5-8-2017

Correlative Rights and Limited Common Property in the Pore Space: A Response to the Challenge of Subsurface Trespass in Carbon Capture and Sequestration

Tara Kathleen Righetti
University of Wyoming College of Law, trighett@uwyo.edu

Correlative Rights and Limited Common Property in the Pore Space: A Response to the Challenge of Subsurface Trespass in Carbon Capture and Sequestration

by Tara K. Righetti

Tara K. Righetti is an Assistant Professor of Law and Director of the academic program in Professional Land Management at the University of Wyoming.

Summary

Carbon dioxide and other substances injected as part of carbon capture and sequestration (CCS) have the potential to migrate beyond the confines of the injection project, creating the potential for trespass. In order for CCS to be viable, legal clarity on the issue of subsurface trespass is required. This Article argues that the challenge of subsurface trespass associated with CCS can be overcome by conceptualizing pore space rights in the storage complex as limited common property with rights of proportionate use. The traditional oil and gas framework of correlative rights can be a valuable model to promote investment, encourage private ordering, and discourage the underutilization of subsurface property for CCS.

The web of interests conveyed by property ownership becomes increasingly tangled as one ventures deeper into the subsurface.[1] An owner's rights to exclude others and to extract economic rent for use of the property are chief among the tenets of private ownership,[2] yet courts have been wary of extending an absolute right of exclusion to subsurface invasions resulting from the transboundary migration of substances.[3] Subsurface trespasses resulting from climate mitigation technologies create a perfect storm of problematic property law issues: fugacious substances, questionable assertions of physical possession, ambiguous damages resulting from anticipated injuries, and compelling public purposes.[4]

Faced with these issues, courts have conflated the doctrines of trespass and nuisance through the application of a "modern view" of trespass to subsurface intrusions.[5] This

Author's Note: This research was made possible through support from the School of Energy Resources. Valuable comments were received from Keith Hall and the faculty and students at Louisiana State University (LSU) during the Bringing the Rockies to the Bayou lecture, at which LSU was gracious enough to invite me to speak. This research builds upon the excellent work of Profs. Alexandra Klass and Elizabeth Wilson on the subject of carbon capture and sequestration, and Profs. David Pierce, Owen Anderson, Bruce Kramer, and Keith Hall on the subject of subsurface trespasses. Any new insights presented here would not have been attainable without the comprehensive foundations provided by their research. Alex Ritchie, Sam Kalen, and Jason Robison all provided insightful comments in the revision process. Casey Terrell (J.D./M.A. 2018) provided excellent research assistance. I thank Chris Rynders and ELR *and its staff for their editorial assistance.*

1. Craig Anthony (Tony) Arnold, *The Reconstitution of Property: Property as a Web of Interests,* 26 Harv. Envtl. L. Rev. 281 (2002).
2. Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419, 435-46 (1982) ("The power to exclude has traditionally been considered one of the most treasured strands in an owner's bundle of property rights.").
3. Owen L. Anderson, *Subsurface "Trespass": A Man's Subsurface Is Not His Castle*, 49 Washburn L.J. 247, 248-49 (2010) [hereinafter *Subsurface "Trespass"*]; Owen L. Anderson, *Geologic CO_2 Sequestration: Who Owns the Pore Space?*, 9 Wyo. L. Rev. 97, 99 (2009) [hereinafter *Geologic CO_2*]; Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. Ill. L. Rev. 363, 365 (2010).
4. *See, e.g.*, Joseph W. Bingham, *The Nature and Importance of Legal Possession I*, 13 Mich. L. Rev. 7 (1915); Richard A. Epstein, *Possession as the Root of Title*, 13 Ga. L. Rev. 1221 (1979); Charles T. McCormick, *Damages for Anticipated Injury to Land*, 37 Harv. L. Rev. 547 (1924).
5. Adams v. Cleveland-Cliffs Iron Co., 602 N.W.2d 215, 220 (Mich. Ct. App. 1999):

> The effects of recent trends in the law of trespass have included eliminating the requirements of a direct invasion by a tangible object, requiring proof of actual and substantial damages, and weighing the plaintiff's damages against the social utility of the operation causing them. This so-called "modern view of trespass" appears, with all its nuances and add-ons, merely to replicate traditional nuisance doctrine . . . . Indeed, the trends recognized or advanced by *Bradley, Borland, Martin,* and their kindred spirits have conflated nuisance with trespass to the point of rendering it difficult to delineate the difference between the two theories of recovery.

amalgamation recognizes the permanent, physical occupation of the subsurface property as a trespass, yet requires a difficult-to-achieve demonstration of harm or loss of use in order to justify a damage award.[6] Further, though courts have preserved the option, injunctive relief is rarely granted.[7] Thus, subsurface trespasses resulting from migration of injected substances are rarely actionable in a way that provides meaningful relief. As a result, the ability to remedy violations of the right of exclusion in the subsurface has become increasingly tenuous.

An examination of the difficulties presented by subsurface trespasses suggests the need for an evolving conceptualization of subsurface property. Non-mineral subsurface reservoirs hold enormous potential for addressing some of the challenges of climate change through carbon capture and sequestration (CCS).[8] The difficulty of exalting both rights of exclusion and rights of use in the subsurface pore space—particularly in the non-hydrocarbon pore space—is that the most evident uses of pore space are intrinsically resistant to confinement within a specific column of space.[9] Reservoirs operate holistically, without regard to property or geopolitical boundaries.[10] While geologists may be able to predict the path of a plume, or to steer it, over time, the reservoir will seek to diffuse any injected material and stabilize pressure.[11]

This in turn suggests that the business of parsing molecules in order to uphold an absolute right of exclusion is unwise, and could create an insurmountable obstacle to carbon capture projects. Injectors will be unwilling to make the significant investments required for carbon storage as long as there exists the potential for injunctive relief or ejectment.[12] Accordingly, property owners will paradoxically be neither able to make full use of their property for carbon storage nor to fully preclude intrusions by others, thus deterring innovation and investment.[13] Therefore, responding to what Prof. David E. Pierce refers to as "the modern property analysis imperative," concepts of property in the non-mineral subsurface should be adapted to reflect characteristics inherent to the property's use.[14]

This Article argues that in order to facilitate the significant public good of carbon capture projects, pore space rights in the deep subsurface should be conceptualized based on the acknowledgment that "compartmentalized ownership of the reservoir is impossible."[15] Doing so permits consideration of deep subsurface pore space ownership as something akin to what Prof. Carol Rose refers to as "limited common property."[16] This concept would create a legal privilege granting each owner within the reservoir community a right of proportionate use.[17] Accordingly, rather than treating ownership as exclusive, the rights of each owner within the private interconnected storage complex would be shared among members of the reservoir community based on principles of proportionate and coequal rights of use.

As Professor Pierce notes, the concept of correlative rights fits neatly within the framework of limited common property.[18] Correlative rights refers to the notion that each

There is also some confusion about whether the doctrines of nuisance or strict liability should apply. *See* Bruce M. Kramer, *Horizontal Drilling and Trespass: A Challenge to the Norms of Property and Tort Law*, 25 Colo. Nat. Resources, Energy & Envtl. L. Rev. 291, 313-14 (2014) ("The wild card in this analysis [of whether hydraulic fracturing results in an actionable trespass] is whether or not a jurisdiction will apply the strict or absolute liability standard of *Rylands v. Fletcher*."). Although the challenge of demonstrating damage would still apply, whether a strict liability standard could apply to migration of carbon dioxide (CO_2) outside a carbon capture and sequestration (CCS) storage reservoir is beyond the scope of this Article.

6. Anderson, *Subsurface "Trespass," supra* note 3, at 207.
7. *Id.* at 207, arguing for a restrained use of injunction ("In circumstances where a landowner or mineral owner suffers actual and substantial subsurface damages, courts should generally limit relief to money damages and deny injunctive relief or ejectment."); Kramer, *supra* note 5, at 302 (citing Gregg v. Delhi-Taylor Oil Corp., 344 S.W.2d 411 (Tex. 1961); Deli-Taylor Oil Corp. v. Holmes, 344 S.W.2d 411, 416 (Tex. 1961)).
8. Klass & Wilson, *supra* note 3, at 372 ("CCS is emerging as a potentially promising but potentially contentious technology that could enable the continued use of fossil fuels while still allowing society to dramatically reduce accompanying [greenhouse gas] emissions."); Int'l Energy Agency, Carbon Capture and Storage: Legal and Regulatory Review 4 (2014).
9. *Id.* at 381 ("[t]here is the real potential for CCS operations to interfere with actual or reasonably foreseeable uses of subsurface pore space and, consequently, subsurface property rights").
10. James Robert Zadick, *The Public Pore Space: Enabling Carbon Capture and Sequestration by Reconceptualizing Subsurface Property Rights*, 36 Wm. & Mary Envtl. L. & Pol'y Rev. 257, 260 (2011) (citing Nat'l Energy Tech. Lab., U.S. Dep't of Energy, 2010 Carbon Sequestration Atlas of the United States and Canada 23-33 (3d ed. 2010)).
11. U.S. Envtl. Prot. Agency, Technical Support Document, Vulnerability Evaluation Framework for Geologic Sequestration of Carbon Dioxide 53 (2008) (EPA430-R-08-009), *available at* https://www3.epa.gov/climatechange/Downloads/ghgemissions/VEF-Technical_Document_072408.pdf); Klass & Wilson, *supra* note 3, at 365.
12. Anderson, *Subsurface "Trespass," supra* note 3 at 206-07 ("[t]he most serious threat to efficient and utilitarian use of the subsurface is the possibility of injunctive relief or ejectment").
13. Zadick, *supra* note 10, at 267 (citing Jerry R. Fish & Thomas R. Wood, *Geologic Carbon Sequestration, Property Rights, and Regulation*, 54 Rocky Mtn. Min. L. Inst. 3-1, 3-19 (2008)) ("The sort of large-scale CCS needed to mitigate continued and increased reliance on fossil fuels cannot begin without a clear delineation of the legal property interests involved.").
14. David E. Pierce, *Carol Rose Comes to the Oil Patch: Modern Property Analysis Applied to Modern Reservoir Problems*, 19 Pa. St. Envtl. L. Rev. 241, 259-60 (2011). For a discussion of an adaptive approach to property interests in other contexts, see Arnold, *supra* note 1; Carol Rose, *Energy and Efficiency in the Realignment of Water Rights*, 19 J. Legal Stud. 261 (1990).
15. Pierce, *supra* note 14, at 244.
16. *Id.* (citing Carol M. Rose, *The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades, and Ecosystems*, 83 Minn. L. Rev. 129, 132 (1998)).
17. *Id.* at 254 (citing 1 W.L. Summers, The Law of Oil and Gas 180 (1954)). Rather than creating what Professor Summers describes as a "legal privilege as against other owners of land therein to take oil and gas therefrom"—permitting withdrawal without conversion, a legal privilege in the non-mineral pore space would grant other owners within the storage complex a privilege to fill through injection—permitting storage without trespass.
18. *Id.* at 245-46.

property owner in a common pool or source of supply has the opportunity to use his or her just and equitable share of that property.[19] Given the established legal framework of correlative rights in oil and gas, it provides a foundation on which laws governing the use of subsurface property for non-mineral purposes can be constructed. While of necessity this Article draws from cases and writings related to use of the pore space for mineral development, its primary focus is on trespasses resulting from non-mineral uses in non-hydrocarbon-bearing subsurface strata. Since courts have yet to adjudicate disputes resulting from migration of injected carbon dioxide (CO_2) for CCS purposes, the Article proceeds based on the assumption that the modern approach to subsurface trespasses would apply.

The Article begins with a brief explanation of the process of carbon capture and an introduction to the issues of transboundary migration of injected substances. Part II summarizes the property interests of surface owners in the non-mineral subsurface, focusing on state declarations of pore space ownership and the still-undefined issue of federal pore space ownership. Part III examines the extent to which owners of pore space interests have a protectable property interest, including an analysis of case law and academic literature relative to subsurface trespasses and the available remedies. This part argues that the hesitance of courts to find an actionable trespass in the absence of interference with the use and enjoyment of a prior established use conflates the requirements of trespass with those of nuisance, thereby forcing property owners to "capture" their property interests and treating rights in pore space as incorporeal. Part IV argues that the traditional correlative rights model used in oil and gas reservoirs offers a solution to the trespass problem in a manner that will encourage private ordering, preserve a protectable private-property interest in the pore space, and encourage investment in CCS projects.

I. CCS and the Problem of Trespass

Carbon capture[20] has been identified as a critical component to meeting internationally established goals related to climate change.[21] The greatest anthropogenic sources of CO_2 are electricity and transportation fuels.[22] Thus, together with other "climate wedges" such as biological storage and energy-efficiency improvements, decarbonizing these sources of emissions offers the potential of stabilizing atmospheric CO_2 concentrations at a level that could prevent the most catastrophic climate change.[23] While, like all carbon mitigation technologies, CCS alone is incapable of solely achieving climate stabilization, scalable implementation of CCS technology has considerable potential as one part of a comprehensive climate mitigation strategy.[24]

CCS refers to the process of capturing, compressing, transporting, and then injecting compressed CO_2 into underground geologic formations for storage.[25] Injection sites for storage projects are evaluated and identified based on integrity, containment, storage capacity, and injectivity estimates.[26] Once a candidate site is identified, the storage project is permitted, wells are drilled, and the injection phase begins.[27]

During the injection phase, captured CO_2 is injected into what is called the "storage complex" for containment.[28] The International Organization for Standardization (ISO) defines the "storage complex" in its draft standard as the "subsurface geological system extending vertically to comprise storage unit(s) and primary and secondary seal(s), and extending laterally to the defined limits of the CO_2 storage project."[29] The draft ISO definition then notes that limits of the complex "can be defined by natural geologic boundaries, regulation, or legal rights."[30]

Importantly, the definition itself contemplates that legal entitlements, including property rights and requirements established by the applicable regulatory authority, may limit the extent of the storage complex or determine storage boundaries and that injected substances may migrate both horizontally and vertically within that complex. Taken together, the amount of land necessary to fully contain a storage complex is immense, thus presenting a challenge to would-be injectors tasked with assembling property rights within the entire storage area.[31] As one practitioner in the field writes, "even a pilot scale project associated with a single 1,000 megawatt ('Mw') coal-fired power plant could require acquisition of subsurface storage rights over a radius of six miles."[32]

19. *Id.* at 254-59.
20. Carbon capture is also referred to as carbon sequestration, geologic storage, and/or carbon storage. While there are some differentiations between these definitions, they are not materially distinguishable with respect to the property issues addressed in this Article. Note that this Article does not address associated storage resulting from the use of CO_2 during enhanced oil recovery (CO_2-EOR) operations. Since associated storage during CO_2-EOR occurs as a result of the lawful use of the mineral owner, and any resultant drainage is considered protected by the rule of capture, subsurface trespass issues are not implicated to the same extent as with other forms of CCS. For a discussion of the negative rule of capture and associated storage, see Anderson, *Subsurface "Trespass," supra* note 3, at 230-36.
21. U.S. Dep't. of Energy, Carbon Capture, Utilization, and Storage: Climate Change, Economic Competitiveness, and Energy Security (2016), https://energy.gov/sites/prod/files/2016/09/f33/DOE%20-%20Carbon%20Capture%20Utilization%20and%20Storage_2016-09-07.pdf.
22. U.S. Envtl. Prot. Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014 (2016) (EPA 430-R-16-002), *available at* https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf.
23. Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Program for the Next 50 Years With Current Technologies*, Science, Aug. 13, 2004.
24. *Id.*
25. Klass & Wilson, *supra* note 3, at 373-77.
26. Int'l Org. for Standardization, *ISO/DIS 27914*: *Carbon Dioxide Capture, Transportation and Geologic Storage—Geologic Storage*, http://www.iso.org/iso/catalogue_detail.htm?csnumber=64148 (last visited Mar. 21, 2017).
27. *Id.*
28. *Id.*
29. *Id.*
30. *Id.*
31. Zadick, *supra* note 10, at 273 (citing R. Lee Gresham, Geologic CO_2 Sequestration and Subsurface Property Rights: A Legal and Economic Analysis iv (Dec. 1, 2010) (unpublished Ph.D. dissertation, Carnegie Mellon University), *available at* http://repository.cmu.edu/dissertations/8).
32. Delissa Hayano, *Guarding the Viability of Coal and Coal-Fired Power Plants: A Road Map for Wyoming's Cradle to Grave Regulation of CO_2 Sequestration*, 9 Wyo. L. Rev. 139, 141 (2009) (citing Steven L. Bryant, *Geologic CO_2*

Scholars have recognized the issue of transboundary migration and trespass as critical to the practical, legal, and economic viability of CCS projects.[33] The enormous scale of CCS projects, combined with the challenges of modeling precisely how a CO_2 plume is expected to behave once it is injected into the brine, create uncertainty in numerous areas of law.[34] These challenges led one scholar to declare that "the major barriers to CCS are legal, not technical, and involve issues of liability, storage field unitization, trespass, and takings."[35] In his article, Trae Gray echoes these concerns, warning would-be lessors of pore space that "the causes of action we will likely see from this type of activity are negligence, negligence per se, subsurface trespass, nuisance, and strict liability."[36]

Model and state rules for CCS operations likewise contemplate the possibility of migration within the storage complex and outside of unit boundaries. The Interstate Oil and Gas Compact Commission (IOGCC) has developed the Model Statute and Model Rules and Regulations for Carbon Storage.[37] The Model Rules acknowledge the possibility of migration, both within the storage complex and to surrounding formations or the surface.[38] To guard against any such migration, the Model Rules recommend that the operator address in its injection plan how "the mechanisms of confinement will 'prevent migration of CO_2 beyond the proposed storage reservoir.'"[39]

Wyoming's CCS law likewise contemplates the possibility that injected substances may migrate outside the "unit area" by providing that the unit can be modified upon application by an owner of pore space not included in the unit area.[40] However, the availability of an administrative remedy for inclusion in the unit by no means preempts the pursuit of other common-law tort remedies.[41] The grant of an administrative permit alone does not preclude claims for trespass.[42] Accordingly, as states rush to enact legislation to regulate and allocate property interests within the pore space, it is worth unpacking the issue of subsurface trespass resulting from transboundary migration within and beyond the storage complex.

II. Ownership in the Subsurface

This part examines rights of ownership in the subsurface, particularly the non-hydrocarbon reservoirs of pore space. It begins with a brief description of pore space and an overview of the background of academic literature, case law, and statutory declarations concerning its ownership and use. This part then explores whether the property interest in the pore space should be categorized as corporeal or incorporeal property.

A. *The Pore Space*

Imagine a split bone—despite the calcified and compact exterior, the inside is spongy, or cancellous; between the mesh-like sheets and spikes of bone are tiny cavities filled with marrow. Rocks have a similar sponginess, albeit on a microscopic level. Between the physical matter of the rock structure are tiny spots of interspersed vacuity known as pores, which together create the pore space of the rock.[43] Together, they comprise the iterative structure of a reservoir, within which may be contained any number of substances: freshwater (otherwise known as an aquifer), brackish water, air, or hydrocarbons.[44] These reservoirs also create the underground storage complexes necessary for CCS.[45]

Describing pore space in layperson's terms without delving into complex scientific details can be a challenge. Prof. Bruce Kramer refers to pore space simply as "the Rock."[46] Drawing from the Greek and Latin roots of the words "pore" and "porosity," *poros* and *porus*, both meaning passages, I find it helpful to describe pore space as the passages in the rock.[47] However, this definition too is limited. While

Storage—Can the Oil and Gas Industry Help Save the Planet?, 54 Rocky Mtn. Min. L. Inst. 2-1, 2-8 (2008)).

33. Zadick, *supra* note 10, at 269 (The potential liability related to subsurface trespass claims could render CCS economically infeasible.) (citing Anderson, *Subsurface "Trespass," supra* note 3, at 255, and Gresham, *supra* note 31).
34. Philip M. Marston & Patricia A. Moore, *From EOR to CCS: The Evolving Legal and Regulatory Framework for Carbon Capture and Storage*, 29 Energy L.J. 421, 439 (2008).
35. Zadick, *supra* note 10, at 267-68 (citing Will Reisinger et al., *Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage*, 11 Vt. J. Envtl. L. 1, 2-3 (2009)).
36. Trae Gray, *A 2015 Analysis and Update on U.S. Pore Space Law—The Necessity of Proceeding Cautiously With Respect to the "Stick" Known as Pore Space*, 1 Oil & Gas, Nat. Resources & Energy J. 227, 326 (2015) (citing Marston & Moore, *supra* note 34, at 490).
37. IOGCC, Interstate Oil & Gas Compact Commission Task Force on Carbon Capture & Geologic Storage: A Legal and Regulatory Guide for States & Provinces 15, 22 (2007).
38. *Id*. at 39-46.
39. Hayano, *supra* note 32, at 158 (quoting IOGCC, *supra* note 37, at 26).
40. Wyo. Stat. Ann. §35-11-313-316 (2011).
41. Kramer, *supra* note 5, at 315 (citing 8 Patrick H. Martin & Bruce M. Kramer, Williams & Meyers Oil & Gas Law §§22.04, 24.02[2][a] (2015); Pickrell Drilling Co. v. Kansas Corp. Comm'n, 654 P.2d 477 (Kan. 1982); Merritt v. Corporation Comm'n, 438 P.2d 495 (Okla. 1968); Preferred Energy Props. v. Wyoming State Bd. of Equalization, 890 P.2d 1110 (Wyo. 1995); and quoting FPL Farming Ltd. v. Environmental Processing Sys., L.C., 351 S.W.3d 306 (Tex. 2011)):
    > As a general rule, a permit granted by an agency does not act to immunize the permit holder from civil tort liability from private parties for actions arising out of the use of the permit . . . . Of course, statutory remedies may preempt common law actions or other standards that may set the bar for liability in tort, but a permit is not a get out of tort free card.
42. *Id*.; *see also* Gray, *supra* note 36 (describing Snyder Ranches, Inc. v. Oil Conservation Comm'n of N.M., 798 P.2d 587 (N.M. 1990) ("Mobil could be held liable for a subsurface trespass even though the injection was approved by the Oil Conservation Commission.").
43. *Pore (n.1(c))*, The Oxford English Dictionary Online (2017) ("A minute interstice between particles of matter esp. in soil or rock; a minute hole or channel in a surface, fabric, natural or artificial membrane.").
44. Richard C. Selley & Stephen A. Sonnenberg, Elements of Petroleum Geology 225 (3d ed. 2015); Sally M. Benson & David R. Cole, *CO_2 Sequestration in Deep Sedimentary Formations*, 4 Elements 325 (2008) (discussing the various physical and geochemical processes whereby CO_2 is sequestered); 8 Patrick H. Martin & Bruce M. Kramer, Williams & Meyers Manual of Oil and Gas Terms (2015) (definition of "Porosity of Rock") ("'The porosity of rock 'measures the capacity of the rock to hold oil, gas, and water' based on the 'relative volume of the pore spaces between mineral grains as compared to the total rock volume.'").
45. Zadick, *supra* note 10, at 267.
46. Kramer, *supra* note 5, at 294.
47. *Pore (n.1)*, The Oxford English Dictionary Online (2017). In her helpful comments to this Article, my colleague Danielle Cover at University

it may describe the pores themselves, it fails to convey the multifarious characteristics of the pores and rock in which they are situated that together determine the property that is necessary for CCS.

As part of efforts to clarify the ownership and use of the subsurface for both hydrocarbon and non-mineral purposes, state legislatures have statutorily defined "pore space."[48] Some states take a broad and technical approach to the definition. For example, Oklahoma, in its statutory definition of "land," defines "pore space" as "any interstitial space not occupied by soil or rock, within the solid materials of the earth, and any cavity, hold, hollow or void space within the solid material of the earth."[49] Similarly, North Dakota, in the context of CO_2 underground storage, defines "pore space" as any "cavity or void, whether natural or artificially created, in a subsurface sedimentary stratum."[50] These definitions are broad, encompassing any pore space that may exist at any strata and for any purpose. As such, the definitions of pore space in these states would apply to the pore space within hydrocarbon and non-hydrocarbon reservoirs alike.[51]

Other states' statutory definitions supplant the technical definition of pore space with an overlay qualifying pore space as something that must have a specific suitability of use in CCS. Wyoming, in its legislative declaration of ownership of the pore space, defines "pore space" as "subsurface space which can be used as storage space for carbon dioxide or other substances."[52] Similarly, Kentucky defines "pore space" as "the voids in the subsurface reservoir strata suitable to contain stored carbon dioxide."[53] In these states, rather than referring to the broader class of subsurface space that exists to some degree in all strata below the surface, the legal definition is more narrow: pore space is limited to that which can be used for CCS.[54] Accordingly, Wyoming and Kentucky exclude hydrocarbon-saturated pore space and the pore space of freshwater aquifers from their definitions. To the extent that both states have declared pore space as private property of the surface owner, that declaration is limited to pore space that can be used for carbon capture.[55]

B. Ownership of the Pore Space

Ownership of the pore space may be determined by statute, conveyancing language in a deed,[56] or the common law.[57] As a result, despite growing consensus in state approaches, there is no hard-and-fast rule of pore space ownership.[58] In states where the legislature has not made its intent clear, determination of pore space ownership requires an investigation into the case law and the facts and circumstances surrounding the specific parcel conveyed.[59] Many of these cases turn on whether the property considered is owned in fee simple; whether the minerals have been leased or separately conveyed; the purpose for which the pore space will be used; and whether the stratum considered is mineral-bearing or non-mineral, or is a depleted stratum where hydrocarbons were previously produced.[60] As a result of these nuances, in several states, the ownership of the pore space underlying a particular parcel may be unclear.[61]

The majority of courts that have ruled on the issue have concluded that pore space is included in the surface estate.[62] Consistent with the proposition that ownership of property extends from the sky to the center of the earth, it follows that the owner of a fee simple inter-

of Wyoming described pore space as the "spaces in the rocks." However, it is important to note that a rock's porosity is separate from its permeability—which measures how well gasses or fluids move through rocks. The two are separate geologic concepts and the potential utility of a subsurface formation depends on both porosity and permeability.

48. Even in states where pore space has not been specifically defined, there are frequently references to pore spaces within statutes, including those addressing groundwater, brownfield redevelopment, dry cleaners, and hydraulic fracturing. *See*, *e.g.*, 225 Ill. Comp. Stat. Ann. 732/1-5 (2013) and 415 Ill. Comp. Stat. Ann. 135/5 (1997) (defining groundwater as water below the land surface that is within the saturated zone or geologic materials where the fluid pressure in the pore space is equal to or greater than atmospheric pressure); N.Y. Envtl. Conserv. Law §27-1405 (2014) (defining residual contamination as "contamination remaining . . . in surface or subsurface soil, geologic matrix pore spaces or fractures"); Mich. Comp. Laws Ann. §324.31701 (1994) (defining groundwater as "water in the zone of saturation that fills all of the pore spaces of the subsurface geologic material").
49. Okla. Stat. Ann. tit. 60, §60-6 (2014).
50. N.D. Cent. Code Ann. §38-22-02 (2015).
51. The pore space would not include the hydrocarbons within those pores, which are subject to removal by the mineral owner.
52. Wyo. Stat. §34-1-152(d) (2011).
53. Ky. Rev. Stat. Ann. §353.800(7) (West 2011).
54. *Id.*; Wyo. Stat. §34-1-152(d) (2011).
55. Because the definition of "pore space" in the Kentucky and Wyoming statutes is limited to pore space that is suitable for storage of CO_2 or other substances, it raises the question of who owns the remainder of the subsurface, including the pore space, in strata that are unsuitable for storage. An additional complication is that pore space that is suitable for CO_2 storage could have residual hydrocarbon saturations.
56. Emeny v. United States, 412 F.2d 1312, 1323 (Ct. Cl. 1969); Burlington Res. Oil & Gas Co., LP v. Land & Sons Inc., 259 P.3d 766 (Mont. 2011); Department of Transp. v. Goike, 560 N.W.2d 365 (Mich. Ct. App. 1996); Tate v. United Fuel Gas Co., 71 S.E.2d 65 (W. Va. 1952).
57. For an overview of cases addressing pore space ownership, see Kramer, *supra* note 5; Anderson, *Geologic CO_2*, *supra* note 3; Zadick, *supra* note 10; Gray, *supra* note 36.
58. Zadick, *supra* note 10, at 281:
> [T]he common law has inconsistently dealt with both whether the surface owner retains ownership of the pore spaces when the mineral estate has been severed (revealing whether they are an intrinsic part of the surface estate), and whether the surface owner possesses a right to excludability when the alleged pore space trespass has produced no real harm.

Reisinger et al., *supra* note 35, at 2-3 (noting that the cases that have dealt with subsurface storage "illustrate the lack of a consistent national view of pore space ownership . . . [v]arious courts . . . have awarded gas storage rights to surface and mineral holders alike").
59. For a comprehensive and up-to-date summary of these cases, see Gray, *supra* note 36, at 281-323. Even where states have made a declaration of pore space ownership, an investigation of title would still be necessary to determine whether there existed any limitations in the chain of title or whether any specific severance of pore space had been made.
60. Kramer, *supra* note 5, at 295-96.
61. *Id.* at 296 ("there is no simple answer to the question of who owns the pore space of the 'rock' after severance").
62. Jean Feriancek, *Resolving Ownership of Pore Space*, 26 Nat. Resources & Env't 49 (2012) ("Ownership of pore space by the surface owner is considered the majority view in the United States."); Christopher J. Miller, *Carbon Capture and Sequestration in Texas: Navigating the Legal Challenges Related to Pore Space Ownership*, 6 Tex. J. Oil, Gas & Energy L. 399, 401 (2010-2011); Blayne N. Grave, *Carbon Capture and Storage in South Dakota: The Need for a Clear Designation of Pore Space Ownership*, 55 S.D. L. Rev. 72, 73 (2010).

est in property owns all that is above and below his or her property, including the airspace and all subsurface strata, pore space, and the minerals contained therein.[63] Following severance of the minerals, the surface owner retains all that was not conveyed.[64] As the U.S. Court of Appeals for the Fifth Circuit determined, "it unbearably strains credulity to suggest that a surface estate, conveyed in a deed describing the land in horizontal terms, only touches a millimeter of the surface, and excludes all other land below the surface."[65]

The determination of whether or not pore space rights have been conveyed or reserved depends on the nature of the conveyance.[66] For example, an oil and gas lease conveys rights to explore for and produce hydrocarbons and certain rights incident to such exploration and production.[67] It does not convey "any right to use the premises for any purpose other than the specified mineral exploration and production."[68] Thus, not having been conveyed, the surface owner retains the "geological structures beneath the surface, including any such structure that might be suitable for the underground storage of 'foreign' or 'extraneous' gas produced elsewhere."[69]

In a conveyance or reservation by deed, the majority of cases seem to reach a similar conclusion. In *Springer Ranch v. Jones*, a Texas court found that a conveyance of the minerals did not convey "ownership of the earth surrounding those substances."[70] The decision relied in part on *Fleming Foundation v. Texaco, Inc.*, in which the Texas Court of Appeals found that "a conveyance of the surface only in a tract of land with a reservation of the minerals vests in the grantee such rights to the use thereof as are usually exercised by owners in fee subject only to the right of the grantor to remove the minerals reserved."[71] The Fifth Circuit summarized that "Texas law establishes that the holder of a mineral estate has the right to exploit minerals, but does not own the subsurface mass."[72]

Similarly, in Montana, a court found that a reservation of minerals did not include "the pore space or other non-mineral materials" and that the "[t]he pore space beneath [the surface owner's] property belongs to [his] surface estate in the same manner that all the non-mineral material beneath the physical boundaries of [the surface owner's] property belongs to [his] surface estate."[73] These cases, while stopping short of an absolute declaration for all purposes, strongly favor surface ownership of pore space to the extent that such ownership does not conflict with or upend well-established principles of mineral estate dominance. Similarly, cases in "Oklahoma, Louisiana, New York, Michigan, West Virginia, New Mexico, and California all recognize the surface owner's ownership of underground pore space for gas storage operations,"[74] and thus would likely similarly find that the surface owner would own pore space useful to operations for CCS.

A small minority of cases, almost entirely related to gas storage, indicates a possibility that a split-estate mineral owner could own the pore space.[75] These cases follow a narrow line of reasoning that considers pore space and minerals as inalienable and that stems in part from the fact that in these cases the storage resources sought were "mineral-bearing."[76] One case often cited for adoption of this reasoning is *Central Kentucky Natural Gas Co. v. Smallwood*.[77] In that case, the court found that a surface landowner was not entitled to compensation from the mineral owner for non-native gas stored beneath her lands. This case is often cited as standing for the adoption of the English Rule of pore space ownership and as an exception to the majority rule of vesting pore space ownership with the owner(s) of the surface. However, Kentucky has since legislatively declared that pore space suitable for carbon storage is owned by the surface owner and, accordingly, at least with respect to its holdings related to non-mineral pore space, *Smallwood* may no longer be good law.[78]

Despite declarations of its demise,[79] vestiges of the minority view still exist. For example, in *City of Kenai v. Cook Inlet Natural Gas Storage Alaska, LLC*, an Alaska court found in 2016 that the state of Alaska, through a mineral reservation, had retained the rights to use the economically depleted reservoir for gas storage.[80] The court in *City of Kenai* relied on a number of factors in reaching its decision

63. Owen L. Anderson, *Lord Coke, The Restatement and Modern Subsurface Trespass Law*, 6 Tex. J. Oil, Gas & Energy L. 203, 210 (2010) [hereinafter *Lord Coke*]; Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 11 (Tex. 2008); Del Monte Min. & Milling Co. v. Last Change Min. & Milling Co., 171 U.S. 55, 65-67 (1898).
64. Anderson, *Geologic CO_2*, *supra* note 3, at 99-100 (citing Duhig v. Peavy-Moore Lumber Co., 144 S.W.2d 878, 880 (Tex. 1940)); Cabrita Point Dev., Inc. v. Evans, Nos. 2006-103, 2006-109, 2009 WL 3245202 (D.V.I. Sept. 30, 2009) (citing 14 Powell on Real Property §81.02 (Michael Allan Wolf ed. 2000) ("It is beyond peradventure that a parcel owned, and not conveyed, is retained by the owner.").
65. Dunn McCampbell Royalty Interest, Inc. v. National Park Serv., 630 F.3d 431, 442, 41 ELR 20063 (5th Cir. 2011).
66. Kramer, *supra* note 5, at 296-97.
67. Key Operating & Equip., Inc. v. Hegar, 435 S.W.3d 794, 44 ELR 20134 (Tex. 2014); Kartch v. EOG Res., Inc., 845 F. Supp. 2d 995 (D.N.D. 2012).
68. Emeny v. United States, 412 F.2d 1319 (Ct. Cl. 1969).
69. *Id.*
70. 421 S.W.3d 273 (Tex. Ct. App. 2013) (citing *Emeny*, 412 F.2d at 284).
71. 337 S.W.2d 846, 851 (Tex. Ct. App. 1960).
72. Dunn McCampbell Royalty Interest, Inc. v. National Park Serv., 630 F.3d 431, 442, 41 ELR 20063 (5th Cir. 2011).
73. Burlington Res. Oil & Gas Co., LP v. Lang & Sons Inc., 259 P.3d 766, 770 (Mont. 2011).
74. Stefanie L. Burt, *Who Owns the Right to Store Gas: A Survey of Pore Space Ownership in U.S. Jurisdictions*, 4 Joule, http://www.duqlawblogs.org/joule/wp-content/uploads/2016/07/Who-Owns-the-Right-to-Store-Gas-A-Survey-of-Pore-Space-Ownership-in-U.S.-Jurisdictions-.pdf.
75. Anderson, *Geologic CO_2*, *supra* note 3, at 103; Kramer, *supra* note 5, at 299.
76. Anderson, *Geologic CO_2*, *supra* note 3, at 103 (citing Mapco, Inc. v. Carter, 808 S.W.2d 262 (Tex. Ct. App. 1991), *rev'd on other grounds*, 817 S.W.2d 686 (Tex. 1991)).
77. 252 S.W.2d 866, *overruled on other grounds by* Texas Am. Energy Corp. v. Citizens Fid. Bank & Trust Co., 736 S.W.2d 25 (Ky. 1987).
78. *Id.*
79. Barry Barton, *The Common Law of Subsurface Activity: General Principle and Current Problems*, *in* The Law of Energy Underground 21 (Donald N. Zillman et al. ed., Int'l Bar Ass'n 2014) ("Pore space is generally owned and possessed by the landowner not the mineral owner . . . . There is no English Rule to the Contrary.").
80. 373 P.3d 473 (Alaska 2016). The court in *City of Kenai* relied extensively on scholarship suggesting that pore space rights may be included in sovereign reservations of the minerals. *See*, *e.g.*, Kevin L. Doran & Angela M. Ciphor,

that the state's mineral reservation encompassed the pore space, including the state's right to dispose of the surface, the language in the city's patent, prior conveyances of the "subsurface estate" pursuant to the Alaska Lands Act, and existing reservations by the state in oil and gas leases that reserved to the state as mineral owner the right to authorize storage of gas.[81] While the precise facts that contributed to the court's determination in *City of Kenai* are unlikely to apply broadly to interpretation of other deeds, the case indicates the highly nuanced and specific analysis required to ascertain pore space ownership and serves as a reminder that a specific inquiry into the title and ownership of the pore space in split estates is necessary even where the law on the matter appears settled.

Increasingly, ownership of pore space is defined by statute. In 2008 and 2009, in acknowledgement of the potential value of the non-mineral pore space and in anticipation of federal laws creating a demand for CCS projects, states rushed to statutorily clarify ownership of the pore space.[82] Accordingly, in Kentucky, North Dakota, Oklahoma, and Wyoming, ownership of the pore space that has not previously been separately conveyed has been statutorily granted to the surface owner.[83] While these declarations have yet to be challenged, Prof. Owen Anderson has suggested that, until there is some case law to the contrary, it is "likely that at least with respect to private and state lands the courts will respect the legislature's designation."[84]

Interestingly, Kentucky's declaration does not necessarily conflict with *Central Kentucky Natural Gas Co*. This creates the possibility of a tiered ownership of pore space in Kentucky, in which mineral owners are considered to own pore space that is used for purposes necessarily incident to the mineral interest, such as gas storage in a depleted reservoir, and in which surface owners are found to own those spaces that are "suitable for stored carbon dioxide."[85] One challenge of this approach is that in many cases, it may not be decisively clear whether a specific stratum is or is not mineral-bearing and, thus, which approach to ownership should apply. Examples of this are strata that contain minerals (hydrocarbon or otherwise) that are not presently economically producible at current prices or with available technologies, or depleted gas reservoirs with stranded minerals that may in the future become economic via the advent of new techniques. In these scenarios, the surface owner may have a property interest in the mineral-bearing pore space, but could be limited in any use of such pore space to uses that did not damage or otherwise interfere with the dominant mineral interest.[86] Further, while no court has addressed the issue, it is possible to presume that, were a reservoir suitable for both natural gas and CO_2 storage, the historical doctrine of mineral estate dominance would apply.[87]

These statutory declarations are not necessarily dispositive with respect to federally reserved minerals or tribal property within state borders.[88] The federal government owns approximately 640 million acres of surface and approximately 700 million acres of mineral rights, at least 58 million of which underlie nonfederal private surface land.[89] The majority of these lands are either acquired lands or lands in which mineral rights were reserved as part of the grant of land patents under the disposal laws of the early 20th century.[90] Thus far, no case has sought to determine the federal government's ownership of pore space on split-estate parcels where it owns solely a surface or mineral interest.[91] Such a determination will likely depend on whether pore space can be classified as a "mineral" that was reserved, like coal or oil and gas, in the early land disposition laws.[92]

There is not a closed set of substances that constitute a "mineral" under these land disposition acts, and thus a precise definition of "mineral" in those acts has never been clear.[93] It is unlikely that cases focusing principally on a mineral's chemical composition or the ordinary common meaning of the term "mineral" would classify pore space as mineral.[94] However, dicta from a number of cases interpreting mineral reservations under early land disposal statutes leave open the possibility that a court could find the federal government as owning the pore space as a split-estate mineral owner.[95]

Does the Federal Government Own the Pore Space Under Private Lands in the West, 42 Envtl. L. 527 (2012).

81. *Id.*
82. Zadick, *supra* note 10, at 259; Arnold W. Reitze Jr., *Electric Power in a Carbon Constrained World*, 34 Wm. & Mary Envtl. L. & Pol'y Rev. 821, 852-53 (2010).
83. Wyo. Stat. Ann. §34-1-152 (2011); Ky. Rev. Stat. Ann. §353.800 (West 2011); N.D. Cent. Code §47-31-03 (West 2011); Okla. Stat. Ann. tit. 60, §60-6(B)(2) (2011).
84. Anderson, *Geologic* CO_2, *supra* note 3, at 137.
85. Ky. Rev. Stat. §353.800 (West 2011).
86. The extent of a surface owner's rights in the subsurface—and the mineral owner or lessees right to exclude others from the subsurface—is presently being considered by the Texas Supreme Court. In *Lightning Oil Co. v. Anadarko E&P Onshore LLC*, 480 S.W.3d 628 (Tx. App. 2015), the U.S. Court of Appeals for the Fourth Circuit held that the mineral lessee could not exclude others from the subsurface earth and that surface owner could grant an adjacent lessee the right to locate a well on the surface and drill through the subsurface to reach the adjoining mineral estate where such use would not tortuously interfere with the underlying mineral lease. Kentucky has previously affirmed the dominance of the mineral estate in *Akers v. Baldwin*, 736 S.W.2d 294 (Ky. 1987) (citing McIntire v. Marion Coal Co., 190 Ky. 342, 227 S.W. 298 (1921)).
87. For a discussion of how the dominant-servient estate doctrine may impede development of "new, fledgling energy sources," see K.K. Duvivier, *Sins of the Father*, 1 Tex. A & M J. Real Prop. 301 (2014).
88. *See* Gray, *supra* note 36, at 319 (citing Anderson, *Geologic* CO_2, *supra* note 3, at 136-38).
89. *See* U.S. Bureau of Land Mgmt., Public Land Statistics 2015 tbl.1-3, at 7 (2016), *available at* https://www.blm.gov/public_land_statistics/pls15/pls2015.pdf.
90. *Id.*
91. While many cases have assessed the extent of federal ownership and dominion over split-estate minerals, few have looked at places where the federal interest is limited to the surface estate under which lie privately owned reserved minerals. One such case, *Minard Run Oil Co. v. U.S. Forest Serv.*, 670 F.3d 236, 41 ELR 20294 (3d Cir. 2011), indicates that where the federal government owns only the surface, state laws on pore space ownership may control. *See* Jonathan Thorpe, Minard Run Oil Co. v. United States Forest Service, 36 Harv. Envtl. L. Rev. 567 (2012).
92. Doran & Ciphor, *supra* note 80.
93. Western Nuclear, Inc. v. Andrus, 475 F. Supp. 654 (D. Wyo. 1979).
94. Amoco Prod. Co. v. Southern Ute Indian Tribe, 526 U.S. 865 (1999).
95. Doran & Ciphor, *supra* note 80 (citing Watt v. Western Nuclear, Inc., 462 U.S. 36, 13 ELR 20849 (1983); *Western Nuclear, Inc.*, 475 F. Supp. 654).

In *Watt v. Western Nuclear, Inc*., the U.S. Supreme Court emphasized that land grants should be construed to favor the government and prohibit the passage of rights by implication.[96] The Court in that case found that gravel could be a mineral due to its distinguishability from the surface and value apart from the soil, despite the fact that at the time of the Stock Raising Homestead Act, the term "mineral" would not have been commonly thought to include gravel.[97] In what might be regarded as a particularly prescient dissent, Justice Lewis Powell wrote that the majority opinion of *Watt* "could leave Western homesteaders with the dubious assurance that only the dirt itself could not be claimed by the Government."[98] Although state declarations and controlling authority within the state may inform the question, until courts definitively address whether mineral reservations include pore space, questions as to pore space ownership will remain.

Approximately 93% of federal land, and almost all split estate land, is concentrated in the West.[99] Proportions of federal ownership vary from state to state, ranging from nearly 35% in Arizona to more than 84% federal ownership in Nevada.[100] Due to the large amount of land needed for CCS projects, any project in the West is likely to involve at least some public land.[101] In addition to the uncertainty with respect to pore space ownership under federal split-estate public land, several other legal issues exist regarding development of scalable projects on federal land. These include the lack of a federal leasing program, questions related to federal authority to lease pore space for CCS under existing laws, and the applicability of the National Environmental Policy Act to projects without surface injection facilities on public land. Together, these questions create a considerable obstacle to the development of scalable CCS projects that include federal land.

C. The Vertical Extent of Pore Space Ownership

Resolving the question of ownership alone is insufficient; there is also the question of depth.[102] As has become clear, ownership is not necessarily infinite: there also exists a question as to the vertical extent of private property.[103] Lord Coke is often attributed the maxim that the owner of land owns from the sky to the center of the earth.[104] Yet, the resistance to an absolute application of *ad coleum* in subsurface property has been apparent since as early as 1929.[105] The Supreme Court in *United States v. Causby* perhaps dealt the concept of absolutist property ownership a fatal blow.[106] Finding that the strong public interest in air travel prohibited the finding of a taking resulting from suprasurface intrusions to property by air traffic, the Court wrote that the "common law doctrine that ownership of land extends to the periphery of the universe . . . has no place in the modern world."[107]

It seems self-evident today that absolute ownership in the deepest reaches of the subsurface is, at least in a way that contemplates an absolute right of exclusion, as clearly an impossibility as is absolute ownership of the upper stratosphere.[108] Prof. John Sprankling has posited absolute ownership must have a terminus, below which everything would be public, and that infinite ownership is "mere poetic hyperbole, not law."[109] The English Court of Appeal adopted this approach, finding that "there is no good reason why a court today should apply a discredited 13th century maxim so as [to] give the claimants [ ] title to substrata so far beneath the surface that they have no conceivable use for them."[110] That court, however, eventually held that the 2,800-foot-deep pore space in question was "not so deep that the physical features such as temperature and pressure would render the concept of the subsurface belonging to anyone absurd."[111]

While it is reasonable to assume that there are some limits to the depths (or heights) of private ownership, each of us would likely reach a different conclusion as to where that would be: whereas one group might suggest that ownership extends to all usable zones of the subsurface, and thus that ownership and possession should extend as technology makes possession in deeper subsurface strata possible, others would suggest that the justifications of private dominion become more diffuse as you move

96. *Watt*, 462 U.S. 36.
97. *Id*.
98. *Id*. (Powell, J., dissenting).
99. Carol Hardy Vincent et al., Congressional Research Service, Federal Land Ownership: Overview and Data (2014), *available at* https://fas.org/sgp/crs/misc/R42346.pdf.
100. *Id*.
101. Christopher Galik et al., Duke University Nicholas Institute, The Role of Public Lands in a Low Carbon Economy (2010) ("Federal lands contain between 127 and 374 $GtCO_2$ storage capacity, a small portion of the total resource but significant in its own right") (citing Nat'l Energy Tech. Lab., U.S. Dep't of Energy, Storage of Captured Carbon Dioxide Beneath Federal Lands (2009) (DOE/NETL-2009/1358)), *available at* https://nicholasinstitute.duke.edu/sites/default/files/publications/the-role-of-public-lands-in-a-low-carbon-economy-paper.pdf.
102. Jules Verne, Journey to the Center of the Earth 119 (2014), ("Wherever he saw a hole he always wanted to know the depth of it. To him this was important.").
103. John G. Sprankling, *Owning the Center of the Earth*, 55 U.C.L.A. L. Rev. 979 (2008); Patrick Wieland, *Going Beyond Panaceas: Escaping Mining Conflicts in Resource-Rich Countries Through Middle-Ground Policies*, 20 N.Y.U. Envtl. L.J. 199 (2013); Stuart S. Ball, *The Vertical Extent of Ownership in Land*, 76 U. Pa. L. Rev. 631 (1928).
104. Anderson, *Lord Coke*, *supra* note 63.
105. Edwards v. Sims, 24 S.W.2d 619, 622 (Ky. 1929) (Logan, J., dissenting):
> The age-old statement, adhered to in the majority opinion as the law, in truth and fact, is not true now and never has been. I can subscribe to no doctrine which makes the owner of the surface also the owner of the atmosphere filling illimitable space. Neither can I subscribe to the doctrine that he who owns the surface is also the owner of the vacant spaces in the bowels of the earth.

106. 328 U.S. 256, 260-66 (1946).
107. *Id*.
108. Anderson, *Subsurface "Trespass," supra* note 3, at 211. The deepest well drilled to date, extending 40,230 feet, is the Kola Superdeep Borehole, drilled in the Soviet Union in the 1970s. For an explanation of interspatial property, see, e.g., Matthew Feinman, *Mining the Final Frontier: Keeping Earth's Asteroid Mining Ventures From Becoming the Next Gold Rush*, 14 U. Pitt. J. Tech. L. & Pol'y 202 (2014); Benoit Ildefonse et al., *Mission Moho Workshop: Drilling Through the Oceanic Crust to the Mantle*, 4 Sci. Drilling 11-18 (2007).
109. Sprankling, *supra* note 103, at 981.
110. Bocardo SA v. Star Energy UK Onshore Ltd., 3 W.L.R. 354 (2010).
111. *Id*.

deeper toward the center of the earth.[112] Deep subsurface use of property challenges conceptions of ownership in that it makes clear the difficulty of excluding others or of establishing possession in the way that traditionally gives rise to claims of ownership.[113]

Thus, even in states where ownership of pore space has been established, open questions remain as to the vertical extent to which an owner has an exclusive possessory interest in all the rock, pore, and fluid under the property. Acknowledgement of these limitations suggests that it may be appropriate to frame interests in deep subsurface property suitable for CCS in a manner that reflects the realities inherent in possession of pore space for that use.

D. The Nature of the Property Interest in the Pore Space: Corporeal or Incorporeal?

Property interests in the non-hydrocarbon pore space have yet to be classified as either corporeal or incorporeal. Ownership of oil and gas is classified as either corporeal or incorporeal, also called possessory and nonpossessory.[114] Possessory interests "give the holder the privileges and rights of possession of the land, and are all present estates, whether of the freehold or the non-freehold class."[115] In contrast, incorporeal interests are inherently nonpossessory, "like reversions and remainders, which may develop into possessory interests" and interests such as easements or licenses, "which do not give the holder possession of the land."[116] Some property lends itself toward possessory ownership—most real property falls into this category: the holder can use it, exclude others from it, and charge economic rents for its use.[117] However, some potential property, such as wildlife, seems to elude possession, at least until such point that it has been captured, and still other "objects of property," like ideas, are so disembodied that they "seem inherently incapable of clear demarcation."[118]

Historically, courts have struggled with the differentiation between the pore space and the oil and gas existing within it, and whether each is corporeal or incorporeal property.[119] State approaches differ, often with overlapping classifications.[120] For example, just as early courts struggled to classify ownership of whales and foxes,[121] they found it similarly impossible to grant ownership in place to fugacious minerals that were subject to flight and could not be properly classified as owned until they were reduced to possession.[122] As a result, many early courts classified the ownership interest in oil and gas as incorporeal, and likewise the oil and gas lease as creating an incorporeal hereditament or a profit-à-prendre.[123] While states such as Colorado and Texas adopt a possessory view of oil and gas in place, others, such as Kansas and Oklahoma, maintain that there is no possessory right to oil and gas in place.[124]

While theories of ownership of oil and gas within pore space may provide some insights into whether pore space itself is considered corporeal or incorporeal property, the interests are decidedly different. Oil and gas moves through the reservoir and therefore cannot be fully and adequately quantified until it has been reduced to absolute possession at the surface of the land. Pore space, on the other hand, is immobile: it can be filled, emptied and refilled, pressurized or depressurized, and fractured to increase permeability, but it fundamentally cannot be moved from one location to another. As such, it is decidedly more corporeal than fluid minerals.

However, there are some analogs between pore space and more incorporeal forms of property. As Kevin Doran and Angela Ciphor write, "[p]ore [s]pace is the conceptual embodiment of nothing . . . outside of that generative structure [that creates it], it does not exist."[125] While pore space cannot exist separate from the rock that creates it, it is itself defined not by what it is, but by what it can or does contain.[126] Owners of pore space may develop their interest into a stronger possessory claim based on their use, and yet at any time prior to that use, they are also subject to dispossession by virtue of their neighbors' use.[127] Therefore, while the tangible bulk of the property cannot be ignored, the present system for allocating property interests in pore space is incorporeal chiefly in that while pore space may physically exist in a clearly embodied form at all times, it is still subject to capture.[128]

112. *Id.* at 2 (the depth of the surface at which minerals could be worked was not so deep that physical features such as temperature and pressure would render the concept of the subsurface belonging to anybody absurd); Sprankling, *supra* note 103, at 1034-38 (Sprankling suggests that private ownership of the non-hydrocarbon subsurface should terminate at 1,000 feet below the surface, thus freeing certain high-public-benefit technologies such as CCS and heat mining from the constraints of private ordering.).
113. Carol Rose, *Possession as the Origin of Property*, 52 U. Chi. L. Rev. 73, 75 (1985).
114. Nancy Saint-Paul, Summers Oil and Gas §8.9 (3d ed. 2015).
115. *Id.*
116. *Id.*
117. Rose, *supra* note 113.
118. *Id.* at 83.
119. Grey-Mellon v. Fairchild, 292 S.W. 743, 745 (Ky. 1927) ("While the oil is fugitive, the sand-bearing oil is as stationary as a bank of coal.").
120. Saint-Paul, *supra* note 114.
121. Pierson v. Post, 3 Cai. R. 175 (N.Y. Sup. Ct. 1805); Swift v. Gifford, 23 F. Cas. 558 (D. Mass. 1872) (No. 13696).
122. Rose, *supra* note 113, at 83; *see*, *e.g.*, Jones v. Forest Oil Co., 194 Pa. 379, 44 A. 1074 (Pa. 1899); Kelly v. Ohio Oil Co., 39 W.L.B. 54 (Ohio 1897); Kolachny v. Galbreath, 110 P. 902 (Okla. 1910).
123. Martin & Kramer, *supra* note 44 (definition of "Corporeal property") ("The differences in the classification of the severed interest as corporeal or incorporeal may have important legal consequences with regards to the following (1) abandonment; (2) remedies, such as ejectment and partition . . . ; and (5) adverse possession.").
124. Joan Burk, Petroleum Lands and Leasing 22 (1983).
125. Doran & Ciphor, *supra* note 80, at 527.
126. See discussion *supra* notes 47-51. This distinction has vexed courts seeking to distinguish the ownership of the fluids within the rock from the physical structure within which they were contained. *See* Gray-Mellon Oil Co. v. Fairchild, 292 S.W. 743, 746 (Ky. Ct. App. 1927) ("The oil-bearing sands are a part of the land. The conveyance of the exclusive right to use these sands for the only purpose for which they can be used is necessarily a grant of an interest in the land.").
127. Vesting ownership based on first-in-time use creates what Professor Sprankling has referred to as "First-in-Time Exploitative Use." *See* Sprankling, *supra* note 103, at 1035 (citing John G. Sprankling, *An Environmental Critique of Adverse Possession*, 79 Cornell L. Rev. 816, 856 (1994)).
128. Sprankling, *supra* note 103, at 1035:
> The logic of this model suggests that the surface owner holds no subsurface rights until and unless she undertakes some economi-

The resulting picture is that ownership of pore space is a much more nuanced and intermingled concept of property than traditional hierarchical metaphors of property suggest.[129] There is no clear "bundle of sticks" in the pore space with easily severable incidents of property that can be distributed among surface and mineral owners.[130] The pore space may be owned by the surface owner, but to the extent that it is "hydrocarbon saturated pore space," it is subject to the dominant rights of the mineral owner.[131] These rights include rights of entry, possession, use, and even destruction, as well as the right to dispose of wastewater or to inject water or CO_2 for enhanced oil recovery purposes.[132] Similarly, even non-hydrocarbon pore space may be subject to use by the mineral owner through exercise of its implied easement to use the surface for purposes including wastewater disposal.[133]

Hydrocarbon pore space, once subject to entry by the mineral owner, may revert to the exclusive dominion of the surface owner once the hydrocarbon resource is depleted, and then be subject to reentry again as technology develops or commodity prices change in a manner that makes mineral use practicable again.[134] And a surface owner, making use of the pore space for non-mineral purposes such as disposal or CCS, may be limited in such use if it unreasonably interferes with mineral operations. The result is a hybrid ownership that seems both corporeal in its limited rights of use and exclusion and yet incorporeal in its ambiguous vertical extent and vulnerability to capture. The eventual classification of pore space as either corporeal or incorporeal property may prove dispositive as to the remedies available to owners for subsurface intrusions.

III. The Inadequacy of Remedies for Subsurface Trespass

The traditional remedies for trespass are injunctive relief,[135] ejectment,[136] restitution,[137] and damages.[138] In addition to recovery for unlawful use of property and any damage caused thereby, an owner of property may also have the right to prevent repeated intrusions and to force removal of material unlawfully placed upon the property.[139] In fact, a prudent landowner has an obligation to do exactly that: a persistent failure to remove a trespasser using property as his or her own can result in vesting in the trespasser title by adverse possession.[140] However, a survey of cases regarding subsurface trespasses resulting from transboundary migration of fluids reveals a hesitance by courts to enjoin further trespasses or to award damages solely on the basis of an injury to possession. Instead, in the majority of cases, remedies are limited to recovery for physical damage to the property or unreasonable interference with that property's existing or foreseeable use.

Subsurface intrusions routinely occur in the context of oil and gas development and production and wastewater disposal.[141] These intrusions take a variety of forms, including a process called "nudging," whereby the heel of a well deviates under an unleased parcel of land in order to enter

cally viable subsurface use. Before that point, she holds merely a potential, inchoate interest in the subsurface, just as one holding a hunting license does not yet own any wild game.

129. Springer Ranch, Ltd. v. Jones, 421 S.W.3d 273, 284 (Tex. Ct. App. 2013) ("We note that the physical structures and subsurface substances that the surface estate and mineral estate owners possess are inherently intertwined, at least with respect to hydrocarbons.").

130. *See* Gray, *supra* note 36. Although it is beyond the scope of this Article, there are also pore space uses related to groundwater and freshwater aquifers.

131. *See* Martin & Kramer, *supra* note 44 (definition of "hydrocarbon saturated pore space"); *see* Yates v. Gulf Oil Corp., 182 F.2d 286, 289 (5th Cir. 1950) ("the grant or reservation of minerals carries with it, as a necessary appurtenance thereto, the right to use so much of the surface as may be necessary to enforce and enjoy the mineral estate conveyed or reserved" (quoting Harris v. Currie, 176 S.W.2d 302, 305 (Tex. 1943))); 4 Nancy Saint-Paul, Summers Oil & Gas §40:4 (3d ed. 2014).

132. Ian J. Duncan, *CO_2-EOR 101: An Overview of CO_2 Enhanced Oil Recovery*, *in* Enhanced Oil Recovery: Legal Framework for Sustainable Management of Mature Oil Fields 1-2 (Rocky Mountain Mineral Law Found. 2015); Feland v. Placid Oil Co., 171 N.W.2d 829 (N.D. 1969); Fischer v. Continental Res., Inc., 49 F. Supp. 3d 637, 646 (D.N.D. 2014).

133. Federal unitization may extend the mineral developer's right to dispose of wastewater into the subsurface pore space to the subsurface underlying any leases within the unit. *See* Tara K. Righetti, *Surface Access to Severed Federal Minerals*, 61 Rocky Mt. Min. L. Inst. 8-1 (2015) (discussing Entek GRB, LLC v. Stull Ranches, LLC, 763 F.3d 1252, 44 ELR 20189 (10th Cir. 2014), *cert. denied*, 135 S. Ct. 1895 (2015)).

134. Wendy B. Jacobs, *Carbon Capture and Sequestration*, *in* Global Climate Change and U.S. Law 581 (Michael Gerrard & Jody Freeman eds., 2d ed. 2014) ("it will be no simple logistical matter to determine when precisely the pore space within the mineral estate has been fully mined and has reverted to the surface owner").

135. Hastings Oil Co. v. Texas Co., 234 S.W.2d 389 (Tex. 1950); Union Oil Co. of Cal. v. Domengeaux, 86 P.2d 127, 130 (Cal. Ct. App. 1939). *See Hastings Oil Co.*, 234 S.W.2d at 398 (quoting 1 James L. High, A Treatise on the Law of Injunctions 693, §730 (4th ed. 1905)) (Continuing trespasses and trespasses to mining property are among those most suited to injunctive relief since "they subtract from the very substance of the estate, hence equity is quick to restrain them."); Thomas W. Merrill, *Trespass, Nuisance, and the Costs of Determining Property Rights*, 14 J. Legal Stud. 13 (1985).

136. Martin & Kramer, *supra* note 44 (the definition of "Ejectment" is "a legal action to recover the possession of land"); Picken v. Adams, 131 N.E.2d 38 (Ill. 1955); Barnsdall v. Bradford Gas Co., 74 A. 207 (Pa. 1909); Venture Oil Co. v. Fretts, 152 Pa. 451, 25 A. 732 (1893).

137. In oil and gas cases, the amount that the owner is entitled to recover may turn on whether the trespasser was acting in good faith, as a "mistaken improver of property," or bad faith as a willful trespasser. *See* Martin & Kramer, *supra* note 41, §227 ("if the driller intentionally bottomed the well on another's land the trespass is in bad faith, and the trespasser is liable for the value of the oil at the surface, i.e., without a credit for drilling and operating costs."); Peter K. Huber, *Mistaken Transfers and Profitable Infringement on Property Rights: An Economic Analysis*, 49 La. L. Rev. 71 (1988).

138. Damages can be nominal, compensatory, or punitive. *See* Alexandra B. Klass, *Punitive Damages and Valuing Harm*, 92 Minn. L. Rev. 83, 105-07 (2007); Jacque v. Steenberg Homes, Inc., 563 N.W.2d 154 (1997); Journey Acquisition-II, L.P. v. EQT Prod. Co., 830 F.3d 444 (6th Cir. 2016).

139. Kyle Graham, *The Continuing Violations Doctrine*, 43 Gonz. L. Rev. 271, 309-10; McCormick, *supra* note 4 (citing Clegg v. Dearden, 12 Q.B. 576, 590 (1848)) ("There is a legal obligation to discontinue a trespass or remove a nuisance.").

140. For an example of a subsurface trespasser who acquired a prescriptive easement, see, e.g., *Ellis v. Arkansas Louisiana Gas Co.*, 609 F.2d 436 (10th Cir. 1979). It is an interesting and unresolved question whether possession of the pore space through intrusion would be considered "open and notorious" or whether a claimant who has met the requirements for adverse possession through occupation of the "pore space" under a parcel from which minerals have been severed will also obtain title to the land surface.

141. For a discussion of the situations in which a subsurface trespass may arise, see, e.g., Anderson, *Lord Coke*, *supra* note 63; Keith Hall, *Hydraulic Fracturing: If Factures Cross Property Lines Is There an Actionable Subsurface Trespass?*, 54 Nat. Resources J. 361 (2014); Klass & Wilson, *supra* note 3; Christopher Kulander & R. Jordan Shaw, *Comparing Subsurface Trespass Jurisprudence—Geophysical Surveying and Hydraulic Fracturing*, 46 N.M. L. Rev. 67 (2016).

the producing formation as near as possible to the lease line,[142] the bottoming of a slant well under the land of another,[143] the intrusion of hydraulic fracturing fluids by forceful injection,[144] and seeps of injected gas or wastewater migrating through the pore space from a nearby parcel.[145] If one applies an absolute corporeal theory of property to the subsurface, each of these unauthorized entries offends the inviolate rights of the property owner to exclusive possession and to exclude trespassers.[146]

Trespass is a tort against the right of exclusive possession by an owner of real property.[147] Establishing exclusive possession in the subsurface can be challenging, as few property owners actually exercise dominion over the subsurface of their property in a manner that gives way to strong claims of possession.[148] However, as Prof. Keith Hall notes, while "few landowners exercise actual possession of regions far above or below the surface . . . a landowner might have constructive possession of such regions, and thus have a remedy against intrusions into the airspace above or the subsurface below his land."[149] As the court notes in *Coastal Oil & Gas v. Garza Energy Trust*, property owners with both possessory and nonpossessory interests can allege trespass.[150]

Despite early attestations that the instrumentality of trespass is immaterial,[151] the temporal and physical nature of an intrusion may be material to determinations of whether that intrusion interferes with the right to exclusive possession.[152] Unlike invasions that are temporary, fleeting, and ethereal, physical and permanent intrusions are more likely to constitute an actionable trespass irrespective of whether the surface owner suffered any actual harm.[153]

For example, courts are more likely to find a trespass to airspace resulting from intrusions of "eaves, cornices, roofs . . . [and] wires passing over a plaintiffs property" than from intangible intrusions such as dust, noise, or vibrations.[154] Likewise, permanent subsurface occupations, such as the intrusion of a foundation wall, have also been found the instruments of trespass.[155] In addition to the conversion arising from any resultant production, numerous cases have recognized a trespass when a person drills a directional well into the property of another, thus physically occupying the space with the wellbore, cement, pipe, and other downhole equipment.[156]

Transient incursions to the airspace, such as the firing of trajectories or the passage of airplanes, and intangible entries, such as noise, light, and vibration, have defied classification as actionable trespasses. For example, in *Pickering v. Rudd*, the court found that "firing a loaded gun with shot into a field was breaking the close" but "that firing in vacuo could [not] be considered a trespass."[157] The majority of cases have found that the firing of a trajectory across (and not onto) land is not a trespass unless the peaceful enjoyment of the property is endangered thereby.[158]

Similarly, airspace intrusions resulting from "the mere entry into the air space" by high altitude air travel are excluded from the definition of trespass.[159] Rather than focusing on owners' rights of exclusion, courts in air traffic cases have engaged in a nuisance-based analysis—giving heavy weight to the limited possessory interest of an owner of property in the high-altitude airspace of the property and balancing the relatively minor nature of the disturbance against the high social utility of the cause.[160] This

142. Despite the growing acknowledgement of the practice of nudging among practitioners, the author could find no cases that directly addressed the scenario of nudging. Note that while the act of nudging is a trespass, there is no continuing trespass by permitting the void to remain. *See* Clegg v. Dearden, 12 Adol. & E. (N.S.) 601.
143. Hancock Oil Co. v. Meeker-Garner Oil Co., 257 P.2d 988 (Cal. Ct. App. 1953).
144. Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 11 (Tex. 2008).
145. Tidewater Oil Co. v. Jackson, 320 F.2d 157 (10th Cir. 1963); Crawford v. Hrabe, 44 P.3d 442 (Kan. 2002); Chance v. BP Chems., 670 N.E.2d 985, 994 (Ohio 1996).
146. Anderson, *Subsurface "Trespass," supra* note 3, at 205; Hall, *supra* note 141, at 369-70; Restatement (Third) of Torts: Liability for Physical & Emotional Harm §50 (Tentative Draft No. 6, 2009), ch. 9 (2016) (A trespasser is liable for intrusions by a thing that he has placed on or caused to enter the land of another "without consent or other legal privilege."); Stephen D. Sugarman, *Land-Possessor Liability in the Restatement (Third) of Torts: Too Much and Too Little*, 44 Wake Forest L. Rev. 1079 (2009).
147. Hall, *supra* note 141, at 374 (citing W. Page Keeton et al., Prosser and Keeton on Torts ch. 3, §13 at 77 (5th ed. 1984)) (noting that a landowner need not have physical possession and that constructive possession will suffice).
148. Sprankling, *supra* note 103, at 1023-25.
149. Hall, *supra* note 141, at 376.
150. 268 S.W.3d 1, 9 (Tex. 2008) (citing Keeton et al., *supra* note 147, §13) (noting that a holder of a possessory interest in property must only demonstrate injury to his or her right of possession through a physical entry onto the land, whereas the holder of a non-possessory interest such as a reversion must demonstrate "actual permanent harm to the property of such sort as to affect the value of his [reversionary] interest").
151. Whittaker v. Stangvick, 111 N.W. 295, 296 (Minn. 1907) (It is also entirely immaterial by means of what instrumentality the trespass is committed.).
152. Miller v. Carnation Co., 516 P.2d 661 (Colo. Ct. App. 1973); Ingmundson v. Midland Cont'l R.R., 173 N.W. 751 (N.D. 1919); Thomas W. Merrill, *Trespass, Nuisance, and the Costs of Determining Property Rights*, 14 J. Legal Stud. 13 (1985).
153. Hanna v. ARE Acquisitions, LLC, 929 A.2d 892, 894 (Md. 2007) (citing Restatement (Second) of Torts §§158, 161 (2016)) (Liability results "irrespective of whether [the trespasser] causes harm to any legally protected interest of the other" and "regardless whether or not [he] has the ability to remove it.").
154. Larry D. Scheafer, Annotation, *Recovery in Trespass for Injury to Land Caused by Airborne Pollutants*, 2 A.L.R. 4th 1052 (1980); Hall, *supra* note 141, at 376 (citing Huber v. Stark, 102 N.W. 12 (Wis. 1905); Aiken v. Benedict, 39 Barb. 400 (N.Y. Gen. Term 1862); Harrington v. McCarthy, 48 N.E. 278 (Mass. 1897); Murphy v. Bolger, 15 A. 365 (Vt. 1888)); Adams v. Cleveland Cliffs Iron Co., 602 N.W.2d 215 (Mich. Ct. App. 1999).
155. Rahn v. Milwaukee Elec. Ry. & Light Co., 79 N.W. 747 (Wis. 1899).
156. Hall, *supra* note 141, at 376 (citing Williams v. Continental Oil Co., 14 F.R.D. 58 (W.D. Okla. 1953); Hastings Oil Co. v. Texas Co., 234 S.W.2d 389 (Tex. 1950); Gliptis v. Fifteen Oil Co., 16 So. 2d 471 (La. 1944); Alphonzo E. Bell Corp. v. Bell View Oil Syndicate, 76 P.2d 167 (Cal. Ct. App. 1938)).
157. Whittaker v. Stangvick, 111. N.W. 295, 296 (Minn. 1907) (quoting Pickering v. Rudd, 4 Camp. 219, 221 (1815)).
158. *See*, *e.g.*, Clifton v. Bury (1887) 4 T.L.R. 8; Herrin v. Sutherland, 241 P. 328 (Mont. 1925); *Whittaker*, 111 N.W. at 295 (shooting of a trajectory alone is not a trespass but becomes one where ducks fall on the land and the hunter enters upon the land to retrieve them as a result).
159. Note, *Trespass by Airplane*, 32 Harv. L. Rev. 569 (1919); Stuart S. Ball, *The Vertical Extent of Ownership in Land*, 76 U. Pa. L. Rev. 631 (1928) (citing Salmond on the Law of Torts §52, 197 (5th ed. 1920)); For an excellent overview of the law related to temporary intrusions in airspace related to air travel, see Anderson, *Lord Coke*, *supra* note 63, at 211-14, Anderson, *Subsurface "Trespass," supra* note 3, at 253-55, and Hall, *supra* note 141, at 380.
160. Anderson, *Lord Coke*, *supra* note 63, at 211-14.

approach, branded a "modern rule" of trespass, modifies the *ad coleum* doctrine such that the "line between trespass and nuisance has become wavering and uncertain."[161]

Courts have applied a version of the modern rule of trespass to cases involving the migration of injected fluids across property lines in the deep subsurface, but without abandoning the requirement of a tangible entry.[162] These cases principally occur in the context of four commercial activities related to energy exploration: (1) hydraulic fracturing,[163] (2) gas storage,[164] (3) wastewater disposal,[165] and (4) enhanced oil recovery.[166] Unlike air travel or the firing of a rifle across land—uses that by their very natures are fleeting—subsurface intrusions resulting from the migration of injected substances across property lines result in a continual intrusion into subsurface property by a tangible mass of gasses and/or fluids, perhaps contributing to lasting pressure changes and altered permeability and fluid dynamics within the reservoir in an area that extends far beyond the actual location of, for example, the CO_2 plume.[167]

However, courts have regularly distinguished these intrusions from surface trespasses.[168] In the absence of "physical damage or interference"[169] with the "reasonable and foreseeable use of the properties,"[170] courts "have largely refused to find harmless deep subsurface invasions actionable."[171] Requiring a showing of actual injury destroys the property owner's right to recover for purpresture under a theory of trespass *quare clausum fregit*. An owner with a possessory interest in property can bring an action in trespass *quare clausum fregit* for intentional intrusions to his or her property, even if they cause no damage.[172] This denies the surface owner recovery for injury to his or her rights of possession in the subsurface and confounds the doctrines of trespass and nuisance by requiring the landowner to demonstrate both an intentional physical intrusion onto the land and actual injury[173] to the property or interference with the right to private enjoyment of the subsurface.[174]

The erosion of the doctrine of trespass and the confusion with the doctrine of nuisance treats subsurface property in pore space as incorporeal, thus requiring an owner of subsurface pore space to "capture" it before he is disseized of it.[175] In order to recover under the theory of damages grounded in nuisance, surface owners must demonstrate that they have some existing or foreseeable use of their subsurface property.[176] In many cases, this makes monetary recovery for subsurface intrusions unlikely.[177]

Further, the prerequisite of establishing use in the subsurface creates an unreasonably high hurdle for plaintiffs trying to demonstrate the irreparable injury in order to obtain injunctive relief against planned or repeated trespasses.[178] Professor Sprankling describes this as the "de

161. Bradley v. American Smelting & Refining Co., 709 P.2d 782, 16 ELR 20346 (Wash. 1985).

162. Tucker v. Southwestern Energy Co., No. 1:11-cv-44-DPM, 2012 U.S. Dist. LEXIS 20697 (E.D. Ark. Feb. 17, 2012):

> The weight of authority from the other states appears to favor [the producers] position that this scenario is a nuisance, not a trespass. But the legal principles at work, *e.g., Restatement (Second) of Torts* §158, support the trespass claim . . . . This claim may be suspenders over the belt of nuisance.

163. My colleagues have provided compelling and thorough analyses of the history of hydraulic fracturing trespasses; *see* Hall, *supra* note 141; Klass & Wilson, *supra* note 3; Anderson, *Lord Coke*, *supra* note 63; Kulander & Shaw, *supra* note 141; Pierce, *supra* note 14; Anderson, *Subsurface "Trespass," supra* note 3. For cases indicating that a trespass would result from the intrusion of fracturing fluids, see, e.g., *Gregg v. Delhi-Taylor Oil Corp.*, 344 S.W.2d 411, 412 (Tex. 1961); *GeoViking, Inc. v. Tex Lee Operating Co.*, 817 S.W.2d 357 (Tex. Ct. App. 1991); *Stone v. Chesapeake Appalachia, LLC*, No. 5:12-CV-102, 2013 U.S. Dist. LEXIS 71121 (N.D. W. Va. Apr. 20, 2013), *order vacated by* 2013 WL 7863861 (N.D. W. Va. July 30, 2013) (The intrusion of hydraulic fracturing fluids "result[s] in an actual, nonconsensual invasion of the plaintiff's property, which interferes with the plaintiff's possession and use of that property.").

164. Beck v. Northern Natural Gas Co., 170 F.3d 1019 (10th Cir. 1999).

165. Chance v. BP Chems. Inc., 670 N.E.2d 985, 992 (Ohio 1996); FPL Farming Ltd. v. Environmental Processing Sys., Inc., 351 S.W.3d 306 (Tex. 2011); Railroad Comm'n v. Manziel, 361 S.W.2d 560, 567-68 (Tex. 1925); Cassinos v. Union Oil Co. of Cal., 18 Cal. Rptr. 2d 574 (Cal. Ct. App. 1993).

166. Crawford v. Hrabe, 44 P.3d 442 (Kan. 2002).

167. Ruben Juanes et al., *Impact of Relative Permeability Hysteresis on Geological CO_2 Storage*, 42 Water Resources Res. W12418 (2006). There is some ambiguity as to whether these lasting changes would constitute a continuing trespass; *see* Christopher M. Rhymes, *Environmental Contamination as Continuing Trespass*, 42 Envtl. L. 1381 (2012).

168. Anderson, *Subsurface "Trespass," supra* note 3.

169. *Chance*, 670 N.E.2d at 989.

170. *Id.* at 993.

171. Anderson, *Subsurface "Trespass," supra* note 3, at 204 ("Landowners must suffer actual damages that affect their reasonable and foreseeable *use* of the subsurface, not mere interference with title or possession."); Raymond v. Union Tex. Petroleum, 697 F. Supp. 270 (D. La. 1988); *Chance*, 670 N.E.2d at 989; *but see* Cassinos v. Union Oil Co., 18 Cal. Rptr. 2d 574 (Cal. Ct. App. 1993) (awarding damages based on the cost of paying for disposal of other wastewater). A subset of gas storage cases have provided recovery for subsurface trespasses on the basis of unjust enrichment; see, e.g., Beck v. Northern Natural Gas Co., 170 F.3d 1019 (10th Cir. 1999), and Van Scyoc v. Equitrans, L.P, No. 2:13-cv-01735, 2015 WL 1346872 (W.D. Pa. Mar. 23, 2015). However, the award of damages in the form of economic rents for use of the property may stem from the fact that in some circumstances the Natural Gas Act can provide the trespassers with condemnation authority by way of a Federal Energy Regulatory Commission certificate. While beyond the scope of this Article, a regulatory framework based on the Natural Gas Act may offer an alternative approach to resolving the issues of subsurface trespass resulting from CCS. *See* Klass & Wilson, *supra* note 3.

172. Neither a remainderman nor owners of incorporeal rights can bring an action for trespass *quare clausum fregit*. *See* Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 10 (Tex. 2008) (citing Slye v. Guerdrum, 29 App. D.C. 550 (1907)) ("It is, of course, axiomatic that at common law the gist of the action of trespass *quare clausum fregit* is injury to the possession, and that, generally speaking, the plaintiff must show actual or constructive possession at the time of the trespass.").

173. Courts differ on whether drainage resulting from the transboundary migration of fracturing fluids is an actual damage or is protected by the rule of capture. *Contrast* Coastal Oil & Gas Corp., 268 S.W.3d at 11 (declining to find an actionable trespass based on a holding that the only damages alleged, drainage, was protected by the rule of capture), *with* ANR Prod. Co. v. Kerr-McGee Corp., 893 P.2d 698 (Wyo. 1995), *and* Stone v. Chesapeake Appalachia, LLC, No. 5:12-CV-102, 2013 U.S. Dist. LEXIS 71121 (N.D. W. Va. Apr. 20, 2013), *order vacated by* 2013 WL 7863861 (N.D. W. Va. July 30, 2013) (analogizing drainage caused by hydraulic fracturing to theft).

174. Smith v. Kansas Gas Serv. Co., 169 P.3d 1052, 1054 (Kan. 2007); Berenger v. 261 W. LLC, 940 N.Y.S.2d 4, 2012 N.Y. slip op. 00738 (N.Y. App. Div. 2012) (Unlike trespass, which arises from the exclusiveness of possession and requires a physical entry onto property, a claim of private nuisance arises from an interest in the use and enjoyment of property.).

175. Sprankling, *supra* note 103, at 1035-36.

176. *Chance*, 670 N.E.2d at 992.

177. *Id.*

178. Sunoco Partners Mktg. & Terminals LP v. Environmental Prot. Agency, No. 05-7472, 2006 U.S. Dist. LEXIS 2817 (E.D. Mich. Jan. 20, 2006) (denying an injunction to bar the expansion of the defendant's injection

facto" system of allocating deep subsurface property rights without regard to surface property boundaries based on "first-in-time exploitative use."[179] Yet, like the unfettered rule of capture, an application of this system and its variants in the subsurface create significant problems: limiting the marketability of property, encouraging waste, and discouraging investment in new technologies.[180]

These challenges are glaringly apparent when applied to subsurface trespasses in non-mineral pore space resulting from operations for CCS. Unlike mineral interests, pore space use for CCS is incompatible with a self-help remedy; whereas a mineral owner who is aggrieved by drainage resulting from the intrusion of hydraulic fracturing fluids under his or her property can "go and do likewise,"[181] an owner of non-hydrocarbon pore space has little reprieve. In fact, the necessity of obtaining a CO_2 supply combined with regulatory requirements associated with permitting of injection units make it unlikely that an owner desiring to try and "capture" his or her share of pore space would be able to do so.[182]

This creates a troubling paradox for owners of non-mineral subsurface pore space. On the one hand, they are without a meaningful remedy if their neighbors trespass into their subsurface property.[183] Unless they have established some prior use of that subsurface, they are unlikely to recover based on the simple fact of the intrusion and are likewise unlikely to enjoin a neighbor's injection or obtain an action for ejectment.[184] However, if they do nothing, they risk that their neighbors may, at a minimum, deplete the storage capacity under their property, or, even worse, obtain title to their non-mineral pore space through prescription.[185]

Further, considering the inability of an owner of pore space to attempt to make separate use of the pore space, the application of the modern rule of trespass to subsurface trespasses to non-mineral pore space resulting from operations for CCS is problematic. Assuming courts treat these trespasses similarly to those involving wastewater,[186] the low probability that the injured landowner will receive an award of damages also makes it unlikely that a neighbor will seek to obtain an easement in the owner's subsurface through private ordering.[187] In the absence of either liability and the corresponding risk of damages or injunctive relief resulting from trespass, or regulation requiring contracting, an injector who can "capture" the pore space through nonconsensual use has little incentive to contract for it.[188] Further, the lack of assurance that the acquirer of property in pore space obtains a right of exclusive possession or use of that property promotes inefficient use of resources and creates further restraints on alienability.[189]

The lack of clarity regarding rights and remedies portends to create an anticommons in the pore space.[190] An anticommons results when "multiple owners are each endowed with the right to exclude others from a scarce resource, and no one has an effective privilege of use."[191] Ironically, while courts have been cautious about granting injunctions to limit pore space intrusions, the mere possibility of injunctive relief may prevent "efficient and utilitarian use of the subsurface."[192] Absent an acknowledgement of common rights in the reservoir, no interest holder could fully use his or her property for CCS because that use, particularly near-border use, would necessarily result in cross-boundary migration and thus would interfere with use by others in the reservoir.[193] Exposure to trespass and nuisance claims, when combined with high transaction costs and imperfect information, are likely to result in underutilization of the resource.[194]

IV. Correlative Rights in the Pore Space

The correlative rights model used in oil and gas development provides an instructive example for addressing the challenges presented by carbon capture. By more fully defining property interests in the pore space within the

of subsurface wastes, even though plaintiff planned a competing project); Doug R. Rendleman, *The Inadequate Remedy at Law Prerequisite for an Injunction*, 33 U. Fla. L. Rev. 346 (1981).

179. Sprankling, *supra* note 103, at 1035-36.

180. *Id.* Perhaps ironically, the problems associated with ambiguity related to private claims for subsurface trespass arising from private and individual ownership of pore space echoes the arguments that critics of common property advance in favor of private ownership, i.e., that "uncertainty about property rights invites conflicts and squanders resources," *see* Carol Rose, *The Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U. Chi. L. Rev. 711 (1986).

181. Texaco Inc. v. Industrial Comm'n of State of N.D., 448 N.W.2d 621, 625 (N.D. 1989) (citing Martin & Kramer, *supra* note 44) (definition of "Rule of Capture").

182. States that have addressed this particular issue only permit one injector per injection unit. *See*, *e.g.*, Wyo. Stat. Ann. §35-11-315 (2011) and Ky. Rev. Stat. Ann. §353.808 (West 2011); R. Lee Gresham & Owen Anderson, *Legal and Commercial Models for Pore-Space Access and Use for Geologic CO_2 Sequestration*, 72 U. Pitt. L. Rev. 702 (2011).

183. *See* discussion *supra* Part III.

184. Anderson, *Lord Coke*, *supra* note 63, at 207 ("In circumstances where a landowner or mineral owner suffers actual and substantial subsurface damages, courts should generally limit relief to money damages and deny injunctive relief or ejectment.").

185. Ellis v. Arkansas Louisiana Gas Co., 609 F.2d 436 (10th Cir. 1979).

186. Anderson, *Subsurface "Trespass," supra* note 3, at 281 ("Although [CCS] can lead to the physical migration of substances beneath neighboring property, [it] should not give rise to actionable trespass without a showing of actual and substantial harm other than drainage.").

187. Nominal damages or remedies which primarily compensate the owner may be inadequate to deter trespassers, *see*, Huber, *supra* note 137 at 100, (If the converter/trespasser makes profits that exceed his expected liability in tort, he should be ready to infringe on the owner's property and pay damages.).

188. For an example of legislation requiring a threshold amount of pore space to be under contract in order to get an injection permit, see Wyo. Stat. Ann. §35-11-315 (2011).

189. Huber, *supra* note 137, at 100 ("Making goods a target of non-contractual appropriation . . . will induce expenditures on preventative measures by the owner, which will in turn lead an infringer to adopt more sophisticated and expensive ways of infringement . . . .").

190. Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition From Marx to Markets*, 111 Harv. L. Rev. 621 (1998); A. Bryan Endres, *Geologic Carbon Sequestration: Balancing Efficiency Concerns and Public Interest in Property Rights Allocations*, 2011 U. Ill. L. Rev. 623 (2011).

191. *Id.*

192. Anderson, *Subsurface "Trespass," supra* note 3, at 206-07 ("[t]he most serious threat to efficient and utilitarian use of the subsurface is the possibility of injunctive relief or ejectment").

193. Hall, *supra* note 141, at 401 (noting that there is a stronger private-property interest in the interior of one's property than at the edges).

194. Endres, *supra* note 190, at 626.

correlative rights framework, it is possible to resolve many of the questions related to rights of exclusion within the subsurface property. An acknowledgment of correlative rights creates a limited legal privilege among owners of a shared reservoir while concurrently protecting rights of exclusion against those outside the reservoir community.

As such, rather than focusing on the creation or abolishment of property rights in the subsurface, the application of correlative rights reframes interests in the CCS "storage complex" as a form of "limited common property" wherein possessive rights are more appropriately allocated according to principles of proportionate use and enjoyment.[195] As Professor Rose describes, this "intermediate stage" between the commons and fully individualized property may induce a group to preserve a resource and to "avoid dissipating time and effort—and the resources themselves—in unproductive disputes and wasteful attempts to grab the most."[196] While the somewhat "diffuse rights of group members" may lead to other inefficiencies, such as investment by an individual, this form of group property may encourage resource-wide investment and may be more efficient than a "more expensive, resource management regime of individualized property rights."[197]

By limiting boundary-related disputes between group members, limited common property may promote private ordering for pore space interests and reduce uncertainty as to liabilities and entitlements, thus encouraging investment and innovation for carbon storage without diminishment of the private-property interest.[198] Consequently, the model of correlative rights provides an interesting solution to the issue of subsurface trespass in the non-mineral subsurface.[199]

A. *The Challenge of Applying Exclusionary Principles to Property Uses That Defy Confinement*

Legal entitlements have historically evolved in response to property use that defies confinement to a specific column of space.[200] In the early days of settlement of the West, the open range presented challenges to the notions of private property and the doctrine of trespass.[201] Implicit in the concept of the open range is an acknowledgement that "the feasibility of protectively fencing [ ] finite crop lands far outstrips the possibility of containing livestock when they wander or are driven over hundreds or thousands of miles."[202] In response, legislators adopted "fence rules" that granted ranchers protection from liability for trespass and damages resulting from intrusions by cattle to unenclosed property. The privilege created by fence rules, however, is limited: intrusions that are willful and wanton, arise via negligence, or occur as a result of overstocking can result in a trespass.[203]

The example of open range laws provides an early American model for the modification or development of property entitlements and allocations based on the realities of custom and use.[204] Like livestock on the range, injected substances are difficult to confine within a specific subcolumn of the total space. In the subsurface, however, it is impracticable to place a burden on the owners of property to protect themselves from intrusions.[205] Thus, the concept of precluding trespasses from proportionate use while permitting trespass via overstocking offers a clear analog to the issues of trespass from carbon capture in that it acknowledges a duty to limit one's use to equitable proportionality and to avoid harm to the shared resource.

Acknowledging the "clear trend of courts limiting the ability of plaintiffs to recover in trespass for intrusions at high elevation and great depths," the majority of scholarship has concluded that the doctrine of trespass requires modification to account for subsurface intrusions resulting from hydraulic fracturing.[206] Professor Anderson suggests that subsurface trespasses should be treated in a manner that is similar to air traffic: where intrusions serve an important public purpose such as mineral development, the restatement should be revised so that intrusions are actionable only when they cause actual and substantial harm.[207] Professor Hall similarly suggests a modification to the law of trespass through the creation of what he calls "a near-border exception."[208] This model would preclude liability for unintentional and non-negligent intrusions of

195. Rose, *supra* note 16, at 132.
196. Rose, *supra* note 14.
197. *Id.*
198. Although consideration of the issue goes beyond the scope of this Article, the question of diminishment as it relates to application of correlative rights in one substratum of the pore space raises interesting questions of conceptual severance. *See*, *e.g.*, Margaret Jane Radin, *The Liberal Conception of Property: Cross Currents in the Jurisprudence of Takings*, 88 Colum. L. Rev. 1667 (1988).
199. Importantly, I do not suggest that this model should be applied in the cases of associated storage related from enhanced oil recovery or to address subsurface intrusions resulting from mineral operations by either lawful split-estate mineral owners or through unlawful trespass from mineral use on adjoining parcels.
200. *See*, *e.g.*, Clark v. Lindsay Light & Chem. Co., 89 N.E.2d 900 (Ill. 1950) (usufructuary interest in water); Pierson v. Post, 3 Cal. R. 175, 2 Am. Dec. 264 (N.Y. 1805) (wildlife); Del Monte Min. & Milling Co. v. Last Chance Min. & Milling Co., 171 U.S. 55 (1898) (mining); Kelly v. Ohio Oil Co., 49 N.E. 299 (Ohio 1897) (oil and gas).
201. Kate Burke, *Colorado's Fence Law: An Overview of Open Range and Fence Out Concepts*, 43 Colo. Law. 29 (2014).
202. *Id.*
203. *Id.* at 32 (citing Lazarus v. Phelps, 152 U.S. 81 (1894)).
204. For a description of medieval, English, and 19th century American cases related to the impacts of custom and use on the emergence of property entitlement, see Rose, *supra* note 180.
205. Gresham & Anderson, *supra* note 183, at 9-86 (citing Pierce, *supra* note 14; David E. Pierce, *Developing a Common Law of Hydraulic Fracturing*, 72 U. Pitt. L. Rev. 685, 693-95 (2011); David E. Pierce, *Oil and Gas Easements*, 34 Energy & Min. L. Inst. 318, 319-21 (2012); David E. Pierce, *Minimizing the Environmental Impact of Oil and Gas Development by Maximizing Production Conservation*, 85 N.D. L. Rev. 759, 768-72 (2009)) ("[A] landowner cannot construct a fence around the boundaries of a subsurface reservoir rock structure because each owner's interest is structurally connected. Indeed, a landowner cannot easily monitor the deep subsurface for possible trespassers.").
206. Hall, *supra* note 141, at 401.
207. Anderson, *Lord Coke*, *supra* note 63, at 239-40.
208. Hall, *supra* note 141, at 401-05.

hydraulic fracturing fluids while preserving a trespass remedy for "interior property" intrusions.[209]

While either of these suggestions may work well as applied to subsurface trespasses resulting from hydraulic fracturing, neither presents a clear framework for subsurface trespasses resulting from CCS. Unlike fracturing operations resulting in a single act of trespass near property lines, carbon capture involves continuing injections over a period of years, the complete depletion of the storage resource, and continued physical occupation of the pore space by injected materials or by areas of increased pressurization for an extended, perhaps indefinite, period.[210] In response to these unique concerns, the majority of scholarship addressing subsurface trespasses from CCS operations arrives at one of two conclusions: (1) eliminating or modifying private property in the deep subsurface pore space, thus creating a public resource[211]; and (2) granting private actors broad powers of eminent domain for the creation of CCS projects as a public use.[212]

The correlative rights model of oil and gas presents a third possibility that draws from the concept of an inherent publicness of CCS that is embodied in both of these approaches.[213] Professor Pierce, in his evaluation of subsurface trespasses from hydraulic fracturing, argues that subsurface property should be characterized according to the philosophy of shared resources and the application of correlative rights principles.[214] This philosophy offers a response to the problems associated with subsurface intrusions resulting from CCS activities.

B. Correlative Rights

Correlative rights are the rights of mineral owners within a common source of supply to produce their equitable share of the oil and gas within a shared hydrocarbon reservoir.[215] Oil and gas law does not view ownership in the shared reservoir as absolute, "but rather provides each reservoir owner with the ability to make acceptable uses of the reservoir to extract oil and gas."[216] As Professor Pierce has noted, correlative rights fit within the property concept of what Professor Rose has called "Limited Common Property," or "property held as a commons among the members of a group, but exclusively vis-à-vis the outside world."[217] Rather than subscribing to compartmentalized notions of exclusive ownership, the correlative rights framework analyzes an individual's property interests relative to others within the reservoir community.[218] Within the reservoir, each individual possesses "similar rights and duties, whereby each can impact the community and the community can impact each individual."[219] This construct thus applies a rule of reasonable use that acknowledges that an owner's use of his or her property is limited by his or her obligation to preserve for others their ability to do the same.[220]

Correlative rights has its genesis in two principles: (1) the rule of capture, whereby each person in a field has a right to produce from and capture such oil and gas as he or she can draw into his or her well without liability for conversion, and (2) the right of mineral owners within that field to be protected against damage to the common source of supply.[221] The rule of capture provides that a producer of oil has ownership of whatever fluids naturally flow into a well lawfully bottomed below his or her property.[222] Thus, property rights are perfected via capture and each property owner is incented to capture as much property as possible to the extent he or she can do so without negligence or waste.[223] The rule of capture protects producers from liability for conversion of oil and gas that crosses property lines and flows naturally into the wells of a neighboring landowner.[224] Rather than permitting an owner to recover for transboundary drainage, the remedy is one of self-help: the owner can drill his or her own well and attempt to capture as much of the common reservoir as the law will permit.[225]

The superlative of correlative rights—that each owner within a common reservoir has a right to attempt to cap-

209. *Id.*
210. Possibly further complicating the continuing trespass analysis, Wyoming has declared that an injector continues to own all substances injected for geologic sequestration. *See* Wyo. Stat. Ann. §34-1-153 (2012).
211. *See* Sprankling, *supra* note 103, at 1032, 1036; Endres, *supra* note 190, at 646-49; Doran & Ciphor, *supra* note 80, at 545; Zadick, *supra* note 10; Will Reisinger et al., *Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage*, 11 Vt. J. Envtl. L. 1, 33 (2009).
212. Klass & Wilson, *supra* note 3, at 425. Klass and Wilson suggest using the model of the Natural Gas Act, which would provide a federal framework permitting eminent domain for CCS operations that presumably would preempt state condemnation laws. At least two states have specifically limited the availability of eminent domain for purposes related to CCS. *See* Wyo. Stat. Ann. §35-11-316(j) (2015) ("No provision of W.S. 35-11-314 through 35-11-317 shall be construed to confer on any person the right of eminent domain and no order for unitization issued under this section shall act so as to grant to any person the right of eminent domain."); Okla. Stat. Ann. tit. 27A, §3-5-106 (2009) ("Nothing in this act shall grant a private operator the right of condemnation or eminent domain for any purpose.").
213. Gresham & Anderson, *supra* note 182, at 9-86.
214. Pierce, *supra* note 14.
215. Martin & Kramer, *supra* note 44 (definition of "Correlative Rights").
216. Pierce, *supra* note 14, at 244.
217. *Id.* at 244 (quoting Rose, *supra* note 16, at 132).
218. *Id.*
219. *Id.* at 245.
220. Endres, *supra* note 190, at 635.
221. Young v. Ethyl Corp., 521 F.2d 771 (8th Cir. 1975) (citing Summers, *supra* note 17, §63 at 180-81:

> The term correlative rights is merely a convenient method of indicating that each owner of land in a common source of supply of oil and gas has legal privileges as against other owners of land therein to take oil and gas therefrom by lawful operations conducted on his own land limited, however, by duties to other owners not to injure the source of supply and by duties not to take an undue proportion of the oil and gas. In addition, of course, to this aggregate of legal relations, each landowner has duties to the public not to waste the oil and gas.

222. Burford v. Sun Oil Co., 319 U.S. 315 (1943) (citing Northcutt Ely, *The Conservation of Oil*, 51 Harv. L. Rev. 1209 (1938)).
223. Breton Energy, L.L.C. v. Mariner Energy Res., Inc., 764 F.3d 394 (5th Cir. 2014).
224. SWEPI, L.P. v. Camden Res., Inc., 139 S.W.3d 322 (Tex. Ct. App. 2004); Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 11 (Tex. 2008).
225. Geo Viking, Inc. v. Tex-Lee Operating Co., 817 S.W.2d 357 (Tex. Ct. App. 1991). The rule of capture can be limited by administrative action such as unitization. *See* Desormeaux v. Inexco Oil Co., 277 So. 2d 218 (La. App. 3rd Cir. 1973), *writ denied*, 302 So. 2d 37 (La. 1974).

ture a just and equitable share of the oil and gas within the reservoir—could not exist without grounding in a prohibition on waste.[226] The opportunity to capture a just and equitable share of a resource is only valuable to the extent that others in the resource are precluded from diminishing that right.[227] Thus, correlative rights in oil and gas arise from, and are subordinate to, the concept of prohibition of waste.[228] Waste can include damage to the shared resource through dissipation of reservoir energy but also economic waste resulting from drilling more wells than are necessary to efficiently produce the reservoir.[229] Given the strong public interest in the efficient utilization of natural resources, actions that render portions of the reservoir unrecoverable harm not only the producer, but also the public and all others with like rights within the shared resource.[230]

C. Correlative Rights in the Pore Space

Correlative rights can easily be applied to notions of ownership in the pore space for purposes of CCS. A migration toward a less-exclusive view of ownership within the storage complex prevents frivolous and most likely unfruitful litigation for trespass and allows landowners and courts to focus instead on equity and efficiency.[231] This removes courts from the tedious and impossible task of parsing molecules among property boundaries and instead allows a broad equitable focus on volume.

There are, however, a few important distinctions. While the concepts of the rule of capture and the prohibition of waste are inseverable from the concept of correlative rights in oil and gas, neither is directly applicable to CCS operations. Carbon capture works opposite to production: rather than drawing down substances from the reservoir and thus depleting the fluid resource, CCS aims to capture the pore space through injection into it, thus depleting the reservoir's storage capacity. Accordingly, the rule of capture as a privilege against conversion does not apply.

Neither does the inverse—or negative—rule of capture apply.[232] The negative rule of capture addresses transboundary migration of injected substances for enhanced oil recovery.[233] However, the negative rule of capture is specific to extraction.[234] The privilege it creates is based on the fact that enhanced recovery operations are necessary to prevent waste and increase ultimate recovery.[235] Therefore, while the injection is trespassory in character, the majority of courts have declined to award damages for the drainage that results.[236] However, as the court in *Chance v. BP Chemicals Inc*. notes, where the injection "has nothing to do with the extraction or storage of oil or gas" it is "fundamentally dissimilar" to cases where the negative rule of capture has been applied.[237]

The rule of capture fits awkwardly in operations for carbon capture in that the traditional remedy of self-help may be inappropriate or unavailable. Unlike the potentially ubiquitous presence of oil and gas within a resource play, CCS depends on the ability of the injector to fill the "embodied nothing" of the pore space. The majority of oil and gas reserves can be drained from multiple locations by multiple independent operators within a reservoir, whereas carbon capture operations are more likely to be centralized. Injection for CCS requires the capture and transportation of a defined CO_2 stream from an anthropogenic source to the injection field. Although a storage project may involve many wells, including wells for monitoring, because the resource is exogenous, not every owner of pore space will have access to that resource, and therefore the ability to "capture" the pore space via independent operations on his or her own land is limited.

Accordingly, because the rule of capture and the remedy of self-help are only marginally applicable, correlative rights as applied in the non-hydrocarbon pore space should attempt to be as proportionate as possible. Even in the context of oil and gas, however, the rule of capture is not "a license to plunder."[238] Use must be reasonable and, to some lesser extent, proportionate.[239] Proportionate use should provide for use that is substantially in proportion to the amount that the pore space under an owner's property bears to the total recoverable storage complex. Additionally, proportionality should allow for and anticipate modification as more detailed geologic and technical information becomes available. While an application of correlative rights acknowledges that some of those fluids will likely migrate under the land of others, the application of these rules would assure that one landowner could

226. Sidney J. Strong, *Application of the Doctrine of Correlative Rights by the State Conservation Agency in the Absence of Express Statutory Authorization*, 28 Mont. L. Rev. 205, 209 (1966).
227. Brown v. Humble Oil & Ref. Co., 83 S.W.2d 935 (Tex. 1935).
228. Mobile Exploration & Producing U.S. Inc. v. State Corp. Comm'n of State of Kan., 258 Kan. 796 (Kan. 1995); Gilmore v. Oil & Gas Conservation Comm'n, 642 P.2d 773 (Wyo. 1982).
229. Breton Energy, L.L.C. v. Mariner Energy Res., Inc., 764 F.3d 394, 406 (5th Cir. 2014) (citing La. Rev. Stat. Ann. §30:3(16) (2013), Owen L. Anderson, *Exploratory Unitization Under the 2004 Model Oil and Gas Conservation Act: Leveling the Playing Field*, 24 J. Land Resources & Envt'l L. 277, 278 (2004), Nancy Saint-Paul, Summers Oil and Gas 4:10 (3d ed. 2013), and Brad Secrist, *Not All "Units" Are Created Equal*, 65 Okla. L. Rev. 157, 159 (2012)); 8 Patrick H. Martin & Bruce M. Kramer, Williams & Meyers Oil & Gas Law 1133 (2015)).
230. Application of Farmers Irrigation Dist., 194 N.W.2d 788 (Neb. 1972).
231. Gresham & Anderson, *supra* note 182, at 9-86 ("In the GCS context, this community approach would balance a landowner's right to use the subsurface with neighboring landowners' equal and correlative opportunity to make productive use of the rock structure held in common with others.").
232. Chance v. BP Chems. Inc., 670 N.E.2d 985, 992 (Ohio 1996).
233. Railroad Comm'n of Tex. v. Manziel, 31 S.W.2d 558 (Tex. 1948); J. Thomas Lane et al., *Ownership and Use of Underground Space*, 32 Energy & Min. L. Found. §23.04 (2011).
234. *Chance*, 670 N.E.2d at 991.
235. Tidewater Oil Co. v. Jackson, 320 F.2d 157 (10th Cir. 1963); Crawford v. Hrabe, 44 P.3d 442 (Kan. 2002).
236. *Id.*
237. *Chance*, 670 N.E.2d at 992.
238. Young v. Ethyl Corp., 521 F.2d 771 (8th Cir. 1975).
239. State conservation statutes differ in the extent to which they are to assure an equitable distribution of the source of supply. *See* Martin & Kramer, *supra* note 41, §204.6. Nevada, for example, defines correlative rights as affording each owner with the opportunity to produce without waste a "just and equitable share of the oil or gas, or both, in the pool and for this purpose to use the owner's just and equitable share of the reservoir's energy." Nev. Rev. Stat. §522.021 (2013).

not use the entire reservoir without the consent of, and likely compensation to, other property owners within the storage complex.

A rule like this would encourage private ordering by incentivizing both coordination and self-restraint.[240] Since no one owner could use more than his equitable share of the pore space without agreement from others within the storage complex, would-be injectors would have the maximum incentive to contract.[241] These "scale returns" or "instructiveness" create the maximum incentive to contract and address the problem of underinvestment[242]: cooperation would yield opportunity, turning an otherwise difficult-to-value asset with limited market value into a usable resource with high societal benefit.[243] A correlative rights model would also limit the self-interest of any owner in the storage complex from blocking development, thus mitigating the problem of holdouts.[244] Since operations could go on without a defecting owner's consent, and all those cooperating would share in the benefits generated therefrom, cooperation would be valuable.

Defection, however, would be injurious. Defectors may have any number of reasons for objecting to the siting of climate mitigation projects under their properties, including the opportunity cost associated with foreclosing other uses of the pore space, apprehensions about reservoir breach and future CO_2 release or liability, concerns related to induced seismicity, or objection to the use of CCS as a climate mitigation technology.[245] Despite these concerns, the ability of a defecting pore space owner to separately use his or her property will be diminished as more members of the reservoir community engage in cooperation.[246] Because it is unlikely that two separate injectors would contract for, transport, and obtain regulatory approval to inject non-native CO_2 into the same reservoir, a defecting owner would likely have no market for his or her pore space outside the cooperative venture. Further, as the reservoir as a whole becomes pressurized, the utility of all pore space within it for separate use (for CCS or other wastewater disposal or gas storage) will be depleted. Thus, a correlative rights framework should not only require proportionate use, but, in addition to discouraging underinvestment at the outset, should also provide a mechanism for early defectors to seek inclusion according to equitable principles.

D. State Rules for Carbon Capture

Like conservation laws structured around correlative rights in oil and gas, a non-hydrocarbon application of correlative rights would benefit from state regulation to "prevent wasteful and inefficient subsurface uses while promoting the affirmative exercise of correlative rights to fully develop connected subsurface rock structures."[247] Already, several states have adopted administrative conservation and unitization rules for CCS.[248] The majority of existing state statutes regulating carbon capture and pore space are consistent with a principle of correlative rights but fall short of a clear extension of that term to pore space owners or an acknowledgment of a "limited commons" among the community of pore space owners in the non-mineral pore space.[249]

For example, Wyoming's carbon capture legislation provides for unitization—the combination of pore space from multiple parcels into an injection unit—and the modification of units to include areas to which injected substances have migrated based on "the fair and equitable determination of pore space storage capacity."[250] Further, a concept of proportionality exists. Relying on what the Wyoming Legislature termed "corresponding rights," all owners within the unit are entitled to share proportionately in the economic benefits generated by the sequestration activities.[251] While corresponding rights edge toward correlative principles with respect to revenue distribution, the reservoir community is limited to the owners within the storage unit. Thus, the concept of corresponding rights may fall short of precluding trespass claims resulting from migration of injected substances into extralateral parcels or strata.

While these laws are consistent with the principles of correlative rights in the non-mineral pore space, they do not obviate the necessity of the clear adoption of the principles of correlative rights and limited common property. An injector, having unitized and created a storage unit and received a permit to inject, may still be liable for trespasses

240. F. Scott Kieff & Troy A. Paredes, *Engineering a Deal: Toward a Private Ordering Solution to the Anticommons Problem*, 48 B.C. L. Rev. 111, 115 (2007).

241. Gresham & Anderson, *supra* note 182, at 9-86. This is the precise reason however that Zadick and Endres, *supra* notes 10 and 190, suggest public ownership would be preferable. They posit that the expenses and transaction costs associated with acquiring storage rights make carbon capture uneconomic, and thus the abolition of private-property interests in the pore space for storage would better further development of CCS projects.

242. Rose, *supra* note 180, at 136, 142; Lee Anne Fennell, *Adjusting Alienability*, 122 Harv. L. Rev. 1403 (2009).

243. *Id.*; Burlington Res. Oil & Gas Co., LP v. Land & Sons Inc., 259 P.3d 766 (Mont. 2011) (noting that presently no market for pore space exists).

244. Gresham & Anderson, *supra* note 182, at 9-86 ("For example, a subsurface owner's desire not to use a connected subsurface structure would not necessarily limit use by other members of Professor Pierce's 'reservoir community.' If the activity is beneficial to the 'community' then it can be pursued, regardless of dissenting community members.").

245. Gray, *supra* note 36, at 326 ("It would be possible for CO_2 to cause saline intrusion into potable aquifers, make sources of oil and gas unattainable, create pressure changes within the ground, and even trigger seismic events."); Klass & Wilson, *supra* note 3, (citing Emily Rochon et al., *False Hope: Why Carbon Capture and Storage Won't Save the Climate*, Greenpeace International (2008)); David Biello, *Can Carbon Capture Technology Be Part of the Climate Solution?*, YaleEnvironment360, Sept. 8, 2014, *available at* http://e360.yale.edu/features/can_carbon_capture_technology_be_part_of_the_climate_solution (noting that CCS critics worry that it will entrench unsustainable technologies).

246. Given the difficulties of excluding migration and the probable application of the modern rule of trespass, however, a defecting owner may be only marginally more disadvantaged within a correlative rights framework than he is presently.

247. Gresham & Anderson, *supra* note 182, at 9-86 (If the activity is beneficial to the "community," then it can be pursued, regardless of dissenting community members.).

248. *Id.* at 9-13, tbl. 1; Miss. Code Ann. §53-11-13 (West 2013); Wyo. Stat. Ann. §34-1-153 (2011).

249. Miss. Code Ann. §53-11-13(c) (West 2013).

250. Wyo. Stat. Ann. §34-1-153 (2011).

251. Wyo. Stat. Ann. §35-11-314 (2011). Note that what would be considered "economic benefits" is unclear.

resulting from the migration of substances both within and outside of the permit boundaries. As is clear in cases regarding wastewater disposal, the grant of an administrative permit is not a defense to a trespass, nuisance, or liability for damages.[252] Professor Kramer writes:

> It is an axiomatic rule of administrative law that in the absence of an express delegation of authority by the legislature, administrative bodies lack the power to adjudicate common law causes of action or otherwise license or permit private actions that would violate some common law duty, be it contract, property, or tort-based.[253]

While a mechanism exists for the owner outside the unit boundaries to petition for inclusion in the unit, the availability of that relief does not preclude the owner's ability to sue under common-law principles of tort. Further, the challenges of administering such a program illustrate the difficulty in demarcating boundaries for injection units and the storage complex. While geologic features such as faults will surely be informative in setting some boundaries, in other cases, modeling will attempt to predict the location of the plume and associated zone of pressurization. Accordingly, the creation of a unit for CCS purposes will not preclude an action by an owner outside the unit for common-law trespass, thus necessitating precisely the type of legislative delegation that Professor Kramer contemplates.[254]

In order to promote CCS, state legislatures should consider integrating correlative rights language into their carbon capture and pore space statutes. The majority of state statutes for oil and gas conservation include correlative rights language, and, although oil and gas conservation is not a direct analog, accordingly state legislatures have an established model from which to draw. Further, while the importance of doing so should not be diminished, through careful drafting, it is possible to avoid potential pitfalls that could unsettle well-established norms of the relative rights and liabilities for mineral and surface owners. For example, legislatures should be intentional as to whether, and under what conditions, if any, a declaration of correlative rights among pore space owners would upend the dominance of the mineral estate in depleted reservoirs, preclude suit by mineral owners for damage to mineral reservoirs resulting from CCS operations,[255] or provide surface owners with entitlements in oil and gas permitting or unitization proceedings.

As Professor Hall notes, the effective administration of a correlative rights framework in the subsurface will require complex and active administration.[256] State conservation agencies are accustomed to making determinations related to proportionality of reservoirs, and are therefore well-positioned to administer CCS programs and to resolve disputes relating to non-mineral pore space use. There are a multitude of boundary-related challenges that state agencies would be tasked with adjudicating, including the extension of the reservoir community and the proportionate ownership within it. Whereas surface acreage over a hydrocarbon reservoir is often upheld as an adequate mechanism for determination of allocation formulas for pools and units, the appropriateness of such a mechanism as applied to pore space should be carefully evaluated.[257] While state legislatures considering a correlative rights framework may add to predictability through their definitions and the establishment of procedures for making boundary and proportionality determinations, it is likely that as state agencies address concerns, the precision and clarity of the doctrine as applied to CCS will increase.

As with any proposal that suggests property law transitions, adoption of a correlative rights framework in pore space would likely give rise to takings challenges. An analysis of whether a transition or clarification of property interests in pore space as correlative would give rise to successful takings litigation, or how any such declarations should be drafted to be resilient to takings challenges, goes beyond the scope of this Article.[258] However, as Professor Pierce emphasizes, correlative rights do not strive to redefine property, but rather to "clarify and elaborate property entitlements."[259] The guiding principles of correlative rights, if applied to pore space, may be dispositive to determine takings challenges.

---

252. Fisher v. Continental Res., Inc., No. 1:13-CV-097, 2015 WL 11400124 (D.N.D. Oct. 8, 2015); Raymond v. Union Tex. Petroleum, 697 F. Supp. 270 (D. La. 1988); Railroad Comm'n v. Manziel, 361 S.W.2d 560 (Tex. 1962); FPL Farming Ltd. v. Environmental Processing Sys., L.C., 351 S.W.3d 306 (Tex. 2011); Hartman v. Texaco Inc., 937 P.2d 979, 983 (N.M. Ct. App. 1997); Greyhouse Leasing and Financial Corp. v. Junior City Unit, 444 F.2d 439 (10th Cir. 1971), Gulf Oil Corp. v. Hughes, 371 P.2d 81 (Okla. 1962).

253. Kramer, *supra* note 5, at 104. Note that in some cases, however, unitization has been found to alter trespass rules with respect to the surface of property within the unit. *See* Nunez v. Wainoco Oil & Gas Co. 488 So. 2d 995 (La. 1986); Entek GRB, LLC v. Stull Ranches, LLC, 763 F.3d 1252 (10th Cir. 2014), *cert. denied*, 135 S. Ct. 1895 (2015).

254. Although a designation of correlative rights may nudge courts away from finding trespass within the permitted unit, legislatures could also consider language limiting remedies for trespass. *See*, *e.g.*, 31 La. Rev. Stat. §§8-10 (1975).

255. Mineral owners experiencing reservoir damage as a result of CCS operations would likely be able to demonstrate the type of substantial harm and interference with use and enjoyment that has been required by courts in subsurface trespass cases to necessitate either injunctive relief or damages. See discussion *supra* notes 86 and 168-74.

256. Hall, *supra* note 141.

257. Anschutz Corp. v. Wyoming Oil & Gas Conservation Comm'n, 923 P.2d 751 (Wyo. 1996); Railroad Comm'n of Tex. v. Pend Oreille Oil & Gas Co., Inc., 817 S.W.2d 36 (Tex. 1991); Grace v. Oil Conservation Comm'n of N.M., 531 P.2d 939 (N.M. 1975); Masonite Corp. v. State Oil & Gas Bd., 240 So. 2d 446 (Miss. 1970).

258. For analysis on whether a "landowner has a sufficient interest in the pore space to implicate the takings clause," see Klass & Wilson, *supra* note 3, at 409; Pierce, *supra* note 14, at 251-52. While it may not be entirely dispositive, compulsory pooling and unitization rules have withstood challenge to both regulatory taking and due process claims, *see, e.g.*, Marrs v. City of Oxford, 24 F.2d 541 (D. Kan. 1928), *aff'd*, 32 F.2d 134 (8th Cir. 1929), *cert. denied*, Ramsey v. City of Oxford, 280 U.S. 563, 573 (1929); Patterson v. Stanolind Oil & Gas Co., 77 P.2d 83 (Okla. 1938), *appeal dismissed*, Patterson v. Stanolind Oil & Gas Co., 305 U.S. 376 (1939); Bruce M. Kramer, *Compulsory Pooling and Unitization With an Emphasis on the Statutory and Common Law of the Eastern United States*, 27 Energy & Min. L. Inst. Ch. 7, 227-29, (2007).

259. Pierce, *supra* note 14, at 251.

Oil and gas conservation laws have largely withstood takings and due process challenges due to the anti-waste elements of those laws.[260] Thus, while it may be unintuitive to apply concepts of waste to CCS uses of pore space, there may be considerable benefit in doing so.[261] The principal of preventing waste is core to both customary and regulatory restrictions on use of shared resources.[262] Waste is the bounding principle of the rule of capture and the basis for conservation laws applied to oil and gas operations.[263] In order to protect the correlative rights of others in the reservoir—and the public good associated with efficient hydrocarbon production—no owner may use his or her private property in the reservoir in a way that makes the reservoir materially unrecoverable, thus diminishing the public interest and damaging the rights of others within the reservoir community to do the same.[264]

The articulation of the concept of waste, at least as it has been traditionally understood in the concept of oil and gas conservation laws, as applied in non-mineral pore space is more challenging.[265] Except to the extent that CCS operations may be injurious to oil and gas operations, a possibility that is adequately covered under the modern rule of trespass, neither the concepts of physical waste or the dissipation of reservoir energy resulting in the stranding of hydrocarbons underground, nor economic waste, are easily applied. Yet, the application of broader waste principles in the pore space offer potential in that it may increase the reactivity and adaptability of property frameworks in the pore space and, through establishment of a public interest in CCS, create resilience to takings claims.[266]

By establishing correlative rights as the framework for understanding property interests in the pore space, legislatures can resolve some of the lingering ambiguities related to subsurface trespass resulting from carbon capture activities. As legislatures move to define ownership and entitlements within the pore space through declarations of ownership and the enactment of conservation and unitization laws for pore space use, they have the ability to set expectations as to the rights of proportionality that exist between members of the reservoir community. When correlative rights can be incorporated as part of the initial declaration of pore space ownership, at least as to those strata that are useful for operations for CCS, legislatures may be able to proactively overcome the natural hardening of entitlements that occurs over time. In so doing, legislatures can promote efficient use of the pore space and encourage investment in CCS projects.

V. Conclusion

The issue of trespass presents a significant obstacle to the efficient and utilitarian development of the subsurface pore space for geologic carbon sequestration. Substances injected as part of carbon capture operations can migrate across property lines. These intrusions violate a property owner's interest in the exclusive possession of his or her property and, based on traditional expressions of the *ad coleum* doctrine, result in a trespass.

However, most courts have been wary to award damages or injunctive relief against intangible subsurface intrusions in the absence of actual physical damage or unreasonable interference with a property owner's existing or foreseeable use of his or her property. This yields a troubling paradox: an owner can neither use and occupy the non-mineral pore space for carbon capture without impermissibly intruding upon the property of a neighbor, nor is the owner assured a remedy against trespasses against him or her. The result diminishes private-property interests in the pore space, discourages private ordering and investment, and results in the underutilization of property.

This Article suggests that rather than eliminating private-property interests within the deep non-mineral pore space, these interests should be more fully defined as a type of limited common property with a strong emphasis on proportionate use. Correlative rights create a legal privilege among members of a subsurface reservoir community whereby each may reasonably use his or her just and proportionate share of the reservoir without liability for trespass resulting from migration of injected substances across property lines. Thus, the correlative rights framework responds to the anticommons problem that threatens to develop with respect to pore space usage in the non-hydrocarbon subsurface.

260. Bruce Kramer, Basic Conservation Principles and Practices: Historic Perspectives and Basic Definitions 1 (Rocky Mountain Mineral Law Found. 2006).
261. Michael Pappas, *Anti-Waste*, 56 Ariz. L. Rev. 741, 788 (2014).
262. Rose, *supra* note 180, at 125 (Customary use of the medieval commons had been hedged with restrictions that limited depletion of resources.).
263. Pierce, *supra* note 14, at 245 (citing *Ely*, *supra* note 223; J. Howard Marshall & Norman L. Meyers, *Legal Planning of Petroleum Production*, 41 Yale L.J. 33 (1931); Howard R. Williams, *Conservation of Oil and Gas*, 65 Harv. L. Rev. 1155 (1952)).
264. *Id.* at 249.
265. Pappas, *supra* note 261. Proposed legislation introduced in Montana adopted definitions of waste as commonly understood in the oil and gas industry, *see* B. No. LC2279, 65th Gen. Assemb., Reg. Sess. (Mont. 2017).
266. *Id.* at 789 (citing J. Peter Byrne, *Rising Seas and Common Law Baselines: A Comment on Regulatory Takings Discourse Concerning Climate Change*, 11 Vt. J. Envtl. L. 625, 642 (2010); Michael Pappas, *Energy Versus Property,* 40 Fla. St. U. L. Rev. 435 (2014); Joseph L. Sax, *Property Rights and the Economy of Nature: Understanding* Lucas v. South Carolina Coastal Council, 44 Stan. L. Rev. 1433, 1447-48 (1993); Barton H. Thompson Jr., *Judicial Takings*, 76 Va. L. Rev. 1449, 1449-50 (1990)).