dec. 179 (1862); Swett v. Cutts, 50 N.H. 439, 9 Am. Rep. 276 (1870)).

[116] Of the western states, where groundwater is often a critically scarce resource, only Texas stills follows the rule of capture. Gabe Collins, *Blue Gold: Commoditize Groundwater and Use Correlative Management to Balance City, Farm, and Frac Water Use in Texas*, 55 NAT. RES. J. 441, 447 (2015) (indicating that the Texas rule springs from deep historical roots, including the English common law, Roman law, and Mexican law). A small handful of American jurisdictions still follow an unlimited rule of capture for groundwater. These include Indiana, Maine, and Texas; only in Texas has the common law rule of capture largely survived despite legislative limitations. Dellapenna, *supra* note 106, at 274–76.

[117] Dellapenna, *supra* note 106, at 266–68.

[118] Clyde O. Martz, *The Law of Underground Waters*, 11 OKLA. L. REV. 26, 27 (1958) (providing a contemporaneous account of the effects of the groundwater revolution).

which permitted rapid expansion of irrigation capacity and thereby increased agricultural demands on water supplies.[119]

The explosive growth of groundwater extraction—termed the "groundwater revolution"[120]—created resource scarcity and depletion in areas where demand outstripped supply.[121] In the arid American West, groundwater levels were quick to decline (and pumping costs quick to rise), making the resource more costly and harder to access for many potential users, and reducing stocks available to posterity.[122] The New Mexico Supreme Court summarized the problem of administering water rights in a non-rechargeable basin in *Mathers v. Texaco, Inc.* as follows: "Each appropriator . . . reduces in amount, and in time of use, the supply of water available to all prior appropriators, with the consequent decline of the water table, higher pumping costs, and lower yields."[123]

These problems were, and continue to be, compounded by the fact that many western groundwater aquifers, while huge, are effectively nonrenewable. Thus, extraction of groundwater is mostly consumptive and groundwater supplies are depletable.[124] Unlike surface waters, which even in times of drought are not permanently depleted, groundwater resources are subject to permanent depletion by extraction exceeding the rate of recharge—sometimes called "groundwater mining"[125] or "over-appropriation."[126] "Such problems could only result in stresses on the received groundwater law" of *Acton*'s rule of capture.[127]

Additionally, though less significantly, the convenience of *Acton*'s rule of capture diminished in importance as technical knowledge about, and the ability to control, subsurface waters improved. As Professor Joseph Dellapenna observed, adopting limitations on groundwater rights "reflected a growing confidence that more knowledge was available regarding groundwater than when the absolute dominion rule developed."[128]

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[119] *Id.*

[120] *See* Griggs, *supra* note 100, at 1282.

[121] Dellapenna, *supra* note 106, at 266–68.

[122] *See generally* Robert Emmet Clark, *Ground Water Legislation in the Light of Experience in the Western States*, 22 MONT. L. REV. 42 (1960) (discussing western states' legislative responses to scarcity of groundwater resources).

[123] Mathers v. Texaco, Inc., 421 P.2d 771, 775 (N.M. 1966).

[124] *See* Griggs, *supra* note 100, at 1,298, 1,282–84 (describing the Ogallala aquifer as an example).

[125] Paula K. Smith, *Coercion and Groundwater Management: Three Case Studies and a "Market" Approach*, 16 ENV'T. L. 797, 802 (1986).

[126] *See* Griggs, *supra* note 100, at 1,296–98 (distinguishing drought from depletion from "permanent depletion"); *see also* Barton H. Thompson, Jr., *Tragically Difficult: The Obstacles to Governing the Commons*, 30 ENV'T. L. 241, 249–53 (2000) (discussing groundwater depletion by "overdrafting").

[127] Dellapenna, *supra* note 106, at 266–68.

[128] *Id.* at 290.

These changes in circumstances influenced jurisdictions to temper the rule of capture in various ways.[129] Some adopted a correlative rights doctrine that permits each reservoir owner to extract its proportional share of available groundwater. Others follow a reasonable use principle, similar to riparian law, in which rights to use water are determined on multiple factors intended to achieve an efficient use of available water. A few states have replaced the reasonable use rule with a straightforward application of nuisance law.[130] Many states in the American West, which is especially arid, instead adopted a modern prior appropriation rule. Each alternative means of limiting the absolute appropriation rule is reviewed briefly below.

3. Correlative Rights Doctrine, Reasonable Use, and the American Rule

In groundwater law, the rule of correlative rights and the rule of reasonable use are related. Under the doctrine of reasonable use, limits on landowners' appropriation of water are determined by balancing the interests of the appropriator, other owners in the aquifer, and the public.[131] Under correlative rights doctrine, in contrast, limits are determined strictly in proportion to the size of the owner's landholdings in the aquifer.[132] Many courts have conflated the two doctrines, or combined them into a so-called "American rule."[133]

The rules, though similar, are in fact distinct.[134] They are similar in that both correlative rights and the reasonable use rule limit the absolute rule of capture by requiring sharing of groundwater resources among owners in the common aquifer.[135] At a general level, both concepts indicate that each owner of a portion of a common pool has legal privileges against other owners therein to use the common pool, as well as corresponding duties not to impair other owners' rights or diminish the

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[129] *See* Martz, *supra* note 118, at 30.

[130] Dellapenna, *supra* note 106, at 275–76 (citing, e.g., Neuse River Found., Inc. v. Smithfield Foods, Inc., 574 S.E.2d 48 (N.C. Ct. App. 2002); State v. Michels Pipeline Constr., Inc., 217 N.W.2d 339, 347 (Wisc. 1974); James Burling, *The Latest Take on Background Principles and the States' Law of Property After* Lucas *and* Palazzolo, 24 U. HAW. L. REV. 497 (2002)).

[131] For early decisions, *see* Bassett v. Salisbury Mfg. Co., 43 N.H. 569, 574–75, 82 Am. Dec. 179 (1862); Swett v. Cutts, 50 N.H. 439, 446 9 Am. Rep. 276 (1870).

[132] For early decisions, *see* Erickson v. Crookston Waterworks, Power & Light Co., 111 N.W. 391 (Minn. 1901); Katz v. Walkinshaw, 141 Cal. 116 (1902); Meeker v. City of E. Orange, 74 A. 379 (N.J. 1909).

[133] *See, e.g.*, State v. Michels Pipeline Constr., Inc., 217 N.W.2d 339, 349 (Wis. 1974) (citing *Subterranean and Percolating Waters; Springs; Wells*, 55 A.L.R. 1,385 (1928)); *see also* Dellapenna, *supra* note 106, at 270 (noting "a judicial tendency to treat the terms correlative rights and reasonable use as merely variant ways of making the same point—that water users drawing from a common source have interrelated rights such that each must consider the equal clam of others on that source").

[134] *See* 93 C.J.S. *Waters* §§ 201–02 (2020).

[135] Dellapenna, *supra* note 106, at 270.

ultimate value of the common pool to all owners.[136] However, careful observers distinguish between correlative rights and reasonable use based on the manner in which they circumscribe owners' rights.

As noted, under reasonable use, the extent of rights is defined by weighing the utility of the defendant's use of water against the harm to the plaintiff's use.[137] Section 850A of the Restatement (Second) of Torts, for example, defines reasonable use of groundwater resources based on the same utility-balancing test as for riparian rights. This test is also closely related to the Restatement's "balance of utilities" test for nuisance liability.[138] Thus, under the Restatement's view, reasonableness of use is determined case by case by balancing various factors intended to maximize social utility, such as the purpose of the use, the suitability of the use to the watercourse, the economic and social value of the use, the harm it causes, and the practicality of avoiding the harm by adjusting one of the uses.[139]

Under the correlative rights rule, in contrast, an owner's share of groundwater from a common aquifer is determined in strict proportion to the surface acreage of her tract.[140] Unlike the reasonable use rule, the proportional correlative rights rule leaves "no room for judicial adjustment of shares to reflect a judge's appraisal of what is the most reasonable use of the groundwater."[141] The strict, proportional approach furnishes a more certain, but also more rigid, allocation of groundwater versus the reasonable use rule. Correlative rights and the rule of reasonable use thus represent alternative methods of divvying up commonly owned groundwater resources.[142]

Some courts have dispensed with both reasonable use and correlative rights in favor of a nuisance standard for governing the use of groundwater aquifers. For

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[136] *See* Pierce, *Modern Property Analysis, supra* note 32, at 257 (discussing that "[c]orrelative rights ensure that each owner in a reservoir has the opportunity to fully develop the oil and gas resource beneath his land, so long as he does so without unreasonably interfering with the rights of other impacted owners").

[137] Dellapenna, *supra* note 106, at 297.

[138] *Compare* RESTATEMENT (SECOND) OF TORTS § 850A (AM. LAW INST.1979) (defining reasonableness in use of water), *with* RESTATEMENT (SECOND) OF TORTS § 826 (AM. LAW INST. 1979) (defining reasonableness in use of land, *i.e.*, nuisance). As the Supreme Court of Nebraska observed, "The Restatement rule [of reasonable use] finds its support in the principles of nuisance law . . . ." Spear T Ranch, Inc. v. Knaub, 691 N.W.2d 116, 129 (Neb. 2005).

[139] *See Spear T Ranch*, 691 N.W.2d at 131 ("Thus, under the Restatement, reasonableness of use is determined on a case-by-case basis and many factors can be considered; the test is flexible.").

[140] *See, e.g.*, OKLA. STAT. TIT. 82, §§ 1,020.2, 1,020.6. (2020).

[141] Dellapenna, *supra* note 106, at 278.

[142] The task of allocating a reasonable amount to each common owner can alternatively be, and in modern times often is, accomplished by legislation and regulation. GETZLER, *supra* note 60, at 44 ("Ultimately the common law's capacity to govern water entitlements proved inadequate, and an ad hoc regime of private (and later public) statute was invoked to perform the task.").

example, in *Henderson v. Wade Sand & Gravel Co.*,[143] the Alabama Supreme Court, following Florida precedent, held "that where a plaintiff's use of groundwater, whether it be for consumption or, as here, for support, is interfered with by defendant's diversion of that water, incidental to some use of his own land, the rules of liability developed by the law of nuisance will apply."[144]

4. Prior Appropriation Doctrine

Several western states follow a modern prior appropriation regime for groundwater, which had been adopted from mining custom in the West for governing rights in surface waters.[145] In general, prior appropriation allocates use rights based not on ownership of the appurtenant land, but on the prior act of diverting water for beneficial use.[146] Water rights acquired under the doctrine are defined by the extent of the beneficial use, such that appropriators receive a property interest in a discrete, quantifiable amount of water.[147] When there is not enough water to satisfy all water rights, priority is determined by the principle, "first in time, first in right."[148] Thus, "[i]n times of shortage, the holder of a senior water right has the legal right to use all of the water authorized under that right, and junior rights holders generally cannot fulfill their rights until the senior rights have been satisfied."[149]

In this sense, appropriation rights are absolute and prohibit a junior rights holder from interfering with (called "impairing") a prior right in any manner.[150] This feature distinguishes prior appropriation rights from correlative rights and reasonable use rules, which balances the equities of various right holders in times of shortage.[151] This feature makes prior appropriation rights more efficient in times of scarcity. It marshals as much water as possible to satisfy senior rights so that they may continue their beneficial uses, rather than force all holders to reduce their stocks, perhaps to levels that cannot sustain any beneficial use.[152]

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[143] Henderson v. Wade Sand & Gravel Co., Inc., 388 So. 2d 900 (Ala. 1980).

[144] *Id.* at 903.

[145] *See supra* Part III.C.4. Most western states largely codified prior appropriation principles, with certain modifications, in the late nineteenth- or early twentieth-century. Reed D. Benson, *Alive but Irrelevant: The Prior Appropriation Doctrine in Today's Western Water Law*, 83 U. COLO. L. REV. 675, 676 (2012) [hereinafter Benson, *Alive but Irrelevant*].

[146] *See* Griggs, *Water for Hydraulic Fracturing, supra* note 104, at 84–85.

[147] *See* Benson, *supra* note 99, at 334 (noting about the prior appropriation doctrine, "[t]he bedrock principle of western water law is that beneficial use is the basis, the measure and the limit of a water right").

[148] Griggs, *Water for Hydraulic Fracturing, supra* note 104, at 84.

[149] *Id.*

[150] *Id.*

[151] *Id.* For a thorough summary of prior appropriation rights, *see id.* at 84–87.

[152] Griggs, *supra* note 100, at 1,313.

While appropriation rights are absolute, they are limited in scope. Unlike absolute rights under *Acton*'s rule of capture, prior appropriation rights permit use of an authorized quantity of water.[153] An appropriation right is also limited in terms of where the water may be produced from (the "point of diversion"), where the water may be used, and what purpose the water may be used for.[154] These limitations are costly to administer and monitor, which helps account for why prior appropriation is the law only in states where water is scarce and, in the case of groundwater, depletable.

The over-appropriation brought about by the groundwater revolution led legislatures in some western states to modify the extent of appropriative rights.[155] As early as 1957, Kansas redefined the meaning of "impairment" under its prior appropriation act to permit interference with a senior appropriative right within "reasonable economic limit[s]."[156] Colorado likewise adopted a modified prior appropriation doctrine for certain nonrenewable groundwater, which protected appropriative rights not absolutely, but only to the extent of "reasonable groundwater pumping levels."[157] Both states also changed prior appropriation law to authorize local groundwater management districts to, among other things, impose restrictions on pumping by senior water rights and require rights holders to share shortages.[158] Likewise, as Professor Reed Benson has chronicled, Idaho's courts and legislature modified the state's prior appropriation regime to limit prior appropriation rights by "conditions of reasonable use."[159]

Thus, once established, groundwater rights in prior appropriation jurisdictions are generally absolute except as limited statutorily. Statutory limitations made in light of over-appropriation and critical scarcity tend to relativize appropriative rights by permitting reasonable impairment of senior rights by junior holders and authorizing local management bodies to impose shared reductions. These changes moved modern appropriative rights in groundwater closer to correlative rights or reasonable use.

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[153] Griggs, *Water for Hydraulic Fracturing, supra* note 104, at 86.

[154] *Id.* at 86–87.

[155] Griggs, *supra* note 100, at 1284.

[156] *Id.* at 1284–85 (citing KAN. STAT. ANN. ¶ 82a-711 (Kan. L. 1957, ch. 539, § 16) (1957)). As Griggs details, the state's policy of liberally granting water rights applications substantially enabled over-appropriation of groundwater despite the limitation imposed on appropriative rights by the definitional change. *Id.* at 1285.

[157] *Id.* at 1288 (quoting COLO. REV. STAT. § 37-90-102(1) (2014)).

[158] *See id.* at 1,289–95 (discussing Kansas and Colorado groundwater management statutory schemes).

[159] Benson, *Alive but Irrelevant, supra* note 145, at 691–95. In his article, Professor Benson highlights other statutory and judicial modifications of prior appropriation principles in New Mexico and Washington. *See generally* Benson, *Alive but Irrelevant, supra* note 145.

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To summarize, groundwater rights, like riparian rights, began as absolute and largely relativized as the availability of groundwater became a concern. The extent of relative rights in groundwater is determined differently in different jurisdictions. In reasonable use jurisdictions, the extent of rights is determined, as with riparian rights, by balancing the interests of the parties and the public. Certain states supplanted the doctrine with nuisance, which itself determines relative rights on a test of reasonableness. In correlative rights jurisdictions, rights are determined strictly in proportion to the size of each owner's land holdings overlying the aquifer. In prior appropriation jurisdictions, where groundwater is extremely scarce and subject to permanent depletion, prior use of groundwater vests absolute rights in the full extent of the established use. These rights are stinted, if at all, by statutory limitations that often impose reasonableness restrictions on use.

D. Oil and Gas

As a model of semicommon property rights, oil and gas law is the closest analogy to reservoir pore space. Pore space activities predominately occur in active and depleted oil and gas reservoirs, including injection and disposal of produced water, hazardous and nonhazardous wastes, carbon storage, horizontal drilling, and hydraulic fracturing.[160] As discussed above, however, oil and gas conservation laws generally do not address these and other uses of pore space.[161] Hence, it is necessary to identify the common law principles governing common pools of oil and gas, as they exist independently of statutory modification, to guide development of pore space property doctrine.

As with common law riparian and groundwater rights, principles of oil and gas property were developed in stages. At the advent of commercial oil and gas production in the United States, rights to produce oil and gas from common reservoirs were determined by an *Acton*-like rule of capture. The waste of resources that resulted from overproduction incentivized by the rule of capture is famous. Oil and gas law accordingly moved into the second stage of development, in which the rule of capture was tempered statutorily by conservation regulation, and doctrinally by a weak theory of correlative rights. Conservation statutes generally retain the absolute character of capture rights, but limited their scope.

Because state legislatures stepped into the breach and limited the rule of capture, correlative rights doctrine is not as fully developed as its counterparts in water law—correlative rights and reasonable use. This doctrinal limitation, though weak, nonetheless serves to relativize rights to common pools of oil and gas. The significant scholarly debate over the precise meaning of correlative rights reflects the tension between determining property limitations based on a rule of strict proportionality or, instead, by a reasonableness standard.

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[160] *See* Schremmer, *supra* note 5, at 321–24.

[161] *See supra* Part II.D.

1. Absolute Rights and the Rule of Capture

In general, courts deciding issues of ownership of oil or gas in early cases followed the approach of *Acton v. Blundell* and applied an absolute ownership rule to oil and gas.[162] Under this "rule of capture," an owner of land "acquires title to the oil or gas which he produces from wells drilled thereon, though it may be proved that part of such oil or gas migrated from adjoining lands."[163] At bottom, the rule of capture is a tort privilege or a rule of non-liability as much as it is a principle of property ownership.

The necessary corollary to the rule of capture is the offset drilling rule,[164] as illustrated in *Kelly v. Ohio Oil Co*.[165] There, the defendant drilled multiple oil wells within 25 feet of the plaintiff's lease line, allegedly with the malicious intent of draining oil from the plaintiff's tract. The plaintiff sued to enjoin the defendant from drilling or operating wells within 200 feet of the property line to protect the plaintiff's oil and gas from draining into the defendant's wells. The court denied relief on the grounds that "[t]he right to drill and produce oil on one's own land *is absolute*" and that injunctive relief was precluded because the plaintiff had an ample self-help remedy: drill a line of offset protection wells along the defendant's tract . . . .[166] Offset drilling thus became the exclusive remedy for damage by drainage.[167]

As some of the early opinions articulate, the absolute rule of capture is administratively convenient. Early courts and litigants lacked sophisticated understanding of the behavior of oil and gas in unseen reservoirs, and the absolute rule avoided the administrative and information costs[168] of proving drainage and allocating production.[169] Yet, while it enjoyed cost advantages, the negative

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[162] *See* Bruce M. Kramer & Owen L. Anderson, *The Rule of Capture – An Oil and Gas Perspective*, 35 ENV'T. L. 899, 904 (2005).

[163] Robert E. Hardwicke, *The Rule of Capture and Its Implications as Applied to Oil and Gas*, 13 TEX. L. REV. 391, 393 (1935). For discussion of the history and development of the rule of capture in oil and gas law, *see generally* DAINTITH, *supra* note 43.

[164] *See* Kramer & Anderson, *supra* note 162, at 900 (referring to the offset drilling rule as the rule of capture's "evil twin").

[165] Kelly v. Ohio Oil Co., 49 N.E. 399, 401 (Ohio 1897).

[166] *Id.* (emphasis added).

[167] *See* Barnard v. Monongahela Nat. Gas Co., 65 A. 801, 802 (Pa. 1907) (holding that a landowner's only remedy for drainage of oil from under his land by a neighbor's well is to "go and do likewise," i.e., drill an offset well).

[168] "[I]nformation costs . . . include the cost of measuring stocks or flows of a resource, and of delineating, monitoring, and enforcing property rights to them." Henry E. Smith, *Governing Water: The Semicommons of Fluid Property Rights*, 50 ARIZ. L. REV. 445, 446 (2008) [hereinafter Smith, *Governing Water*].

[169] Kramer & Anderson, *supra* note 162, at 927 (discussing Edwards v. Lachman, 534 P.2d 670 (Okla. 1974)).

consequences of the absolute rule are well documented.[170] Briefly, the rule of capture and the offset drilling rule incentivized the drilling of many more wells than were necessary to efficiently produce oil and gas reservoirs.[171] This resulted in needless expenditure of capital and excessive use of surface property for wells.[172] Additionally, the legal regime incentivized production of more oil than market demand could bear and caused price instability.[173] Finally, and most importantly, unrestrained production prematurely dissipated the natural energy of reservoirs that drives oil and gas into wellbores in the first place, trapping a great deal of hydrocarbons in the reservoir forever.[174]

In sum, the absolute ownership regime led to many forms of physical and economic waste and a classic example of a tragedy of the commons. Moreover, understanding of the physical characteristics of oil and gas reservoirs improved rapidly. By the 1920s, it was apparent that a strict rule of capture was not completely justified on the ground that the behavior of oil and gas is unknowable.[175] Nonetheless, the rule remained administrative- and information-cost-effective.

2. Limits on Capture Under the Correlative Rights Doctrine

The legal response to rampant waste resulting from the absolute rule of capture primarily came from state legislatures, which adopted conservation statutes to limit the scope of capture rights. These statutes do not relativize capture rights, but instead merely place administrative limitations on where and how capture rights may be exercised through rules governing well spacing, density, and prorationing of production from individual wells.[176] The resulting rights to produce oil and gas are absolute, in that they do not impose reciprocal duties among owners, but narrowed by administrative limitations, somewhat like groundwater rights under modern prior appropriation statutes.[177]

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[170] For discussion of the waste of reservoir energy and drilling of needless wells, *see generally* Hardwicke, *supra* note 163, at 391–92 n.1; Robert E. Hardwicke, *Oil-Well Spacing Regulations and Protection of Property Rights in Texas*, 31 TEX. L. REV. 99, 111 (1952); Northcutt Ely, *The Conservation of Oil*, 51 HARV. L. REV. 1209, 1219–21 (1938).

[171] Hardwicke, *supra* note 163, at 391–92 n.1.

[172] DAINTITH, *supra* note 43, at 8; Hardwicke, *supra* note 163, at 391 n.1.

[173] *See* DAINTITH, *supra* note 43, at 9; Hardwicke, *supra* note 163, at 391 n.1.

[174] Ely, *supra* note 170, at 1,219–20; DAINTITH, *supra* note 43, at 9.

[175] DAINTITH, *supra* note 43, at 9–11 (discussing the early critic of the rule of capture, Harry Doherty, who campaigned for unitization in the 1920s).

[176] *See* David E. Pierce, *Minimizing the Environmental Impact of Oil and Gas Development by Maximizing Production Conservation*, 85 N.D. L. REV. 759, 760–66 (2009) [hereinafter Pierce, *Maximizing Production Conservation*]; Gruger v. Phillips Petroleum Co., 135 P.2d 485, 488 (Okla. 1943) (holding that such administrative limits imposed by conservation statutes do not abrogate the rule of capture).

[177] *See supra* Part III.C.4.

The principal common law limitation that developed to temper the absolute extent of oil and gas rights under the rule of capture is the correlative rights doctrine. Although, "[t]he term 'correlative rights' has meant different things to different people at different times,"[178] it generally describes judicial limitations on an absolute application of the rule of capture.[179] Courts have long recognized that property rights in a common pool of oil or gas are relative because of the physical interconnectedness of reservoirs,[180] and have accordingly upheld statutory limits on the rule of capture against takings challenges.[181] However, because of the success of such statutory conservation regimes, few courts have had occasion to precisely define the common law limits on oil and gas ownership. The substantive content of oil and gas correlative rights doctrine thus remains unsettled. The doctrine has developed, such as it has, primarily through scholarly literature.

Professor Summers provided an early and influential definition of correlative rights as follows:

> (a) each owner of an interest in a common source of supply of oil and gas has a legal privilege, as against the other owners, to take oil and gas by lawful operations, limited by dual duties to the other owners (b) not to injure the source of supply, and (c) not to take an undue proportion of the oil and gas.[182]

The dual duties of Summers's definition address two aspects of property rights in a common pool. The first—the duty not to damage the source of supply—proscribes the manner of using elements of the common pool. I will call this the "conduct prong." The conduct prong is universally accepted as an element of common

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[178] Kramer & Anderson, *supra* note 162, at 903 n.9.

[179] *Id.* at 903 n.9, 911–12.

[180] The Supreme Court of the United States first identified rights in a common source of oil or gas supply as "correlative" in the 1900 case of Ohio Oil v. Indiana. The Court noted that while the "surface proprietors within the gas field all have the right to reduce to possession the gas and oil beneath . . . *there is a co-equal right in them all* to take from a common source of supply . . . ." Ohio Oil Co. v. Indiana, 177 U.S. 190, 209–10 (1900) (emphasis added); *see also* 1 SUMMERS, OIL AND GAS LAW § 3:4 (3d ed.) ("These 'correlative rights' were not created by the statute in question, but existed because of the physical properties of oil and gas.).

[181] 1 SUMMERS, *supra* note 180, at § 3:4; Maurice H. Merrill, *The Evolution of Oil & Gas Law*, 13 MISS. L.J. 281, 289–90 (1941); *see also* Robert E. Hardwicke & M.K. Woodward, *Fair Share and the Small Tract in Texas*, 41 TEX. L. REV. 75, 79 (1962) (noting the power to regulate production may be "based on the 'police power,' which includes the authority to make effective the legal maxim [*sic utere tuo*]").

[182] 1 SUMMERS, *supra* note 180, at § 3:3. *See also In re* Methyl Tertiary Butyl Ether (MTBE) Prods., 457 F. Supp. 2d 455 (S.D.N.Y. 2006) *and* Exxon Corp. v. Yarema, 516 A.2d 990 (Md. Ct. App. 1986) (explaining that these dual duties—the duty not to injure the reservoir and not to take an undue portion—are similar to limitations imposed on owners' conduct in groundwater aquifers).

owners' correlative property rights. The second—the duty not to take an undue portion of the oil and gas—addresses the allocation of the contents of a common pool among its owners. I will call this the "allocation prong." Courts and commentators generally have not accepted Summers's version of the allocation prong.[183] I will examine each prong, starting with the allocation prong.

(a) The Allocation Prong: The Duty Not to Take an Undue Portion

Much like groundwater law's correlative rights doctrine, under Summers's definition of correlative rights, an owner would be entitled to a share of production from the common pool of oil or gas in proportion to the surface area of his tract overlying the pool. Summers envisioned that each owner's portion of oil and gas in place in a common pool could be determined by technical information about the reservoir.[184] The American Petroleum Institute (API) initially held the same view, writing in 1931 that "each owner of the surface is entitled only to his equitable and ratable share of the recoverable oil and gas energy in the common pool in the proportion which the recoverable reserves underlying his land bears to the recoverable reserves in the pool."[185]

However, as Professor Pierce has observed, "[i]f this principle were applied literally, then a producer would have to stop producing once it had recovered its 'equitable and ratable share of the recoverable oil and gas' from the reservoir," which would "severely limit the rule of capture and the entrepreneurial spirit that the rule inspires."[186] Perhaps with similar concerns in mind, the API amended its position in 1942, stating that "each operator should have an *opportunity* equal to that afforded other operators to recover the equivalent of the amount of recoverable oil (and gas) . . . underlying his property."[187]

Courts also adopted a fair-opportunity definition of correlative rights, as opposed to a fair-share definition,[188] as did legislatures when drafting conservation statutes.[189] Contemporary commentators are likewise emphatic that correlative rights merely entitle an owner to the opportunity to produce and not a particular

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[183] Pierce, *Intra-Reservoir Horizontal Drilling, supra* note 29, at 256.

[184] 1 SUMMERS, *supra* note 180, at § 3:3.

[185] Wronski v. Sun Oil Co., 279 N.W.2d 564, 569–70 (Mich. Ct. App. 1979) (quoting Graham, *supra* note 20, at 64–65).

[186] Pierce, *Reservoir Community Analysis, supra* note 25, at 800.

[187] Wronski v. Sun Oil Co., 279 N.W.2d 564, 570 (Mich. Ct. App. 1979) (quoting Graham, *supra* note 20, at 65) (emphasis added).

[188] *See, e.g.*, Elliff v. Texon Drilling Co., 210 S.W. 2d 559, 562 (Tex. 1948) (stating that a landowner's "reasonable opportunity to produce his fair share of the oil and gas [in a common reservoir] is the landowner's common law right under our theory of absolute ownership of the minerals in place").

[189] *See, e.g.*, N.M. STAT. ANN. § 70-2-33; COLO. REV. STAT. ANN. § 34-60-103 (West); 58 PA. STAT. ANN. § 402 (West); W. VA. CODE ANN. § 22C-9-2 (West); OHIO REV. CODE ANN. § 1509.01 (West).

share of production.[190] Accordingly, the doctrine has not developed, as envisioned by Summers, to specifically delimit the proportion of production an owner may take from a common reservoir.[191]

How does the doctrine uphold common owners' rights to a fair *opportunity* to produce from the common reservoir? In most cases, self-help under the offset drilling rule provides an effective means of ensuring each owner's opportunity to produce a common reservoir by permitting each owner to drill offset wells in the reservoir from the surface of their land.[192] Thus when *A* sinks a producing well into the Mississippi Lime and drains oil from a portion of the formation underlying *B*'s land, *B*'s recourse is to go and do likewise.[193] Under the rule of capture, *B* may drill an offset well on her own property and drain oil from the portion of the Mississippi Lime underlying *A*'s (or *C*'s, *D*'s, *E*'s, etc.) land. The law will provide no recourse for *B* if she fails to do so, as her correlative right is merely the *opportunity* to produce the reserves.[194]

Certain kinds of reservoir conduct, however, even when done with reasonable care, deprive other owners of the opportunity to conduct similar operations. The primary examples are secondary and tertiary recovery operations, like waterflooding or carbon dioxide flooding, which inject fluids to sweep hydrocarbons into producing wellbores from large swaths of a depleted reservoir. The sheer areal extent of operations like these prevent every owner in a common reservoir from engaging in them at once.

Thus, while "[e]ach owner in a common source of supply has the correlative right to a fair opportunity to conduct secondary recovery operations," before conducting such an operation, an owner must extend a fair opportunity to the other reservoir owners to participate in the operation. This rule avoids unjust enrichment of both the active owner and passive owners. The active owner must offer each passive owner a reasonable chance to enjoy a share of the value of the operations, and passive owners are not entitled to block the operations to extract an unjust portion of the value.[195]

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[190] Pierce, *Intra-Reservoir Horizontal Drilling, supra* note 29, at 256–58; *e.g.*, 1 BRUCE KRAMER & PATRICK H. MARTIN, THE LAW OF POOLING AND UNITIZATION 5–16 (3d ed. 2010).

[191] Pierce, *Intra-Reservoir Horizontal Drilling, supra* note 29, at 255–72.

[192] *Elliff*, 210 S.W. 2d at 562 (explaining that, under the fair-opportunity principle, "if all operators exercise the same degree of skill and diligence, each owner will recover in most instances his fair share of the oil and gas"); *see also* A.W. Walker Jr., *Property Rights in Oil and Gas and Their Effect upon Police Regulation of Production*, 16 TEX. L. REV. 370, 373–74 (1938) ("The 'correlative right' . . . is simply the remedy of self-help, to wit, the right to drill offset wells which will counteract and equalize the drainage between the two tracts.").

[193] *See* Kelly v. Ohio Oil, 49 N.E. 399, 401 (Ohio 1897).

[194] *See, e.g.*, *id.*; *see also* Walker, *supra* note 192, at 373–74.

[195] *See* 1 KUNTZ, *supra* note 56, § 4.8 (citing Reed v. Texas Co., 159 N.E.2d 641 (Ill. App. 1959)); *see, e.g.*, Baumgartner v. Gulf Oil Corp., 168 N.W. 2d 510, 518–19 (Neb.1969) (holding that an oil and gas lessee who withheld consent from a reasonable offer to unitize

(b) The Conduct Prong: The Duty Not to Damage the Source of Supply

The conduct prong of common law correlative rights is much more developed than the allocation prong, yet remains crudely defined.[196] Lacking judicial development, much of the jurisprudence concerning the limits on reservoir conduct is found in the scholarly literature. Three of the most prominent commentators in this field since Summers have been Professors Eugene Kuntz, David Pierce, and Owen Anderson. I will briefly survey each scholar's theory of reservoir conduct in turn.

(i) Professor Kuntz's "Special Community"

Writing after Summers, Kuntz developed a view of correlative rights grounded in reservoir-specific standards of conduct.[197] Kuntz described the common reservoir as a "special community"[198] in which owners' rights to develop are defined by social standards of conduct.[199] Per Kuntz, "[i]t is a simple doctrine that owners of rights in a common source of supply may not inflict loss upon one another by conduct which is considered to be socially undesirable."[200] The social acceptability of conduct in his model "must be determined, not only by applying the standards applicable to conduct generally, but by also considering the utility of the conduct in the light of its peculiar consequence to others operating in the same community."[201] Accordingly, Kuntz's model defines the correlative duties of owners based on a reasonableness, or negligence, standard: "While each operator owes a duty to use due care in operations to protect the common source of supply from spoilage, there is no liability for harm caused unintentionally in the absence of negligence, and the doctrine of res ipsa loquitur does not apply."[202]

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its lease is precluded from seeking damages for trespass and drainage caused by unit operations).

[196] Pierce, *Intra-Reservoir Horizontal Drilling, supra* note 29, at 254 (discussing how "[c]ourts have marshaled rights in the geophysical system only in the crudest of terms under the rubric of 'correlative rights.' This is not because of a lack of technical expertise, but rather the lack of an effective legal theory").

[197] 1 KUNTZ, *supra* note 56, § 4.3; *see also* Pierce, *Modern Property Analysis, supra* note 32, at 256–57 (comparing the views of Summers and Kuntz).

[198] Eugene Kuntz, *Correlative Rights in Oil and Gas*, 30 MISS. L.J. 1, 8 (1958); 1 KUNTZ, *supra* note 56, § 4.3.

[199] Pierce, *Reservoir Community Analysis, supra* note 25, at 803 (discussing Kuntz's "special community").

[200] 1 KUNTZ, *supra* note 56, § 4.3.

[201] *Id.*

[202] *Id.* at § 4.5 (citing Larkins-Warr Trust Co. v. Watchorn, 174 P.2d 589 (Okla. 1946)).

(ii) Professor Pierce's Reservoir Community Analysis

Building on Kuntz's reservoir community analogy, Pierce has developed a mode of analysis for determining when particular reservoir conduct violates community standards—the "reservoir community analysis." Unlike Kuntz, Pierce focuses on the "positive" correlative right to affirmatively develop the common reservoir, even by use of the subsurface of other owners.[203] Pierce defines owners' correlative rights with reference to the characteristics of the particular reservoir and what development techniques available at the time are likeliest to maximize ultimate recovery of the oil or gas from the reservoir as a whole.[204] Consequently, under Pierce's reservoir community analysis, "the correlative rights within a particular reservoir community must be evaluated on a case-by-case basis," and may evolve as technology and oilfield practice change.[205]

Pierce's reservoir community analysis involves basically three steps.[206] The first step is to define membership within the reservoir community by reference to the *ad coelum* doctrine. Owners of land with *ad coelum*-defined boundaries that overlie a reservoir enjoy correlative rights in the reservoir and are "members" of the reservoir community.[207] The second step is to define the physical attributes of the reservoir, such as the reservoir's porosity, permeability, pressures, lithology, and fluid content and saturation. The goal is to evaluate, through expert testimony and other technical evidence, the geological and geophysical characteristics of the reservoir.[208] The final step is to evaluate the activity impacting the reservoir with reference to the reservoir's physical attributes. In this step, "[t]he analysis should consider only what is necessary to maximize development and value from" the reservoir, ignoring collateral issues like impacts to the surface.[209] As with the second

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[203] David E. Pierce, *New Subsurface Property Rights in an Old Trespass World*, 65 ROCKY MTN. MIN. L. INST. 4-1, 4-9 (2019) [hereinafter Pierce, *New Subsurface Property Rights*].

[204] *See* Pierce, *Modern Property Analysis, supra* note 32, at 259 (discussing how "[c]orrelative rights are a matter of time and place. The 'time' element considers the state of the art in developing oil and gas. The 'place' encompasses the unique conditions presented by a particular reservoir. Development techniques and practices appropriate for one reservoir may be inappropriate for a different reservoir. Development techniques and practices that were reasonable at one time may become unreasonable as they are eclipsed by new techniques and practices").

[205] *Id.*

[206] The following is drawn from Pierce, *Reservoir Community Analysis, supra* note 25, at 804–06.

[207] *See id.* at 804.

[208] *Id.* at 805 ("Depending upon the conduct being evaluated, extensive geological and geophysical information may be collected for consideration. The goal is to figure out how the reservoir community works.").

[209] *Id.* at 805 n.104.

step of the analysis, this step turns on expert testimony and technical evidence of prevailing production techniques for reservoirs of that type.

Under reservoir community analysis, a reservoir owner may have to tolerate certain physical entries into her subsurface, and resulting drainage, that are done "reasonably [to] develop the reservoir."[210] For example, on the facts presented in *Coastal Oil & Gas Corp. v. Garza Energy Trust*,[211] no trespass would lie where fractures from the defendant's hydraulic fracturing treatment entered the plaintiffs' adjoining subsurface. The plaintiffs accordingly would have no right to recover damages for natural gas drained from their land into the defendant's well. Reservoir community analysis identifies two grounds for this result. First, the underlying tight shale formation at issue in *Garza* could be produced efficiently only through hydraulic fracturing. Second, while the plaintiffs must tolerate fissures and resulting drainage under their land, by the same rule they may benefit from placing fissures under neighboring land, including the defendant's land.[212]

(iii) Professor Anderson's Subsurface Trespass

Anderson has developed yet a different model of acceptable reservoir conduct. Anderson's "subsurface trespass" theory would privilege conduct that intrudes on another owner's portion of a common reservoir, "whenever the trespasser's subsurface intrusion accomplishes an important societal need (including private commercial needs) if the subsurface owner suffers no actual and substantial harm."[213] Anderson would privilege subsurface intrusions caused by waste disposal, secondary and enhanced recovery, hydraulic fracturing, horizontal drilling, natural gas storage, and carbon storage—all on the basis that they are societally beneficial and that damages are paid for actual harm caused.[214] Anderson's subsurface trespass theory is a faithful synthesis of the case law dealing with such kinds of intrusions. It is somewhat unclear, however, what criteria courts should use to determine when subsurface intrusions are societally beneficial. It may be that any non-wasteful use of the subsurface is "socially beneficial" for purposes of the rule.[215]

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[210] Pierce, *Modern Property Analysis, supra* note 32, at 259–63.

[211] Coastal Oil Coastal Oil & Gas Corp. v. Garza Energy Trust & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1 (Tex. 2008). *Garza* is discussed *infra* in Part III.D.3.(a).

[212] Pierce, *Modern Property Analysis, supra* note 32, at 259–63.

[213] Anderson, *supra* note 44, at 247; *see also* Owen L. Anderson, *Lord Coke, The Restatement, & Modern Subsurface Trespass Law*, 6 TEX. J. OIL GAS & ENERGY L. 203, 204–07 (2010) [hereinafter Anderson, *Lord Coke*].

[214] *See* Anderson, *supra* note 44, at 258–82 (discussing intrusions caused by these activities).

[215] For a further discussion of the strict liability aspect of subsurface trespass, *see* Schremmer, *supra* note 5, 350–52.

3. Utility and Formalism in Defining Oil and Gas Correlative Rights

As in water law, the tension between defining relative common pool rights formally, based on a rule of strict proportionality, and flexibly, based on an instrumentalist "reasonable use" standard, run throughout the scholarship and case law of oil and gas rights. As the following section summarizes, instrumentalist, utilitarian standards dominate, though examples of formal rules also exist.

(a) The Dominance of Utilitarian Standards

Courts and commentators have generally rejected a strictly proportional definition of correlative rights, as advanced by Summers, in favor of a context-sensitive reasonableness standard. Common reservoir owners, under such a rule, are entitled only to a "reasonable" opportunity to produce a ratable share of the oil and gas in place in the reservoir. In determining whether an owner's reservoir conduct is a "reasonable" exercise of its correlative rights, most scholars and courts consider specific characteristics of the reservoir and the wider social context.

Kuntz's view of correlative rights is explicitly utilitarian. In his definition, reasonableness is defined with regard to whether the conduct is "considered to be socially undesirable."[216] The standard of liability in Kuntz's model is negligence, itself a utilitarian concept.[217] Anderson's subsurface trespass model also expressly references social benefit in determining when to privilege subsurface intrusions from liability, though his model otherwise provides a clear ex ante rule of liability.[218]

Pierce's reservoir community analysis also incorporates significant utilitarian concepts.[219] To determine whether given conduct is a reasonable exercise of the actor's correlative rights under reservoir community analysis, it is necessary to reference the commonness of the activity in the locality and the social value of the activity (*i.e.*, the extent to which the activity efficiently produces the reservoir).[220] Both considerations are also factors in the Restatement's balance-of-utilities test for nuisance.[221] The ultimate goal of reservoir community analysis, as with utilitarian versions of nuisance doctrine, is to order the rights of common owners so as to maximize the value of the reservoir for them and the public at large.[222]

Utilitarian balancing also predominates in courts' analyses of cases involving intra-reservoir disputes. Three well-known cases are illustrative, and a brief description of the role of utility and social context in determining the relative

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[216] 1 KUNTZ, *supra* note 56, § 4.3.

[217] *See* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW § 6.1 (7th ed. 2007 Wolters Kluwer) (discussing negligence as a utilitarian concept).

[218] Anderson, *supra* note 44, at 247.

[219] *See supra* Part III.D.2.(b)(ii).

[220] *See supra* Part III.D.2.(b)(ii).

[221] *See* RESTATEMENT (SECOND) OF TORTS § 826 (1979) (setting forth the balance-of-utilities test).

[222] Pierce, *Maximizing Production Conservation, supra* note 176, at 772.

property rights of the parties in each case will suffice. In *Railroad Commission v. Manziel*, an unleased mineral owner sued to enjoin a commission order permitting water injection for secondary recovery on neighboring land, arguing that the injected water would encroach into his subsurface and trespass on his interest. The court denied an injunction, holding that the plaintiff's property rights "do not exceed" those of the injector when weighed in the context of the value of enhanced recovery operations to the public.[223] Consequently, the plaintiff's property interest in the common reservoir was subordinated to that of the injector for the purpose of maximizing production from the reservoir.[224]

The Texas Supreme Court construed *Manziel* broadly in a later subsurface trespass case, *Coastal Oil & Gas Corp. v. Garza Energy Trust*, characterizing it as holding that "a salt water injection secondary recovery operation did not cause a trespass when the water migrated across property lines . . . ."[225] In *Garza*, the Salinas parties claimed that hydraulically fractured fissures from Coastal's offset natural gas well invaded their tract and wrongfully drained natural gas into Coastal's well. Because the Salinas parties' interest in the common reservoir happened to be nonpossessory, under Texas law they could establish liability only by showing actual damages. The question thus became whether the drainage of natural gas from transboundary frac fissures, which clearly damaged the Salinas parties' interest, constituted a legal violation of their interest.

The court resolved the dilemma in favor of no liability—finding invasion and drainage by frac fissures to be *damnum absque injuria*—based on four, largely public policy, rationales: (1) the law already affords the Salinas parties full recourse in the form of drilling a self-help offset well; (2) "allowing recovery for the value of gas drained by hydraulic fracturing usurps to the courts and juries the lawful and preferable authority of the Railroad Commission to regulate oil and gas production;" (3) "determining the value of oil and gas drained by hydraulic fracturing is the kind of issue the litigation process is least equipped to handle"; and (4) "no one in the industry appears to want or need" the rule of capture to apply differently to drainage by hydraulic fractures that cross property boundaries.[226] Each of the latter three considerations is expressly utilitarian in that it references social context to determine the property rights of the parties in the dispute.

A final example, also from the Texas Supreme Court, is *Lightning Oil Co. v. Anadarko E&P Onshore, LLC*.[227] Lightning Oil owned an oil and gas lease on the Briscoe Ranch. The dispute arose when Anadarko obtained a lease from the surface owner of the Ranch to drill horizontal wellbores from a surface location on the Ranch to produce from its own oil and gas lease on adjoining land, where it was not permitted to disturb the surface. Lightning Oil sued to enjoin Anadarko's drilling

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[223] R.R. Comm'n v. Manziel, 361 S.W.2d 560, 566–72 (Tex. 1962).
[224] *Id.* at 574.
[225] Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 12 (Tex. 2008).
[226] *Id.* at 14–16.
[227] Lightning Oil Co. v. Anadarko E&P Onshore LLC, 520 S.W. 3d 39, 49 (Tex. 2017).

operations, asserting the proposed wellbores would trespass Lightning Oil's interest in the mineral estate.

The court began its analysis by adopting the court of appeals' description of the legal nature of the surface estate, including the geological substrate. The surface estate, the court stated, includes the surface overlying a mineral estate as well as the ownership rights in "the geological structures beneath the surface," and "all non-mineral 'molecules' of the land, i.e., the mass that undergirds [the surface estate]."[228] The mineral estate, according to the court, "is only entitled to 'a fair chance to recover the oil and gas in or under' the surface estate."[229] The mineral estate therefore lacks the right to exclusively control the earth surrounding any hydrocarbon molecules, and can only bring a cause of action to defend its rights against interference with its fair chance to recover the hydrocarbons.[230]

Based on this reasoning, the court held for Anadarko, finding that the proposed wellbores would not interfere with Lightning's "ability to exercise its rights" under its lease.[231] The *Lightning Oil* court further held that any minerals lost as a result of Anadarko's drilling through the subsurface would be outweighed by the interests of Anadarko and the public in maximizing recovery of oil and gas by horizontal drilling.[232] Once again, in determining the extent of a litigant's property interest in a common reservoir, the Texas Supreme Court considered the social value of the interfering activity.

(b) Examples of Formal Rules

While such instrumentalist versions of correlative rights doctrine dominate the oil and gas literature and case law, there are examples of formalist applications as well. Summers's theory of correlative rights is non-utilitarian and formalist. In his system, each reservoir owner would be entitled to a definite, ascertainable share of reservoir production based on the size of the owner's surface tract. An owner is liable for taking more than its proportional share of production or injuring the source of supply.[233] Thus, under Summers's theory, owners' correlative rights are capable of clear, determinate definition without reference to specific aspects of the reservoir or social context.

Although Summers's strict-proportional theory of allocating oil and gas in a common reservoir has not gained wide adoption, some courts have applied other kinds of formalist rules in resolving intra-reservoir disputes. These rules tend to

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[228] *Id.* at 46 (citing Humble Oil & Refin. Co. v. West, 508 S.W. 2d 812, 815 (Tex. 1974); Dunn-McCampbell Royalty Int., Inc. v. Nat'l Park Serv., 630 F.3d 431, 441 (5th Cir. 2011)).

[229] *Id.* at 47 (quoting Lightning Oil Co. v. Anadarko E&P Onshore LLC, 480 S.W. 3d 628, 635 (2015) (citing *Garza*, 268 S.W.3d at 15)).

[230] *See id.* at 47.

[231] *Id.* at 49.

[232] *Id.* at 51.

[233] *See supra* Part III.D.2.

incorporate the principle that reservoir owners have the fair opportunity to produce a proportional share of the reservoir's contents. Oklahoma law, for example, applies "a modified private nuisance doctrine," altered by a provision of the Oklahoma Constitution that the Oklahoma courts have said "removes the common law elements of carelessness or unreasonableness."[234] Oklahoma courts do not consider the utility of the defendant's injection operations,[235] the commonness of the activity in the locality,[236] the implied consent or assumption of risk of the nonconsenting owner,[237] or the approval of a conservation agency.[238]

Under Oklahoma's modified private nuisance doctrine, liability for trespass for injection into a common reservoir lies only where it interferes with another's existing use of the common reservoir or his ability to use the common reservoir for similar purposes. For instance, *West Edmond Hunton Lime Unit v. Lillard* held that injection of saltwater that caused the plaintiff's producing well to water out and increased the plaintiff's plugging costs was actionable because it interfered with the plaintiff's existing use of the reservoir.[239] Compare *West Edmond Salt Water Disposal Association v. Rosecrans*, which held that injection of saltwater into a saline formation under the property of another was not actionable because it merely displaced brine under the plaintiff's property but did not prevent the plaintiff from also using the formation for disposal.[240]

Decisions from Arkansas also demonstrate elements of a formalist approach based on a fair-opportunity principle.[241] *Jameson v. Ethyl Corp.* involved a waterflood to produce bromine.[242] The defendant injector was held liable to a nonconsenting plaintiff mineral owner for the value of minerals that were drained from the plaintiff's tract in excess of natural depletion by the defendant's operations.

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[234] Greyhound Leasing & Fin. Corp. v. Joiner City Unit, 444 F.2d 439, 441–42 (10th Cir. 1971).

[235] *Id.* at 443–44 (declining to modify Oklahoma nuisance doctrine to deny liability for water encroachments based on the utility of the defendant's secondary recovery operations).

[236] Fairfax Oil Co. v. Bolinger, 97 P.2d 574, 575–76 (Okla. 1939) (declining to consider whether the subject oil and gas operations were common in the area surrounding the plaintiff's land).

[237] *Greyhound Leasing*, 444 F.2d at 445 ("We agree with the trial court that the defense of assumption of risk was not available to the defendant."); *Fairfax Oil Co.*, 97 P.2d at 576 (declining to recognize a defense of implied consent).

[238] *Greyhound Leasing*, 444 F.2d at 444–45 (distinguishing authorities supporting the view that administrative approval of conservation operations should immunize the operations from liability for resulting damage).

[239] West Edmond Hunton Lime Unit v. Lillard, 265 P.2d 730, 731–32 (Okla. 1954).

[240] W. Edmond Salt Water Disposal Ass'n v. Rosecrans 226 P.2d 965 (Okla. 1950). The court also denied liability on the grounds that the saltwater, once injected, ceased to be the property of the injector. *Id.* at 971.

[241] *See* Pierce, *Correlative Rights Doctrine, supra* note 37, at 414–16, 423 (discussing Jameson v. Ethyl Corp., *infra* note 242).

[242] Jameson v. Ethyl Corp., 609 S.W.2d 346 (Ark. 1980); *see also* Pierce, *Correlative Rights Doctrine, supra* note 37, at 414–16, 423.

Liability in *Jameson* turned largely on the unavailability of self-help through offset operations; even if the plaintiff was ready and willing to develop her portion of the reservoir, she was effectively precluded from doing so by the defendant's waterflood operations.[243]

Jameson cited *Young v. Ethyl Corp.*, in which the Tenth Circuit found an actionable trespass where the defendant's bromine recovery operations removed brominated saltwater from under the plaintiff's tract.[244] In so holding, *Young* predicted the Arkansas Supreme Court would decline to apply the rule of capture to privilege the drainage,[245] as the plaintiff's tract was located within, as opposed to outside of, the area of the defendant's recovery operations, which prevented the plaintiff from engaging in self-help operations.[246]

The Oklahoma and Arkansas cases thus provide examples of non-utilitarian definitions of correlative rights based on the principle that each owner has an equal opportunity to produce its ratable share of reservoir minerals. Under the case law of those states, the extent of owners' correlative rights is fairly determinate: a reservoir owner is entitled to use the common source of supply in any manner that does not interfere with another owner's lawful existing use or opportunity to make a lawful use.

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In summary, the development of rights in common pools of oil and gas began with the familiar rule of capture embodied by *Acton v. Blundell*. As demand for the resource grew sharply, scarcity, permanent depletion, and waste abounded. Rather than wait on the doctrine to respond through the common law process, state legislatures passed statutes to curtail the place and manner of capture, but retained the absolutism of the property right. The common law eventually developed a weak correlative rights doctrine to relativize the right, which largely applied instrumentalist principles of reasonable use rather than a formalist rule of proportionality.

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[243] *See Jameson*, 609 S.W.2d at 348–49.

[244] Young v. Ethyl Corp., 521 F.2d 771, 775 (8th Cir. 1975) (Ark.).

[245] *Id.*

[246] *Id.* at 772–73 (discussing Budd v. Ethyl Corp., 474 S.W.2d 411 (Ark. 1971), where the Arkansas Supreme Court declined to apply the rule of capture and permitted recovery of lost brominated saltwater by a plaintiff whose tract was within the embrace of the defendant's bromine recovery operations).

IV. LESSONS FROM THE MODELS FOR DEVELOPING RIGHTS IN A SEMICOMMONS

A. Lesson One: Use Rights Shift from Absolute to Relative (and Sometimes Back Again) in Response to Resource Conditions

In the doctrinal histories of riparian, groundwater, and oil and gas law, rights to use the resource tended to move, like an accordion, between being absolute and being relative as physical and economic conditions changed. As Professor Carol Rose has put it, definitions of property move back and forth between "crystal" definitions and "mud" definitions.[247] In the early days of development of a resource, when competition for the resource is low or information about its physical nature and behavior is prohibitively costly or unavailable, courts tend to adopt clear-cut, absolute rights. Rights in this initial stage either absolutely forbid any disturbance of the resource (e.g., rights under the natural flow doctrine) or absolutely permit exploitation of the resource regardless of any resulting disturbance to the rights of others (e.g., rights under the rule of capture).

In each case, the absolute rule in the initial stage appears to be convenient, simple, and efficient for courts to administer, especially when little is known about the physical nature of the resource. Moreover, the incentive effects of absolute rights encourage resource development. Thus, absolute rights function well when resources are sufficient to satisfy all interested users. When resources are no longer able to satisfy all such demands, however, absolute ownership rights begin to cause various forms of physical and economic waste. Under such conditions, the case studies reveal, courts incline toward limiting the extent of absolute rights.

When demand for use of the resource increases and the resource grows scarcer, absolute rights often yield to vaguer, correlative or reasonable use rights. Rights in this second stage are relative; they permit more or less equitable access to the resource among all holders. Relative rights enable "more or less informal group control" over the resource.[248] When, however, the resource becomes extremely scarce and valuable, it may be efficient to assign, administer, and monitor limited absolute property rights in it. This third stage of development occurs when the resource is nonrenewable and depletable, and use of the resource is principally consumptive, as was the case for oil and gas reservoirs and western water supplies.[249] Yet, even such limited absolute rights tend to become relativized by the imposition of reasonableness principles when extraction of the resource leads to severe permanent depletion.

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[247] Carol M. Rose, *Crystals and Mud in Property Law*, 40 STAN. L. REV. 577, 577–80 (1988).

[248] Rose, *Common-Law Water Rights, supra* note 68, at 295.

[249] Professor Carol Rose has made similar observations about the structural progression of use rights in riparian waters. *See generally* Rose, *Common-Law Water Rights, supra* note 68. Much of the discussion in this section draws from Rose's work in this area.

In the case of riparian waters, the natural flow doctrine protected riparians from any and all disturbances of the flow of a watercourse, except those caused by long-established "ancient" uses. Ancient uses, in turn, were absolutely free from interference by junior users. This regime was simple to administer. In a case alleging interference of a watercourse, only two factual inquiries were relevant: whether the flow was impaired, and whether the interfering use was ancient.[250] As industrialization led to sharp increases in demand for watercourses to generate power, however, the simple, absolute rule became untenable.[251] Under the ancient use doctrine, newer, competing water uses were difficult or impossible to develop, because they lacked any protection from interference and would be liable for interfering with vested uses.[252] Because new users lacked rights under ancient use, they could obtain rights only from ancient users contractually.

The overall level of private bargaining needed to reallocate use rights in this fashion mushroomed as competitions for stream flow multiplied.[253] Such large-scale bargaining entailed high transaction costs.[254] As Professor Rose asserts, the law's default rule of ownership accordingly shifted to a doctrine of reasonable use to obviate the need for private agreements among competing owners, thus avoiding many transaction costs.[255] Accordingly, the riparian rights doctrine of reasonable use permits junior users a quantum of use rights without the need for bargained-for agreements among competing owners. Water rights thus relativized because transaction costs precluded contractual limitation of absolute rights.

A similar pattern is present in the development of groundwater rights. In early cases, like *Acton v. Blundell*, many courts adopted an absolute ownership rule—the rule of capture. This absolute rule was the mirror image of the absolute rule of natural flow doctrine; it permitted all extractions of groundwater regardless of resulting disturbance. Absolute ownership was simpler and cheaper to administer than a relative rights rule, especially given the lack of information available about subterranean waters.[256] It was thought that the practical difficulties in determining

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[250] *See supra* Part III.B.1.

[251] *See* Rose, *Common-Law Water Rights, supra* note 68, at 264.

[252] *See* GETZLER, *supra* note 60, at 119 (noting the rule precluded newer, competing uses).

[253] *See* Rose, *Common-Law Water Rights, supra* note 68, at 270–73.

[254] *Id.*

[255] *Id.* at 266 ("[T]he system of correlative reasonable rights obviated the need for agreements among all the owners along the stream."). Morton Horwitz, in contrast, explains the shift from absolute to reasonable use rights as a function of courts' willingness to subsidize private development of water resources. HORWITZ, *supra* note 89, at 102.

[256] *See* GETZLER, *supra* note 60, at 264–65 (discussing Acton v. Blundell (1843) 12 M. &. W. 324; 152 E.R. 1,222, 1,233–55)); Dellapenna, *supra* note 106, at 267–68 (discussing the dearth of scientific knowledge of early courts in fashioning rules for the use of groundwater).

whether one owner's subsurface activities affected another owner's production of groundwater would prohibit application of the reasonable use rule of riparian law.[257]

Despite its low administrative costs, the rule of absolute appropriation of groundwater eventually proved untenable in arid American states, where groundwater is finite, nonrenewable, and depletable.[258] As demand for the resource rose, the absolute rule compounded groundwater scarcity by permitting any single owner to over-appropriate water from a common aquifer. Over-appropriation lowered groundwater levels and increased costs of production to the exclusion of other potential present and future users.[259] The over-appropriation problem is most pronounced in aquifers that recharge more slowly than they are produced, or where production is akin to groundwater mining.

Relativizing the right to produce groundwater helped avoid or mitigate these inefficiencies. Under a reasonable use or American rule approach, an owner may not exclude other owners from a common aquifer by extracting excessive volumes, at excessive rates, or for unreasonable purposes.[260] The correlative rights approach likewise limited an owner's use of water, but on a strictly proportional basis.[261] Under either approach, access to water rights is expanded beyond the first or biggest appropriators. In this way, correlative or reasonable use rights served a similar function in groundwater law as in riparian law.

Most western states, however, adopted prior appropriation doctrine rather than correlative rights or reasonable use doctrine. These states, where surface water is scarce and groundwater depletable, undertook the administrative and monitoring costs to allocate individual property rights in water to appropriators based on the extent of their beneficial use.[262] Appropriation rights are generally absolute rather than relative. While absolute, appropriation rights differ meaningfully from the sort of first-stage absolute rights under *Acton v. Blundell*. Appropriation rights are limited in certain respects, such as the quantity of water to be extracted and the purpose and place of use of the water, whereas rights under the first-stage absolute rule generally are not.[263]

What accounts for the move in western states from relative to limited absolute appropriation rights? The answer has to do with how much water is available in the

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[257] Acton v. Blundell, (1843) 12 M. &. W. 324, 349–54; 152 E.R. 1,222, 1,233–55; Budd, *supra* note 107, at 240–41.

[258] *See supra* Part III.C.2.

[259] *See* Clark, *supra* note 122, at 43 (noting that prior appropriation statutes "were enacted to provide more rational methods of allocation and distribution so that more users in the future will have a secure share in what amounts to the community's whole future").

[260] *See supra* Part III.C.3.

[261] *See supra* Part III.C.3.

[262] *See* Rose, *Common-Law Water Rights, supra* note 68, at 295 ("[A]t some point, it will be worth the cost to move from the group's custom to the stage 3 of individualized property rights. This was the case, more or less, in the development of appropriative water rights in the West.").

[263] *See supra* Part III.C.4 (discussing prior appropriation rights).

West and how it is used. Western states experience higher levels of water scarcity. Drought and water shortages are more common. Moreover, uses of water in the West tend to be consumptive (e.g., irrigation), whereas uses of water in the east generally leave water in the same watercourse (e.g., waterpower generation).[264] Finally, groundwater is largely finite, nonrenewable, and depletable in western states. These factors combine to generate more intense competition for groundwater resources in western states. Prior appropriation doctrine responded by allocating precisely defined absolute property rights that function more efficiently in times of scarcity than relative rights, which require holders to share shortages.[265] The additional administrative and monitoring costs of prior appropriation regimes (over those of reasonable use regimes) are justified by these efficiency advantages.

Yet, in the face of extensive permanent depletion of groundwater reserves, some states passed legislation to relativize appropriation rights. In the wake of the groundwater revolution, Colorado and Kansas, both prior appropriation states, statutorily modified prior appropriation doctrine to permit "reasonable" impairment of senior rights. Both states also deferred significant administrative control over groundwater rights to local management bodies.[266] Importantly, both Colorado and Kansas have substantial water rights in the nonrenewable and depleting Ogallala aquifer, in which rates of extraction exceed natural recharge.[267] Thus, where groundwater is so limited that extraction is tantamount to mining, rights may once again relativize to permit group control, as they did in the second stage of riparian law.

In oil and gas law, the *Acton*-style absolute rule of capture was originally adopted as a convenient, low-administrative- and information-cost rule instead of a rule of correlative rights.[268] The rule of capture provided early courts an efficient and wieldy alternative to allocating production among competing owners by placing absolute title in the producer, regardless of how much is produced or from where in the reservoir it is drained. Although the rule of capture was efficient in this sense, nearly from its inception, the rule also produced multiple kinds of waste.[269] Together with the offset drilling corollary, the rule of capture incentivized overuse of the surface of land for drilling and production facilities, overinvestment in drilling, production of more oil than demand could soak up, and premature dissipation of reservoir energy.[270]

Reservoir owners could contractually modify the rule of capture to avoid much of this waste. They could voluntarily pool and unitize their various tracts to

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[264] Rose, *Common-Law Water Rights, supra* note 68, at 293.

[265] Griggs, *supra* note 100, at 1313.

[266] *See supra* Part III.C.4.

[267] Griggs, *supra* note 100, at 1,282–84, 1,298.

[268] Kramer & Anderson, *supra* note 162, at 927 (noting that the rule of capture "is in large part a rule of convenience").

[269] *See supra* Part III.D.1.

[270] *See supra* Part III.D.1.

coordinate development of the reservoir and allocate the proceeds of production.[271] The transaction costs of coordinating large groups of reservoir owners, however, like coordinating large groups of riparian owners, are prohibitive.[272] Against this backdrop of waste and prohibitive transaction costs, the administrative and information costs of a regime of limited rights appear justifiable.

Indeed, statutory conservation measures were developed to limit the absolute regime to prevent waste and obviate total reliance on private bargaining.[273] Generally, under such statutes, owners are limited in the number of wells they may drill, and hydrocarbons they may produce, from a common reservoir,[274] and any single owner may petition to force other common owners into pooling or unitization.[275] Such production and spacing limitations turn the initial-stage absolute rights that prevail under a pure rule of capture into something more akin to the constrained version of absolute rights under prior appropriation doctrine.

Additionally, the common law doctrine of correlative rights developed weak relative limitations on the absolute capture regime, based largely on a reasonable use standard.[276] Thus, oil and gas ownership rights began as absolute and then became subject to constraints that both limited their scope and also, somewhat, made them relative. In this sense, oil and gas rights loosely resemble groundwater rights in prior appropriation states that permit reasonable impairment of senior rights in nonrenewable aquifers.

To encapsulate the first lesson from the development of riparian, groundwater, and oil and gas ownership regimes, absolute ownership rights yield to relative rights, which sometimes yield again to limited absolute rights, as resource conditions change. In the first stage of rights development, an absolute rights rule functions well, and at a low cost, where the resource is plentiful. By placing title clearly in one party—the first possessor—the absolute rule enables private bargaining to reallocate rights in a given resource. Absolute rights begin to produce inefficient results and become untenable, however, as demand for the resource increases and large numbers of individuals seek access. While bargaining for access from holders of the initial rights is possible, the transaction costs prove prohibitive. Moreover, the absolute rights regime incentivizes overproduction of a resource without consideration of the external effects on other common owners, leading to dissipation of the resource's ultimate economic value.

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[271] *See* JOHN S. LOWE, OWEN L. ANDERSON, ERNEST E. SMITH, DAVID E. PIERCE, CHRISTOPHER S. KULANDER, & MONIKA U. EHRMAN, CASES & MATERIALS ON OIL & GAS LAW 305–07 (7th ed. 2018) (discussing voluntary pooling arrangements).

[272] *See* Rose, *Common-Law Water Rights, supra* note 68, at 270–72 (discussing transaction costs associated with large-scale bargaining among numerous riparian owners).

[273] LOWE ET AL., *supra* note 271, at 806–814 (discussing statutory compulsory pooling and unitization).

[274] 1 KRAMER & MARTIN, *supra* note 190, §§ 5.01–5.02 (discussing statutory well spacing and allowables).

[275] *See* LOWE ET AL., *supra* note 271, at 762–63, 806–814 (discussing statutory compulsory pooling and unitization).

[276] *See supra* Part III.D.3.(a)–(b).

In response to these problems, more or less, rights tend to become relative in a second stage of development. Relative rights distribute initial entitlements among all common owners, reducing the need for private transactions, and prohibit wasteful production of the common pool. Where, however, the resource is critically scarce and permanently depletable, as is the case for oil and gas as well as much groundwater in the West, rights move on to a third stage of development. Here, greater competitions for use lead to limited, but still absolute private property rights in the resource. These rights nonetheless may become tinged with reasonableness limitations—for example through the correlative rights doctrine of oil and gas or the statutory modifications to prior appropriation doctrine—if depletion becomes severe and irreversible. Thus, broadly summarized, the extent of rights in any given semicommon natural resource is a function of the physical and economic conditions surrounding the resource at a given time.

B. Lesson Two: Absolute Rights Are Limited and Relativized by Principles of Nuisance

1. Nuisance as the Tort for Vindicating Relative Property Rights

It is one thing to say that property rights in a semicommons move between absolute and relative roughly in response to changes in resource conditions, and quite another to explain how this occurs doctrinally. In this section, I hope to demonstrate that the "how" is the application and judicial modification of nuisance law.

Nuisance doctrine has played an important role in remedying excessive use of semicommon property since at least the days of Bracton.[277] In the case of riparian rights, from the medieval common law through Blackstone, nuisance was the cause of action to vindicate interferences with rights in a watercourse.[278] The controlling principle in riparian rights before *Tyler v. Wilkinson*—*sic utere tuo*—is a doctrine of nuisance law and was first announced in a nuisance case.[279] The reasonable use rule of *Tyler* effectively applied precepts of nuisance to use of a common watercourse.[280] These same precepts also form the foundation of reasonable use doctrine in groundwater law.[281] As detailed below, although oil and gas law has not explicitly

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[277] GETZLER, *supra* note 60, at 52 (observing that "[t]he medieval law of water rights was subsumed within the various categories of action dealing with the wrong of nuisance"); Lauer, *supra* note 60, at 67 (stating that, by the thirteenth-century, the assize of nuisance provided the principal procedural vehicle for seeking relief for actions that were wrongful but amounted to less than a trespass or an act of disseisin, including actions for interference with rights in a watercourse).

[278] GETZLER, *supra* note 60, at 182, 185.

[279] S*ee supra* text accompanying notes 61–67 (discussing Aldred's Case (1610), 77 Eng. Rep. 816, 9 Co. Rep. 57 b).

[280] *See* Rose, *Common-Law Water Rights, supra* note 68, at 286.

[281] *See supra* Part III.B.2.

acknowledged the role of nuisance in defining reservoir rights, nuisance principles also underlie the doctrine of correlative rights.[282] Nuisance principles of limited, "reasonable," use of property, therefore, appear to be the doctrinal mechanism for limiting, and thereby relativizing, the extent of rights in semicommon property.[283]

Like trespass, nuisance is a tort whose application defines the extent of property.[284] Nuisance law derives from the principle, familiar to students of relative rights, that every person has the right to use her land as she desires and the corresponding duty not to make use of her land so as to interfere with the rights of her neighbors.[285] The provisions of nuisance law define when a particular interference with use rights in property is unreasonable and thus actionable; nuisance both determines the extent of relative rights in property and remedies violations of those rights. The doctrine that discerns reasonable from unreasonable conduct to impose liability for, and remedy violations of, property rights is inseparable from the definition of the substantive rights themselves. Nuisance is to correlative rights as trespass is to exclusive possessory rights.

Nuisance doctrine thus furnishes the analytical process by which courts determine the extent of relative property interests in common pools.[286] It is unsurprising, then, that classic articulations of correlative rights doctrine mirror descriptions of nuisance doctrine. Consider, for example, the echoes of nuisance language in the following descriptions of correlative rights in oil and gas:

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[282] *See infra* Part IV.B.1.

[283] *See* Rose, *Several Futures of Property, supra* note 39, at 137–38 (discussing that "in the absence of property rights to constrain their uses of the commons in air, water or wildlife, these resources may be taken heedlessly. Indeed, when overuse begins . . . courts often develop a crude new form of property rights in the form of nuisance law").

[284] *See* RICHARD A. EPSTEIN, TAKINGS: PRIVATE PROPERTY AND THE POWER OF EMINENT DOMAIN 96–98 (1985) (noting the relationship between tort and property law) [hereinafter EPSTEIN, TAKINGS]; Richard A. Epstein, *Nuisance Law: Corrective Justice and Its Utilitarian Constraints*, 8 J. LEGAL STUD. 49, 52 (1979) (same) [hereinafter Epstein, *Nuisance Law*]; GETZLER, *supra* note 60, at 180–81 (discussing Blackstone's view that torts protect legal rights in property and thus have a role in defining those rights).

[285] 66 C.J.S. *Nuisances* § 9 (2020).

[286] Noting this relationship, Summers wrote, without citation, that "[a]s to the state, the waste of oil and gas is a public nuisance and as to landowners in a common source of supply an act of waste or a taking of an undue portion by one of them is a private nuisance." 1 SUMMERS, *supra* note 180, at § 3:1.

i. Correlative rights refer to the "reciprocal rights and duties of the owners in a common source of supply."[287]
ii. Correlative rights arise where the use by one owner of his property in a resource inherently affects the use of other owners of property in the same resource.[288]
iii. Correlative rights require owners to use their property reasonably, and protect owners from the unreasonable use by others of their property.[289]
iv. Correlative rights doctrine is "[a]n analytical construct for defining" legally acceptable use of property.[290]
v. Correlative rights is a "guide or precept [to ordering competing rights] that is to be applied to particular facts."[291]
vi. "Damages should be recoverable where a correlative right has been invaded," and the proper measure of damages may be diminution in property value, lost profits and increased costs, or a participation formula if the loss is the opportunity to participate in an enhanced recovery project.[292] Each of these is a variety of a traditional measure of nuisance damages.

Every one of these statements could be made about nuisance. Correlative rights and nuisance are thus two sides of the same coin—the former, a description of the substantive rights included in the property interest, and the latter, a tort protecting those substantive rights from infringement.

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[287] Pierce, *Modern Property Analysis, supra* note 32, at 256–57; Abbinett v. Fox, 703 P.2d 177, 181 (N.M. Ct. App. 1985) (noting the "privilege of a landowner to make use of his property as he sees fit is generally qualified by the requirement that he exercise due regard for the interests of those who may be affected by the landowner's activities on the property").

[288] 1 KUNTZ, *supra* note 56, § 4.3 ("Owners of land overlying a common source of supply stand in a peculiar relationship to one another in the sense that any extractive operation by one owner will have an apparent and inevitable effect upon the economic welfare of the others."); *see, e.g.*, Comanche Duke Oil Co. v. Texas Pac. Coal & Oil Co., 298 S.W. 554, 560 (Tex. App. 1927) ("In a sense, one tract of land cannot be used unless there be also consequential user of neighboring tracts.").

[289] Louisville Gas Co. v. Kentucky Heating Co., 77 S.W. 368, 369 (Ky. 1903) ("[A] man is only allowed to make a reasonable use of those natural supplies which are for the common benefit of all."); *see also* Bone, *supra* note 16, at 1,133 (stating, with reference to nineteenth-century riparian law, "[e]ach was entitled to a 'reasonable use,' and each owed all others a duty to limit her use to what was 'reasonable' under the circumstances").

[290] Pierce, *Modern Property Analysis, supra* note 32, at 255 (discussing that "'[c]orrelative rights' are not a collection of do's and don'ts, but rather an analytical construct for defining . . . acceptable behavior within a specific reservoir community under specific circumstances").

[291] 1 KRAMER & MARTIN, *supra* note 190, at 5–16 ("[T]he concept of correlative rights is in the nature of a guide or precept that is to be applied to particular facts.").

[292] 1 KUNTZ, *supra* note 56, § 4.8.

2. Nuisance and Relative Rights Turn on Defining Injuria *and* Laedas

Nuisance and doctrines of reasonable use and relative rights all proscribe the use of property in a manner that injures another's legal interest in related property. Thus, when disputes arise among owners of common property, logically and doctrinally the first issue is to define the parties' respective property rights.[293] As experience in riparian, groundwater, and oil and gas disputes demonstrates, however, defining property rights is difficult, even circular, when they are relative.

In a hypothetical two-party property dispute, the first step would be to determine the extent of the defendant's relative rights in the common property, which are essentially limited by a rule of reasonable use. Yet, to determine whether given conduct was either reasonable and nonactionable, or unreasonable and actionable, one must first define the extent of the defendant's positive (or affirmative) rights. The problem is not solved by first determining the plaintiff's rights. The plaintiff has a negative (or passive) right to be free from unreasonable interferences, but whether a given interference is unreasonable turns on whether it violated the plaintiff's negative right to be free from it. One must first know the extent of the right to know whether it has been legally violated; yet, one must know what will legally violate the right to know its extent.[294]

For the eighteenth- and nineteenth-century jurists that developed relative rights,[295] this circularity may have been a feature, more so than a bug, of the theory. As Professor Jeff Lewin has illuminated, these courts operated under a natural rights theory of property that, "[i]n contrast to the modern positivist conception, that [held] the rights of private property owners were created by law . . . posit[ed] that property rights existed prior to and independent of the legal and social system."[296] These courts struggled to resolve the tension between the right of beneficial use and the right against interference by others when they conflict, yet are both a priori rights.[297] The relative rights theory accommodated this tension, without undermining property's natural law foundation, by defining relative property rights to include only the right to *reasonable* use and the right to be free from another's *unreasonable* use. An unreasonable use of land was one that interfered with another's reasonable

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[293] *See* Epstein, *Nuisance Law*, *supra* note 284, at 52 ("Tort law then presupposes some prior, independent method for defining and recognizing property rights . . . in external objects.").

[294] Bone, *supra* note 16, at 1,118–19 ("Langdell explained, 'if one knows what the [relative] right is, he will necessarily know what will be an infringement of it; and, if one knows what will be an infringement of the right, he will also know what the right itself is.'" (alterations in original)).

[295] To be accurate, one should note that the medieval common law, borrowing heavily from Roman law, conceived of rights in semicommon property as relative long before the seventeenth century. *See supra* Part III.B.1.

[296] Lewin, *supra* note 64, at 199; *see also* Bone, *supra* note 16, at 1,118–19.

[297] *See* Lewin, *supra* note 64, at 199–200.

use. With property rights so defined, there could never be a conflict between the natural rights of two landowners.[298]

The circularity dilemma has dogged the definition of ownership in common property since the time of Bracton, who himself struggled to distinguish *damnum* from *injuria*.[299] *Damnum*, or damage, means "actual harm," whereas *injuria*, or legal injury, refers to "an infringement, or violation, of a legal right of the plaintiff."[300] To illustrate the difference between *damnum* and *injuria*, Bracton wrote that one who "erects a mill on his own land and takes from his neighbor his own suit and that of others . . . does his neighbor damage but no *injuria* since he is not prohibited by law or a constitution from having or erecting a mill."[301] Likewise, it may be said that one who drills an oil well on his own land and thereby takes oil from under his neighbor's land does his neighbor damage but no *injuria*, since he is privileged under the rule of capture to drain oil from the common reservoir.

Starting in 1610 with *William Aldred's Case*, courts applying *sic utere tuo* faced the identical quandary in defining *laedas*, or harm. As noted in the riparian rights discussion, some courts, including Justice Story in *Tyler v. Wilkinson*, employed the ambiguity in *laedas* to inject their own conceptions of utility and social good into the property–tort analysis to resolve the circular impasse. Blackstone, and courts influenced by his writings, took the approach on the opposite extreme. They collapsed *laedas* and harm into functional synonyms, such that any harm (in the colloquial sense) to a plaintiff's established use of surface water constituted *laedas* ("harm" in the legal sense).[302]

C. Lesson Three: Discerning Injuria *and* Laedas *Comes Down to Instrumentalism Versus Formalism*

To escape the circularity dilemma, it is necessary to discern *damnum* from *injuria*, and harm from *laedas*. As the models of semicommon property show, some legal tests define legal injury by balancing the perceived social utility of the defendant's conduct with the harm done to the plaintiff's property interest to reach a desired result or achieve an instrumental purpose. Such instrumentalist tests usually go by the name "reasonable use." Some tests, on the other hand, apply a formal definition of the extent of property rights, usually based on strict proportionality, without reference to surrounding social context or instrumentalist purposes.

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[298] *Id.* at 207; Bone, *supra* note 16, at 1,200.

[299] *See generally* GETZLER, *supra* note 60, at 52–79 (discussing Bracton's writings on water rights and other common property).

[300] Smith, *supra* note 76, at 386–87.

[301] Louise A. Halper, *Nuisance, Courts and Markets in the New York Court of Appeal, 1850–1915*, 54 ALB. L. REV. 301, 311 (1990) (quoting 3 BRACTON, DE LEGIBUS ET CONSUETUDINIBUS ANGLIAE 164 (S. Thorne ed. 1977)).

[302] *See supra* notes and text accompanying notes 78–79.

1. Instrumentalist "Reasonable Use" Standards

Defining property rights by a reasonable use standard is accomplished with reference to the competing interests of the parties and the physical and social context of the dispute. These tests generally proceed by balancing the relative utilities of the party's activities and their fit within the locality to subordinate one party's rights to another's in order to maximize social good. Examples of this kind of test can be found in Justice Story's opinion in *Tyler v. Wilkinson*;[303] the reasonable use rule and the Restatement's provisions on groundwater law;[304] Kuntz's view of correlative rights;[305] and Pierce's reservoir community analysis.[306]

The instrumentalist, or utilitarian, approach is also predominant in modern nuisance law. Unable to define *laedas* or *damnum* with certainty, nineteenth-century courts deciding nuisance cases increasingly relied on surrounding social context to determine the property rights of the parties.[307] As Bone notes, "[t]he fundamental problem for the relative property rights model was how to defend a theory of the property right derived from social context without positivizing the right."[308] According to Jeff Lewin, rejection of social determinism in the late nineteenth-century made this task impossible, and legal positivism became the norm.[309] Thereafter, courts began to more freely consider factors such as "the locality," as well as "the nature and extent of the harm to the plaintiff and the social value of the defendant's activity," to determine the reasonableness of given conduct.[310] The positivist revolution in legal theory eventually culminated in the Restatement of Torts and its balance-of-utilities test for nuisance.[311]

Utilitarian approaches to defining property rights have been criticized on normative grounds. While the utilitarian approach may maximize efficient production and use of property in any given case, it does so at the expense of obscuring the definition of property rights. A common owner's right is the *result* of a utility-balancing analysis, rather than the *starting point* for application of tort law. Consequently, when the extent of relative rights depends on each judge's peculiar concept of utility, property rights are unascertainable without litigation.[312] Such a

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[303] *See supra* text accompanying notes 85–89.

[304] RESTATEMENT (SECOND) OF TORTS § 858. (AM. LAW INST. 1979).

[305] *See supra* Part III.D.2.(b)(i).

[306] *See supra* Part III.D.2.(b)(ii).

[307] *See* Lewin, *supra* note 64, at 209.

[308] Bone, *supra* note 16, at 1201.

[309] Lewin, *supra* note 64, at 209.

[310] *Id.*

[311] *Id.* at 200, 210–12.

[312] Bone, *supra* note 16, at 1214–15 ("The [New Hampshire Supreme] [C]ourt frequently repeated the teaching of its early cases that what was reasonable could not be ascertained in advance of particular cases and that reasonableness depended on the conditions and circumstances of each social context."); *see* Middlesex Co. v. McCue, 21

view turns every nuisance action, in some sense, into a suit to quiet title. Defining rights this way can have a destabilizing effect on property,[313] which may discourage public and private investment in resource development. Uncertainty has been said to plague systems of riparian rights and reasonable use doctrine in groundwater law.[314]

Defining rights by utility balancing entails yet another criticism. In circumstances when the social utility of a defendant's conduct is deemed to justify the resulting interference with a plaintiff's rights, the defendant is made, in effect, an agent of the public. Yet, such a defendant "is entitled to do with absolute impunity"—taking the property of another for a public purpose—that which the public, acting through the state, "could do only upon the condition of [paying] compensation."[315] The principal may not do through an agent (the defendant) what it could not do itself directly.[316] Thus, the crudest utilitarian definitions of property rights may implicate constitutional prohibitions against uncompensated takings.[317]

2. Formalist Rules of Proportionality

Alternatively, it is possible to precisely define *injuria* and *laedas* by establishing, ex ante, a determinate definition of correlative rights, with minimum reference to social context, and by imposing liability ex post for any violation of the rights so defined. In water law, the correlative rights rule accomplishes this by allocating to each common owner a share of groundwater strictly in proportion to the surface area of the owner's land.[318] This approach undergirds the allocation prong of Summers's definition of correlative rights.[319] Blackstone's application of

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N.E. 230, 231 (Mass. 1889) ("The respective rights and liabilities of adjoining land-owners cannot be determined in advance by a mathematical line, or a general formula . . .").

[313] Halper, *supra* note 301, at 306 (noting that Gilded Age courts approaching nuisance attempted to avoid "strict utilitarianism which carried a dangerously destabilizing attitude toward private property"). Additionally, Professor Richard Epstein blames utilitarian variants of nuisance law for the doctrine's reputation for intellectual incoherence. EPSTEIN, TAKINGS, *supra* note 284, at 115.

[314] *See* Dellapenna, *supra* note 106, at 304 ("Analysts of riparian rights often conclude that the application of riparian rights produces such uncertainty and even confusion as to impede the settlement of problems arising during severe water shortages, to leave significant public interests unprotected, and to discourage public or private investment in water development.").

[315] Smith, *supra* note 76, at 393–94.

[316] *See* Boomer v. Atlantic Cement Co., 257 N.E.2d 870, 876 (N.Y. 1970) (Jasen, J., dissenting) (stating that in private nuisance, injunctive relief is preferred because the common law does not countenance the private right of eminent domain).

[317] *See generally* Stop the Beach Nourishment, Inc. v. Fla. Dep't of Env't. Prot., 560 U.S. 702 (2010) (considering judicial takings claims based on modifications to property doctrine).

[318] *See supra* Part III.C.3.

[319] *See supra* Part III.D.2.(a).

sic utere tuo and the modern prior appropriation doctrine exemplify another type of formalist approach. Under these doctrines, once established by prior appropriation, a party's water right is inviolable. Thus, the extent of a water right is defined strictly as the extent of the first appropriation.[320] All such formalist approaches define property rights more or less categorically.

Although formalist rules provide a measure of certainty by starkly defining property rights, they can lead to harsh or unjust results in close cases.[321] Critics of the strictly proportional correlative rights doctrine in groundwater law further argue that the rule incentivizes strategic behavior among landowners.[322] For instance, in correlative rights doctrine states like California, groundwater users have strong incentives to pump as much as possible to establish a prescriptive right to a greater proportion of groundwater than their land holdings initially justify. Waste thus "becomes a means for capturing future rents for the water pumped now," and the result may be a version of the tragedy of the commons.[323]

Additionally, formalist rules may proscribe socially beneficial conduct, like massive hydraulic fracturing or carbon storage projects, which may be privileged under a reasonable use standard. Reservoir owners would be free to cooperate in such operations by transferring or consolidating their respective, clearly defined, reservoir rights. However, experience teaches that transaction costs often prove prohibitive.[324] Formalist approaches may, therefore, provide certainty at the expense of development.

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The instrumentalist and formalist approaches represent two different resolutions to the "on-going tension between encouraging development and protecting private property."[325] In selecting one or the other scheme, one must choose, to some extent, between promoting resource use and certainty in property rights. While it is possible in theory to derive a perfectly fluid and flexible utilitarian or purely formalist system of nuisance or correlative rights, in practice neither such

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[320] *See supra* Part.B.2 (discussing Blackstone's theory) and Part III.C.4 (discussing modern prior appropriation doctrine).

[321] *See* EPSTEIN, TAKINGS, *supra* note 284, at 118 ("So long as we are sure that the vast bulk of the cases falls clearly on one side of the line or the other, we can easily tolerate some ambiguity at the margins: litigation exerts powerful forces to select the most difficult cases for adjudication, no matter what the underlying standard.").

[322] Dellapenna, *supra* note 106, at 279 ("In actual practice, [correlative rights] provide incentives for problematic behavior and create uncertainty.").

[323] *Id.*

[324] *See* Rose, *Common-Law Water Rights, supra* note 68, at 270–72 (discussing transaction costs associated with large-scale bargaining among numerous riparian owners).

[325] Halper, *supra* note 301, at 328 (noting the "on-going tension between encouraging development and protecting private property. When the pendulum swings too far in one direction, it is certain to swing eventually too far in the other direction").

system is workable. As Professor Richard Epstein teaches, even a perfectly formalist, or "corrective justice," theory of nuisance must yield to certain utilitarian constraints.[326] Properly viewed, therefore, the choice is not between fluidity and certainty, but rather where on the spectrum running from absolute fluidity and absolute certainty to ideally locate a rule for defining the extent of property rights in a semicommons.[327]

V. APPLYING THE LESSONS TO SYNTHESIZE A DOCTRINE OF PORE SPACE PROPERTY

A. Pore Space Property Is in an Absolute Stage of Development, But a Relative Stage Is Around the Corner

1. Pore Space Rights Are Currently Absolute and Determined by a Rule of First Use

Pore space law currently resembles the absolutist prior appropriation doctrine of Blackstone, but lacks the limitations imposed by modern prior appropriation regimes.[328] In this sense, pore space rights fall within the first stage of development identified in the models of semicommon property. In general, one who injects into pore space for purposes of waste disposal, secondary or enhanced oil recovery, natural gas storage, hydraulic fracturing, horizontal drilling, or the like is free from liability for encroaching under the land of another, unless the injection interferes with another owner's prior-established use of the pore space. Once an injector establishes such a right by using unoccupied pore space, later injectors will be liable for any substantial interference.

Consequently, pore space rights are not determined by a strict rule of capture, which would permit interference with preexisting uses. Instead, regardless of where within the common reservoir the pore space is located, in pore space cases the first user of pore space wins. Pore space rights are thus established by first use and are absolute. In this sense, pore space rights somewhat resemble appropriation rights under Blackstone's prior appropriation doctrine.

Other work has systematically reviewed the case law on intra-reservoir property disputes.[329] It has been observed that many of the cases in this area are "neither unified nor coherent."[330] However, Professor Anderson's study of the cases shows that a consensus of courts do not consider injection of material into the

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[326] Epstein, *Nuisance Law*, *supra* note 284, at 73.

[327] *See* Smith, *Governing Water*, *supra* note 168, at 448 (noting that property rights in fugitive resources tend to include a little exclusion and increasing amounts of governance).

[328] *See supra* Part III.B.3–4, C.4.

[329] *See, e.g.*, Anderson, *supra* note 44, at 255–81; Anderson, *Lord Coke*, *supra* note 213; Schremmer, *supra* note 5, at 342–73.

[330] Anderson, *supra* note 44, at 255.

subsurface underlying another's land to be actionable, unless it results in actual and substantial property damage.[331] Consider a leading and emblematic case, *Chance v. BP Chemicals, Inc.*[332] Plaintiff landowners sued BP for trespass, claiming BP had injected fluid waste into a common saline aquifer that then migrated into portions of the aquifer underlying their land.[333] The Ohio Supreme Court held BP free from liability because the plaintiffs failed to show the injected waste physically damaged or interfered with the plaintiffs' preexisting or foreseeable uses of the subsurface.[334]

Because the plaintiffs had not established a prior use of the pore space underlying their land, BP was privileged to use it without paying compensation. Hypothetically, under the same rule, if the plaintiffs were to later start injecting into the same saline aquifer and impede BP's injection operation, BP would have a viable claim for damages for interference with its existing use. Echoing the concerns of early courts in groundwater and oil and gas cases, *Chance* acknowledged that this result was justified, in part, by its lack of knowledge about the migration of the injected fluids. Despite complex fluid migration models offered by the plaintiffs, the court remained uncertain whether BP's injectate in fact invaded the plaintiffs' subsurface.[335] Other courts have likewise acknowledged the difficulty in determining the migration of fluids through subsurface pore space.[336]

As *Lightning Oil Co. v. Anadarko E&P Onshore, LLC*,[337] discussed above,[338] demonstrates, the first-to-use principle extends beyond using common pore space for fluid disposal. The Texas Supreme Court denied Lightning Oil's request for an injunction against Anadarko because it failed to show Anadarko's proposed wellbores would interfere with Lightning Oil's existing or foreseeable development

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[331] *See id.* at 258–81 (reviewing cases involving property disputes from hydraulic fracturing, horizontal drilling, waste disposal, enhanced oil recovery, and natural gas storage operations).

[332] Chance v. BP Chems., Inc.670 N.E.2d 985 (Ohio 1996).

[333] *Id.* at 986.

[334] *Id.* at 992–93.

[335] *Id.* at 993 ("All of these and more disputed variables went into the construction of the hypothetical models that attempted to illustrate the lateral extent of the migration. Given all these variables, there were great difficulties in appellants' establishing, as a factual matter, that a property invasion had occurred, so that appellants' claim must be regarded as somewhat speculative.").

[336] *See, e.g.*, Hill v. Sw. Energy Co., 858 F.3d 481, 485–87 (8th Cir. 2017) (reviewing district court's exclusion of expert testimony pertaining to the spread of injected "fracking waste"); Raymond v. Union Tex. Petroleum Corp., 697 F. Supp. 270, n.7 (E.D. La. 1988) ("Considering the expert testimony in this case regarding the uncertainty of determining if, when, and where injected salt water might migrate, it is unlikely that an operator would undertake to execute leases with all landowners under whose property injected salt water might migrate.").

[337] Lightning Oil Co. v. Anadarko E&P Onshore LLC, 520 S.W.3d 39 (Tex. 2017).

[338] *See supra* text accompanying notes 288–33.

of the mineral estate.[339] Just as in *Chance*, superior rights to the pore space were given to the first user (here, Anadarko).

A first-use rule also appeared to be at work in the hydraulic fracturing context in *Coastal Oil & Gas Corp. v. Garza Energy Trust*.[340] As discussed above,[341] Coastal's hydraulic fractures into the Salinas parties' subsurface pore space were held not actionable because they did not physically damage the Salinas parties' land or existing subsurface operations.[342] Notably, the record in *Garza* contained conflicting expert testimony on the extent of the fractures under the Salinas parties' land.[343] The fact that the invasion occurred two miles underground, where even expert knowledge is uncertain, appeared to weigh in the court's reasoning. In one frequently quoted passage, the majority opinion remarks, "The law of trespass need no more be the same two miles below the surface than two miles above."[344]

The themes identified in the foregoing cases are readily apparent in many others involving injection into pore space for disposal, storage, enhanced recovery, hydraulic fracturing, and horizontal drilling. Rights to pore space are established on a rough rule of first use and, once established, are entitled to be free from interference. Courts justify this approach, in part, on the lack of knowledge about fluid migration in the deep subsurface and the attendant costs of proving and remedying invasions.[345] In this way, pore space rights appear to be in an absolute stage of development of semicommons.[346]

2. To Avoid Waste, Absolute Pore Space Rights Will Eventually Yield to Relative Rights

The influences that led courts to limit absolute rights in water and oil and gas are also likely to emerge in the context of pore space. In general, when competition

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[339] *Lightning Oil Co.*, 520 S.W.3d at 49. As a mineral lessee, Lightning Oil's interest in the subsurface included merely the opportunity to produce the oil and gas contained within subsurface pore space underlying its lease premises. *Id.*

[340] Coastal Oil & Gas Corp. v. Garza Energy Tr., 268 S.W.3d 1, 2 (Tex. 2008).

[341] *See supra* text accompanying notes 226–27.

[342] *See supra* notes and text accompanying notes 224–25.

[343] *See Garza*, 268 S.W.3d at 44 (Johnson, J. concurring) ("Coastal's expert testified that the effective length of the fractures (that length through which gas will flow) did not extend into Share 13, while Salinas's expert opined that it did.").

[344] *Id.* at 11. In another case alleging trespass by hydraulic fracturing, Briggs v. Southwestern Energy Production Company, the Supreme Court of Pennsylvania likewise noted, "[t]he judiciary . . . lacks institutional tools necessary to investigate the continuing feasibility of self-help remedies under the myriad of circumstances that may present themselves in the context of a dispute such as this one." Briggs v. Sw. Energy Prod. Co. 224 A.3d 334, 348 (Pa. 2020).

[345] Determining whether an injected substance has migrated beyond the boundaries of the injector's tract is a category of information cost. *See* Smith, *Governing Water*, *supra* note 168, at 446 (defining information costs in governing fluid property rights).

[346] *See supra* Part IV.A. (discussing the first stage of development).

for a resource increases, the inefficiencies produced by a regime of absolute rights eventually militate toward a regime of relative rights in which more holders are entitled to use the resource at lower levels of intensity.[347] Broadly, these inefficiencies include various forms of waste (economic, surface, underground, etc.) as a result of excessive use of the resource, and transaction costs that prohibit contractual coordination of resource development among numerous common owners.[348]

The forces that lead to relativized rights tend to arise when competition for the resource becomes intense. The precise level of competition, and thus of scarcity, at which rights in semicommon resources start to become limited and relative is not clear.[349] Although it is difficult to predict when it may occur, the costs of the absolute first-use rule of pore space rights are likely to overwhelm its administrative efficiencies, just as occurred in the development of water and oil and gas rights. At some point, the first-use rule currently governing pore space rights will lead to waste of pore space capacity, which will not be remediable by private agreement because of high transaction costs. The only question is when the turning point will occur.

Recent developments suggest that pore space scarcity may be on the horizon. The use of pore space for temporary and permanent storage of various substances is rising. Pore space capacity is increasingly used for temporary storage of compressed air as a form of energy in a technique called compressed air energy storage (CAES).[350] Similarly, technology enables storage of water in aquifer pore space for later retrieval in aquifer storage and retrieval (ASR).[351] Carbon capture and storage (CCS) garners increasing attention from policy-makers and private actors interested in injecting anthropogenic carbon dioxide into deep pore space for permanent storage to mitigate greenhouse gas emissions.[352] In 2018, the President signed into law a federal investment tax credit incentivizing large-scale geologic carbon dioxide sequestration.[353] The United States Department of Energy, Office of Fossil Energy, has funded—to the tune of nearly $100 million—several research and development projects intended to demonstrate the feasibility of commercial-scale carbon storage across the country.[354]

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[347] *See supra* Part IV.A.

[348] *See supra* Part IV.A.

[349] *See generally* Smith, *Governing Water*, *supra* note 168 (articulating an information-cost theory of determining property rights in water).

[350] Gresham & Anderson, *supra* note 50, at 706–07.

[351] *Id.*

[352] *See generally* MICHAEL G. FAURE & ROY A. PARTAIN, CARBON CAPTURE AND STORAGE: EFFICIENT LEGAL POLICIES FOR RISK GOVERNANCE AND COMPENSATION (2017) (discussing carbon storage technology as well as its significant legal, regulatory, and public policy obstacles).

[353] *See* 26 U.S.C. § 45Q (Supp. 2018) (Discussing the credit for carbon dioxide sequestration).

[354] UNITED STATES DEPARTMENT OF ENERGY, ENERGY.GOV, *DOE Announces $68.4 Million in Funding to Advance the Safe and Permanent Storage of CO_2* (June 24, 2016),

In addition to these cutting-edge pore space uses, traditional pore space activities appear to be growing. Pore space has long been used as an underground landfill for fluid waste. Under the federal Safe Drinking Water Act,[355] many kinds of fluid waste, including hazardous wastes, are injected for disposal in deep pore space. The largest of these wastes by volume is produced water, which is the saltwater commingled with extracted oil and natural gas.[356] While produced water has long been injected for disposal, in parts of the country experiencing significant oil and gas production, disposal volumes have spiked to critical levels. In the Permian Basin, for instance, volumes of produced water are mushrooming as a result of unconventional production techniques like so-called batch drilling and "zipper fracs."[357]

Disposal capacity for produced water is struggling to keep up with demand.[358] In areas of high injection activity, pressures from injection wells are even causing the casing in producing oil and gas wells to collapse.[359] Additionally, high-volume water injection has been linked to induced earthquakes in Oklahoma, Kansas, Texas,

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https://www.energy.gov/fe/articles/doe-announces-684-million-funding-advance-safe-and-permanent-storage-co2 [https://perma.cc/B4YC-X5PV]; Alvina Board, IEA Clean Coal Centre, USA, *Energy Department Selects Additional Carbon Storage Feasibility Projects to Receive Nearly $30M in Federal Funding* (May 30, 2018), https://www.iea-coal.org/usa-energy-department-selects-additional-carbon-storage-feasibility-projects-to-receive-nearly-30m-in-federal-funding/ [https://perma.cc/V6QW-PBW2].

[355] 42 U.S.C. §§ 300f–300j-26 (Supp. 2018).

[356] *See* Nat. Res. Def. Council, Inc. v. U.S. Env't. Prot. Agency, 863 F.2d 1420, 1425 (9th Cir. 1988) (discussing and defining produced water).

[357] *See* Sergio Chapa, *Permian Basin Water Disposal Volumes Expected to Double by 2022*, HOUSTON CHRONICAL (Apr. 15, 2019), https://www.houstonchronicle.com/business/energy/article/Permian-Basin-water-disposal-volumes-expected-to-13765666.php? [https://perma.cc/CQ34-5CDQ]; Wire Services, *'Disposal Nightmare': In Permian Basin, Every Barrel of Oil Means Four Barrels of Toxic Water*, DALLAS MORNING NEWS (Aug. 29, 2018), https://www.dallasnews.com/business/energy/2018/08/29/disposal-nightmare-in-permian-basin-every-barrel-of-oil-means-four-barrels-of-toxic-water/ [https://perma.cc/8P2T-2JCH] [hereinafter *Disposal Nightmare*]; *Hell or High Water in the Permian Basin? Will Water Be the Industry's Next Bottleneck?*, WOOD MACKENZIE (last accessed June 30, 2020), https://www.woodmac.com/news/feature/hell-or-high-water/ [https://perma.cc/HH5F-EYT3] [hereinafter *Hell or High Water*]; *See also* Velda Addison, *Shale Operators Aim to Tame Water Woes in Permian Basin*, HART ENERGY (Mar. 1, 2019), https://www.hartenergy.com/exclusives/shale-operators-aim-tame-water-woes-permian-basin-177907 [https://perma.cc/KMA6-LWTE].

[358] *Hell or High Water*, *supra* note 357 ("The number of completed Permian wells continues to increase, and water disposal volumes are forecast to double by 2022 . . . . This produces increasingly large volumes of water. Even with 100% water reuse for completions, which is unlikely, the current salt water disposal infrastructure is expected to hit capacity in the near future.").

[359] *Disposal Nightmare*, *supra* note 357.

Arkansas, Ohio, and New Mexico.[360] State conservation agencies have responded by stinting injection volumes in permitted wells, thereby limiting use of the pore space.[361] Moreover, in what appears to be a first-of-its-kind policy, the State Land Office of New Mexico now protests applications for authority to inject produced water into wells that are near state-owned lands. The practice is a means of requiring compensation for occupation of its pore space by injected produced water.[362]

Individually, these factors do not amount to a critical level of scarcity, but together, and over time, they may well result in greater demands for pore space capacity. As demand increases, so too does the risk of overexploitation incentivized by the absolute rule of first use. If the analogy to water and oil and gas law holds, the resulting waste will likely be difficult or impossible for private reservoir owners to address contractually.[363] Absent legislative intervention, like was seen in the history of oil and gas law and prior appropriation of groundwater, the common law's likely response will be to refine pore space rights established by prior use into relative rights.

It is somewhat beyond the reach of this Article to predict whether pore space rights will someday reach a third stage of development. However, it follows from the foregoing study of groundwater and oil and gas rights that the question of whether strictly limited but absolute rights to use pore space will develop statutorily or doctrinally will depend on how scarce and valuable pore space becomes and whether the costs of administering and monitoring such a regime would be worthwhile.

B. Limits on Pore Space Rights Will Develop Through Nuisance Doctrine

As the models of semicommon property demonstrate, the mechanism by which rights in common pool natural resources are limited and relativized is the tort of

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[360] *See* Monika U. Ehrman, *Earthquakes in the Oilpatch: The Regulatory and Legal Issues Arising Out of Oil and Gas Operation Induced Seismicity*, 33 GA. ST. U. L. REV. 609, 611–13 (2017) (discussing issues of induced earthquake activity in Texas, Oklahoma, Kansas, Arkansas, and Ohio); *see also Disposal Nightmare*, *supra* note 357 (discussing earthquake problems in Texas and New Mexico as a result of development in the Permian Basin).

[361] *See* Ehrman, *supra* note 360, at 637–45 (surveying state regulatory responses to concerns about induced seismicity from oil and gas and produced water disposal operations).

[362] Joseph Schremmer, *Crystal Gazing: Foretelling the Next Decade in Oil and Gas Law*, 66 ROCKY MTN. MIN. L. INST. (forthcoming 2020) (manuscript at 74–77) (on file with author); Ari Biernoff, *Presentation at the State Bar of New Mexico Oil and Gas Law in New Mexico CLE: What's New at the State Land Office in Oil & Gas* (Dec. 4, 2019) (presentation by General Counsel, New Mexico State Land Office, 2019).

[363] *See supra* Part IV.A (discussing the problem of high transaction costs when many owners hold an interest in semicommon property). In the case of using pore space for carbon dioxide storage, some states have addressed this problem by passing statutes to unitize pore space rights. Righetti, *supra* note 2, at 10436.

nuisance. Even where nuisance is not expressly acknowledged as the limiting mechanism, as in oil and gas law's correlative rights doctrine and the reasonable use rule in water law, nuisance's principles for ordering competing uses of related property are clearly at work when rights relativize.[364]

In fact, nuisance concepts already underlie existing case law dealing with subsurface property rights.[365] When a landowner sues for invasion of the subsurface of its land by foreign material, lawyers and judges typically frame the dispute as an alleged trespass.[366] Notwithstanding this label, courts tend to eschew the rules and remedies traditionally associated with trespass in favor of more malleable provisions. While traditional trespass presumes damage by the mere fact of unauthorized encroachment, subsurface trespass cases usually require a showing of actual damage to establish liability.[367] Even where an invasion is indisputably established, courts are wont to balance the severity of the harm sustained by the plaintiff with the societal good accomplished by the offending activity to determine liability.[368] Further, where liability is found for a subsurface invasion, the usual trespass remedies of ejectment and nominal damages are discarded, and only compensatory damages are awarded.[369]

Such departures from the traditional tort of trespass reveal the nature of subsurface property as nonpossessory. The strict, possession-protecting provisions of trespass lead to absurd results when faithfully applied to subsurface encroachments because the nature of interconnected rock structures—and their interstitial pore spaces—is nonexcludable (nonpossessory, in legal jargon).[370] Nuisance's use-protecting provisions instead are apposite when disputes arise over excessive use of a common pool resource.

As currently applied in subsurface-use disputes, however, nuisance principles tend to define *injuria* or *laedas* to include only actual damage to preexisting subsurface activities, thus resulting in a kind of absolute property right.[371] This is similar to how Blackstone applied nuisance law's *sic utere tuo* to protect prior-established uses of water from any and all interference.[372] To limit, or relativize, pore space rights, courts would need to redefine legal injury (and, therefore, the extent of the property right) to encompass a broader set of harms than merely actual damage to established subsurface activities. Defining legal injury is the crux of

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[364] *See supra* Part IV.B.1.

[365] *See* Schremmer, *supra* note 5, at 342–73.

[366] *Id.*

[367] *Id.*

[368] *Id.*

[369] *Id.*

[370] *See supra* Part II (discussing pore space as a rivalrous but nonexcludable resource).

[371] *See supra* Part V.A.1 (summarizing the current state of pore space rights as absolute based on a principle of prior use).

[372] *See supra* text accompanying notes 71–79 (noting that Blackstone's application of *sic utere tuo* conflated harm and *laedas*).

governing a semicommons and, as the semicommons models illustrate, doing so ultimately requires balancing certainty with flexibility.[373]

C. Defining the Extent of Pore Space Rights by Reasonableness, Proportionality, and Otherwise

Above, I discussed the dominant methods of delineating relative rights in common pool natural resources: instrumentalist reasonableness standards and formalist rules of strict proportionality.[374] An instrumentalist reasonableness method underpins modern riparian rights doctrine, the reasonable use rule in groundwater, and Professors Kuntz's and Pierce's definitions of correlative rights in oil and gas law.[375] Groundwater law's correlative rights doctrine and Professor Summers's theory of oil and gas rights adopt a formalist, proportional method of defining relative rights.[376] In this section, I will briefly consider how each method could be applied to define pore space rights, and suggest a third method, synthesized from principles of oil and gas correlative rights, which may promote certainty while accommodating unavoidable utilitarian constraints.

1. A Reasonable Use Definition of Pore Space Rights

Defining rights to use pore space based on a rule of reasonable use would resemble Professor Pierce's reservoir community analysis,[377] which, in turn, somewhat resembles the Restatement's tests for nuisance[378] and excessive use of surface and groundwater resources.[379] Under reservoir community analysis, defining pore space use rights would proceed case by case based on the physical attributes of the common reservoir, the suitability of the competing pore space uses to the reservoir, and whether the invading activity is necessary to maximize the value of the reservoir's pore space capacity. Similarly, under the Restatement's balance of utilities test for nuisance and its test for liability for overuse of water, pore space rights would be defined, in broad terms, by balancing the utility of the invading pore space use with the gravity of harm to the invaded interest.[380]

As conceived by Professor Pierce, the reservoir community analysis is concerned with maximizing efficient production of oil and gas from common

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[373] *See supra* Part IV.C.

[374] *See supra* Part III.D.

[375] *See supra* Part III.C.1 & III.D.

[376] *See supra* Part III.D.

[377] The reservoir community analysis is described *supra* in Part III.D.2.(b)(ii).

[378] *See* RESTATEMENT (SECOND) OF TORTS § 826 (AM. LAW INST. 1979) (setting forth the balance of utilities test for nuisance liability).

[379] *See id. at* § 858 (setting forth the factors for determination of liability for withdrawal of groundwater).

[380] *See id. at* § 826 (setting forth the balance of utilities test for nuisance liability); *id.* at § 858 (setting forth the factors for determination of liability for withdrawal of groundwater).

reservoirs. Pierce has amply demonstrated how the analysis would apply to disputes arising over activities intended to produce oil and gas, like horizontal drilling and hydraulic fracturing.[381] In oil and gas production, there is a single purpose: maximize ultimate recovery of the resource. The value of any given production technique is thus determinable with reference to its ability to maximize production.

Pore space, on the other hand, can serve many functions that are not directly related to oil and gas production, or any other single purpose, such as waste disposal, carbon storage, and energy storage. Applying the analysis to the use of pore space for such non-extractive injection activities is more difficult, because the purposes and values of each activity are different and incommensurable with each other. To account for the incommensurability problem, the reservoir community analysis would need to consider the utility of the injection activity more broadly than merely whether it maximizes oil and gas production. Ultimately, this may require prioritizing certain types of pore space uses, much as some jurisdictions prioritize domestic and agricultural uses of water in applying the reasonable use test of riparian and groundwater law.[382]

To illustrate the incommensurability problem, suppose *A* and *B* own separate tracts of land overlying the Entrada Sandstone reservoir. *A* obtained a permit to inject carbon dioxide into the Entrada Sandstone for geologic storage. When offered a fair chance to participate in the carbon dioxide storage project by *A*, *B* refused. *B* objected to the storage project because it would interfere with *B*'s existing saltwater injection well, which disposes of water produced from *B*'s natural gas well into the Entrada Sandstone formation. Notwithstanding *B*'s objection, *A* began construction of its carbon dioxide injection well, and *B* sued to enjoin further operations, alleging imminent interference with its disposal operations.

Applying a reservoir community analysis to these hypothetical facts, a court would proceed in three steps.[383] First, it would determine *A*'s and *B*'s "membership" in the "reservoir community" based on their owning land overlying a portion of the common reservoir. Second, the court would consider the geological and geophysical evidence to determine relevant reservoir conditions, such as porosity, permeability, and pressure, with the goal of evaluating the suitability of the reservoir for carbon storage and saltwater disposal. Third, the court would evaluate *A*'s intended use of the pore space for carbon storage and *B*'s existing use of the pore space for produced water disposal with reference to the Entrada Sandstone's physical character.

If it turns out that the Entrada Sandstone is equally suitable for both carbon storage and saltwater disposal, it will be difficult to determine which competing activity maximizes the value of the pore space, because "value" is measured differently for each activity. What should be the measure of value—the net present value of the revenue from each activity, the anticipated return on investment of each, the capital outlay required for each, the social good each activity produces, or the

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[381] *See supra* Part III.D.2.(b)(ii) (describing Pierce's theory as applied to oil and gas production activities).

[382] *See supra* text accompanying notes 100–01.

[383] *See supra* Part III.D.2.(b)(ii) (discussing reservoir community analysis generally).

value of each activity to its respective user? Some courts in this situation might determine that the social value of *A*'s carbon storage project justifies the harm to *B*'s saltwater disposal operations. Perhaps other courts may strike the balance in favor of *B*, because to condemn the produced water disposal would force B to plug and abandon its natural gas well, resulting in the waste of natural gas.

Until the matter is litigated and decided by a court, neither *A* nor *B* can be confident of the result. Such is also a problem in the application of water law's reasonable use rule and the Restatement's version of utility-balancing nuisance doctrine.[384] Thus, while a utilitarian, reasonable use approach may maximize the value of pore space capacity in any given case (assuming a commensurable measure of "value"), it may do so at the expense of clearly defining property rights. Obscuring the definition of property rights may, in turn, undermine investment in the development of pore space activities.[385]

2. A Strictly Proportional Definition of Pore Space Rights

A strictly proportional definition of pore space rights is easy to conceptualize, but difficult to apply in practice. In groundwater law, the correlative rights doctrine defines owners' rights in a common groundwater aquifer on the basis of the acreage of their land holdings overlying the aquifer.[386] Professor Summers proposed a definition of correlative rights in oil and gas reservoirs based on the same kind of allocation.[387] In groundwater law, the proportional correlative rights doctrine was not widely adopted.[388] The allocation prong of Professor Summers's definition of correlative rights also was not widely adopted.[389] For the reasons explained below, a strict-proportional allocation of pore space rights would likely suffer from the same impediments to widespread adoption.

Professor Tara Righetti has favorably discussed a proportional rule for allocating pore space rights for carbon dioxide storage. Righetti asserts that a proportional rule would clearly delineate parties' rights to inject carbon for storage into common pore space, and thus enable private bargaining and cooperation to consolidate rights for field-wide storage operations.[390] Righetti implicitly acknowledges that the transaction costs associated with such large-numbers of transactions are generally prohibitive, and accordingly indicates that a proportional-

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[384] *See supra* Part IV.C.1 (discussing uncertainty associated with utilitarian, reasonable use rules).

[385] Schremmer, *supra* note 5, at 323–24.

[386] 1 SUMMERS, *supra* note 180 at §3:3; *see, e.g.*, OKLA. STAT. tit. 82, §§ 1020.2, 1020.6 (2020).

[387] *See supra* text accompanying note 169.

[388] *See* Dellapenna, *supra* note 106, at 276–77 (discussing the proportional variety of correlative rights and its adoption in relatively few states, including Oklahoma and, to an extent, California).

[389] *See supra* Part III.D.2.(a).

[390] Righetti, *supra* note 2, at 10,435–36.

use rule would require administration by a state regulatory agency.[391] In fact, some states have adopted legislation providing for the unitization of pore space rights for carbon storage.[392] Experience in oil and gas demonstrates that administrative regulation is indeed necessary where rights in a common reservoir are broadly distributed among many holders, because the problems of transaction costs and holdouts impede efficient development of the entire reservoir.[393]

The administrative and information costs of a formalist, proportional scheme of pore space rights administered by a regulatory agency would be significant. Righetti acknowledges that, given the technical complexity of delineating reservoir pore space capacity underlying any given tract of land, using surface acreage as a proxy for determining proportionality may not be an ideal mechanism for pore space.[394] As Professor Clyde Martz noted half a century ago about groundwater law's correlative rights doctrine, the significant administrative cost of proportional allocation may overwhelm the benefits.[395]

Further, where statutory administrative regimes are not adopted, defining pore space rights on a strictly proportional basis may invite strategic behavior among pore space owners. In California, which follows a strictly proportional variety of correlative rights doctrine for groundwater, groundwater rights holders intentionally over-pump aquifers to establish prescriptive rights to more than their proportional allocation of the common groundwater.[396] The result is a tragedy of the commons in which users are able to internalize the benefits and externalize the costs of over-appropriation to other users.[397] In sum, a formalist, proportional definition of pore space rights has conceptual allure; however, in application it generally requires administrative regulation, is expensive to administer, and may incentivize strategic behavior among common owners.

3. A Third Method? Defining Pore Space Rights Based on the Fair-Opportunity Principle

The models of semicommon property demonstrate, to varying degrees, the difficulties in defining rights by either an instrumentalist reasonable use standard or a formalist rule of proportionality. As detailed in the preceding sections, these difficulties inhere equally in defining rights in pore space. The dilemma may ultimately be resolved by statutory schemes, which themselves would need to

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[391] *Id.* at 10,436–37.

[392] *Id.* at 10,436.

[393] *See* Rose, *Common-Law Water Rights, supra* note 68, at 270–72 (discussing the transaction costs associated with large-scale bargaining).

[394] Righetti, *supra* note 2, at 10,437.

[395] Martz, *supra* note 118, at 32 ("The principal criticism that has been leveled against the correlative rights doctrine has been that it gives rise to . . . serious administrative problems . . . .").

[396] Dellapenna, *supra* note 106, at 279.

[397] *Id.*

grapple with the tradeoffs between fluidity and certainty. There is no perfect solution. It is possible, however, to derive from the models a definition of reservoir pore space rights that is relatively flexible without being indeterminate, and relatively certain without being prohibitively costly to administer.

Professor Righetti demonstrated how a rule allocating pore space rights proportionally would function.[398] Yet, at least in the oil and gas context, correlative rights are both more and less than the right to produce a proportional amount of the contents of a common reservoir. Correlative rights are *less* in that they entitle holders only to the *fair opportunity* to produce a proportional share of reserves, and not to a guaranteed portion of production or its value.[399] Correlative rights may also entitle holders to *more* than merely their proportional share of reserves, since active holders may produce a disproportionate share if other holders do not exercise their opportunity to produce. This fair-opportunity principle from oil and gas doctrine furnishes a limitation on the absolute rule of capture that is more flexible than strict proportionality, yet does not rely as heavily on judicial discretion as would a reasonable use limitation. As discussed above, similar limiting principles are applied in fluid injection cases under Oklahoma and Arkansas law.[400]

Briefly, under Oklahoma's modified doctrine of private nuisance, injectors are liable for interfering with the lawful preexisting reservoir activities of other reservoir owners.[401] Injectors are not liable for merely occupying the pore space underlying another owner's property, so long as it would not prevent the owner from using the formation for like operations.[402] Oklahoma's nuisance doctrine does not consider the utility of the defendant's injection operations, whether they have been authorized by a regulatory agency, or the nature of the locality.[403] Arkansas courts privilege invasions of fluid injected for enhanced recovery in situations where the plaintiff, despite the invasion, has the self-help ability to conduct like operations.[404] Where the invasion would prevent the plaintiff from doing likewise, on the other hand, Arkansas courts have held the injector liable for the value of minerals extracted from the plaintiff's tract in excess of natural depletion.[405]

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[398] *See supra* Part V.C.2.

[399] 1 KRAMER & MARTIN, *supra* note 190, at 5–16; *see, e.g.*, Elliff v. Texon Drilling Co., 210 S.W.2d 558, 562 (Tex. 1948) ("This reasonable opportunity to produce his fair share of the oil and gas is the landowner's common law right . . . .").

[400] *See supra* Part III.D.3.(b).

[401] *See supra* text accompanying note 239 (discussing W. Edmond Salt Water Disposal Ass'n v. Rosecrans, 226 P.2d 965 (Okla. 1950)).

[402] *See supra* text accompanying note 239 (discussing W. Edmond Hunton Lime Unit v. Lillard, 265 P.2d 730 (Okla. 1954)).

[403] *See supra* notes and text accompanying notes 233–37.

[404] *See supra* text accompanying notes 242–45 (discussing Jameson v. Ethyl Corp., 609 S.W.2d 346 (Ark. 1980) and Young v. Ethyl Corp., 521 F.2d 771, 775 (8th Cir. 1975)).

[405] *See supra* text accompanying notes 242–45 (discussing Jameson v. Ethyl Corp., 609 S.W.2d 346 (Ark. 1980)).

Other courts privilege fluid invasions caused by enhanced recovery operations that the plaintiff refused a fair opportunity to join consensually.[406] Thus, as in *Baumgartner v. Gulf Oil Corp.*,[407] even if a defendant's waterflood operation precludes a plaintiff from developing the reserves under her tract, the plaintiff cannot sue for trespass and drainage damages if he previously refused an offer to participate in the operation on the same terms as similarly situated reservoir owners. In circumstances like these, the plaintiff's correlative rights entitle him only to a fair opportunity to participate in the defendant's reservoir-wide operation, which he received and declined to exercise.[408]

These principles can be synthesized into a "fair-opportunity doctrine" to define the extent of property rights in common pore space, including rights to use pore space for all manner of disposal and storage.[409] The synthesized doctrine could also be applied to define rights to conduct secondary and enhanced recovery operations, hydraulic fracturing, and horizontal drilling for oil and gas production in common reservoirs.

The fair-opportunity doctrine permits an owner to use shared pore space for any activity, so long as it does not interfere with the lawful existing operations of other owners, or deprive other owners of a fair opportunity to conduct like operations from their respective land or participate in the proposed operations. In effect, the doctrine grants pore space owners an incomplete privilege[410] to use a disproportionate quantity of pore space anywhere within a reservoir, provided they offer a fair opportunity to participate in the benefits and burdens of the operation to any and all common owners whose appurtenant pore space may be condemned for further use by the operation.

According to the doctrine, an owner is liable for use of pore space in a common reservoir only when (1) the defendant by an affirmative act (2) physically invades

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[406] For cases denying liability for trespass and drainage from enhanced recovery operations where the plaintiff was given a reasonable opportunity to participate beforehand, *see, e.g.*, Tide Water Assoc. Oil Co. v. Stott, 159 F.2d 174, 179 (5th Cir. 1946); California Co. v. Britt, 154 So. 2d 144, 150–51 (Miss. 1963); Syverson v. N.D. Industrial Commission, 111 N.W.2d 128, 134 (N.D. 1961); Baumgartner v. Gulf Oil Corp., 168 N.W.2d 510, 518–19 (Neb. 1969). *See also* 1 KUNTZ, *supra* note 56, at § 4.8.

[407] *Baumgartner*, 168 N.W. 2d at 518–19.

[408] *See supra* notes and text accompanying notes 191–94 (discussing the correlative rights of oil and gas owners to a fair opportunity to participate in operations that will occupy the entire portion of the reservoir underlying their respective tracts).

[409] Professor Pierce has recognized that fair-opportunity principles from enhanced recovery cases may be applicable to defining reservoir rights for other purposes, like carbon sequestration or storage. *See* Pierce, *New Subsurface Property Rights, supra* note 203, at 4-39 ("Therefore, the carbon sequestration correlative rights may include a more formalized opportunity to participate than is the case with the waste disposal cases. This opportunity would be like that for marshalling enhanced recovery correlative rights with passive participants being offered a chance to participate on reasonable terms.").

[410] *See generally* Francis H. Bohlen, *Incomplete Privilege to Inflict Intentional Invasions of Interests of Property & Personality*, 39 HARV. L. REV. 307 (1926) (providing a classic discussion of qualified or incomplete privileges to trespass).

the boundaries of the plaintiff's subsurface as defined by the *ad coelum* doctrine, (3) and damages the plaintiff by impairing either the plaintiff's (a) existing lawful use of the reservoir pore space or (b) fair opportunity to lawfully use the reservoir pore space. The fair-opportunity principle is incorporated into the test via element (3)(b)—the plaintiff's fair opportunity to lawfully use the reservoir. Essentially, element (3)(b) prohibits destruction of the reservoir, waste of its resources, or occupation of it to the total exclusion of other reservoir owners. Element (3)(b) is not met where a plaintiff declined the fair opportunity to participate on equivalent terms as other similarly situated owners in a defendant's proposed reservoir-wide operation (e.g., an enhanced recovery or carbon storage project). The plaintiff in such a case would be deemed to have exercised her fair opportunity to use the reservoir by declining such an offer to participate.

Just as each owner in a common pool is entitled to a fair opportunity to obtain the value of the oil or gas recoverable from its portion of the reservoir, each owner is entitled to a fair opportunity to obtain the use value of its portion of the reservoir's storage capacity. The only conceptual difference is in valuing the resource. In contrast to the value of pore space, the value of oil and gas is easily determined because there are established markets for the products. Nevertheless, the value of the pore space may be extrapolated from the amount of compensation, if any, paid to the owner of the pore space at the injection site for the storage rights.

If, as is typical, none or only a small portion of the compensation paid to the injection site owner is attributable to the use of pore space,[411] a plaintiff would need to establish some other method of valuing the pore space capacity to be entitled to market value damages. If a plaintiff cannot prove a market value for the pore space or show other losses, she cannot satisfy the damage requirement and cannot establish liability under this (or any other) test for nontrespassory invasions. In such a case, nothing of value was lost by the plaintiff or taken by the defendant, and compensation would be inappropriate.

The fair-opportunity doctrine limits absolute rights in shared pore space capacity in a principled, reasonably predictable manner that neither invites significant judicial discretion nor requires excessive administrative or information costs. Information and transaction costs are unavoidable, but this framework minimizes them. The information needed by the court to resolve the dispute is not each tract owner's proportionate share of the total reservoir pore space, but merely whether any owner's pore space activity precludes the other from doing the same in the reservoir.

Moreover, the fair-opportunity doctrine more clearly allocates initial property rights than a reasonable use standard and thus enables parties to more easily govern their behavior and exchange property rights consensually ex ante to avoid disputes. Transaction costs are reduced (though not eliminated) because only a fair offer is

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[411] *See, e.g.*, Burlington Res. Oil & Gas Co., LP v. Lang & Sons Inc., 2011 MT 199, ¶ 29, 259 P.3d 766 (2011) (noting testimony by Burlington's expert witness appraiser in a dispute over unauthorized use of Lang & Sons Inc.'s pore space for produced water disposal that "no demonstrable market exists for pore space").

required, not the consummation of a fair deal. Prior-established users are prevented from holding out and rent seeking by virtue of the fact that their prior rights are protected only by a liability rule. Through this mechanism, the doctrine avoids many of the holdout and transaction-cost problems that plague voluntary pooling and unitization of oil and gas rights.

To illustrate how the fair-opportunity doctrine functions, let us return to our earlier hypothetical dispute between common owners in the Entrada Sandstone, *A* and *B*.[412] *A* has a permit to flood the common reservoir for CCS, which will interfere with *B*'s existing saltwater disposal operations. Rather than apply a reasonableness standard to resolve these clashing pore space activities, a court applying the fair-opportunity doctrine would reason as follows:

- *B* has an established right to conduct its saltwater disposal operation, because it was first in time.
- Because *B*'s activity is prior in time and in right, *A* may not, without liability, undertake any affirmative act that would cause a physical invasion of *B*'s *ad coelum*-defined subsurface property and impair either *B*'s existing disposal operations or her fair opportunity to conduct like operations in the reservoir.
- Thus, *A* may not flood the entire reservoir with carbon dioxide, because it would invade *B*'s subsurface and preclude *B* from doing the same, without offering *B* (and all other affected owners in the Entrada Sandstone) a fair opportunity to participate in the CCS operations. In *B*'s case, to be considered "fair," *A*'s offer to *B* would need to include compensation for the lost use value of *B*'s disposal well (because it was prior in right), as well as a proportionate share of any income from the CCS operations.[413]
- If *B* rejects a fair offer from *A* and the parties are unable to negotiate an alternative, *A* will be entitled to proceed with the CCS operations. *B* will be barred from bringing an action against *A* for any resulting trespass or nuisance, and accordingly would not be entitled to an injunction.
- If *A* fails to make a fair offer to participate before conducting the CCS operations, it will be liable to *B* (and any other affected reservoir owners) for damages for impairing existing operations and precluding future ones. *B*

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[412] *See supra* Part V.C.1.

[413] As is true in oil and gas cases, there is a lot of play in the joints in defining a "fair opportunity" to participate, and this may have to be litigated in extreme cases. *See, e.g.*, Johnson v. Kell, 626 N.E.2d 1002, 1005–06 (Ohio Ct. App. 1993) (holding that, to be fair, an offer of voluntary pooling must take into account the impact on the offeree of the proposed operations). In certain cases, money alone may not fairly compensate an offeree owner for its loss of existing operations, or the value of the loss may be impossible to accurately estimate. In such situations, an offeree may invoke equity to enjoin the offeror's proposed operations. Equity may also intervene to curtail opportunism where the offeror's proposal is intended merely as leverage or extortion. *See generally* Henry E. Smith, Equity as Second-Order Law: The Problem of Opportunism (Jan. 15, 2015) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2617413 (explaining equity as a failsafe against opportunistic exercise of legal rights).

> will be entitled to damages for nuisance under the fair-opportunity doctrine. If *B* can prove the necessary elements for an equitable injunction, one may be available as a remedy, but it is not required by the legal doctrine.[414]

In sum, if, but only if, *A* is willing to allow *B* (and other reservoir owners) to participate in the CCS project and compensate *B* for the loss of the saltwater disposal well, there is nothing to stop *A* from proceeding with the CCS on that basis. This result follows from the nature of the relative property interests of *A* and *B* as articulated under the fair-opportunity doctrine.

The fair-opportunity doctrine, as I have articulated it here, may be said to permit too much exploitation of reservoir pore space. This is ultimately an empirical question, since the appropriate level of exploitation for any given reservoir cannot be known precisely except by experience. If it eventually appears necessary to further limit use of pore space, legislatures may at that time adopt statutory conservation laws similar to those adopted for oil and gas or non-rechargeable aquifers.

It may also be argued that the fair-opportunity doctrine could fail to maximize the value of any given reservoir's pore space because it does not consider the purpose or value of an owner's pore space use. For example, under the doctrine, assume *A* uses common pore space to inject produced water for disposal that migrates beyond the boundaries of *A*'s surface tract. *A*'s disposal operation could prevent other present or future reservoir owners from using pore space under their land for purposes that may be more valuable, like energy storage. If the net present value of *A*'s produced water disposal is less than the net present value of the potential alternative (e.g., energy storage), then the fair-opportunity doctrine would have permitted a sub-optimal use of the pore space.

While the problem of maximizing the present value of pore space capacity is significant, it is not unique to the fair-opportunity doctrine; it could occur under either a strict-proportional allocation regime, which also does not weigh the utility or value of any particular pore space use. It could also occur under a utilitarian reasonable use regime for the simple reason that new pore space uses are still developing, and the relative value of competing uses in the future is unknowable in the present. Moreover, the use of pore space for purely malicious purposes would be actionable because such a waste of shared resources is generally prohibited.[415]

In sum, defining pore space property on the basis of the fair-opportunity doctrine may prove more certain and efficient than tests based on reasonable use or strict proportionality. Additionally, the principles underpinning the doctrine are already established, in oil and gas law. Employing the doctrine in any particular case would require merely an extension or novel application of existing principles.

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[414] *See* RESTATEMENT (SECOND) OF TORTS § 822, cmt. d (1979) (distinguishing the legal action for damages for nuisance from an equitable suit for injunction).

[415] *See, e.g.*, Louisville Gas Co. v. Kentucky Heating Co., 77 S.W. 368, 370 (Ky. 1903) (granting an injunction against the defendant's spiteful dissipation of natural gas reservoir shared with the plaintiff).

Therefore, the fair-opportunity doctrine furnishes a ready starting point for analysis if and when circumstances call on courts to refine property rights in pore space.

VI. CONCLUSION

The extent of rights to use the pore space in subsurface rock formations is a frontier in property law. In developing a common law of pore space property, it is important to recognize that its fundamental physical characteristics—nonexcludability, rivalrousness, and depletability—are similar to other common pool natural resources such as surface waters, groundwater, and oil and gas reservoirs. These similarities justify studying the historical and legal development of water and oil and gas property to derive lessons for governing pore space semicommons.

In applying these lessons to pore space property, it appears that pore space rights are currently in an initial absolute stage of development, but may need to relativize imminently to accommodate increasing demands for pore space capacity. In limiting pore space rights into relative rights, courts may apply either a utilitarian reasonable use test or a strict proportional test. Each approach, however, as demonstrated in the development of water and oil and gas property rights, entails significant disadvantages.

Alternatively, pore space property rights may be defined by a principle that owners are entitled to a *fair opportunity* to use a proportional amount of common pore space capacity. The fair-opportunity doctrine permits an owner to use shared pore space for any activity so long as it does not interfere with the lawful existing operations of other owners, or deprive other owners of a fair opportunity to conduct the same type of activity from their respective land or to participate in the operation on equitable terms. Ultimately, the fair-opportunity doctrine may provide a more certain and administratively efficient means of defining pore space and reservoir rights in a wide variety of contexts, including injection for waste disposal, carbon sequestration, secondary and enhanced recovery, hydraulic fracturing, and horizontal drilling.