Contracting the Void: Land, Capital, and Sequestration

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Carbon capture and sequestration (CCS) is poised to play a critical role in efforts to mitigate climate change. As CCS projects proliferate across the United States, they are fundamentally recasting the nature of certain property rights in the subsurface. This has given rise to novel legal and economic questions regarding the acquisition and valuation of pore space for long-term carbon dioxide (CO_2) storage. This article examines the emerging legal frameworks and market dynamics for transactions of pore space for geologic carbon sequestration, contributing both a theoretical and uniquely empirical perspective on early transactional models and impacts to the long-term development of the CCS industry.

This article offers the first empirical assessment of compensation structures in pore space contracts. Analyzing structures from publicly available agreements, it reveals how project developers and landowners are allocating risk and value at different stages of project development. This illustrates how uncertainties associated with the extent of the subsurface resource, revenue sources, and the timing of development impact deal structure. This has led to emerging trends such as phased bonus payments, dynamic rental structures, and volumetric compensation mechanisms. The structure of these contracts incorporates aspects of other depletable resource contracts, such as oil and gas leases.

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Carbon sequestration, however, requires greater commonality of pore space resources to assure adequate storage capacity and manage environmental and containment risks. This can require tremendous amounts of land and coordinated operations within the project area. These differences, along with the vital role of carbon removal to climate mitigation, provide an opportunity to critically explore the choice to develop carbon sequestration projects using the same models adopted for oil and gas. Land acquisition adds cost and complexity to these projects. Moreover, landowners may defer leasing until markets are more developed or subsurface resources are more fully characterized, increasing the ultimate cost of climate mitigation. While states have endeavored to reduce transactions costs through legislation, the combination of property law and political choices regarding the development of CCS projects may ultimately impede the timely achievement of climate mitigation as a public good.

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I. INTRODUCTION

Landowners hold the key to achieving the United States' carbon removal ambitions.[1] Sequestering carbon dioxide (CO_2) from energy production and other industrial activities via carbon capture and sequestration (CCS) will require the acquisition of tens of millions of acres of subsurface property rights in pore space—a geologic term referring to the deep network of spaces, pores, and voids between particles in deep underground formations.[2] The growth of the CCS industry has therefore resulted in an emerging market for reservoir storage rights that is distinct from the conventional subsurface rights transactions.

As CCS projects proliferate across the U.S., a new frontier in property rights is unfolding as prospective storage operators race to secure the subsurface rights needed for CO_2 injection and permanent storage. In recent years, numerous scholars have opined on the challenge pore space presents to foundational doctrines of property law and the need to reconceptualize the rules that govern the use and legal character of rights in the subsurface.[3] Much of this scholarship has considered the question of *who* owns the pore space in split estates,[4] but once the owner has been identified, scholars have paid markedly less attention to the contracting instruments by which

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1. *See* Intergovernmental Panel on Climate Change [IPCC], *Summary for Policy Makers, in* CLIMATE CHANGE AND LAND (P.R. Shukla et al. eds., 2019); *see also* INT'L ENERGY AGENCY, ENERGY TECHNOLOGY PERSPECTIVES 2020 (2020), https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf [https://perma.cc/6D9W-HUYB].

2. Joseph Schremmer, *Pore Space Property*, 2021 UTAH L. REV. 1, 8 (2021). Suitable underground formations may include saline aquifers, shales, basalts, coal seams, and depleted oil or gas fields that are capable of receiving and securely storing injected CO2. *Carbon Storage FAQs*, NAT'L ENERGY TECH. LAB., https://netl.doe.gov/carbon-management/carbon-storage/faqs/carbon-storage-faqs [https://perma.cc/4VAC-N42A] (last visited Jan. 8, 2024).

3. *See, e.g.*, K.K. Duvivier & Tara Righetti, *Changing Paradigms for a Low-Carbon World*, 46 HARV. ENV'T L. REV. 59, 66–67 (2022); Owen L. Anderson, *Geologic CO2 Sequestration: Who Owns the Pore Space?,* 9 WYO. L. REV. 97, 99 (2009); John Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979 (2008).

4. Schremmer, *supra* note 2, at 3.

interests in pore space can be acquired.[5] These inquiries have been limited to normative explorations into potential regulatory models[6] or the theoretical parallels in oil and gas development that *could* inform contracting mechanisms for pore space.[7] Because the market for pore space storage rights is only now beginning to develop at scale, scholarly assumptions about the structures and mechanisms by which rights in pore space are conveyed and valued have not yet been validated.

Contracting for pore space is first unique in a spatial sense. Pore space introduces a four-dimensional complexity where rights may cross multiple property boundaries both laterally and vertically. These often intersect with other rights and resources in the subsurface, the priority of which may change over time.[8] Though the spatial complexity of the resource is not completely novel—with oil and gas operations having presented similar nuances for decades—pore space is nevertheless unique. To be economically viable, geologic carbon storage projects must typically operate at a scale of injection up to several million metric tons.[9] This volume, combined with regulatory requirements, translates to the need for significant contiguous pore space access, sometimes up to several hundreds of

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5. Professor Keith Hall has written the primary paper on this topic. *See* Keith Hall, *Drafting and Negotiating Instruments to Acquire Pore Space Rights for CCS*, 69 NAT. RES. & ENERGY L. INST. 5-1, 5-17 (2023).

6. *See* Interstate Oil & Gas Compact Comm'n Task Force on Carbon Capture & Geologic Storage, Storage Of Carbon Dioxide In Geologic Structures, A Legal And Regulatory Guide For States And Provinces 31–35 (2007), https://oklahoma.gov/content/dam/ok/en/iogcc/documents/publications/co2-storage/CCGS%202007%20Final.pdf [https://perma.cc/NQ5T-SP2L].

7. See R. Lee Gresham & Owen L. Anderson, Legal and Commercial Models for Pore-Space Access and Use for Geologic CO2 Sequestration, 72 U. PITT L. REV. 701, 704–05 (2011).

8. In split estates, the mineral estate is dominant relative to the surface estate. *See, e.g.*, Hunt Oil Co. v. Kerbaugh, 283 N.W.2d 131, 134–35 (N.D. 1979). Accordingly, the mineral owner would have priority to use the pore space for purposes related to oil and gas extraction. Merriman v. XTO Energy, Inc., 407 S.W.3d 244, 248–49 (Tex. 2013) ("[I]ncidental rights reasonably necessary for [extraction] . . . include . . . the right to use as much of the surface as is reasonably necessary to extract and produce the minerals"). Once oil and gas ceased to be commercially producible, the mineral owner's right to use the pore space would cease. However, if minerals became commercially producible at a later time due to increased prices or improved technology, the mineral estate would regain priority and have the right to use the pore space—irrespective of whether the surface owner had used it for storage during the interim period. Otherwise stated, the mineral estate is always dominant, but its rights to use the pore space are limited to those related to production. Where production is feasible, it has priority. *See* Kevin M. Beiter & Austin W. Brister, *Divided Surface and Mineral Estates––What's Mine Is Mine and Sometimes What's Yours Is Mine Too*, 64 RMMLF-INST. 4, 4–8 (2018).

9. *Carbon Storage FAQs*, *supra* note 2.

thousands of acres. Pore space therefore requires greater commonality and unanimity to develop than oil and gas resources.

The nature of property interests in pore space can also be distinguished from conventional depletable natural resources. Unlike oil and gas resources that can be extracted and severed from the subsurface, pore space derives its value from the absence of corporeality. This translates to its capability to receive and store injected CO_2 or other substances. Pore space derives its value as a resource from its storage *potential*. This may not necessarily correlate with the amount of CO_2 that an operator is able to offtake from various point sources and transport to the location. At least currently, with significant transportation constraints, this creates highly localized markets that may have only one realistic buyer. This requires the landowner to consider the opportunity costs of leasing given the real possibility for under-injection and the potential utility of the pore space for other purposes.

Next, contracting for geologic carbon sequestration presents unique challenges from an economic perspective. These challenges stem largely from the lead character of the CCS industry: CO_2. CO_2 has long been commodified for applications in diverse manufacturing, food, beverage, and medical settings, and is also widely used as an injectant to aid in enhanced oil recovery (EOR).[10] Yet, the CO_2 used for these purposes has historically been derived from naturally occurring underground reservoirs of CO_2—i.e., terrestrial or geologic sources. So-called anthropogenic CO_2, on the other hand, is regarded as a waste product. In 2008, the United States introduced the 45Q tax credit to incentivize the capture and storage of anthropogenic CO_2, with substantial enhancements to the credit introduced in 2022 via the passage of the Inflation Reduction Act (IRA). Along with other sources of direct funding through the IRA and the Infrastructure Investment and Jobs Act of 2021 (IIJA), 45Q tax credits are the primary driver of the CCS industry. However, commercial models for CCS under 45Q remain largely untested. They are highly dependent on the continued availability of the tax credit as well as the buildout of capture and transport infrastructure that does not yet exist. These contingencies pose uncertainties that must be accounted for

10. *Putting CO2 to Use*, INT'L ENERGY AGENCY (Sept. 2019), https://iea.blob.core.windows.net/assets/50652405-26db-4c41-82dc-c23657893059/Putting_CO2_to_Use.pdf [https:/perma.cc/3VBU-MD3Y].

throughout various stages of project development and addressed as part of the entire buildout of the industry.

Regulatory and liability considerations also introduce risk for both the landowner and the operator. The Class VI regulatory program that applies to injection wells for geologic sequestration requires the operator to take long term responsibility for plume management and monitoring, reporting, and verification throughout the entire area of review (AOR)—an area that encompasses the entire free CO_2 plume and which is likely to exceed the boundaries of any single parcel.[11] These active obligations continue for 50 years or as long as 100 years under some state programs.[12] This discourages multiple concurrent or successive operations, compounding the risk of under-injection. If the operator does not fully exhaust the storage potential, permit requirements for post-injection monitoring, reporting, and verification (MRV), along with other private and public liabilities, make it highly unlikely that a successor operator will contract with the landowner for the residual pore space. In this aspect, the formation is equivalent to a brownfield property, where imbedded liabilities create substantial barriers to reuse.[13]

The nascent nature of the CCS industry introduces unique risks that may impede contracting for pore space. For as many unknowns that exist for the CCS operators pioneering this industry, such unknowns are greater still for the landowners being asked to sign over rights in their property in perpetuity. From a landowner's perspective, risk lies not only in the technology, but also in the capabilities and qualifications of the particular operator. The landowner must consider the operator's ability to secure a reliable source of CO_2 sufficient to compensate for the landowner's lost opportunity value and Congress' continued support for carbon removal. These risks and

11. 40 C.F.R. § 146.84; U.S. Env't Prot. Agency, EPA 816-R-13-005, Underground Injection Control (UIC) Program Class VI Well Area of Review Evaluation and Corrective Action Guidance 2 (2013) ("[T]he [area of review] encompasses the region overlying the separate-phase (e.g., supercritical, liquid, or gaseous) carbon dioxide plume and the region overlying the pressure front where fluid pressures are sufficient to force fluids into a USDW.").

12. EPA requires 50 years of post-injection site care, *see* 40 C.F.R. § 146.93; California's CCS protocol requires a post injection site care and monitoring period of 100 years following cessation of injections, CAL. CODE REGS. 17 § 95480 et seq. (Barclays 2024).

13. Federal law defines a brownfield as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant," *see* 42 U.S.C. § 9601(39)(A). As with CCS, much of the challenge associated with brownfield redevelopment arises by virtue of regulatory requirements—namely CERCLA—that could impose liability on future owners, *see* Joseph Schilling, *Beyond Brownfields Redevelopment*, 5 J. COMP. URB. L. & POL'Y 468, 471 (2022).

uncertainties may emerge in different forms throughout the phase of the project—from site characterization to post-injection monitoring—requiring adjustment of contractual and compensatory mechanisms. These concerns may raise existential questions about the extent to which a landowner should bear risk related to receiving and storing a waste product for which society is collectively responsible.

This article first addresses the gamut of rights that must be acquired for operation of a carbon sequestration project, the forms of contracts that can be used to acquire those rights, and emerging norms regarding compensation in contracts for pore space access. Part II lays the groundwork for this assessment with a summary of the doctrinal laws, legislation, and jurisprudence that inform the classification of pore space interests as rights in real property. As with any form of real property, a threshold question is ownership. It explores trends in the emerging body of legislation codifying this right, with special inquiry into the challenges posed by split estates. Against this backdrop, Part II describes the challenge of resource fragmentation relative to pore space access for CCS.

Part III identifies the rights that an injector requires as prerequisites for project development. The extent of access required for geologic sequestration projects is not only widely encompassing in a geographical sense, but also technically and temporally, requiring the operator to secure authorizations for characterization, facilities construction, and monitoring at various stages before, during, and after injections. The acquisition of and compensation for each right must be accounted for in negotiation. Though compensation mechanisms that have become standard for contracts for oil and gas extraction may serve as some precedent to instruct compensation models for geologic sequestration projects, the unique nature of property rights in pore space and the distinct market risks involved in geologic sequestration projects requires adjustments from conventional fossil fuel leasing models.

In Part IV, the article examines the extent to which the doctrinal and theoretical assumptions about pore space acquisition, contracting, and valuation hold against a number of publicly available pore space leases and easements. These agreements span several states with CCS projects in development, including California, Colorado, Louisiana, Mississippi, North Dakota, Texas, and Wyoming. Embracing a uniquely empirical approach in this section, the article details the results of an extensive search through hundreds of recording memoranda and dozens of publicly available pore space leases to assess the evolution of new leasing frameworks and compensation mechanisms. This evaluation of contract and compensation structures for grants of interest in pore space can support the development of commercial models and implementation of state laws allowing for condemnation of subsurface rights or unitization laws mandating payment of fair market value.

Although trends are beginning to emerge, existing transactions represent only a fraction of the rights that will be needed to achieve carbon sequestration at scale. The uncertainties that impede pore space contracting may also undermine achievement of the United States' climate ambitions. Part V examines the challenges that pore space acquisitions present relative to scaling CCS to the level required to achieve large scale carbon removal. Notwithstanding contracting in a few areas throughout the country, the uncertainties associated with CCS may encourage landowners to delay contracting until values increase due to changes in technology, transport, capacity and markets. Expropriation, unitization or other state level amalgamation laws will not solve all of these challenges, requiring reconsideration of the mechanisms by which pore space is acquired and carbon sequestration is incentivized.

II. THE NATURE OF RIGHTS IN PORE SPACE

Understanding the legal frameworks by which pore space can be acquired and valued for geologic sequestration projects first necessitates inquiry into a threshold question: what *is* pore space? This section examines the complex nature of rights in pore space, analyzing how pore space interests are positioned within existing bedrock principles of property law. A growing body of legislation and case law has begun to provide needed definition around pore space as a real property resource. Precedents from oil and gas provide insight into its nature and the relationships that govern its use. These relationships are particularly complex in the case of split estates, where the necessary rights for sequestration projects may overlap with those conveyed by oil and gas leases in the same parcel, limiting the surface owners' ability to grant exclusive rights. These complexities, in combination with jurisdictional and geologic delineators, fragment the pore space resources needed for large commercial-scale projects and introduce challenges for property rights acquisition and coordination.

A. Pore Space as Property

Pore space is an interest in real property. Thus, it is governed by general property concepts and laws related to ownership, use, and conveyance. The application of these concepts to pore space, however, presents novel issues because, despite existing in the earth, pore space lacks the "thingness" normally associated with property.[14] As observed by some scholars, "[P]ore space is the conceptual embodiment of nothing. It is defined by that which creates it. Outside of that generative structure, it does not exist."[15] Yet together, pore space and the surrounding rock are clearly an interest of value which encompasses the rights, responsibilities, and relationships associated with property. Together, these interests comprise what some legislatures and scholars have referred to as the "reservoir estate."[16]

While there is no debate that pore space is property, the nature of the interest is much less clear. Though the pore spaces and the generative structures within a specific parcel of land are physically immoveable, the reservoirs they comprise are interconnected as part of subsurface geologic and hydrologic systems that cross property boundaries. This creates a division between ownership of the thing—the pore volume itself—and the right to use the resource for storage of CO_2 or other substances. The likely migration of injected substances or displacement of fluids across property boundaries raises the question of whether ownership of pore space is corporeal or incorporeal, and possessory or non-possessory. This distinction is not only a theoretical dichotomy but also influences the mechanisms for bringing potential property into ownership and the rights and procedures related to, *inter alia*, abandonment of ownership, actions for ejectment, partition, and trespass, as well as adverse possession.[17]

Property interests are in general classified as either corporeal or incorporeal. Corporeal property is tangible, meaning the property can

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14. Meredith M. Render, *The Law of the Body*, 62 EMORY L. J. 549, 556 (2013); Michael A. Heller, *The Boundaries of Private Property*, 108 YALE L.J. 1163, 1193–94 (1999).

15. Kevin L. Doran & Angela M. Cifor, Does the Federal Government Own the Pore Space Under Private Lands in the West? Implications of the Stock-Raising Homestead Act of 1916 for Geologic Storage of Carbon Dioxide, 42 ENV'T. L. 527, 540–41 (2012).

16. *See, e.g.*, NEB. REV. STAT. § 57-1610 (West 2024).

17. Martin & Kramer, Williams & Meyers Manual of Oil and Gas Terms (2015).

be seen, touched, or possessed—while incorporeal property is intangible and incapable of being physically possessed.[18] Whereas possessory, corporeal 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," incorporeal interests are abstract and nonpossessory in nature.[19] An incorporeal interest embodies a right to a thing, which "inheres in and is supported by a corporeal thing."[20] Incorporeal types of property interests include future interests such as reversions and remainders, which may eventually become possessory, or interests such as easements or licenses,[21] which only confer on the owner certain rights of access and use—not possession.[22]

Most interests in real property, such as fee simple ownership in a house, tract of land, or other piece of real property are considered corporeal: the object to which the interest pertains is capable of being occupied, possessed, or marketed for economic rent.[23] This is true for both the land itself and for solid minerals, including hard rock minerals and coal. Where these substances exist, their quantity and location are immutable.[24] Thus, anyone possessing real property will of necessity also be in physical possession of those minerals. Fluid minerals are more difficult to classify because they are fugacious and subject to migration. As a result, some courts have found that the owner of a fluid mineral interest in land has only an incorporeal interest. The owner cannot be in physical possession of the minerals until it has brought them to the surface or otherwise contained them, because, for so long as they remain within the reservoir, they may be subject to migration.[25] In these states, the incorporeal mineral

18. Carol M. Rose, *Possession as the Origin of Property*, 52 U. CHI. L. REV. 73, 83 (1985) (citing Millar v. Taylor, 98 Eng. Rep. 201, 230–31 (K.B. 1769) (Yates, J., dissenting)).

19. Tara K. Righetti, Correlative Rights and Limited Common Property in the Pore Space: A Response to the Challenge of Subsurface Trespass in Carbon Capture and Sequestration, 47 ENV'T. L. REP. 10420, 10428 (2017) (citing NANCY SAINT-PAUL, SUMMERS OIL AND GAS § 8.9 (3d ed. 2015)).

20. 1 TIFFANY REAL PROP. § 4 (3d ed.) (West 2024).

21. *See* Mueller v. Hoblyn, 887 P.2d 500, 504 (Wyo. 1994).

22. *Id*.

23. *Id*.

24. LA. STAT. ANN. § 31:18 (1974) ("A mineral right is an incorporeal immovable. It is alienable and heritable. The situs of a mineral right is the parish or parishes in which the land burdened is located."); Gerhard v. Stephens, 442 P.2d 692, 706 (Cal. 1968); Funk v. Haldeman, 53 Pa. 229, 249 (1867).

25. *See, e.g.,* Connell v. Kanwa Oil, 653, 170 P.2d 631, 634 (Kan. 1946); Dabney-Johnston Oil Corp. v. Walden, 52 P.2d 237, 243 (Cal. 1935).

interest is more akin to a profit which provides the owner with the exclusive right to try to bring the minerals into possession from the property.[26] In contrast, states taking a corporeal view consider the owner of a mineral interest to be in possession of the minerals within that land, subject to the potential of capture by others.[27]

Pore space tests the limits of these classifications. Debates about the corporeality of fluid mineral interests (and similarly groundwater) focus on the ownership of the physical substance within the pores while it remains in the ground. While these substances may migrate within the land, once brought to the surface they are a physical thing capable of being possessed. Pore space never achieves this finality. While the capacity of pore space can be exhausted or depleted in place, the resource itself remains subject to reservoir factors that could cause migration of substances into the pores. Pore space therefore has both corporeal and incorporeal characteristics. It is embodied at all times as part of the land, yet its capacity as a reservoir (and therefore its value) is still subject to capture. As stated by Professor Righetti, "[pore space] 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."[28]

How pore space is classified has significant implications for pore space contracts and values. Some scholars have classified the interest as possessory, thus giving the holder an exclusive right to fill, empty,

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26. *See, e.g., Connell*, 170 P.2d at 634 ("an oil and gas lease conveys no interest in the land therein described but merely a license to explore, and is personal property—an incorporeal hereditament—a profit a prendre"); *Dabney-Johnston Oil Corp.*, 52 P.2d at 243 ("The owner of land has the exclusive right on his land to drill for and produce oil. This right inhering in the owner by virtue of his title to the land is a valuable right which he may transfer. The right when granted is a profit á prendre, a right to remove a part of the substance of the land. A profit á prendre is an interest in real property in the nature of an incorporeal hereditament.").

27. *See* Powers v. Union Drilling, Inc*.*, 461 S.E.2d 844, 848–49 (W. Va. 1995) ("[T]he owner of the fee is vested with title in the oil and gas underlying the boundary to which he holds title, although it is admitted that due to the nature of both or either they may not remain in place and are not the subject of actual possession until brought to the surface, because until that occurs there is no way to determine positively that oil or gas does, in fact, lie under a designated boundary.") (internal citations omitted); Stephens County v. Mid–Kansas Oil & Gas Co., 254 S.W. 290, 292 (Tex. 1923) ("We do not regard it as an open question in this state that gas and oil in place are minerals and realty, subject to ownership, severance, and sale, while embedded in the sands or rocks beneath the earth's surface, in like manner and to the same extent as is coal or any other solid mineral.").

28. Righetti, *supra* note 19, at 10428.

and occupy it and to exclude others.[29] In this classification, one of the values of obtaining an interest in pore space would be the right to exclude others from the land—thereby granting a measure of exclusivity to the holder. Injected CO_2 itself is classified as a personal property interest, the title to which remains with the injector.[30] It does not become part of the realty in which it is stored. Therefore, if the interest in the pore volume is considered possessory, intrusion of CO_2 or other substances owned by another could be considered a trespass that interferes with the right of possession. The acquirer of pore space would thus have a right to protect its economic interests in use of the subsurface through the operation of civil law. Yet, that classification poses significant challenges in administrability. Pore space resources are inherently connected. If occupation of the pore volume is possession, the owner is at all times subject to dispossession through the actions of other owners within the same reservoir system. Other scholars have found that this susceptibility to capture renders a property interest in pore space fundamentally incorporeal, more akin to a usufruct.[31]

While there is not yet any direct case law considering trespass claims resulting from indirect migration of CO_2, cases arising in the context of oil and gas, wastewater, and chemical disposal may provide some guidance.[32] In the context of split estates, cases involving claims by surface owners related to subsurface intrusions from adjacent property indicate different views on the corporeal nature of a pore space interest. In one of the earliest cases, *Chance v. BP Chemicals, Inc.*, a group of landowners brought a class action alleging trespass resulting from indirect migration of injected chemical and wastewater.[33] The Supreme Court of Ohio allowed the trespass action to proceed, finding that BP's receipt of an injection permit did not insulate it from liability. The court, however, declined to establish an absolute right in the subsurface, finding instead that the injector would be liable only if its operations interfered with the landowner's

29. The Restatement of Property (Fourth) classifies the interest as corporeal. RESTATEMENT (FOURTH) OF PROPERTY § 1.12 (AM. L. INST., Tentative Draft No. 4, 2023).

30. WYO. STAT. § 34-1-153. This approach aligns with long standing oil and gas case law holding that gas injected for storage does not revert to the realty. *See* Northern Natural Gas Co. v. L.D. Drilling, Inc., 862 F.3d 1221 (10th Cir. 2017); B.L. McFarland Drilling Contractor v. Connell, 344 S.W.2d 493, 495-97 (Tex. Civ. App. 1961).

31. *Compare* Schremmer, *supra* note 2, at 9, *with* Righetti, *supra* note 19, at 10428–29.

32. Righetti, *supra* note 19, at 10429–30.

33. Chance v. BP Chems., 670 N.E.2d 985 (Ohio 1996).

"reasonable and foreseeable use of the subsurface."[34] By focusing on the owner's rights of use, rather than its rights to exclude, *Chance* takes more of an incorporeal view of pore space ownership. The court distinguishes the surface owner's interest in the rock from its interest in the "native brine" into which the injectate is dispersed.[35] It found, therefore, that the owner could not assert an absolute and exclusionary right in the voids within the rock, but that it could claim injury if its right to use the subsurface of its property were damaged.

In a similar case, *FPL Farming, Ltd. v. Environmental Processing Systems, L.C,* a landowner claimed trespass based on indirect migration of wastewater from an adjoining property.[36] As in *Chance*, the Texas Supreme Court found that the operator's permit to inject did not insulate it from civil liability for trespass.[37] Yet, in contrast to the incorporeal view adopted in *Chance,* the appellate court found that the landowner's property interest in the surface extended to the saltwater beneath its property.[38] Accordingly, the court found that a landowner could bring a claim for trespass to protect its right to "exclusive use of its property."[39] This holding is consistent with a corporeal view of the landowner's interest in pore space—namely that the landowner has the right to exclude.

This same absolute view of pore space ownership is reflected in more recent precedent. In a 2022 holding, the North Dakota Supreme Court in *Northwest Landowners Association v. State of North Dakota* invalidated as unconstitutional portions of a bill prohibiting a cause of action for pore space trespass.[40] It found that by allowing "third-party oil and gas operators to physically invade a landowner's property by injecting substances into the landowner's pore space, [the

34. *Id.* at 992.

35. *Id.*

36. FPL Farming, Ltd. v. Env't Processing Sys., L.C., 383 S.W.3d 274 (Tex. App. 2012), *rev'd*, 457 S.W.3d 414 (Tex. 2015).

37. Env't Processing Sys., L.C. v. FPL Farming, Ltd. 457 S.W.3d 414 (Tex. 2015).

38. *FPL Farming*, 383 S.W.3d 274 (Tex. App. 2012), *rev'd*, 457 S.W.3d 414 (Tex. 2015). The jury's verdict for the operator was eventually upheld. The jury found the landowner had consented to the injections, thereby obviating any claim for trespass. In upholding this verdict, the Texas Supreme Court expressly declined to address the appellate court's holding that the landowner could bring a trespass action for indirect fluid migration.

39. *Id.* Notwithstanding this, the jury's verdict for the operator was eventually upheld. *Env't Processing Sys.*, 457 S.W.3d 414 (Tex. 2015). The jury found that the landowner had consented to the injections, thereby obviating any claim for trespass. In upholding this verdict, the Texas Supreme Court expressly declined to address the appellate courts' holding that the landowner could bring a trespass action for indirect fluid migration.

40. N.W. Landowners Ass'n v. State, 978 N.W.2d 679 (N.D. 2022).

statute would] . . . take[] away one of the most treasured property rights because it takes away landowners' right to exclude oil and gas operators from trespassing and disposing waste into their pore space."[41] Citing *Loretto v. Teleprompter Manhattan CATV Corp*., the court invalidated the statute as authorizing third-party companies to occupy the landowners' subsurface property through the migration of fluids, thus destroying "the owner's right to possess, use, and dispose of the property."[42] By focusing on the owner's right to exclude, rather than its right of use, the opinion suggests a corporeal and possessory view of property in the reservoir estate. In 2025, the Supreme Court of Texas in *Myers-Woodward v. USM* issued a similar view, finding that the owner of salt production rights in a split estate had no rights of ownership or use in the subsurface salt caverns created by its salt recovery operations.[43] While the conveyance by which the mineral owner acquired its rights included salt, the court found it persuasive that the conveyance made no reference to the empty spaces or non-salt formations in which such salt was contained.[44] In so finding, the court drew a bright-line rule applied in favor of the surface owner, that "'the surface owner, and not the mineral lessee, owns the possessory rights to the space under the property's surface,' absent an agreement otherwise."[45]

Where cases involve subsurface trespass claims made by mineral owners, the outcomes are different. In the 2017 case of *Lightning Oil v. Anadarko E&P Onshore, LLC*, the Supreme Court of Texas declined to extend the holding in *FPL*.[46] In that case, the mineral owner alleged trespass by a licensee of the surface owner who drilled through its mineral estate.[47] Finding that the mineral owner's interest in the subsurface strata was nonexclusive, the appellate court refused to recognize a trespass by the traversing wellbore. Instead, in a holding the *Myers-Woodward* court found instructive, the court determined that the mineral owner had a "fair chance to recover the oil and gas" and a corporeal interest in the oil and gas molecules themselves, but

41. *Id*. at 691–92.
42. *Id*. (citing *Loretto*, 458 U.S. 419 (1982)).
43. Myers-Woodward, LLC v. Underground Services Markham, LLC, No. 22-0878, –– S.W.3d–– (Tex. 2025).
44. *Id.* at 13.
45. *Id.* at 14 (quoting Regency Field Servs., LLC v. Swift Energy Operating, LLC, 622 S.W.3d 807, 820 (Tex. 2021)).
46. Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 520 S.W.3d 39 (Tex. 2017).
47. Id.

that its interest did not translate to a right to control the "mass that undergirds the surface."[48] The Texas Supreme Court affirmed, finding an interference with the "place where the minerals are located constitutes a trespass as to the mineral estate only if the interference infringes on the mineral lessee's ability to exercise its rights."[49] The court held the permitting rules of the Railroad Commission and the accommodation doctrine were sufficient to mitigate subsurface conflicts.[50] *Lightning* stands for the proposition that while the mineral owner of a split estate has a corporeal interest in the minerals within the pores, its interest in the subsurface itself is not exclusive vis-à-vis the surface owner. The same can be said for the surface owner of a split estate. Such a surface owner owns the subsurface subject to the mineral owner's right of use. Within the community of owners, the rights are not exclusive, and therefore one cannot claim trespass by the other unless the use unreasonably infringes on its rights.

A similar rule may apply in cases between mineral owners in the same reservoir. In *Railroad Commission v. Manziel* the Supreme Court of Texas considered whether the Texas Railroad Commission erred in approving a plan of unitization, based on neighboring mineral owners' claims that injected water from the unit operations was likely to invade their property and water-out one of their oil wells.[51] In that case, both parties were conducting waterflood operations, both of which were resulting in migration of water and displacement of oil.[52] The court refused to prohibit the injections, finding that the rule of capture—which allows a mineral owner to capture oil and gas migrated from adjoining tracts—also permits it to "inject into a formation substances which may migrate through the structure to the land of others, even if it thus results in the displacement under such land of more valuable with less valuable substances."[53] The court deferred to the decision of the Railroad Commission that the waterflood was necessary to protect correlative rights of the injector.

Both *Lightning Oil* and *Manziel*, however, illustrate more about the nature of the mineral interest than they do about the interest in pore space. In both cases, the claimants were mineral owners. As

48. Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 480 S.W.3d 628 (Tex. App. 2015).
49. *Lightning Oil Co.*, 520 S.W.3d 39 (Tex. 2017).
50. *Id*.
51. R.R. Comm'n of Tex. v. Manziel, 361 S.W.2d 560 (1962).
52. *Id*. at 568.
53. *Id*. (quoting Williams and Meyers: Oil and Gas Law, § 204.5, n. 1).

recognized in *Lightning Oil* and *Myers-Woodward,* Texas considers a mineral interest to be a possessory, non-exclusive interest in the minerals in place under the land, but not an interest in the pore spaces itself. Although Texas courts have recognized trespasses against the mineral interest, the damages awarded in those cases relate either to the loss of speculative value or to conversion of oil, not invasion of the subsurface itself.[54] This is an important distinction because the harm is not based on a right of exclusion in the rock subsurface but rather the loss of minerals caused thereby.[55] Had the claim in *Manziel* been brought by an adjoining surface owner, outside the waterflood unit, the decision likely would have followed the reasoning in *FPL*, finding that the subsurface injections violated the surface owner's corporeal property rights.

The cases and legislation discussed in this section relate to use of pore space for waste disposal or oil and gas production. Courts have not yet decided to what extent these will extend to cases on pore-space use for CO_2 sequestration. The adjacent property cases indicate that permits to inject will not insulate the operator from an adjoining surface owner's claim of trespass resulting from fluid intrusion. Where subsurface interests are classified as possessory, these claims take the form of trespass *quare clausum fregit* and where interests are non-possessory, they resemble claims for trespass on the case, yet in both cases a trespass can be recognized. As many scholars have recognized, if courts adopt this view it could create an unworkable standard that could preclude use of the subsurface in basins with fragmented ownership and could also raise questions about the constitutionality of unitization statutes.[56] As the CO_2 sequestration industry develops, courts will need to consider not only claims of trespass by adjoining property owners but, as in *Manziel*, also how it will manage trespass claims by competing injectors, each with a permit to inject, and each resulting in brine migration and loss of storage capacity for others.

54. Humble Oil & Ref. Co. v. Kishi, 299 S.W. 687 (Tex. Civ. App. 1927); Champlin Ref. Co. v. Aladdin Petroleum Corp., 238 P.2d 827 (Okla. 1951).

55. This could be considered as a potential analog for competing injection activities by adjoining owners with reservoir rights. The court allowed competing injection activities notwithstanding transboundary migration of fluids, yet relied on the regulator to assure that neither party could exercise such rights in a way that unreasonably diminished the rights of the other.

56. *See infra* notes 40–42 and accompanying text.

The first United States case directly relating to migration of CO_2 injected for carbon sequestration has only recently reached the courts. In 2023, a putative class of Illinois landowners filed suit in Cook County, Illinois against Archer Daniels Midland Company (ADM) in an attempt to enjoin the company's injection of CO_2 captured from a nearby ethanal plant into pore space more than a mile below the surface of plaintiffs' property.[57] Plaintiffs have urged the court to adopt the reasoning set forth in *Northwest Landowners Association*, namely, that the right to exclude is paramount and therefore even minimal invasions require compensation. Conversely, defendant ADM asserted the plaintiffs' claims should be dismissed owing to their failure to demonstrate how the injections would interfere with any preexisting uses of the subsurface. They liken the alleged trespass to an invasion of air space, the ownership of which an Illinois court has held is limited only to that which a property owner "can practicably use."[58] Other issues at stake in the litigation include whether owners of pore space accrue an actionable claim of trespass based solely on plume modeling within the injector's Class VI application that demonstrates the potential for future expansion into unleased pore space. Indeed, in March 2024, defendant ADM filed for dismissal of the *Leach* lawsuit, claiming plaintiffs not only failed to demonstrate interference with a preexisting use of the subsurface but also failed to demonstrate an actual intrusion of CO_2 into the pore space underlying the plaintiffs' property.[59]

B. Ownership of Pore Space

The American common law of subsurface property is grounded in the English common law maxim *cujus est solum, ejus est usque ad coelum et ad inferos* ("from the heavens to the depths").[60] Taken literally, the result of this doctrine is that each landowner "supposedly owns a slender column of rock, soil, and other matter stretching downward over 3900 miles from the surface to a theoretical point in

57. Class Action Complaint, Leach v. Archer Daniels Midland Co., 2023CH06676 (July 19, 2023).

58. Memorandum in Support of ADM's Motion to Dismiss the Amended Complaint, Leach v. Archer Daniels Midland Co., 2023CH06676 (Cir. Ct., Cook Cty., Ill., Mar. 15, 2024) (quoting Geller v. Brownstone Condo Assn., 82 Ill. App. 3d 334, 337 (1st Dist. 1980)) (citing United States v. Causby, 328 U.S. 256 (1946)).

59. *Id*.

60. *Ad Coelum Doctrine*, *in* BLACK'S LAW DICTIONARY (12th ed. 2024).

the middle of the earth."[61] Even though English courts at the time had "almost entirely done away with" the maxim, early American courts nonetheless adopted it to resolve disputes "in conformity" with earlier English decisions that had relied on the rule.[62] Quoting Blackstone, in 1878, for instance, the Supreme Court of Colorado found that

At common law a grant of land carries with it all that lies beneath the surface down to the center of the earth. At this pleasure the owner of the soil may apply to his own purposes whatever is included in the segment of the earth carved out by his descending exterior boundary lines.[63]

Courts have long acknowledged the maxim should "not always to be construed in a literal sense"—excluding loose articles resting on the soil, for example.[64] By 1940, the United States Supreme Court observed, with regard to the aerial extent of the doctrine and the potential for airplane-related trespass, that the "doctrine has no place in the modern world."[65]

Notwithstanding the obvious limitations inherent to a literal interpretation of the *ad coelum* doctrine,[66] courts have taken a consistent approach as to the subsurface: in the United States, an interest in land "includes all things of a permanent and substantial nature; not only the face of the earth, but every thing under it or over it."[67] Applied to pore space, the maxim implies the fee ownership of property includes the subsurface.[68] This, however, merely stands for the proposition that the right to possess and use the pore space is among the various incidents of property enjoyed by an owner of an interest in land. When interests in land are divided into surface and mineral subfractions, the conclusion that pore space *is* property does little to resolve the question of *whose* property it is.

61. John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 981 (2008).

62. King v. Caitlin, 1802 WL 343, 365 (Va. 1802) (emphasis in original).

63. Wolfley v. Lebanon Min. Co., 4 Colo. 112 (1878).

64. Mills v. Pierce, 2 N.H. 9 (1819).

65. United States v. Causby, 328 U.S. 256, 261 (1946).

66. Opining on these limitations, for instance, Professor Hall has noted how "[n]o court has ever applied the doctrine in a case in which parties disputed rights anywhere near the center of the earth or the outer reaches of space," concluding "the literal expression of the *ad coelum* doctrine is not well-established law, but instead is merely oft-repeated dicta." Keith B. Hall, *Hydraulic Fracturing: If Fractures Cross Property Lines, Is There an Actionable Subsurface Trespass?*, 54 NAT. RES. J. 361, 391 (2014)

67. Canfield v. Ford, 28 Barb 336 (N.Y. Gen. Term 1858).

68. Owen L. Anderson, *Geologic CO2 Sequestration: Who Owns the Pore Space?,* 9 WYO. L. REV. 97, 99 (2009), *but see*, John Sprankling, *Owning the Center of the Earth*, 55 UCLA L. R. 979 (2008).

In a severed estate, in which the mineral and surface interests have been separately conveyed, most scholars have reached consensus that in the United States, at common law, the owner of the surface estate also owns the pore space underlying his or her tract of land subject to the dominant rights of use and enjoyment by the mineral owner.[69] For example, as early as 2009, Professor Owen Anderson concluded that the surface owner was "the most likely 'owner' of the pore space"—and thus the most likely holder of the right to inject CO_2 for sequestration.[70] In the context of rights to natural gas storage, courts have referred to this as the "American rule."[71]

A few well-settled principles of law support inclusion of pore space in the surface estate rather than the mineral estate. Foremost among them is that the law of property generally presumes that a right not expressly conveyed is retained.[72] This basic principle is highlighted, for instance, in *Emeny v. United States*, a 1969 case before the U.S. Court of Claims that involved a determination of whether, under Texas law, an oil and gas lease entitled the federal lessee to store helium in the geological structures underlying the leased premises. Construing the relevant leases, the court found that the leases expressed an intent for the landowners to divest themselves only of "the right to explore for, produce, possess, use, and dispose of the gas and oil in place" and, as a consequence, did not create or convey any storage rights.[73] In so holding, the court noted "[t]he surface of the leased lands and everything in such lands, except the oil and gas

69. Anderson, *supra* note 68, at 99; Stefanie L. Burt, *Who Owns the Right to Store Gas: A Survey of Pore Space Ownership in U.S. Jurisdictions*, 4 JOULE: DUQ. ENERGY & ENV'T L.J. 1, 2 (2016).

70. Anderson, *supra* note 68, at 99.

71. Ellis v. Arkansas Louisiana Gas Co., 450 F. Supp. 412, 421 (E.D. Okla. 1978), *aff'd*, 609 F.2d 436 (10th Cir. 1979) (wherein the court, in describing application of the so-called "American Rule" to a determination of ownership in a depleted gas reservoir, noted "the surface owner alone should be compensated for the use per se of a stratum. He is the owner of this formation, and like an owner of a warehouse, he is entitled to the rental or other compensation paid for the use of his property[]") (quoting Roger Scott, *Underground Storage of Natural Gas: A Study of Legal Problems*, 19 OKLA. L. REV. 47, 61 (1966)); *see also* Burt, *supra* note 69, at 2. In contrast, the "English rule" refers to Crown ownership of pore space. Interestingly, however, the English rule does not even appear to be the law in England. In contrast with the claim in King v. Catlin that English jurisprudence had abandoned the *ad coelum* doctrine as a relic, 1802 WL 343, 362 (Va. 1802), in 2010 an English court noted that the "brocard still has value in English law," finding that while the Petroleum Production Act of 1934 vested ownership of the fluid minerals in the Crown, it did not "assert ownership of the strata that surround it." Star Energy Weald Basin Ltd. v. Bocardo SA [2010] UKSC 35, [42] (appeal taken from 2008 EWCA (Civ) 579).

72. Anderson, *supra* note 68, at 99–100. *See also* Joseph Schremmer, *Crystal Gazing: Foretelling the Next Decade in Oil and Gas Law*, 66 RMMLF-INST. 5, 5–18 (2020).

73. Emeny v. U.S., 412 F.2d 1319, 1323 (Ct. Cl. 1969).

deposits covered by the leases, were still the property of the respective landowners."[74]

Emeny formed the basis for a continuing line of cases that have generally reinforced the inclusion of pore space within the surface estate. In 1975, relying on *Emeny*, the Texas Supreme Court in *Humble Oil & Refining Co. v. West* first considered whether a grantor's conveyance of fee simple title with a reservation of oil and gas royalties resulted in the grantor's retention of any rights in the underlying geologic storage structures.[75] The court answered this question in the negative, holding "the surface of the leased lands remaining as the property of the [surface estate owners] included the geological structures beneath the surface."[76] Subsequently, in 2013, a Texas appellate court further clarified the distinction between oil, gas, and— in the words of Professor Kramer—the "rock"[77] containing fugacious minerals.[78] In that case, the appellate court observed, "ownership of the hydrocarbons does not give the mineral owner ownership of the earth surrounding those substances."[79] Similarly, as stated by the Fifth Circuit applying Texas law in 2011, "the conveyance of mineral rights ownership does not convey the entirety of the subsurface."[80] Courts in other states have followed the same line of reasoning. For example, citing *Emeny* and its progeny in *Burlington Resources*, the Montana Supreme Court found the pore space to inhere in the surface estate, "in the same manner that all the non-mineral material beneath the physical boundaries of [the surface owner's] property belongs to [the] surface estate."[81]

As with other surface interests in split estates, the surface owner's interest in pore space remains subject to use by the mineral estate. When mineral rights are severed from the surface—thus disrupting the heaven-to-earth nature of the property interest—courts have implied an easement allowing the mineral owner reasonable use of the surface as is reasonably necessary to the production of the oil and

74. *Id.*
75. Humble Oil & Ref. Co. v. West, 508 S.W.2d 812, 815 (Tex. 1974).
76. *Emeny*, 412 F.2d at 1323.
77. Bruce M. Kramer, Horizontal Drilling and Trespass: A Challenge to the Norms of Property and Tort Law, 25 COLO. NAT. RES., ENERGY & ENV'T L. REV. 291, 298 (2014).
78. Springer Ranch, Ltd. v. Jones, 421 S.W.3d 273 (Tex. App. 2013).
79. *Id.* at 283 (citing *Emeny*, 412 F.2d at 1323).
80. Dunn-Mccampbell Royalty v. Nat'l Park Serv., 630 F.3d 431, 441 (5th Cir. 2011).
81. Burlington Res. Oil & Gas Co., LP v. Lang & Sons Inc., 2011 MT 199, ¶ 29, 413, 259 P.3d 766, 770 (Mont. 2011).

gas.[82] This easement is derived from the physical nature of the two estates: in the absence of the right to use the surface, the mineral owner would be unable to use and enjoy its estate without the agreement of the surface owner. Courts have recognized that use of the pore space is included in this implied right, including for enhanced oil recovery and for disposal of oil and gas wastes.[83]

Consider, for example, the 2015 North Dakota case of *Mosser v. Denbury Resources*. In *Mosser*, a federal district court applying North Dakota state law was asked to determine whether an oil and gas lessee was obligated to compensate a surface owner plaintiff for use of its pore space for produced water disposal.[84] The court noted that, while the lease did not expressly authorize the lessee's use of pore space for produced water injection, such use was an "implied right" given to the lessee as a "necessary consequence of oil and gas production."[85] One consequence of cases such as *Mosser* is that split-estate surface owners cannot guarantee exclusivity in the pore space because it remains subject to the mineral owner's dominant right of use. Pragmatically, this means that storage operators injecting into hydrocarbon-bearing rock will likely need to acquire interests from the owners of both the surface and subsurface estates to assure permanent sequestration.

Judicial determinations of ownership of pore space in split estates have thus far been limited to disputes between the owners of surface property and the owners of fluid minerals. United courts have not yet adjudicated cases related to the ownership of pore spaces in coal or other locatable minerals.[86] This is likely because most non-fluid minerals are not porous enough to be suitable for storage. However, coal is a very effective storage resource, where CO_2 absorbs into the

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82. Getty Oil Co. v. Jones, 470 S.W.2d 618, 621 (Tex. 1971).

83. Giacometto Ranch v. Denbury Onshore LLC, No. CV 16-145-BLG-SPW, 2020 U.S. Dist. LEXIS 200802, at *12-13 (D. Mont. July 15, 2020) (enhanced oil recovery); Mosser v. Denbury Res., Inc., 112 F. Supp. 3d 906 (D.N.D. 2015) (produced water).

84. *Mosser*, 112 F. Supp. 3d at 913.

85. *Id.* at 913–14.

86. Most sequestration projects currently operating are offshore in areas where the government has a fee interest, and thus the issue has not yet arisen. The United States and Canada are the first countries to pursue commercial onshore carbon sequestration projects at scale. Canadian guidance indicates that Canadian provinces "own their subsurface resources – including the pore space underground where CO2 will be stored," *see,* NAT. RES. CAN., CAPTURING THE OPPORTUNITY: A CARBON MANAGEMENT STRATEGY FOR CANADA (2023), https://natural-resources.canada.ca/energy-sources/carbon-management/canada-s-carbon-management-strategy [https://perma.cc/8RQ8-KZW6].

coal itself.[87] This unique characteristic of the coal estate may lead to different results than in cases evaluating the extent of pore space ownership in oil and gas estates. These will likely rely on mining law cases as well as cases relating to ownership of coal bed methane and are likely to differ based on variations in state law.[88] The Texas Supreme Court is currently considering the question of who owns the right to use subsurface caverns created through salt-brine production.[89] The appellate court disallowed the mineral owner from using that cavern to store hydrocarbons, finding that the cavern was the property of the surface owner.[90] While a cavern differs from storage within a formation, the confining structure of the cavern is comprised of the mineral. Therefore, resolution may be instructive for cases evaluating pore space ownership in coal and other solid mineral formations.

The legislatures of several states have statutorily decided the matter of pore space ownership in split estates.[91] The majority of these states have essentially codified the common law as it has evolved between the owners of surface and fluid minerals, finding that ownership of the pore space should vest in the surface owner but maintaining the dominance of the mineral estate.[92] These statutes, however, do not amend prior conveyances, which will still be interpreted according to state rules of construction. Accordingly, even in those states where pore space ownership is established by legislation, questions may still arise around the extent of the ownership right, as well as the interpretation of conveyances that

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87. Robert Stanton, et. al., *Coal bed sequestration of carbon dioxide*, NAT'L ENERGY TECH. LAB. (2001).

88. Joseph Schremmer, Conflicts and Confluences between Surface and Mineral Estates in CCUS, 24 WYO. L. REV. 295, 353 (2024).

89. Myers-Woodward, LLC v. Underground Servs. Markham, LLC, Case 22-0878 (Tex.) (oral argument Oct. 29, 2024).

90. Myers-Woodward, LLC v. Underground Servs. Markham, LLC, 699 S.W.3d 1 (Tex. App. 2022), *reh'g denied* Sept. 26, 2022, *pet. granted* Aug. 30, 2024).

91. *See*, *e.g*., IND. CODE § 14-39-2–3 (West 2024).; N.D. CENT. CODE § 47-31-03 (West 2024).; 60 OKLA. STAT § 60-6 (West 2024); WYO. STAT. ANN. § 34-1-152 (West 2024).

92. Jean Feriancek, *Resolving Ownership of Pore Space*, 26 NAT. RES. & ENV'T 3, 49 (2012) ("[O]wnership of pore space by the surface owner is considered the majority view in the United States"). *See, e.g*., IND. CODE § 14-39-2-3 (West 2024); N.D. CENT. CODE § 47-31-03 (West 2024); 60 OKLA. STAT § 60-6 (West 2024); WYO. STAT. ANN. § 34-1-152 (West 2024); KY. REV. STAT. ANN. § 353.800(8) (West 2024) (instructing through its statute, which vests pore space ownership with the surface owner, that "the pore space owner shall include all persons reasonably known to own an interest in the pore space.").

predate pore space ownership laws and leave the matter unaddressed.[93]

III. CONTRACTING FOR PORE SPACE

Through the acquisition of land, a project developer can protect itself against potential claims for trespass from migration of injected substances[94] and against competition for limited storage resources. Acquiring the land interests necessary to develop a project begins with determining the rights necessary for the project, identifying the rights holders of those interests, delineating the geographic extent of land needed, and deciding on the form of the contract.

A. Property Rights Necessary for a Sequestration Project

While often referred to as the acquisition of the "pore space," an operator requires numerous other rights to support the development and operation of the project in addition to the right to access and deplete the pore volume. These can be classified according to the following categories: (1) injection rights; (2) development and access rights; (3) aggregation rights; and (4) protective rights. While many pore space acquisition contracts mimic oil and gas leases or development agreements, these must be modified to align with the regulatory and technical requirements for sequestration.

The primary purpose of the sequestration agreement is to acquire the right to inject CO_2 into the subsurface and to permanently store CO_2 therein.[95] Commercial scale CO_2 sequestration projects will likely have several wells that inject CO_2 which will migrate through the

93. Montana's pore space law appears to anticipate the possibility of ambiguity in the chain of title, providing: "[i]f the ownership of the geologic storage reservoir cannot be determined from the deeds or severance documents related to the property by reviewing statutory or common law, it is presumed that the surface owner owns the geologic storage reservoir." MONT. CODE ANN. § 82-11-180(3) (West 2024). *See also* Righetti, *supra* note 19, at 10426 (discussing City of Kenai v. Cook Inlet Nat. Gas Storage Alaska, LLC*,* 373 P.3d 473 (Alaska 2016)) ("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.").

94. Righetti, *supra* note 19, at 10421; Hall, *supra* note 5.

95. Brandon Lobb, *Intent of the Deposition: Storage & Withdrawal vs Permanent Sequestration*, STATE BAR OF TEX. 2022 ADVANCED OIL, GAS & ENERGY RES. 16-V (2022). This provision should clearly define what the parties mean by CO2. In addition to pure CO2, for instance, a CO2 stream may include other constituents and fluids.

formation for storage in a large area. This means that the agreement must include the right to store CO_2 that migrates under the property from the operators' injections as well as CO_2 that is injected into it.[96] These storage rights granted should be perpetual. Only CO_2 that is permanently sequestered qualifies for the 45Q tax credit.[97] Accordingly, the contract should either grant a perpetual storage right through an easement or similar mechanism.

The operator will also require extensive development and access rights. The extent and intensity of development and access rights needed will differ depending on the stage of development. During the initial development period the operator will require access and rights of geologic characterization activities, which can include drilling stratigraphic test wells, groundwater sampling, or conducting geophysical surveys. Geological exploration is vital to assessing the extent and suitability of the storage resource.[98] This information must be included in the Class VI injection well permit application[99] and will most likely be needed over the full extent of the storage complex.

The rights necessary to construct facilities may be more geographically limited. If a permit is filed, the operator will also need the right to engage in construction activities including drilling wells, building roads, and installing surface facilities for compressors, pipeline connections, and other necessary equipment. The operator may also be required to perform corrective action on existing wellbores during the construction and injection period to mitigate the risk that those wells could serve as conduits for releases of CO_2 into other underground formations or to the surface. Although these activities may be more physically intrusive than geologic characterization, they are less extensive. In much of the storage area there may be no above ground facilities or monitoring wells. Accordingly, not all grants of injection rights will include rights of ingress and egress or surface use, allowing some customization based on the operators needs and separate negotiation for surface damages.

96. Depending on the project, the operator may also want the rights to withdraw brine and dispose of this produced water into formations other than the sequestration formation. This can create additional storage capacity or help steer the plume.

97. 26 U.S.C. § 45Q.

98. *See* Righetti, *supra* note 19, at 10422; Christopher S. Kulander & R. Jordan Shaw, *Comparing Subsurface Trespass Jurisprudence—Geophysical Surveying and Hydraulic Fracturing*, 46 N.M. L. REV. 67 (2016).

99. 40 C.F.R. § 146.82(a)(3) (2024).

Once injection begins, and during periods of post-injection stewardship, the operator will require continued rights of ingress and egress for operational purposes and for monitoring, reporting, and verification. In many cases, injection and development operations may overlap as the operator continues to acquire offtake agreements for CO_2 and permit additional wells to increase storage density. These operational activities may extend for decades, including maintenance of injection equipment, infill drilling, and post-injection monitoring. Although it may be unclear where these facilities will be located at the time of contracting, pore space acquisition agreements with the surface owner will ideally provide access and flexibility to determine future monitoring well locations.

Aggregation rights are also critical to a sequestration project. CO_2 sequestration projects typically require use of a large area including numerous parcels. Operations and infrastructure must therefore be planned and coordinated on a project-wide, rather than parcel-specific, basis. Additionally, because the plume will cover many parcels, the operator will want the right to proportionately adjust injection-based payments to landowners based on their share of the entire storage area. Aggregation rights authorize the operator to combine the parcels with others in a voluntary operating agreement or similar structure or to pursue aggregation under state statues allowing for the formation of geologic storage units.[100]

While most of the rights needed are positive rights, an operator also requires a negative right that prohibits other interest owners from interfering with the integrity of the projects. A loss of containment would be disastrous for a CCS operator. Not only would it result in recapture of any 45Q credits,[101] but the operator could face tort and contract liability[102] as well as administrative penalties.[103] These claims could include contract claims by emitters arising under the terms of offtake agreement, penalties for breaches of environmental laws, and civil claims for damages from any resulting injury to human

100. Hall, *supra* note 5, at 5–24.

101. 26 C.F.R. § 1.45Q-5 (West 2024).

102. For a wide-ranging discussion on potential liabilities, *see* David E. Adelman, Ian J. Duncan, *The Limits of Liability in Promoting Safe Geologic Sequestration of CO2,* 22 DUKE ENV'T L. & POL'Y F. 1 (2011).

103. *See* Michael Palmer, *Environmental Liability Risks Under U.S. Federal Laws*, 2024 1 FNREL-INST. 15, 15-7–15-8 (2024).

health or the environment.[104] To minimize risks of damage to the storage complex by the landowner or its licensees, sequestration operators may require restrictive covenants that prevent a landowner from using its property or authorizing others to use it in a way that could impact the integrity of the storage resource. This is most important with regards to the right to drill through the sequestration formation to use or access deeper formations.

B. Identifying Rights Holders in the Subsurface

The extensive scope and range of rights required for sequestration projects will likely mean that, in the case of split estates, a developer of a sequestration complex will be unable to obtain all necessary rights for access, development, and injection from either the surface or the mineral owner.[105] Both the mineral owner and the surface owner enjoy the right to use the subsurface, to different extents and for different purposes.

It is long established that ownership in the mineral estate generally includes the right to reasonable use and occupation of the surface—including the pore space—as necessary for production of the underlying minerals.[106] This right of reasonable use includes the right to inject CO_2 as needed in relation to production activities.[107] As a result, where a parcel identified for geologic storage is already subject to oil and gas activities, the mineral owner (or its lessee) may already

104. Randall Edgerly Reck, Carbon Capture and Sequestration in California: A Necessary Component to Achieve Greenhouse Gas Reductions, 40 SPG ENVIRONS ENV'T L. & POL'Y J. 223, 230–31 (2017).

105. The mineral estate may also be divided based on interests or substances, including separate ownership of coal, locatable minerals, sand and gravel, and oil and gas, which may be further fragmented among royalty, leasehold and other estates. *See* Joseph A. Schremmer, *Conflicts and Confluences Between Surface and Mineral Estates with CCUS*, 24 WYO. L. REV. 295, 355 (2024). Not all of which have rights of occupancy. *See* Bruce M. Kramer, *Royalty Interest in the United States: Not Cut from the Same Cloth*, 29 TULSA L.J. 449, 450 (1994) ("The royalty interest therefore would not be a possessory estate and would likewise not have any easement to use or occupy the surface.").

106. Mosser v. Denbury Res., Inc., 112 F. Supp. 3d 906, 919 (D.N.D. 2015). The lease does not include the right to dispose of CO2 or other wastes from off the leased premises because of the limitation on use for extralateral parcels, *see* EQT Production Co. v. Crowder, 828 S.E.2d 800 (2019).

107. Giacometto Ranch Inc. v. Denbury Onshore, LLC, CV 16-145-BLG-SPW-KLD, 2020 WL 6205725 (D. Mont. July 15, 2020) ("Where express language granting the lessee reasonable access to the surface is absent from the lease, such right is implicit. . . . The mineral interest holder therefore has a right to enter and "use reasonably the surface estate in the production of the mineral.") (internal citations omitted).

have the right to use the pore space for sequestration activities that occur in conjunction with oil and gas production. These rights, however, are limited to the extent that they support economic recoveries of oil and gas. They are therefore most likely insufficient to support operations for permanent sequestration, requiring supplemental contracts with the surface owner.

Conversely, while a geologic storage project principally involves use of the surface estate,[108] the surface owner of a split estate parcel may also be unable to convey the full suite of rights required.[109] Any grant of injection rights would still be subject to the dominant right of the mineral owner to use the surface and pore space for oil and gas production.[110] The mineral owner retains the right to produce from hydrocarbon-bearing formations[111] and to use saline formations in the land for waste disposal.[112] As a result, a surface owner is limited in the extent to which it can authorize uses of the lands that could result in damage or loss of value to the mineral estate. It therefore could not authorize access to existing wellbores owned or controlled by the mineral owner. Nor could it guarantee exclusivity in the subsurface or covenant to prevent penetration of the storage complex or other mineral development activities that might result in loss of containment. The surface owner's right to authorize characterization of the mineral estate through seismic or other means is also limited.

108. *See* Righetti, *supra* note 19, at 10424.

109. Although we speak of the surface owner or mineral owner in the singular, ownership of either of these estates could be divided across numerous parties. For example, due to laws of intestate succession, some land could have dozens or more co-tenant owners, each with fractional interests. This may be particularly complicated in heirs' property where land has passed without documented conveyances or clear proof of ownership after the death of an owner, leaving his or her descendant owners without clear or marketable title, *see, Heirs' Property*, U.S. DEPT. OF AG., https://www.farmers.gov/sites/default/files/2022-03/general-heirs.pdf [On File with the Columbia Journal of Environmental Law] (last visited May 21, 2024). In these situations, it may be difficult to determine which parties have the right to authorize storage.

110. Righetti, *supra* note 19, at 10426. Fisher v. Cont'l Res., Inc., 49 F. Supp. 3d 637, 641 (D.N.D. 2014) [hereinafter Fisher I] ("The mineral estate is dominant because the law implies in the mineral estate a right to make use of the surface estate to the extent necessary to find and develop the minerals.")

111. Cassinos v. Union Oil Co., 18 Cal. Rptr. 2d 574 (Cal. Ct. App. 1993) (where an oil and gas operator secured the surface rights on adjacent lands to inject wastewater into a saline formation, the court found trespass as to the mineral owner's rights in the parcel because it was determined to bear hydrocarbons).

112. Fisher I, *supra* note 110, at 647.

1. Rights of the Mineral Owner

The mineral owner's right to use of the pore space can be either express or implied as part of the right of surface use and can be conveyed to an operator through the grant of an oil and gas lease. In the case of *Continental Resources v. Fisher,* a federal district court in North Dakota reached this conclusion in a dispute regarding whether an oil and gas lease granted the operator the right to use the surface landowners' pore space for saltwater disposal.[113] Though use of the pore space had not been addressed by the lease, the operator, Continental Resources, contended it had acquired an implied easement for the disputed use as a result of both the "dominancy of its mineral interest and as unit operator for the other mineral interest owners."[114] The court agreed, holding that "[r]easonable use of the surface is implied, even if not expressly granted by lease or deed, based on the principle that when a thing is granted all reasonable means to obtain it are granted as well."[115]

The question of reasonableness becomes increasingly important when the operator is injecting CO_2 with the intent of claiming tax credits or other benefits for incidentally stored carbon, even though injection occurs in conjunction with oil and gas production. Whether the injection activities are necessary for production is often judged according to the standard of reasonableness in light of "usual, customary, and reasonable practices in the industry under like circumstances of time, place, and servient estate uses."[116] The Montana case of *Giacometto Ranch Inc. v. Denbury Onshore, LLC* explores application of these legal principles in the context of CO_2 injection.[117] In *Giacometto*, a surface landowner argued that the oil and gas operator (Denbury) was injecting primarily for CO_2 sequestration and not for enhanced recovery.[118] The court in that case granted summary judgment, finding the plaintiff had failed to

113. *Id.* at 641 (citing 4 SUMMERS, OIL AND GAS § 40:4 (3d ed. 2009)). Following the North Dakota Supreme Court's ruling in *Mosser*, the parties subsequently litigated the matter of compensation for the use in Cont'l Res., Inc. v. Fischer, No. 1:18-CV-181, 2022 WL 17960531 (D.N.D. Dec. 27, 2022), *aff'd sub nom.* Cont'l Res., Inc. v. Fisher, No. 23-1147, 2024 WL 2500999 (8th Cir. May 24, 2024).

114. Fisher I, *supra* note 110, at 641.

115. *Id.* (citing 4 SUMMERS, OIL AND GAS § 40:4 (3d ed. 2009)).

116. Hunt Oil Co. v. Kerbaugh, 283 N.W.2d 131, 136 (N.D. 1979).

117. Giacometto Ranch Inc. v. Denbury Onshore LLC, No. CV 16-145-BLG-SPW-KLD, 2020 WL 6205725 (D. Mont. July 15, 2020).

118. *Id.*

establish a factual dispute as to the permanence of the injections, thus rendering the claim both unripe and speculative.[119] The court, however, acknowledged that "Denbury's use is limited to purposes that are reasonably necessary to produce oil" and that "the "reasonably necessary" determination is a fact question the jury must resolve."[120] To be successful on their claims, because oil and gas production operations were ongoing, the aggrieved plaintiffs in that case would likely have had to show that the operator's uses exceeded those reasonably necessary to oil and gas production based on customary practices in the oil and gas business.

Giacometto also raises the important question of whether the mineral interest includes the right to permanently abandon CO_2 in the subsurface at the conclusion of oil and gas operations.[121] Case law and statutes thus far indicate that when CO_2 is injected for EOR or for geologic sequestration, it remains the personal property of the injector and does not become part of the realty.[122] At the conclusion of mineral operations, a mineral developer is generally under an obligation to remove its personal property from the premises.[123] A failure to do so can result in liability for trespass.[124] Accordingly, at the end of mineral development operations, when the mineral owner loses its right to possess the surface, there is a question as to what its obligations are with regard to the injected CO_2. If the CO_2 is characterized as the personal property of the injector, it might be treated similar to casing, wellbore cementing, and other property that is affixed to the realty, which can be abandoned in place. Once abandoned, this property becomes subject to use by and ownership of the surface owner.[125] A similar standard has been applied to injected substances such as produced water, to the same result.[126] While several state statutes vest ownership of produced water in the operator, any claim the operator may have to the water is forfeited

119. *Id.* at 3.

120. *Id.* at 4.

121. This issue was found not to be ripe in *Giacometto*, *see id.* at 3.

122. *See e.g.*, WYO. STAT. ANN. § 34-1-153(a) (2024). As discussed *infra*, many sequestration agreements also expressly stipulate to the operator's retained ownership of injected CO2.

123. *See* Bonds v. Sanchez-O'Brien Oil & Gas Co., 715 S.W.2d 444 (Ark. 1986).

124. *See* Bay v. Anadarko E&P Onshore, LLC, 912 F.3d 1249 (10th Cir. 2018).

125. Jeffrey R. Akins, Oil and Gas: Ownership and Use of Abandoned Oil Well Casing When the Surface and Mineral Estates Have Been Severed, 34 OKLA. L. REV. 399 (1981).

126. Joseph Schremmer, *Crystal Gazing: Foretelling the Next Decade in Oil and Gas Law*, 66 ROCKY MTN. MIN. L. INST. ch. 5, 5-18–19 (2020) [hereinafter "Crystal Gazing"]; W. Edmond Salt Water Disposal Ass'n v. Rosecrans, 226 P.2d 965 (Okla. 1950).

when the water is injected.[127] Once in the formation, the injected water becomes *ferae naturae* and any claim of ownership by the injector is lost, thus subjecting the substance to capture by the owner of the realty (the surface owner).[128] While reversion of ownership to the surface owner might resolve some doubt about subsurface trespass, it is inconsistent with the long term monitoring, reporting, and verification (MRV) responsibilities required for geologic sequestration. The possibility of later withdrawal, sale, or use of the CO_2 would disqualify the CO_2 operator from claiming the 45Q tax credit.[129] These cases imply that an operator has the right to abandon CO_2 in place, provided it does not intend to claim any credits for carbon sequestration. This adds property dimensions to the commodity/waste distinction for CO_2.[130] When injected as a waste, title is lost and no trespass results, but when stored as a commodity, the injector must have reservoir rights.

The limited nature of the mineral owner or lessees' rights to use the pore space also precludes an oil and gas operator from continuing to inject CO_2—called incremental storage—following the conclusion of oil and gas production operations.[131] The mineral lease is defeasible.[132] It terminates when production ceases in paying quantities.[133] This requires not only that the lease have production, but that said production is profitable.[134] The profitability limitation would preclude a mineral operator from continuing to inject CO_2 in order to claim credits or offsets while maintaining only marginal production merely to extend its rights to use the surface property.[135]

127. Crystal Gazing, *supra* note 126, at 5-17.

128. W. Edmond Salt Water Disposal Ass'n, 226 P.2d at 970.

129. 26 C.F.R. § 1.45Q-5(a) (observing the occurrence of a recapture event "when qualified carbon oxide for which a section 45Q credit has been previously claimed ceases to be disposed of in secure geological storage").

130. Wyoming statute, for example, provides that substances injected for the purpose of geologic sequestration are presumed to be owned by the injector, *see*, WYO. STAT. ANN. § 34-1-153 (2024). However, this does not speak to incidental storage as part of waste disposal or EOR.

131. *See* Righetti, *supra* note 19.

132. *See* Gerhard v. Stephens, 442 P.2d 692, 704 (Cal. 1968) (holding that an oil and gas lease is a defeasible interest).

133. R. Neal Pierce et. al., The Quick and the Dead: Cessation of Production and Shut-Ins During the Secondary Term of an Oil and Gas Lease, 88 N.D. L. REV. 727, 733 (2012).

134. Clifton v. Koontz, 325 W.D.2d 684 (Tex. 1959).

135. In Stradley v. Magnolia Petroleum Co., 155 S.W.2d 649, 652 (Tex. Civ. App. 1941), a Texas court observed "the general rule seems to be that a person who owns the minerals in certain land has as incidental to his ownership the rights and privileges that are necessary for the profitable production of such minerals, and in determining his rights the courts take into

Owing to the inherent limitation of the mineral owners' rights of surface use, a mineral owner could not authorize incremental storage operations in an oil and gas lease any more than it could conduct those operations itself.[136]

Surface damage statutes may further require a mineral operator conducting sequestration activities to compensate the surface owner for the damage to the reservoir estate.[137] While this would not preclude a mineral owner from using the pore space as part of the enjoyment of its estate, surface damage statutes require payment for loss of use or value.[138] This could require payment for damages to the surface owner related to loss of pore volume. At least two cases have examined the application of split estate statutes to a mineral owner's use of the pore space. The courts in both *Mosser v. Denbury Resources, Inc.* in North Dakota and *Burlington Resources Oil & Gas Co., LP v. Lang and Sons, Inc.* in Montana found their respective states' split estate statutes applied to mineral owner uses of the pore space for waste injection.[139] Neither court, however, found the plaintiffs had proven damages consistent with the governing statute. In *Burlington*, for instance, the Montana Supreme Court denied a surface owner's request for additional compensation for a mineral owner's use of the pore space for wastewater injection associated with the mineral development.[140] Absent evidence of a demonstrable market for pore space at the time, the surface owner was unable to prove damages consistent with the statute.[141] The court in *Brown v. Continental*

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consideration the circumstances, the right conveyed, the purpose for which it was conveyed and the information of the grantor and grantee in order to ascertain the intention of the parties." Pursuant to this general rule, a lease authorizing CO2 injection for the purpose of hydrocarbon production would be unlikely to authorize injections for an unrelated purpose. *See also* Tara Righetti, *Associated and Incremental Storage: Opportunities for Increased CO2 Removal with Enhanced Oil Recovery*, *in* CLIMATE GEOENGINEERING LAW AND GOVERNANCE (Wil Burns, David Dana, & Simon Nicholson, eds., 2021).

136. Tara Righetti, *Associated and Incremental Storage: Opportunities for Increased CO2 Removal with Enhanced Oil Recovery*, *in* CLIMATE GEOENGINEERING LAW AND GOVERNANCE, at 207 (Wil Burns, David Dana, & Simon Nicholson, eds., 2021).

137. *See* Mosser v. Denbury Res., 898 N.W.2d 406, 415 (N.D. 2017) (construing North Dakota's surface damage statute, N.D. CENT. CODE ANN. § 38-11.1-04 (West 2024), as possibly entitling a surface owner to compensation for a mineral owner's use of subsurface pore space). *See also* Tara K. Righetti, *Unseen Injury*, 40 WYO. LAW. 26, 28 (2017).

138. *See, e.g.,* S.D. CODIFIED LAWS § 45-5A-4 (West 2024); WYO. STAT. ANN. § 30-5-405 (West 2024).

139. Mosser v. Denbury Res., 112 F. Supp. 3d. 906, 919 (D.N.D. 2015); Burlington Res. Oil & Gas Co., LP v. Lang & Sons Inc., 259 P.3d 766, 770 (Mont. 2011).

140. *Burlington Res.*, 259 P.3d at 771.

141. *Id.*

Resources reached a similar result. In that case, surface owners in South Dakota sought damages for the loss of use of their pore space resulting from a mineral developer's enhanced oil recovery operations.[142] The Eighth Circuit affirmed the district court ruling that the South Dakota surface damage statute covered only "losses of agricultural production, lost land value, and loss of the value of improvements."[143] While these early plaintiffs were unsuccessful, as sequestration becomes more established as a source of land value, surface landowners may have more success illustrating losses in land value from injection activities.

Agreements between surface and mineral owners are common in the oil and gas sector, even where states do not have surface damage statutes. The limitations on a mineral owners' rights to permanently sequester CO_2 in the subsurface, including rights for incremental injections, and issues related to abandonment of injected gas make contracting particularly important. While some aspects of sequestration may be covered by legacy agreements, most likely, additional rights and extensive due diligence will be needed to assure that the operator has the full suite of rights necessary for its operations.

2. Rights of the Surface Owner

The surface owner's estate is also limited with respect to its ability to convey certain rights, especially for geologic characterization activities. Both the surface and mineral owner hold rights of exploration for their separate estates.[144] However, in both cases, exploration of one estate necessarily reveals information about the other. In the context of mineral exploration activities, courts have held that a surface owner cannot consent to exploration of the mineral estate and that oil and gas exploration activities by the mineral owner do not result in a trespass.[145] Yet this principle cannot be so absolute to mean that a surface owner cannot explore the extent of its own subsurface interests. If the mineral owners' right of exploration was exclusive, it would enjoy a key holder right over the surface such that the surface owner could only enjoy its own property with the mineral

142. Brown v. Cont'l Res., Inc., 58 F.4th 1023, 1025 (8th Cir. 2023).
143. *Id*. at 1026.
144. Katherine Hendry, Seismic Survey: The Surface's Owner's Next Great Hurdle in Conducting Geological Carbon Sequestration, 18 TEX. J. OIL GAS & ENERGY L. 234, 237-238 (2023).
145. *See* Grynberg v. City of Northglenn, 739 P.2d 230, 234 (Colo. 1987).

owners' consent. Because the two estates are of equal dignity,[146] the surface owner should have the same rights of exploration as a mineral owner, provided that the operations are for the purpose of exploring the surface estate.[147] Applying the inverse of oil and gas law cases, this would imply that a surface owner can unilaterally consent to seismic and other geophysical testing for surface-derived uses[148] provided that there is no damage to the mineral interest.[149] Conversely, it implies that a mineral owner could not consent to exploration of the reservoir estate for sequestration purposes.

Rarely, however, will a sequestration project implicate only the surface or mineral interest. In many cases, geologic assessments for sequestration projects will require information about both estates. For instance, the project developer may need to prove the existence of a suitable storage formation and *disprove* the existence of producible minerals.[150] This raises questions about the extent to which the owner of either estate can unilaterally consent to the acquisition of geophysical data (or use data which was already obtained) to assess the property for sequestration purposes. Current case law provides little guidance, indicating only that one owner cannot consent to characterization activities for the sole purpose of exploring the other estate and that an owner can pursue damages for use of data that was unlawfully obtained.[151]

A surface owner may also be unable to grant access to existing wellbores for corrective action.[152] Corrective action refers to

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146. Robert Matthew Park & Ryan Lammert, Split Estate Issues (Mineral, Wind, Solar and Water) (Mar. 27, 2020) (unpublished manuscript presented at 46th Annual Ernest E. Smith Oil, Gas and Mineral Law Institute), https://utcle.org/ecourses/OC8376/get-asset-file/asset_id/48916 [On File with Columbia Journal of Environmental Law]

147. Hall, *supra* note 5, at 5–17.

148. Hendry, *supra* note 144, at 250–52.

149. Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 520 S.W.3d 39, 49 (Tex. 2017).

150. 20-24 WYO. CODE R. § 10(xviii) (LexisNexis 2024).

151. *See, e.g.*, Macquarie Bank Ltd. v. Knickel, 723 F. Supp. 2d 1161 (D.N.D. 2010); Grynberg v. City of Northglenn, 739 P.2d 230 (Colo. 1987). Professor Hall notes that a strict intent-based rule could require an operator to obtain consent from both owners in order to avoid liability for geophysical trespass or other torts, *see* Hall, *supra* note 5, at 5–19.

152. Class VI regulations require an operator conduct corrective action. *See* 40 C.F.R. § 146.84 (2024). The Class VI permit requires the operator to demonstrate that it has a plan for "[h]ow site access for future corrective action will be guaranteed." *See* U.S. ENV'T PROT. AGENCY, CLASS VI PERMIT APPLICATION COMPLETENESS CHECKLIST, https://www.epa.gov/system/files/documents/2022-07/UIC%20Class%20VI%20Completeness%20Checklist.pdf [https://perma.cc/P2FX-MRKR].

operations performed on existing wellbores[153] so that they cannot serve as a conduit for CO_2 to flow into other formations or to reach the surface.[154] Corrective actions can include recementing to prevent corrosion or plugging or re-plugging abandoned wellbores. The simplest illustrative scenario is where a well is producing from an active mineral lease and is owned by the mineral operator. The operator may be unwilling to provide a sequestration company with the right to conduct operations on its wells, at least without extensive indemnities against potential loss or damage and compensation for interruptions in production. Obtaining this access may be complicated, requiring consent from all parties with operating interests. Where wellbores have been transferred,[155] a project operator may need to contract with a third ownership group who are neither surface nor mineral owners, adding to the challenging of assembling the rights needed for a sequestration project.

Finally, a split estate surface owner will not be able to prevent the mineral owner's use or penetration of the storage complex. The dominance of the mineral estate guarantees the mineral owner the right to access and enjoy its property.[156] This could include drilling through the storage complex as long as there was a necessity to do so in order to produce minerals in deeper formations or producing residual minerals within depleted hydrocarbon formations.[157] In states adopting the accommodation doctrine, the mineral owner would need to accommodate the existing use of the property for sequestration, but only to the extent that such accommodations were reasonable.[158] Split estate statutes do not diminish this right.[159]

153. Abandoned wells pose their own suite of problems. Not only may they be physically difficult to locate but ownership may be unclear. *See* Evan Halper, *There Could be Millions of Abandoned Wells in the U.S. Plugging Them is a Monumental Task*, WASH. POST (Apr. 11, 2023), https://www.washingtonpost.com/climate-solutions/2023/04/11/plugging-abandoned-oil-wells/ [On File with Columbia Journal of Environmental Law]; Akins, *supra* note 125, at 399.

154. 40 C.F.R. §§ 146.81(d), 146.84 (2024); *See also* GLOBAL CCS INST., BUILDING OUR WAY TO NET-ZERO: CARBON DIOXIDE PIPELINES IN THE UNITED STATES 18 (May 2024) (explaining CO2 constitutes a fluid when it surpasses sufficient pressure and temperature markers to become supercritical CO2).

155. *See* William B. Burford, 7 West's Tex. Forms, Minerals, Oil & Gas § 10:9 (4th ed. 2024).

156. Baker v. Royal Lead & Spar Co., 107 S.W. 704 (Ky. 1908).

157. Pyramid Coal Co. v. Pratt, 99 N.E.2d 427 (Ind. 1951).

158. Merriman v. XTO Energy, 407 SW.3d 244, 248–49 (Tex. 2013).

159. Pragmatically, however, a mineral developer would be unlikely to develop if the statutory damages exceeded the expected profit from production of the minerals, *see*, Tara Righetti, *Liberating Split Estates*, 14 INT'L J. COMMONS 638 (2020).

Ultimately, only the mineral owner can disclaim or limit its rights to produce minerals within or under the sequestration formation.

3. Third-Party Rights Holders

In addition to the surface and mineral owner, third parties may have interests in the property that are implicated by the sequestration project. This includes the existing licensees, lessees, permittees, and grantees of both the surface and mineral owner. Encumbrances such as mortgages and liens introduce risk that the landowner or mineral owner could lose its interests and may require subrogation. Conservation easements or other covenants may limit use of the property. Identifying these rights holders requires an examination of title in the property and may necessitate additional contracting.

C. The Geographic Extent of Rights Required

Uncertainty regarding how trespass and nuisance laws will be applied to the subsurface creates ambiguity as to the lateral extent to which pore space rights must be obtained. While wastewater injectors have customarily only obtained rights from the owners where the facility is located,[160] sequestration operators are likely to require more extensive interests due to regulatory, liability, and commercial considerations. This could include the geographic extent of the plume as well as areas of pressure increase and brine displacement. Acquisition of pore space throughout the project area prevents other users from developing competing or inconsistent uses of the pore space on adjacent parcels and protects the operator from liability arising from trespass claims.[161]

Although the EPA's jurisdiction under the Underground Injection Control (UIC) program governing injection of CO_2 does not extend to property disputes,[162] regulatory requirements within the Class VI program require an operator to conduct operations and evaluate risk over a large area, called the area of review. This includes the CO_2 plume and areas where brines have resulted in increased

160. *See, e.g.,* Boudreaux v. Jefferson Island Storage & Hub, LLC, 255 F.3d 271 (5th Cir. 2001).
161. Chance v. BP Chems., Inc., 670 N.E.2d 985, 986 (Ohio 1996); FPL Farming Ltd. v. Env't Processing Sys., L.C., 351 S.W.3d 306, 314 (Tex. 2011).
162. LeBlanc v. EPA, 310 F. App'x 770 (6th Cir. 2009).

pressures.[163] Within this area, the operator must conduct extensive geologic characterization, corrective action, and MRV activities throughout the project lifecycle.[164] These functions will require access to the surface of the land throughout the planning, injection, and monitoring phases—access which would likely not be granted independent of the injection rights.

Sequestration operators may also be motivated to acquire pore space within an extensive area to manage liability and commercial concerns. For example, the CO_2 plume will displace brine and increase the pressure in adjoining parcels. This pressure front could result in claims for liability for nuisance, or in trespass claims resulting from indirect migration.[165] Expansive leasing also secures a competitive advantage. Were owners within its area of review to lease to competing operators, a sequestration operator would risk losing storage capacity. This could undermine commercial models, complicate MRV, and create ambiguity as to stewardship obligations within the complex. Acquiring pore space rights therefore provides the operator with both the positive rights to inject and the negative rights to exclude, both of which may be necessary for the project.

The operator will also need to consider the vertical extent to which it needs to acquire subsurface rights. As with oil and gas leases, which frequently reserve lower formations, sequestration agreements can include depth limitations. At a minimum, this should include the receiving formation and the confining formation. These may be difficult to identify with certainty prior to the commencement of geologic characterization activities and therefore could be challenging to define within the lease. Additionally, while vertical limitations could reduce acquisition costs, it could also preclude stacked injection opportunities and introduce the potential for conflicting operations above or underlying the operator's storage facility. Managing this risk may require the negotiation of protective covenants to assure that deeper development does not threaten containment losses.

163. 40 C.F.R. § 146.84 (West 2024); U.S. ENV'T PROT. AGENCY, UNDERGROUND INJECTION CONTROL (UIC) PROGRAM, CLASS VI WELL AREA OF REVIEW EVALUATION AND CORRECTIVE ACTION GUIDANCE 2 (2013) ("Therefore, the AoR encompasses the region overlying the separate-phase (e.g., supercritical, liquid, or gaseous) carbon dioxide plume and the region overlying the pressure front where fluid pressures are sufficient to force fluids into a USDW.").

164. U.S. Env't Prot. Agency, Underground Injection Control (Class VI) Well Site Characterization Guidance (May 2013).

165. *See* Laura Leach v. Archer Daniels Midland Co., 2023-CH-06676 (Ill. 2023).

D. The Form of Contract

Pore space acquisition agreements must convey the specific rights needed and align with the timelines of a sequestration project. The high risk of the industry and the perpetual nature of sequestration introduce challenges when selecting the form of contract for pore space access acquisition agreements. While oil and gas agreements have informed the development of early pore space agreements,[166] they leave several core needs of the parties unaddressed.

Oil and gas leases and other depletable natural resource contracts do well at managing the early term risk of non-development and protecting the landowner against speculation. The primary term of oil and gas leases provide the operator with the right—but not the obligation—to develop the property.[167] If development is not commenced within the specified term, the lease expires.[168] This initial structure works well for sequestration agreements as well, which must provide the operator with sufficient time to characterize the resource, permit the project, and commence construction of the well. This also serves the landowner's interest in assuring the property is not needlessly tied up without development.

The form of contract becomes more complicated when injection starts. In oil and gas leases, the commencement of production marks the start of the secondary term—or habendum—which continues until production ceases. At the end of production all rights to the remaining minerals revert to the mineral owner. This is where oil and gas projects and sequestration projects diverge. In some respects, the end of injection merely marks the beginning of the third and fourth phases of a sequestration project: monitoring, reporting and verification—a period which may extend for decades following the cessation of injection[169]—and post-closure stewardship. While site closure marks the end of the operator's regulatory obligations,[170] the operator's ownership of the CO_2 and potential civil liability for any harm caused thereby continues in perpetuity. An agreement that terminates and reverts all pore space rights to the landowner at the cessation of injection, or even at site closure, would leave these

166. See generally Hall, *supra* note 5.
167. Timothy C. Dowd, *A Review of Ownership Interests in Lands and Ownership Entities, in* NUTS AND BOLTS OF MINERAL TITLE EXAMINATION (Apr. 2015).
168. *Id.*
169. *See* discussion *supra* note 12 and accompanying text.
170. 40. C.F.R. § 146.93 (West 2024).

demands unaddressed. Therefore, in addition to the development rights granted by a lease, some sort of perpetual grant is needed.

Perpetual interests could be granted through either an easement grant or purchase. While early projects purchased fee interests for the locations of injection wells, [171] in areas where only CO_2 will be stored the purchase of surface and mineral fee interests would include more rights than are necessary to a sequestration project.[172] The severance and purchase of reservoir rights alone, however, may not be possible. In some areas, severance of pore space is prohibited by law.[173] Granting a perpetual storage easement at the start of injection may be preferable. This would provide the operator with the permanent right of storage without requiring severance of the pore space.

Valuing a perpetual storage interest at the outset of a project, however, is challenging. Permitting risk and geologic uncertainty are likely to result in substantial discounts to purchase price. Information uncertainties related to resource extent and markets are major barriers to purchase transactions. In these scenarios, parties may want to consider option contracts that allow the developer to de-risk certain portions of the project through characterization and permitting work with lower up-front costs to secure the option. If exercised, the option contract would provide the seller higher value through the eventual lease or purchase than it could have commanded prior to the characterization work.

Uncertainty about resource extent can also be addressed through the structure of compensation provisions. In other resource contexts, parties address this by structuring compensation volumetrically. For example, in an oil and gas lease, a royalty reserves a share of the resource for the mineral owner, which is paid by the lessee for each

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171. Acquisition of pore space by deed was a strategy favored in several early sequestration projects, including ADM's Decatur Project in the Illinois Basin. However, ADM allegedly acquired ownership only of the well sites, failing to acquire interests in the surrounding pore space, which ultimately resulted in the pending class action suit. *See* Class Action Complaint, *supra* note 57 and accompanying text.

172. Mark A. De Figueiredo, Property Interests and Liability of Geologic Carbon Dioxide Storage: A special Report to the MIT Sequestration Initiative 5, 6 (Sept. 2005).

173. In some states, severance of the pore space is disallowed, *see*, *e.g.,* 415 ILL. COMP. STAT. ANN. 185/10 (West 2024); N.D. CENT. CODE § 47-31-05 (West 2024); W. Va. Code § 22-11B-18(a) (West 2024).

barrel of oil removed from the property.[174] As long as the lease is in effect, the lessor-mineral owner has an implied covenant to diligently use the property to try and maximize production.[175] When the lease ends, any remaining resource reverts to the mineral owner, who can re-lease the property for further development. Although the volumetric payment principle holds for CCUS, the reversionary interest illustrates another unique challenge for sequestration leases. Unlike oil and gas and other extraction, subsequent operations for sequestration are unlikely once injection ceases even if accessible pore volume remains. Regulatory mandates related to site closure and liability transfer require the operator of a project to illustrate plume stability for 30–100 years following the cessation of injection.[176] To satisfy this requirement, the operator must prove that the CO_2 plume has ceased expanding,[177] something that can only occur if there have been no further injections into the formation. Therefore, if the landowner agrees to a volumetric payment, once injection starts and it grants the easement, the pore space owner assumes the risk that the resource may not be fully used.

IV. STRUCTURING PORE SPACE AGREEMENTS & COMPENSATION

Prior scholarship has contemplated the range of possible structures for pore space acquisition and compensation considering applicable legal principles and best contracting practices.[178] In addition to legal and theoretical parameters, transactional structures are informed by external and commercial factors including project timelines, financial modeling, and the perceived balance of risk and reward among specific landowners and operators. Accordingly, empirical evidence from pore space agreements represents the best source of

174. Carroll v. Bowen, 180 Okla. 215, 68 P.2d 773, 775 (Okla. 1937). Economists debate whether this is a form of rent for the superior location or quality of the resource or a share of mineral removed, or some portion of the two, *see* John E. Orchard, *The Rent of Mineral Lands*, 36(2) Q.J. ECON. 290, 290–91 (1922).

175. David E. Pierce, Exploring the Jurisprudential Underpinnings of the Implied Covenant to Market, 48 ROCKY. MTN. MIN. L. INST. 10-1, 10-10 (2002).

176. For example, Subpart RR defines the maximum monitoring areas as encompassing a minimum half mile buffer around "the area expected to contain the free phase CO2 plume until the CO2 plume has stabilized," *see* 40 C.F.R. § 98.449 (West 2024).

177. Wyoming's transfer of liability statute allows for issuance of a certificate of project completion only when "the underground place or pore space where the carbon dioxide was injected or stored is no longer expected to expand vertically or horizontally," *see* WYO. STAT. ANN. § 35-11-319 (West 2024).

178. *See, e.g.*, Hall, *supra* note 5; Gresham & Anderson, *supra* note 7.

information about contractual and compensatory mechanisms. Yet, CO_2 sequestration agreements are still relatively new, paralleling the gradual buildout of the industry over the last decade. Standard "form" agreements are only beginning to emerge.[179] Reviewing existing contracts therefore provides insights to the emergence of contracting norms and geographic variations.

Few agreements between storage operators and private landowners currently exist within the public domain. Recording memoranda, which evidence the existence of agreements but omit key provisions, are more common. In theory, the absence of a significant body of publicly available private agreements, and thus precedent to draw from, has the potential to result in noniterative leases that do not adhere to similar structures and standards for acquisition and compensation. Yet, analysis of hundreds of recording memoranda and nineteen full pore space agreements from California (one), Colorado (five), Louisiana (six), Mississippi (one), North Dakota (two), Texas (two), and Wyoming (two) reveals the emergence of shared structures and compensation mechanisms.

While pore space acquisition agreements bear many similarities to oil and gas leases, they must be adapted to account for the unique demands of the sequestration industry and nature of property interests in the pore space. Moreover, common law liability rules, state and federal regulatory frameworks, and markets for carbon removal are all evolving. Pore space acquisition agreements must therefore allocate risk related to each of these factors between the project developer and the pore space owner.

A. Acquiring Private Pore Space: Evidence from Recording Memoranda

Parties to pore space agreements are typically reluctant to disclose the full terms of their agreements[180]—nor are they generally required to. Instead, most resort to the use recording memoranda that provide notice of the existence of an agreement.[181] Pursuant to longstanding practices under state recording acts, sequestration agreements are

179. Hall, *supra* note 5, at 5-09–10.

180. There are many possible reasons for this reluctance, including but not limited to a desire to shield sensitive compensation metrics from the prying eyes of meddlesome legal scholars, such as these authors.

181. Terry I. Cross, Donald G. Sinex & Susan A. Stanton, *Drafting Basic Agreements Used In Developing Oil and Gas Prospects* (2009 No. 2 RMMLF-INST. Paper No. 8, 2009).

often evidenced by memoranda of lease, memoranda of servitudes, and memoranda of pore space agreements, among others.

The content of these memoranda will differ according to the notice requirements of state statutes, with some states requiring only minimal detail and others requiring certain key terms.[182] In Louisiana, for instance, which has passed a statute specific to recording memoranda for geologic storage agreements, parties are required to identify themselves, declare the existence of an agreement, and provide a description of the surface and depths encompassed by the agreement.[183] They must also describe the term of the agreement, along with any provisions for extension and renewal, as well as any restrictions "on drilling through or otherwise penetrating the carbon dioxide storage reservoir for purposes of exploring, developing, or producing minerals from or below the reservoir."[184] While the detail varies, memoranda typically contain several common, critical elements that speak to the structure of their underlying agreements.

A sweeping public records search of United States counties with known geologic sequestration projects, conducted between 2023 and 2025, revealed a large number of pore space agreements.[185] The search yielded hundreds of memoranda, the sheer number of which evince the growing prevalence of pore space leasing across the country. These provide a sense of the scale at which pore space leasing is occurring in various counties, the forms of agreements used, the range of parcel sizes, and the identities of operators that are obtaining pore space rights in different basins.

Areas likely to have pore space leasing activities include counties where projects have been publicly announced through press releases or disclosed in 10-K Securities and Exchange Commission (SEC) filings, as well as counties for which Class VI permits are filed.[186] An abundance of memoranda recorded in these counties indicate a proliferation of recent leasing activity, ranging drastically in acreage, from less than 0.2 acres to nearly 75,000 acres. They further revealed that in most counties, leasing activity is presently exclusive to a single

182. *Compare* NEB. REV. STAT. § 76-238 (West 2024) *and* N.D. CENT. CODE § 47-19-05 (West 2024) *with* LA. REV. STAT. § 30:1112(A)(3) (West 2024).

183. LA. REV. STAT. § 30:1112(A)(3) (West 2024).

184. *Id.*

185. For a summary of the authors' research methodologies, *see infra* Appendix I ("Method ologies").

186. *See infra* Appendix I.

operator, suggesting a near total market share for operators pursuing storage activities in a given region, a limitation possibly resulting from the expansive AOR for large projects that require availability of the region's entire storage potential.

County or Parish		Operator(s) with Leasing Activity	Number of Leases	Acreage (Lowest)	Acreage (Highest)
Alabama	Baldwin County	Denbury Carbon Solutions	44	4.30	665.05
	Randolph County	One Carbon Partnership	51	0.16	260.47
Louisiana	Allen Parish	Denbury Carbon Solutions	269	1.00	31,129.75
	Ascension Parish	Blue Sky Infrastructure, River Parish Sequestration & Air Products Blue Energy	34	0.5	57,100
Texas	Chambers County	Oxy Low Carbon Ventures, LLC & ExxonMobil Low Carbon Onshore Storage, LLC	58	1.97	1,995.00
	Ector County	Oxy Low Carbon Ventures, LLC	1	22,684.21	--
	Jefferson and Liberty Counties	Oxy Low Carbon Ventures, LLC	30	46.48	246.80

		& Pineywoods CCS, LLC			
	Midland County	Milestone Carbon, LLC	1	5,120.00	--
Wyoming	Laramie County	Tallgrass High Plains Carbon Storage, LLC	232	3.21	14,909.49
	Lincoln and Uinta Counties	Moxa Carbon Storage	2	5,790.37	27,420

Recording memoranda also provide some evidence of the information included in underlying leases, easements, or options. As with documents evidencing the transfer of other forms of real property, memoranda generally begin by identifying the grantor and grantee, along with their respective addresses and the effective date of the agreement.[187] Moreover, even in states where recording acts require less detail, memoranda still commonly specify applicable depth limitations and other specific details of the transaction. Referencing the granting clause used in the underlying agreement, memoranda often detail the property and rights covered by the agreement, outlining the various surface and subsurface rights granted under the agreement, and the permissible commercial and domestic land uses thereunder. The majority of underlying agreements address whether rights were granted to pool, unitize, or amalgamate reservoirs or subsurface pore spaces. Further, most identify the initial lease or easement term and whether any extension options are provided.[188] In almost every case, however, key compensation metrics are omitted.

B. Acquiring Public Pore Space: Evidence from Publicly Available

187. This is generally consistent with the scope of information included in memoranda recorded for other transactions. *See* Karen E. Abrams, *"Memorandum of Lease" Clause*, 23(6) PROB. & PROP. 58 (2023).

188. Cross et al., *supra* note 181 (noting, in general, or at least in the setting of natural resource development, that a recording memorandum should provide sufficient notice of the agreement and the rights that arise under it).

Contracts

In contrast to private agreements, several complete sequestration agreements with state or other governmental landowners are available in the public domain due to application of public record laws.[189] California, Colorado, Louisiana, Mississippi, North Dakota, Texas, and Wyoming each have agreements available for examination via public request mechanisms. Analysis into these agreements provides the first empirical look at how pore space agreements are structured and how pore space is valued. Because state agreements are the first and only publicly available examples in emerging markets for pore space, they are likely to bear significant impact on the development of private leasing structures.

County or Parish		Operator Acquiring Pore Space Interest	Form of Agreement	Acreage	Year of Execution
California[190]	Kern County	Carbon TerraVault Holdings, LLC	Easement	797.89	2023

189. Exceptions to disclosure requirements may limit availability. In Texas, for instance, Section 552.104 of the Texas Government Code carves an exemption for disclosure under the Texas Public Information Act where the release of information related to a competitive bidding process could create an unfair advantage. The Office of the Texas Attorney General recently cited this provision as a basis for denying access to a carbon sequestration lease. *See* Letter Ruling Denying Request for Information, OR2024-011772 (Att'y Gen. of Tex., Apr. 5, 2024).

190. *Easement Agreement for Carbon Dioxide Sequestration*, by and between North Kern Water Storage District and Carbon TerraVault Holdings, LLC, Kern County, California (June 20, 2023) (unrecorded), *available at* https://ser-web.arcc.uwyo.edu/files/cerpa/leases/CA-Carbon-Terra-Vault-Easement.pdf [hereinafter "California-TerraVault Easement"].

Colorado[191]	El Paso, Lincoln, and Pueblo Counties	EOS Sequestration, LLC	Exploration Lease with Preliminary Terms for Carbon Sequestration Lease	47,127.18 (reduced as amended to 2,440.00)[192]	2023
	Washington County, Colorado	Denova Sequestration, LLC	Exploration Lease	10,241.51	2022
	Weld County, Colorado	Capturepoint Solutions LLC	Exploration Lease with Preliminary Terms for Carbon Sequestration Lease	2,881.27	2023
	Ascension, Iberville, Pointe Coupee, St. John the Baptist, St. Martin, and St. Landry Parishes	Capio Sequestration, LLC	Operating Agreement	44,511.00	2021

191. Carbon Storage Exploration Lease No. 114345, by and between the Colorado State Board of Land Commissioners and Denova Sequestration, LLC, Washington County, Colorado (Jan. 1, 2022) (unrecorded), available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/CO-Denova-Lease.pdf [hereinafter "Colorado-Denova Lease"]; Carbon Storage Exploration Lease No. 116038, by and between the Colorado State Board of Land Commissioners and Eos Sequestration, LLC (Aug. 24, 2023) (unrecorded), available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/CO-EOS-Lease.pdf [hereinafter "Colorado-Eos Lease"]; Carbon Storage Exploration Lease No. 116089, by and between the Colorado State Board of Land Commissioners and CapturePoint Solutions LLC, Weld County, Colorado (Sept. 14, 2023) (unrecorded), available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/CO-Capturepoint-Lease.pdf [hereinafter "Colorado-CapturePoint Lease"; together with Colorado-Eos Lease and Colorado-Denova Lease, "Colorado Leases"]. The Colorado-Eos and Colorado-CapturePoint Leases each contain as "Exhibit C" documents entitled "Preliminary Terms for Carbon Sequestration Lease," which are considered separate leases for the purpose of this article.

192. First Amendment to Carbon Sequestration Exploration Lease No. 116038, by and between the Colorado State Board of Land Commissioners and Eos Sequestration, LLC (Sept. 1, 2023) (unrecorded), available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/CO-First-Amendment-To-Colorado-EOS-Lease.pdf.

Louisiana[193]	Cameron Parish	Castex Carbon Solutions, LLC	Operating Agreement	24,181.00	2023
	Cameron Parish	Venture Global CCS Cameron, LLC	Operating Agreement	18,022.95	2022
	Cameron, Livingston, St. James, St. John the Baptist, and Tangipahoa Parishes	Air Products Blue Energy, LLC	Operating Agreement	122,455.00	2021
	Jefferson and Plaquemines Parishes	Venture Global CCS Plaquemines, LLC	Operating Agreement	9,101.13	2022
	Jefferson and St. Charles Parishes	High West Sequestration, LLC	Operating Agreement	21,079.18	2023

193. *Carbon Dioxide Storage Agreement, La. R.S. 30:209(4)(e) Operating Agreement*, by and between the State of Louisiana, the Louisiana Department of Wildlife and Fisheries and the Louisiana Wildlife and Fisheries Commission and Capio Sequestration, LLC, East Baton Rouge Parish, Louisiana (Oct. 12, 2021) (unrecorded) [hereinafter "Louisiana-Capio Agreement"]; *Carbon Dioxide Storage Agreement, La. R.S. 30:209(4)(e) Operating Agreement*, by and between the Louisiana State Mineral and Energy Board and Castex Carbon Solutions, LLC, Cameron Parish, Louisiana (Aug. 30, 2023) (unrecorded) [hereinafter "Louisiana-Castex Agreement"]; *Carbon Dioxide Storage Agreement, La. R.S. 30:209(4)(e) Operating Agreement*, by and between the Louisiana State Mineral and Energy Board and Venture Global CCS Cameron, LLC, Cameron Parish, Louisiana (Sept. 14, 2022) (unrecorded) [hereinafter "Louisiana-Global CCS Cameron Agreement"]; *Carbon Dioxide Storage Agreement, La. R.S. 30:209(4)(e) Operating Agreement*, by and between the State of Louisiana, the Louisiana Department of Wildlife and Fisheries and the Louisiana Wildlife and Fisheries Commission and Air Products Blue Energy, LLC, Livingston, St. James, St. John the Baptist, Cameron, and Tangipahoa Parishes, Louisiana (unrecorded) (Oct. 13, 2021) [hereinafter "Louisiana-Air Products Agreement"]; *Carbon Dioxide Storage Agreement, La. R.S. 30:209(4)(e) Operating Agreement*, by and between the Louisiana State Mineral and Energy Board and Venture Global CCS Plaquemines, LLC, Plaquemines and Jefferson Parishes, Louisiana (Sept. 14, 2022) (unrecorded) [hereinafter "Louisiana-Global CCS Plaquemines Agreement"]; *Carbon Dioxide Storage Agreement, La. R.S. 30:209(4)(e) Operating Agreement*, by and between the Louisiana State Mineral and Energy Board and High West Sequestration, East Baton Rouge Parish, Louisiana (Aug. 9, 2023) (unrecorded) [hereinafter "Louisiana-High West Agreement", collectively, the "Louisiana Agreements"], *available at* State of Louisiana Department of Energy and Natural Resources, *Office of Mineral Resources (OMR) Carbon Capture Sequestration and Wind Energy Operating Agreements*, https://www.dnr.louisiana.gov/page/carbon-capture-and-wind-energy-agreements [https://perma.cc/XZA5-SFBN] (last visited Jan. 8, 2025).

Mississippi[194]	Sharkey County	Capturepoint Solutions LLC	Commercial Lease Agreement	1,280	2022
North Dakota[195]	Oliver County	Minnkota Power Cooperative, Inc.	Easements (two)	160.00 – 640.00	2022
Texas[196]	Chambers County	OLCV Land Holdings	Lease	130.81	2024
	Jefferson County	Bayou Bend CCS LLC	Lease	40,864.34	2022
	Laramie County	Tallgrass High Plains Carbon Storage, LLC	Special Use Lease	8,115.00	2023

194. *Commercial Lease*, by and between South Delta School District and CapturePoint Solutions, LLC, Land Deed Record No, 342, Page 5050 of the records of Chancery Court of Sharkey County, Mississippi (Oct. 11, 2022), *available at* https://ser-web.arcc.uwyo.edu/files/cerpa/leases/MS-Capture-Point-Lease.pdf [hereinafter "Mississippi-CapturePoint Lease"].

195. *Carbon Dioxide Storage Easement Agreemen*t, entered by and between the North Dakota Game and Fish Department (unrecorded) (Feb. 28, 2022), *available at* https://ser-web.arcc.uwyo.edu/files/cerpa/leases/ND-Game-And-Fish-Easement.pdf [hereinafter "North Dakota Game and Fish Easement"]; *Carbon Dioxide Storage Easement Agreement*, entered by and between the State of North Dakota Board of University and School Lands and Minnkota Cooperative Power, Inc., recorded at Book UU, Page 642 of the records of the Oliver County Recorder (Feb. 17, 2022), *available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/ND-School-Lands-Easement.pdf* [hereinafter "North Dakota School Lands Easement"; together with North Dakota Game and Fish Easement, "North Dakota Easements"].

196. *Carbon Dioxide Transportation and Storage Lease*, by and between the Permanent School Fund of the State of Texas and Bayou Bend CCS LLC, Jefferson County, Texas (Apr. 1, 2022) (unrecorded), *available at* https://ser-web.arcc.uwyo.edu/files/cerpa/leases/TX-Bayou-Bend-Lease.pdf [hereinafter "Texas-Bayou Bend Lease"]; *Carbon Dioxide Underground Storage Lease Agreement*, by and between Chambers County and OLCV Land Holdings, Chambers County, Texas (Aug. 27, 2024), *available at* https://ser-web.arcc.uwyo.edu/files/cerpa/leases/TX-Chambers-County-Lease.pdf [hereinafter "Texas-Chambers County Lease"; together with Texas-Bayou Bend Lease, "Texas Leases"].

Wyo	Uinta County	Pond Field LLC	Special Use Lease	6,720.00	2023

1. The Structure of Pore Space Agreements

a. Form of the Agreement

Selecting a form of agreement for a pore space contract requires a balancinprag act of interests: the landowner's interest in locking the highest possible price can weigh against the operator's interest in reducing risk wherever possible, while the landowner's concerns about underutilization and desire for reversion may be contrary to the operator's need for perpetual access. In all cases, there is a need to value a resource about which little may be known at the time of contract. Of the nineteen agreements analyzed in this research, ten take the general form of a lease,[198] while three purported by their title to take the form of an easement.[199] The remaining six agreements (all in Louisiana) were fashioned as operating agreements.[200] However, a closer look at the agreements proves their titles are not necessarily determinant of their function. Though the California and both North Dakota agreements bore the label of an "easement," all three agreements are defeasible in their early term, thus fundamentally resembling a lease structure. Specifically, each easement terminates automatically should injection operations fail to commence by the end of the initial or, as applicable, the extended primary term.[201] The

197. *Special Use Lease*, by and between the State of Wyoming Board of Land Commissioners and Pond Field LLC, Lincoln, Sweetwater, and Uinta Counties, Wyoming (application approved by the Wyoming State Board of Land Commissioners Feb. 27, 2023) (unrecorded), available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/WY-Pond-Field-Lease.pdf [hereinafter "Wyoming-Pond Field Lease"]; *Special Use Lease*, by and between the State of Wyoming Board of Land Commissioners and Tallgrass High Plains Carbon Storage, LLC, Laramie County Wyoming (approved at the Meeting of the Wyoming State Board of Land Commissioners June 1, 2023) (unrecorded), *available at https://ser-web.arcc.uwyo.edu/files/cerpa/leases/WY-Tallgrass-Lease.pdf* [hereinafter "Wyoming-Tallgrass Lease"; together with Wyoming-Pond Field Lease, "Wyoming Leases").

198. *See* Colorado Leases, *supra* note 191; Mississippi Lease, *supra* note 194; Texas Leases, *supra* note 196; and Wyoming Leases, *supra* note 197.

199. California-TerraVault Easement, *supra* note 190 and North Dakota Easements, *supra* note 195.

200. *See* Louisiana Agreements, *supra* note 193.

201. California-TerraVault Easement, *supra* note 190, at 5; North Dakota School Lands Easement, *supra* note 195, at 4; North Dakota Game and Fish Easement, *supra* note 195, at 4.

California easement may also terminate in part as to acreage that goes unused or is deemed undesirable by the operator, much like a Pugh clause of an oil and gas lease.[202] Moreover, both of the North Dakota easements (unless terminated earlier pursuant to the terms of the lease) end ninety-nine years following the easement execution date.[203]

Function again prevails over form in the Louisiana agreements, all of which are titled as "Operating Agreement." The agreements all follow a similar structure, likely originating from the same statutorily prescribed form for oil, gas, and other energy development agreements entered into by state agencies.[204] While "operating agreement" is used under the statute and in the agreements entered into thereunder, operating agreements function in this context more like leases, with the operator receiving the rights needed to develop the resource and the state receiving revenues therefrom and accepting a portion of the risk.[205]

Finally, though the Colorado leases each take the form of a lease, most are exploration leases only, entitling the operator to an initial period of exploration (six months to a maximum extended term of three years).[206] Following exploration and characterization, as marked by the completion of a seismic survey or the filing of a stratigraphic test well permit, the operator receives the exclusive right to negotiate a sequestration lease, the preliminary terms of which are decided at the time of executing the exploration lease.[207]

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202. California-TerraVault Easement, *supra* note 190, at 6. A Pugh clause is a provision found in oil and gas leases which stipulates that "operations on, or production from a pooled unit established under the lease, embracing a part of the lessor's lands and other lands, will serve to maintain the lease in force and effect only as to the lands in the unit." 38 AM. JUR. 2D GAS AND OIL § 164 (2024). By restricting the acreage held by production, the Pugh Clause allows the unproductive acreage to be returned to the lessor, freeing it for new leasing or other purposes.

203. North Dakota School Lands Easement, *supra* note 195, at 4; North Dakota Game and Fish Easement, *supra* note 195, at 4.

204. LA. REV. STAT. § 30:209(4) (West 2024). *See also* Keith B. Hall, *Local Government Regulation of CCS*, 24 WYO. L. REV. 473, 532, n. 162 (2024) ("Under certain circumstances, the State Mineral and Energy Board can grant leases through direct negotiation, rather than through a bidding process. The leases granted through direct negotiations are called "operating agreements.").

205. *See* Louisiana Agreements, *supra* note 193, *e.g.,* Louisiana-Castex Agreement, at 2 ("[T]he parties agree and acknowledge that this Agreement . . . create[s] a limited relationship between the Parties whereby the State (i) will receive a share of revenues from the Storage of Carbon Dioxide Stream(s) . . . and (ii) will assume a portion of the risk of the cost of such activities.").

206. *See* Colorado-Denova Lease, Colorado-Eos Lease, and Colorado-CapturePoint Lease, *supra* note 191.

207. Colorado-Eos Lease and Colorado-CapturePoint Lease, *supra* note 191, at Ex. C.

Accordingly, the Colorado leases function—at least initially—more like an option agreement than a lease. This distinction is important and has practical effect in the allocation of market risk between the parties. The initial option bonus in Colorado is lower than the bonus paid in other states, but whereas in those states the final economic terms of the lease are guaranteed, a project operator in Colorado assumes a future market risk by agreeing to negotiate the bonus at the time that it exercises the option.

b. The Granting Clause

The quantity of land granted in the agreements varies substantially, ranging from a meager 160 acres at the smallest to a sprawling 122,455 acres at the largest.[208] Other than the outliers in Colorado and Mississippi, the agreements were also depth-limited, either by reference to a specific number of feet or specific formation. Despite these commonalities, the acreage and land characteristics of each lease vary by region, reflecting history and context of land ownership patterns. In some examples, the agreement covered numerous, non-contiguous lands owned by the state over a large area. For example, in Wyoming, state parcels are most often a square mile. When Wyoming was then admitted to statehood, the federal government conveyed some of its holdings to the state, including sections 16 and 36 of every township, which were reserved as school trust lands.[209] In contrast, in Texas and Louisiana, the majority of the transactions have been for large contiguous blocks in submerged lands.[210] In these and other Gulf Coast states, state ownership of submerged lands is attributable to the Submerged Lands Act of 1953, under which Gulf Coast states are entitled to claim ownership of submerged lands up to "three marine leagues," provided the state's boundary extended as far at the time of its admission to the United States.[211]

208. Louisiana-Air Products Agreement, *supra* note 193.

209. Wyoming Act of Admission, 26 Stat. 222 (1890).

210. J. Dickens and B.B. Pollett, Carbon Dioxide Transport and Sequestration in the Submerged Lands of the United States Gulf of Mexico Region, 21 OIL, GAS & ENERGY L. J. 1, 29–32 (July 2023).

211. *Id.* at 4.

c. The Term

Agreements generally divide the term of the project into three or four distinct phases timed around pivotal points in the development of a sequestration project. State land agreements in Louisiana have four segments. These include: the "initial term," a period of time during which the project operator may characterize the property and apply for a Class VI permit; the "construction term" during which the developer constructs the well and begins injection, the "operational term" during which injection activities continue; and a "post-operations" term during which the operator can conduct restoration and monitoring activities and obtain a certificate of completion for the project.[212] While the names of the terms differ, agreements in California, Mississippi, Texas, and Wyoming generally follow the same structure.[213]

The initial term (or sometimes "development"[214] or "primary" term[215]) is fixed by a number of years during which the grantee is expected to conduct geologic characterization activities and apply for a Class VI permit. In Mississippi, this term is broken into an "initial study term" followed by a separate "Class VI permit approval period."[216] The initial period of characterization and permitting activities (whether consolidated within a single term or broken into two) typically spans between three and five years,[217] or up to ten in one case.[218] Following this initial permitting phase, some agreements set forth a subsequent "construction term" for well and facility construction prior to injection. [219] The construction term in these agreements is also fixed by a number of years––typically between

212. *See* Louisiana Agreements, *supra* note 193, e.g., Louisiana-Air Products Agreement, at ¶¶ 3.2–3.4

213. In Texas, for example, phases include an initial "development term" during which the grantee must apply for a Class VI permit, followed by a construction term, then an "operations term" and a subsequent "maintenance term." Texas-Chambers County Lease, *supra* note 196, at 3–5, ¶¶ 2.02–2.05.

214. *Id.* at 3, ¶ 2.02; Wyoming-Tallgrass Lease, *supra* note 197, at 5, ¶ 4.3(b).

215. California-TerraVault Lease, *supra* note 190, at 4, ¶ 3.

216. *See* Mississippi-CapturePoint Lease, *supra* note 194, at 16, Ex. B.

217. *See id.* (36 months for permitting); Louisiana-Venture Global Cameron Agreement *supra* note 193, at ¶ 3.1 (three years with a possible two-year extension).

218. Texas-Chambers County Lease, *supra* note 196, at 3–5, ¶ 2.02.

219. The agreements from California, Colorado, Mississippi, and North Dakota do not contain an explicit construction term.

three and five.[220] Activities during the permitting and construction phases require significant financial investment. As a result, the project developer will customarily demand a period of exclusivity, during which it has the option, but not the obligation, to develop the property.[221] The segmentation of the term into two tranches—characterization and permitting, and construction—is designed to limit the amount of time the project operator can hold a lease without progress toward injection.

However, not all agreements adhere to the majority structure or timeline. The California lease, for instance, includes only a single consolidated five-year "Primary Term" during which permitting, construction, and any other activities prerequisite to injection must take place.[222] The North Dakota leases include a similar, consolidated "Initial Term" which can span between twenty years to an extended term of forty years, unless injection sooner begins, rendering those agreements outliers in both structure and timing.[223] Although these agreements do not segment characterization and permitting from construction, thus leaving discretion to the operator as to its allocation of time on pre-injection activities, the same outcome results: if the operator does not obtain a permit within the initial term, the lease terminates.

In every agreement examined, the commencement of injection marks the start of an "operational term" or "operations term." The operations term is structured as a defeasible term, the maximum

220. *See* Louisiana Agreements, *supra* note 193, e.g., Louisiana-Venture Global Cameron Agreement, at ¶ 3.3. The Louisiana Agreements include identical language on this point. Texas-Bayou Bend Lease, *supra* note 196, at 5–6, ¶¶ 2.03(a), (b); Texas-Chambers County Lease, *supra* note 196, at 3–5, ¶ 2.02 (both providing an initial three-year construction period with possibility of two-year extension); Wyoming-Tallgrass Lease, *supra* note 197, at 5, ¶ 4.3(a) and Wyoming-Pond Field Lease, *supra* note 197, at 4, ¶ 1.27(b) (both allowing four years for construction).

221. *See, e.g.*, California-TerraVault Lease, *supra* note 190, at ¶ 2(a) (granting "an exclusive easement in and to the Property for the purpose of conducting any investigations, inspections, studies, surveys and or/tests"). For language disclaiming the obligation to develop after exploration and characterization, *see, e.g.*, Wyoming-Tallgrass Lease, *supra* note 197 ("Lessee shall have no obligation, express or implied, to begin, pursue, construct, or continue storage operations in the Storage Unit, or store all or any portion of the CO2 stored therein. The timing, nature, manner, and extent of Lessee's operations, if any, under this Lease shall be at the sole discretion of Lessee, unless otherwise stated herein.").

222. California-TerraVault Lease, *supra* note 190, at 4, ¶ 3.

223. *See* North Dakota School Lands Easement, *supra* note 195, at ¶ 2.3 ("This Easement shall . . . continue for an initial term of twenty (20) years unless sooner terminated . . . Grantee may request . . . to extend the Initial Term for up to four successive five-year periods; *provided*, however, that the Storage Payment may be renegotiated for each such extension."). The North Dakota Game and Fish Easement contains an identical provision, *see supra* note 195, at ¶ 2.3.

duration of which is determined either by an external event or by a term of years. For example, in California the operational term lasts for so long as injections continue without interruption, similar to how the habendum clause of an oil and gas lease is defined by the period of production.[224] Theoretically, the operations term could endure indefinitely provided injections continue. North Dakota adopts a variation of this structure, providing that the operational term remains in effect for so long as the covered lands are subject to a relevant Class VI permit.[225] Some agreements, including those in North Dakota and Wyoming, also set an outer limit on the operations term—along with the lease in its entirety—terminating automatically after a fixed number of years.[226] In these leases the terms are still defeasible, and can end earlier if injection activities cease. In Wyoming, for instance, the operational term terminates at the earlier of 1) the passage of thirty years from the first injection, or 2) a cessation of injections for a continuous period greater than two years.[227] The final stage of the agreement is a "post-operations" term allowing continued use of and access to the land following injection during which the operator can conduct restoration and monitoring activities and obtain a certificate of completion for the project.

Agreements with the Colorado State Board of Land Commissioners follow a different overall structure in comparison to other agreements.[228] In Colorado, agreements are structured as an exploration lease with the option to enter into a separate lease for carbon storage. The exploration period grants the operator the exclusive right to conduct activities such as seismic surveying and drilling test wells. At the end of the exploration lease, the operator has the right (but not the obligation) to enter into a carbon storage lease, which is divided into permitting/construction, injection, and monitoring terms. Cumulatively, viewed together, the Colorado option and lease pairing follow a similar structure to other agreements.

224. *See, e.g.*, Wyoming-Pond Field Lease, *supra* note 197, at ¶ 4.3(c).

225. *Id.*; North Dakota Game and Fish Easement and North Dakota School Lands Easement, *supra* note 195, at ¶ 2.1.

226. Wyoming-Tallgrass Lease, *supra* note 197, at ¶ 4.3(c).

227. *Id.* Under the Wyoming-Tallgrass Lease (but not the Wyoming-Pond Field Lease), if the operational term terminates due to ceased injection activities, the operator can restore the lease to the operational term by recommencing injections within four years.

228. Private agreements in Randolph County, Indiana also adopt this option-lease.

An agreement between the South Delta School District in Sharkey County, Mississippi and CapturePoint Solutions, LLC also presents key differences from the leasing structure adhered to in other agreements, representing a notable outlier. The Mississippi lease, which was executed using a generic Mississippi secretary of state commercial lease form, includes an "initial study period" of eighteen months, after which the operator has the option, but not the obligation, to apply for a Class VI permit and enter a subsequent "Class VI permit approval period."[229] If the project proceeds to injection, the operator enters an "operational phase," with the "operational" aspect encompassing injection activities as well as post-injection aftercare and monitoring operations.[230] While these aspects track the structures of other states, the lease is unique in that permitting and injection activities are not segmented. The three phases are combined for treatment as a cumulative twenty-five-year "primary term," which the operator reserves the option to extend for an additional twenty-five years.[231]

2. Compensation Provisions

The compensation mechanisms for pore space acquisition take a variety of forms to balance risk and reward at various stages of a project. These include combinations of different compensation forms, among them lump sum payments, acreage based annual rents, net profits interests, and volumetric payments for injection. Parties' decision-making around the use or combination of these compensation mechanisms illustrates how operators and landowners are balancing, allocating, and mitigating various risks throughout the lifetime of the project.[232] In general, the type of compensation payable aligns with the different stages of development reflected in the agreement's terms. During the initial and construction terms, for instance, compensation to pore space owners is paid through bonus payments and annual rentals, calculated on a gross or per-surface-acre basis. If the operator commences injection activities, the form of compensation pivots towards a volumetric mechanism, whether through a royalty structure or, more commonly, a fee-per-ton. The

229. Mississippi-CapturePoint Lease, *supra* note 194, at Ex. B, ¶ 33.
230. *Id.*
231. *Id.*
232. For a discussion related to how different payment structures allocate risk, *see,* H. Leland, *Optimal Risk Sharing and the Leasing of Natural Resources, with Application to Oil and Gas Leasing on the OCS,* 92 Q. J. ECON. 413, 433 (1978).

combination of a bonus plus a volumetric payment aligns with the fixed and variable fee structure for mineral extraction contracts. Of the agreements reviewed, all followed a common structure except for the agreement with the South Delta School District in Mississippi.[233] That agreement is unique in that it includes no bonus payment structure, nor does it include volumetric payments. Rather, compensation during all of the lease phases is based on an annual fixed per-acre fee.

a. Bonus Payments

Bonus payments are compensation payable to the landowner for the initial grant of rights upon signing the lease or within a specific time frame based on the execution of the agreement. In addition to paying for the access, bonus payments compensate the pore space owner for the opportunity cost borne by the landowner while the grantee navigates the characterization and permitting process. Bonus structures strike a compromise between the developer's uncertainty during early leasing stage, its potential unwillingness to give up a larger portion of long-term project value, and the need to compensate the landowner for its opportunity cost. For instance, while the developer will need to tie up the property for potentially a long time, it may not want to pay a bonus to compensate the landowner for the entire period if there is a high likelihood that the project may not get developed. Similarly, the developer may not want to engage in characterization and permitting activities if it must absorb the risk of the leasing market. Conversely, however, the landowner will not want to tie up the property for a long time without development, potentially foregoing the opportunity to negotiate a higher value contract in the future.

The agreements take three distinct approaches to address this risk asymmetry (excluding the Mississippi lease, which omits a bonus structure).[234] In Louisiana, the project operator takes all the development risk, while the developer and landowner split the market risk. If pore space appreciates in value, the contract favors the developer; if the value of pore space falls, the fixed fee provides a higher than market return to the landowner. In Louisiana, the project operator pays the full amount of bonus upfront to secure contract

233. Mississippi-CapturePoint Lease, *supra* note 194.
234. *Id.*

terms.[235] If the project succeeds, the landowner cannot negotiate higher terms, but if the project fails the operator will have lost a large upfront cost. In Colorado, the operator limits its development risk but internalizes the market risk through an option-lease structure.[236] The option-lease structure allows the operator to limit upfront capital investment because a bonus is only paid for the first exploration term. However, it hazards that the value of the lease at the time of exercise will have substantially increased. While some of the option agreements specify a per-ton fee or royalty, if that proves lower than market value at the time of exercise, then the developer benefits. In California, Texas, and Wyoming, agreements have allowed the project operator to limit both its development and market risk by phasing bonus payments according to key development milestones.[237] The first payment is made upon signing the lease, the second upon commitment of a minimum volume of CO_2 to the project, and the third upon commencement of injection.[238] The project operator therefore limits its upfront capital investment to the first tranche, paying more only as development risk decreases. However, unlike under the Colorado agreements, the landowner gives up any opportunity to negotiate more favorable terms if the project moves forward.

The agreements also incorporate temporal segmentation to address uncertainty around development timelines. Due to the amount of new infrastructure required and uncertainties related to permitting timelines, it may be many years between the time of contracting and the commencement of injection. At the time of contracting, the parties may not know how long characterization, permitting, or construction will take. In fact, including all possible extensions, the leases reviewed (excluding outliers) allowed for extensions between seven and thirteen years prior to injection, with between four and six years for characterization and permitting. Every agreement reviewed includes the opportunity for extensions of the pre-injection terms, while agreements in California, Colorado, Texas, and Wyoming grant the project operator a unilateral right to extend the initial and

235. *See, e.g.,* Louisiana-Castex Agreement, *supra* note 193, at ¶ 4.1.

236. *See* Colorado Leases, *supra* note 191.

237. *See* California-TerraVault Easement, *supra* note 190; Texas Leases, *supra* note 196; Wyoming Leases, *supra* note 197.

238. California-TerraVault Easement, *supra* note 190; Texas Leases, *supra* note 196; Wyoming Leases, *supra* note 197.

construction terms through the payment of an additional bonus.[239] This allows the project operator to limit its investment so that it does not pay for time it does not need, while allowing an extension if necessary. In contrast, the Louisiana agreements do not require an additional bonus, nor do they guarantee an extension, instead leaving the decision to the state's discretion upon showing of good cause.[240]

b. Per-Acre Annual Rentals

Per-acre annual rentals compensate the landowner for the opportunity cost imposed by the contract, as well as by continued use of the surface of the property. During the pre-injection period, annual rentals can encourage expeditious development of the property by imposing a cost on delay. During the injection period, annual rentals discourage underutilization of the property while assuring the landowner a minimum annual rate of return. A per-acre annual rental may also encourage the developer to release unused portions of the property back to the landowner, thus liberating them for other uses.

Notably, only some agreements (California, Colorado, Louisiana, Mississippi, and one Texas agreement) require an annual per-acre rental.[241] In California, Colorado, and Louisiana, these rentals continue during both the pre-injection and injection phases, indicating they are designed to compensate for the encumbrance of the contract as well as the cost of delay. In addition, the leases allow for partial surrender of the leased premises, indicating the rentals are intended to encourage release of unused portions of the property. The Texas agreement is an exception, here, however, requiring the lessee's payment of an annual rental fee until the fifth anniversary of the agreement, an obligation which continues as to the entire acreage "notwithstanding the termination of the Agreement or the release of any portion of [acreage]."[242] The Mississippi agreement, too, sets forth an anomalous structure. It includes an extended per-acre rental fee, payable even throughout the operational period for as long as the leased lands are utilized for storage with cessation of no more than

239. California-TerraVault Easement, *supra* note 190; Texas Leases, *supra* note 190; Wyoming Leases, *supra* note 197; Colorado Leases, *supra* note 191.

240. *See*, *e.g.*, Louisiana-Global CCS Cameron Agreement, *supra* note 193, at ¶¶ 3.1–3.3.

241. *See, e.g.,* California-TerraVault Easement, *supra* note 190, at ¶¶ 4(a), (b); Colorado-Denova Lease, *supra* note 191, at 1; Louisiana-Global CCS Cameron Agreement, *supra* note 193, at ¶ 4.2; Mississippi-CapturePoint Lease, *supra* note 194, at Ex. B, ¶ 33.

242. Texas–Chambers County Lease, *supra* note 196, at 6, ¶ 3.01(b).

one year.[243] The per-acre rental does, however, vary during the initial and operational periods, increasing from $62.50 per acre during the initial period to $65 per acre during the operational period.[244]

Between Louisiana and Colorado, however, the allocation of value between the bonus payment and the rental differs substantially. In Louisiana, rentals are small in relation to the bonus amount. For example, in the Castex agreement, the bonus is $300 per acre whereas the rentals are $60 per acre.[245] This structure more closely resembles an oil and gas lease where the bonus constitutes the primary compensation for the grant of rights and rentals are a small portion of the bonus and meant primarily to compensate the landowner for the privilege of deferring development. In contrast, under the Colorado leases, the amount of bonus and annual rental are the same, at $12 per-acre per-year during the exploration period.[246] Under this structure, the initial bonus payment is relatively low.[247] However, because the full amount of the bonus is payable annually, after a few years the total amount paid would exceed the amounts paid as bonus in Wyoming. While the preliminary terms for the carbon sequestration lease suggest that rentals will continue during the carbon storage lease if the option is exercised, the state retains the right to adjust the rentals based on market terms at the time of exercise, up to a maximum of twice the amount of the annual rental.[248] As seen in the bonus structure of the Colorado leases, allowing initial exploration with very little capital investment may limit development risk, but also requires the project operator to assume the market risk. Combined with the bonus structure, this format may encourage project operators in Colorado to complete sequestration as quickly as possible to limit the amount of upfront capital invested through bonus and rentals, and to limit the risk that the market for sequestration leases will substantially increase during its sequestration period.

c. Volumetric Payments

Excluding the Mississippi lease, every agreement contained volumetric payments based on injection. Volumetric payments are the

243. Mississippi-CapturePoint Lease, *supra* note 194, at Ex. B, ¶ 33.
244. *Id*.
245. Louisiana-Castex Agreement, *supra* note 193.
246. *See, e.g.,* Colorado-CapturePoint Lease, *supra* note 191, at 1.
247. *Id*.
248. Colorado-CapturePoint Lease, *supra* note 191, at Ex. C, ¶ 4.

primary way that parties to pore space agreements address the risk of *price* and *extent*. They are analogous to mineral extraction contracts with a gross production royalty, wherein a resource owner is paid based on a measure of the extent of the resource once that extent is realized *ex post*.[249] In oil and gas, this is the amount of production from the property—or the amount that can be captured. In pore space contracts, conversely, volumetric payments are based on the volume of injection measured in tons of CO_2.[250] This approximates the extent of the resource, with more accessible pore volume translating in theory to higher injection volumes. However, the way CCS projects generate revenue differs markedly from traditional mineral extraction projects. Geologically sequestering CO_2 does not inherently produce something of monetary value like mineral extraction. Instead, at least for the time being, CCS projects generate revenue from payments for carbon removal. These markets are only beginning to develop.

Currently, the market for carbon removal is primarily driven by public subsidy in the form of tax credits. The 45Q tax credit provides a payment for every ton of CO_2 that is captured and put into permanent sequestration.[251] 45Q payments differ depending on the manner of capture, how it is sequestered, and whether certain prevailing wage requirements are met. For example, CO_2 stored through enhanced oil recovery receives a lower credit ($60) than CO_2 placed in geologic storage ($85).[252] However, if the CO_2 was captured through direct air capture and prevailing wage requirements are met, the credit is much higher to cover the greater capture costs—$130 for EOR and $180 for geologic storage.[253] Other federal and state credits incentivize production of hydrogen, which could also require pore space for carbon storage.[254] These payments not only vary but are also subject to significant uncertainty in the long-term. They may increase, decrease, or expire. The limitations on the credit, also limit the areas where CCUS projects are likely to develop. For example, the 45Q credit is only authorized for projects that place capture equipment into service before 2033. For projects that meet this

249. R. Lee Gresham et al., *Implications of Compensating Property Owners for Geological CO2 Sequestration*, 44 ENV'T SCI. TECH. 2897, 2898 (2010).
250. *Id.*
251. 26 U.S.C. § 45Q (West 2024).
252. *Id.*
253. *Id.*
254. *See, e.g.,* 26 U.S.C. § 45V (West 2024).

deadline, eligibility is limited to only twelve years. If nothing changes, payments under the program will sunset by 2045. Since the current credit level is insufficient to render capture from most industrial sources economical, development may be limited to areas near low-capture cost point sources.[255] If Congress intends to expand capture to other industries, it may have to increase the credit or extend its availability.

Sequestration operators can also monetize carbon removals by selling offsets in voluntary carbon markets or by generating products that can be sold at a premium due to their lower carbon intensity. Regulatory frameworks and guidance to govern carbon offset markets are only beginning to emerge.[256] Historically, the value of carbon offsets has varied drastically based on the company's marketing efforts.[257] For example, some credits may be higher priced because they include community consultation, support habitats, or invest in indigenous communities. In addition to offsets, some sequestration operators may realize revenue through low-carbon product credits. These include credits such as California's Low Carbon Fuel Standard, which provides a supplemental payment for low-carbon fuels sold into California markets.[258] Revenue generated from carbon offsets or value-add products is in addition to that, which can be claimed for 45Q credits. These additional payments are referred to in pore space leases as "environmental attributes," which, as the name suggests, may be tied to numerous factors other than the volume of carbon injected.[259]

Therefore, the value received for each unit of volume may be highly specific based on the specific business model and offtake sources available to the sequestration operator. Carbon credit and product incentives are paid to the company that operates the capture equipment or which produces the product, not to the storage

255. U.S. Dep't of Energy, The Pathway to Carbon Management Commercial Liftoff, figs. 1 & 2 (Apr. 2023).

256. Commission Guidance Regarding the Listing of Voluntary Carbon Credit Derivative Contracts, 89 Fed. Reg. 83378 (Oct. 15, 2024) (to be codified at 17 C.F.R. pt. 38).

257. Regarding the effect of marketing, there has emerged relative consensus among policymakers on the potentially negative impact of marketing efforts that fail to accurately represent the decarbonization impact of the credit. In a joint statement, federal agencies in May 2024 released new guidance to standardize methodologies and encourage transparency. *See* WHITE HOUSE, VOLUNTARY CARBON MARKETS JOINT POLICY STATEMENT AND PRINCIPLES (May 2024).

258. CAL. AIR RES. BD., *Low Carbon Fuel Standard*, https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard [https://perma.cc/7VSA-8BGY] (last visited May 8, 2025).

259. *See, e.g.,* California-Carbon TerraVault Easement, *supra* note 190, at 2, ¶ 1(d).

operator. The storage operator must, therefore, negotiate a fee for disposal of the CO_2 through an offtake agreement.[260] Depending on the costs of capture and transport, the amount a capture facility can pay will also vary. The sequestration operator's revenue will, therefore, rely on the type of capture facilities it can access as well as when those sources come online. This, in turn, determines how much the operator can pay to the landowner for storage rights. Unlike oil and gas markets, which are readily transparent, the pore space owner may have little insight into the revenue available to the sequestration operator.

The volumetric payments set forth in the examined agreements use a fee per-ton, which aligns with tipping fees used in other waste management projects; a royalty percentage on the proceeds generated from environmental attributes generated by the project; or sometimes a hybrid of both. The Louisiana and Wyoming agreements take the first of these approaches, with compensation during the injection term paid as an annual injection fee on a per-ton basis.[261] In these agreements, the project operator absorbs 100% of the ultimate price variability. Volume is the only factor that impacts payments made to the pore space owner. Therefore, under a fixed fee contract, the pore space owner takes the risk that values will increase for carbon storage and that it will have foregone a share of potential revenue.

To address this potential imbalance, several pore space agreements include price escalators to assure that the landowner participates in positive changes in the market for carbon sequestration. More recent leases in Louisiana include an escalator tied to the 45Q tax credit, assuring that injection fees will increase proportionately as the credit increases.[262] While this ensures the landowner will receive more value, it may not reflect market increases for pore space. 45Q is more reflective of the cost of capture than it is of the value of carbon removal. These increases may merely allow capture at additional facilities, such as cement plants or pulp and paper mills, but not increase the surplus available to pay for storage. Additionally, if the

260. Tade Oyewunmi, Offtake and Transportation Agreements in Carbon Capture Utilization and Storage Projects, 2024 NO. 1 FNREL-INST. 6, 6-3, 6-5 (2024); Austin Lee, et al., The Way Forward: A Legal and Commercial Primer on Carbon Capture, Utilization, and Sequestration, 16 TEX. J. OIL GAS & ENERGY L. 43, 68 (2021).

261. *See, e.g.,* Louisiana-High West Agreement, *supra* note 193, at ¶ 4.3; Louisiana-Castex Agreement, *supra* note 193, at ¶ 4.3; Wyoming-Tallgrass Lease, *supra* note 197, at ¶ 5.3.

262. *See* Louisiana-High West Agreement, *supra* note 193, at ¶ 4.5.

storage operator cannot access CO_2 streams benefiting from increased credits, its revenues may be stagnant, notwithstanding the increased credit value.

In contrast, a royalty structure may capture these future value streams by providing the pore space owner with the right to a share of future environmental attributes generated by the injection activities. More like an oil and gas lease, the Texas agreement for Bayou Bend uses this approach.[263] Under that lease the pore space owner participates directly in the revenues generated from any "environmental attributes" generated by the project, sharing directly alongside the project operator in the marketing risk of the project.[264] While this could result in higher returns to the pore space owner, it also assumes the potential risk that the project operator will be unsuccessful in monetizing the credits.

Finally, the proposed lease terms in the Colorado option model adopt a hybrid approach that combines aspects of both the fee-per-ton and royalty approaches.[265] Under that lease structure, the pore space owner receives the higher of a fixed fee or 3% of the 45Q credit, plus a percentage of the value of any monetization of credits, non-45Q credits, or other revenues.[266] Through this compensation approach, the pore space owner limits the downside with a minimum per ton fee but preserves the right to participate in the upside as markets develop.

All forms of volumetric fees introduce the risk of under-injection for the pore space owner. Under-injection is problematic because the landowner wants to assure efficient, full, and expeditious development to maximize value in the fastest possible time frame. The faster the property is developed, and the more injection occurs, the more present value the project will have for the landowner. Even if the property was eventually fully utilized, under-injection could extend the period of payment over a longer period thereby lowering annualized returns. Minimum injection provisions can address part, but not all, of this risk. Like a minimum royalty,[267] minimum injection provisions provide a floor for the number of tons the project operator

263. *See* Texas-Bayou Bend Lease, *supra* note 196, at ¶ 3.01(d), 3.02(e).

264. *Id.*

265. *See, e.g.,* Colorado-Eos Lease, *supra* note 191, at Ex. C, ¶ 8.

266. *Id*.

267. For a discussion of minimum royalty provisions in oil and gas and wind contracts, *see*, Ernest Smith, *Wind Energy: Siting Controversies and Rights in Wind,* 1 ENV'T & ENERGY L. & POL'Y J. 281, 313 (2007).

must pay per year or per month. Minimum payments allow pore space owners to offset some of the risks that could arise if operations are slow to develop and could disincentivize injection operators from holding unused pore space in the hope of market or regulatory changes impacting the value of injected CO_2. However, while these payments may protect the pore space owner in the early period of the lease, they would not protect against—and might contribute to—the early abandonment of the project.[268] For example, as the pressure in the formation increases, regulators may lower permissible injection volumes to protect against fracturing the sealing formations. If the injection rate is lower than the minimum payments, the operator may cease injections altogether if the agreement cannot be renegotiated.

All of the agreements reviewed, with the exception of leases in Mississippi and Wyoming, included one of two forms of minimum injection provisions: a pay-terminate clause and a pay-only clause, which resemble take-or-pay provisions that have been used in transportation markets.[269] The Texas Bayou-Bend lease is an example of a pay-terminate clause, providing for a minimum "true up payment" if the standard annual volume of 1,000,000 tons is not injected in any one year.[270] Under this structure, the state has the right to terminate the lease if the project operator fails to inject the standard annual volume for three consecutive years.[271] Colorado also adopts this structure, except the contract defines the minimum injection as a percentage of the total volumes committed to the project rather than setting a specified volume. If this amount (20%) is not met for five consecutive years, the state has the right to terminate the lease.[272] The Louisiana leases use a pay-only clause.[273] These leases include an annual minimum payment based on a specified tonnage, yet, unlike the Texas lease, under-injection is not cause for termination.[274] The state may terminate only in the event of non-injection. Given the challenge associated with re-leasing to new operators for additional storage, however, a party may not want to enforce minimum injection

268. Exhaustible resource contracts that do not encourage full utilization of the resources are suboptimal and result in undervaluation to the landowner, *see*, Harold Hotelling, *The Economics of Exhaustible Resources*, 39 J. POL. ECON. 137 (1931).

269. Hollye C. Doane, *Take-or-Pay: FERC's Regulatory Dilemma*, 2 NAT. RES. & ENV'T 18, 18 (1987).

270. *See* Texas-Bayou Bend Lease, *supra* note 196, at ¶ 3.01(e).

271. *Id*.

272. *See, e.g.,* Colorado-CapturePoint Lease, *supra* note 191, at Ex. C, ¶ 7.

273. *See, e.g.,* Louisiana-Castex Agreement, *supra* note 193, at ¶ 4.3.

274. *Id.*

provisions or exercise its right of termination, as early termination of the lease could result in waste of the remaining pore volume.[275] Though minimum injection provisions may provide a landowner with some assurances against lost revenue for under-injection, minimum payment provisions still fail to resolve the possibility that the operator could abandon the project before the landowner's pore space is developed fully.

d. Payments in the Post-Injection Period

When either the expiration of a fixed term of years or a cessation of injection activity draws the operational term to a close, most operators remain under obligation to conduct continuing post-injection MRV activities. Only in certain leases (two from Colorado) is the landowner compensated for the operator's post-injection access for MRV activities. Under those agreements, the landowner is compensated at a rate equal to 50% of the rent owed during the operational ("storage") phase.[276]

V. LAND, CAPITAL, AND SEQUESTRATION

These examples of publicly available pore space agreements, while potentially useful to practitioners, reveal the challenge of contracting in a nascent market. In addition to the uncertainties related to the extent of the resource, sequestration is subject to considerable execution and market risks. In many areas, these risks may depress the value of pore space, or, where capture or transport costs are high, leave insufficient surplus to induce landowners to contract. In these cases, landowners may prefer to hold out until markets are more certain and values increase.

Today, most pore space in the country likely has no value for sequestration. Even where storage resources exist in abundant quantities, projects may not be feasible because CO_2 cannot be

275. The agreements we reviewed did not address under-utilization. Under-utilization would occur if the injector pre-maturely abandoned the project, leaving some portion of the pore volume unutilized.

276. *See,* Colorado-Eos Lease, *supra* note 191, at Ex. C, Sec. 4 ("Rentals payable during the Injection Phase and Monitoring Phase shall be 50 percent of the then-current Initial Rental rates."); Colorado-CapturePoint Lease, *supra* note 191, at Ex. C, Section 4 ("Lessee will pay rent during the Monitoring Phase to the extent of any surface disturbance, including but not limited to surface facilities, geologic studies and monitoring, or other use of or access to the surface, on the Leased Premises at 50 percent of the rent due during the Storage Phase.").

captured and transported profitably to the injection location.[277] According to the DOE liftoff report, capture is only currently viable for ethanol production or gas processing.[278] Additionally, CO_2 pipelines have proven nearly impossible, and very expensive to develop in many areas of the country.[279] This means that CO_2 sequestration projects may only be viable where capture and transportation elements are already in place.

Landowners, therefore, may be rational in holding out for higher values. Public investments in research and development and new transportation infrastructure are anticipated to lower capture costs significantly and increase the availability of transport.[280] If these investments are successful, landowners should be able to capture some portion of that value. In 1922, John Orchard observed that even if a mine was worthless or operated at a loss, an owner would not permit mining without compensation because he would gain nothing while losing "an asset that may bring in an income for himself or his heirs with a change in market conditions."[281] Owners will not allow depletion of a resource for nothing, even if the other party does not stand to profit.

If values are low, but non-zero, landowners who anticipate that these public investments will result in increased values would be rational to wait. The opposite, of course, could also be true. It is still unknown whether and to what extent carbon removal will emerge as

277. CONG. BUDGET OFF., CARBON CAPTURE AND STORAGE IN THE UNITED STATES (Dec. 2023) ("The main reason CCS is used to such a limited extent is that the cost to implement CCS technology exceeds its value in most potential settings. Estimates of the cost to capture CO2 come mainly from engineering and economic modeling and can vary widely depending on the assumptions made in that modeling. An indicative range of estimates is from about $15 to $120 per metric ton of CO2 captured, with additional costs for transporting and storing the CO2. Sectors at the lower end of that range provide fewer opportunities for capturing significant amounts of CO2.").

278. Ramsey Fahs et al., *Pathways to Commercial Liftoff: Carbon Management,* DEP'T OF ENERGY (2023), https://liftoff.energy.gov/wp-content/uploads/2024/02/20230424-Liftoff-Carbon-Management-vPUB_update4.pdf [https://perma.cc/D5QM-TFZR].

279. GLOB. CCS INST., BUILDING OUR WAY TO NET-ZERO: CARBON DIOXIDE PIPELINES IN THE UNITED STATES (May 2024), https://www.globalccsinstitute.com/wp-content/uploads/2024/05/Building-Our-Way-to-Net-Zero-Carbon-Dioxide-Pipelines-in-the-United-States.pdf [https://perma.cc/V69U-8A3T].

280. In 2016, DOE set an ambitious target to lower the cost of capture in the power sector to $30-40 per metric ton through R&D investments, *see* U.S. DEP'T OF ENERGY, CARBON CAPTURE, UTILIZATION, AND STORAGE: CLIMATE CHANGE, ECONOMIC COMPETITIVENESS, AND ENERGY SECURITY 5 (Aug. 2016).

281. Jayni Foley Hein & Caroline Cecot, *Mineral Royalties: Historical Uses and Justifications*, 28 DUKE ENV'T L. & POL'Y F. 1 (2017) (citing John E. Orchard, *The Rent of Mineral Lands*, 36 Q.J. ECON. 290, 295 (1922)).

a viable, market-based climate mitigation technology. If Congress does not expand tax incentives or require widespread carbon removals, and if consumer demand and willingness to pay for low-carbon products wanes, the market for pore space could evaporate. While this might encourage early contracting, the relatively small values that landowners would receive under current contracts impose very little opportunity cost on waiting. Even if there is surplus value in a sequestration project under today's conditions,[282] the payment to any individual landowner may not be sufficiently large to overcome costs of contracting. For example, the agreement between Pond Field and the State of Wyoming paid a bonus of $75 per acre for a minimum development period of seven years. If a well was drilled, the landowner would receive its proportionate share of $1 per ton injected. Based on information included in the Class VI permit, the operator would expect to inject approximately 3,300 tons of CO_2 per acre over a 12-year period. For a landowner with the median lot size of 0.31 acres,[283] this would equate to an initial payment of $23 for the initial seven years, with the possibility of $85 per year during the injection period if—and only if— the project is successfully developed to its full scale. These values are hardly sufficient to induce a landowner to jump out of bed, let alone invest in legal representation, educate themselves about sequestration, and overcome concerns about stigma, impacts on property values or employment, and the safety of CCS.[284]

Pore space owners may also be hesitant to contract out of concern that they may grant rights to the "wrong" party. Unlike oil and gas, where the holder of even a fractional mineral interest in a small parcel could pool land and drill a well, sequestration requires extensive land interests and infrastructure across a huge area.[285] As discussed in

282. Lewis Cecil Gray, *Rent Under the Assumption of Exhaustibility*, 28 Q.J. ECON. 466, 467–70 (1914) (arguing that the maximum rent a resource can yield is the surplus income it can produce).

283. Carmen Ang, *The Median Lot Size in Every U.S. State in 2022*, VISUAL CAPITALIST (Nov. 29, 2022), https://www.visualcapitalist.com/cp/the-median-lot-size-in-every-american-state-2022/ [On File with Columbia Journal of Environmental Law].

284. Amanda Boyd, *Communicating about Carbon Capture and Storage, in* OXFORD J. CLIMATE CHANGE COMMC'N (Oxford Univ. Press, 2018); David E. Adelman & Ian J. Duncan, *The Limits of Liability in Promoting Safe Geologic Sequestration of CO2*, 22 DUKE ENV'T L. & POL'Y F. 1 (2011).

285. Uncoordinated injections by multiple rights-holders could result in inefficiencies either rendering portions of the reservoir less valuable or requiring more expensive infrastructure for development, *see* Jens Birkholzer, *Managing a Gigatonne CCS Future: A Framework for Basin-*

Part I, sequestration projects require a large amount of land, ownership of which may span tens of thousands of acres[286] and be fragmented across thousands of different surface, mineral, and other rights holders. Moreover, to deliver a sequestration project, the operator must have the pore space, a Class VI permit, offtake commitments from emitters, and access to CO_2 pipeline capacity. These requirements, particularly pipeline access, introduce a risk of monopolization. In an area where there is competition for pore space among several potential operators, the landowner may prefer to wait and see which operators are able to get offtake commitments or CO_2 capacity or acquire the requisite threshold of interests to move forward with a project.

These rational concerns will encourage holdouts and make it less likely that an operator can acquire sufficient pore space resources to move forward with a project. Professor Anderson has suggested that by acquiring both pore space and mineral interests storage operators might insulate themselves against the potential risks of trespass liability or conflicting uses that threaten containment losses.[287] To do so, it would need to acquire interests in both the "property covering the total area under which the injected carbon oxide will migrate " and "a buffer area beyond the expected plume and migration radius . . . to minimize the risk profile of any storage project in the event of unexpected migration."[288] While acquisition of all property rights within a project could manage legal risks, even without concerns about monopolization or opportunity cost, coordination challenges make this unlikely on a commercial scale.

States with high CCS potential have enacted laws to help remove transactional barriers to contracting.[289] These fall into two

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Scale Storage Optimization Based on Geomechanical Studies, NAT'L ENERGY TECH. LAB. https://netl.doe.gov/sites/default/files/netl-file/23CM_CTS31_Birkholzer.pdf [https://perma.cc/9DSD-SS4Y] (last visited May 15, 2024).

286. For example, one request for public land for a sequestration project in Wyoming includes more than 400,000 acres, *see SW Wyoming CO2 ePlanning Description*, BUREAU OF LAND MGMT. (Apr. 18, 2023), https://eplanning.blm.gov/eplanning-ui/project/2023000/570 [https://perma.cc/HJV6-6T9C].

287. Owen Anderson, *Legal and Commercial Models for Pore-Space Access and Use for Geologic Sequestration of CO2*, (No. 4 RMMLF-INST. Paper No. 9, 2015). Potentially incompatible activities could include existing chemical or wastewater injection operations within the same formation and oil and gas, mining, or geothermal development in or below the storage complex.

288. *Id.*

289. In addition to unitization laws, states have enacted statutes that clarify pore space ownership, thereby reducing information costs associated with identifying landowners, and

categories: laws authorizing expropriation and those authorizing unitization. Louisiana and Indiana initially authorized expropriation of pore space for CCS projects. Expropriation would allow a CCS developer to condemn pore space from non-consenting landowners. Louisiana law, for example, provided that upon receipt of a certificate of public convenience and necessity, an operator could "exercise the power of eminent domain and expropriate needed property to acquire the surface and subsurface rights and property interests necessary or useful for the purpose of constructing, operating, or modifying a storage facility."[290] Other statutes in Louisiana declared that the storage of CO_2 was in the "public interest for a public purpose." Indiana's condemnation law also declared CO_2 storage to be in the public interest,[291] but authorized the use of eminent domain only for a specific carbon capture sequestration pilot project located in West Terre Haute.[292] In Louisiana, however, the expropriation of subsurface interests proved unduly arduous, potentially requiring the initiation of dozens of condemnation proceedings. Accordingly, in 2024, with the passage of House Bill 966, the Louisiana legislature repealed the right of eminent domain, replacing it instead with a process for unitization.[293]

Unitization—also referred to as "amalgamation"[294] or "integration"[295] depending on the jurisdiction—describes a procedure through which numerous interests in contiguous, separately owned tracts are consolidated for development as a single, jointly operated storage unit.[296] Unitization first emerged from the oil and gas industry where it was established as a tool to coordinate production from mineral reservoirs in which numerous owners hold an interest, helping to maximize and streamline resource recovery, reduce waste, and prevent minority holdout interest owners from

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transfer of liability and CO2 ownership statutes that may assuage landowner concerns about long term stewardship, *see* Joseph A. Schremmer, *Subsurface Trespass: Private Remedies and Public Regulation*, 101 NEB. L. REV. 1005 (2023).

290. LA. STAT. ANN. § 30:1108(A)(1) (2024).

291. IND. CODE ANN. § 14-39-1-3 (2019).

292. *Id.* § 14-39-1-7 (authorizing the exercise of eminent domain "by the operator of the carbon sequestration pilot project"); § 14-39-1-3.5 (defining the "sequestration pilot project" as the specific West Terre Haute Project).

293. La. H.B. 966 (2024).

294. N.D. CENT. CODE § 38-22-10 (2024) (amalgamation of pore space).

295. IND. CODE ANN. § 14-39-2-4.

296. *See* Tara Righetti, Jesse Richardson, Kris Koski & Sam Taylor, *The Carbon Storage Future of Public Lands*, 38 PACE ENV'T L. REV. 181, 204 (2021).

unilaterally blocking development.[297] It can be voluntary or compulsory.[298] In the context of geologic sequestration, unitization serves many of the same ends. By coordinating development through jointly operated storage units, unitization can ensure that common storage reservoirs are utilized fully and efficiently, allow for the use of shared infrastructure, and maximize as well as coordinate the distribution of benefits among many owners.[299] In light of these benefits, several states have already passed legislation to authorize the unitization of pore space.[300]

Yet unitization is not a silver bullet to solve all problems related to pore space acquisition. Unitization is designed to overcome coordination challenges between landowners by preventing minority holdouts from blocking projects that most owners support. It does not overcome poor economic drivers that may depress pore space values and discourage *any* contracting. As a result, high consent thresholds may make the statutes difficult to operationalize. Unitization statutes typically require the owners of between 60–80% of the pore space capacity to consent to the formation of the geologic storage unit.[301] In areas with poor economics (high costs to develop

297. Madeleine Lewis, Ctr. for Energy Regul. & Pol'y Analysis, Sch. of Energy Res. at the Univ. of Wyo., Pore Space Unitization for Geologic Sequestration of Carbon Dioxide, Great Plains Inst. 3 (2024), https://carboncaptureready.betterenergy.org/wp-content/uploads/2024/07/SER-Unitization-Analysis_FINAL.pdf [https://perma.cc/V756-VHZK]; Sean Cassidy, *Unitization Provisions*, 30 Energy & Mineral L. Found. § 12.04 (2009).

298. Cassidy, *supra* note 297.

299. *See* Paula C. Murray Frank, *The Case for A Texas Compulsory Unitization Statute*, 23 St. Mary's L.J. 1099, 1101 (1992) (describing the benefits of unitization in the parallel oil and gas context).

300. As of the date of publication, these states include: Alabama, Arkansas, California, Indiana, Kentucky, Louisiana, Mississippi, Montana, Utah, West Virginia, and Wyoming. *See* CAL. PUB. RES. CODE § 71461 (West 2024) (requiring the California Air Resources Board to "publish a framework for governing agreements regarding two or more tracts of land overlying the same geologic storage reservoir or reservoirs for purposes of managing, developing, and operating a carbon dioxide capture, removal, or sequestration project" by July 2025). *See also* IND. CODE ANN. § 14-39-2-4 (West 2024); KY. REV. STAT. ANN. § 353.806 (West 2024); MISS. CODE ANN. § 53-11-13 (West 2025); NEB. REV. STAT. ANN. § 57-1612 (West 2025); N.D. CENT. CODE ANN. § 38-22-08 (West 2025); UTAH CODE ANN. § 40-11-11 (West 2025); W. VA. CODE ANN. § 22-11B-19 (West 2025); WYO. STAT. ANN. § 35-11-314 (West 2024). North Dakota has also passed legislation to authorize pore space amalgamation, *see* N.D. CENT. CODE ANN. § 38-22-10 (West 2025), but the future of the law is unclear due to constitutional challenges. *See* Nw. Landowners Ass'n v. State, No. 20240298 (N.D. filed Oct. 24, 2024); Nw. Landowners Ass'n v. State, 2022 ND 150, 978 N.W.2d 679.

301. CAL. PUB. RES. CODE § 71461 (West 2024) (instructing the California Air Resources Board to promulgate pore space amalgamation rulemaking with a requirement for operators to obtain

projects), and thus little to no surplus for landowners, operators may be unable to obtain consent from a supermajority of owners to voluntarily contract.

On the one hand, it could be argued that if the economics are not adequate to induce a majority of landowners to contract, the project should not progress. Were sequestration a simple economic development project or even an oil and gas production project, that would be true. For example, if the majority of owners in an oil field oppose a drilling plan, a minority developer should not be able to use unitization to force development over the objection of intended beneficiaries of the development. To apply this logic to sequestration, however, ignores the fact that carbon removal is being encouraged as a public benefit. This dynamic illustrates one of the main challenges with the current approach to sequestration. Although sequestration agreements mimic oil and gas resource contracts in their bonus-volumetric fee structure, the business model of sequestration is fundamentally different than oil and gas. There is no natural market for carbon removal. Other than limited markets for voluntary carbon offsets, the public—through 45Q—is the only buyer. Sequestration is therefore being procured as a public service, but through private companies operating as a for-profit business. Within this framework, it is understandable that landowners want to maximize potential rents, notwithstanding the potential costs of developing sequestration projects and delays to meeting carbon removal goals.

Overcoming contracting challenges for a nascent market and minimizing the public costs of carbon removal, therefore, requires reconceiving sequestration as a public service and contemplating alternatives to the current, for-profit commercial models. Land-intensive projects that are core to the public interest often have a high degree of government involvement to prevent individual self-interest from impeding the public good.[302] This is the essence of eminent domain, which requires a public purpose and assures landowners the fair market value of their property while preventing them from extracting additional rents from the public. As with utilities, private enterprises that enjoy condemnation authority for

consent of owners representing at least 75% of the total interests subject to the proposed agreement); MONT. CODE ANN. § 82-11-204 (West 2025) (default threshold consent requirement of 60%); WYO. STAT. ANN. § 35-11-316(c) (West 2024) (default threshold consent requirement of 80%). *But see* MISS. CODE ANN. § 53-11-11 (West 2025) (requiring "majority interest").

302. Daniel B. Kelly, The "Public Use" Requirement in Eminent Domain Law: A Rationale Based on Secret Purchases and Private Influence, 92 CORNELL L. REV. 1, 33 (2006).

public purpose projects are limited in the extent that they can use such property for private gain. Projects operated on a public service model could justify a stronger hand in land acquisition. For example, in a utility-type sequestration model, a sequestration operator would have the right to condemn pore space as necessary in exchange for agreeing to limit their rates of return and offering non-discriminatory access to sequestration services.[303] Landowners would still receive compensation for the fair market value of their interest in the reservoir estate, which, depending on the region and current technologies, could be very little. While this model would perhaps overcome landowner hesitance due to low market values, it would still be administratively difficult. Unlike linear infrastructure which can, to an extent, be routed to avoid difficult areas, sequestration projects tend to be massive in scale and can require millions of acres. The administrative requirements alone would be immense.

If pore space acquisition truly proves to be the Achilles heel of geologic carbon sequestration, looking beyond conventional acquisition processes will be necessary. However, the currently low or nominal pore space values in much of the country present an opportunity for public acquisitions of reservoir space—call them "carbon storage preserves." In this model, Congress could create programs and appropriate funds to acquire pore space in areas with known geologic storage potential but where high-capture costs currently render commercial projects uneconomic. Acquisitions could be accomplished through a combination of voluntary transactions and eminent domain. The resulting "preserves" would be owned by and managed for the benefit of the public and then made available to operators for storage at fair market values. Rents could be used to invest in climate adaptation projects rather than accruing to individual landowners or to private enterprises.

While by no means easy, acquisition at this scale would not be unprecedented. Under the Weeks Act, the federal government purchased approximately twenty million acres of cut-over land to create several eastern national forests.[304] Similarly, in the 1930s, the

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303. This model, including draft legislation for a public utility model, was explored by Professor Schremmer. *See* YEVHEN "EUGENE" HOLUBNYAK & MARTIN DUBOIS, INTEGRATED CCS FOR KANSAS (ICKAN) FINAL TECHNICAL REPORT (2018), https://www.osti.gov/servlets/purl/1491482/ [https://perma.cc/JXC2-VXJB].

304. Press Release, Forest Serv., U.S. Dep't of Agric., US Forest Service Celebrates 100th Anniversary of Weeks Act (Mar. 2, 2011), https://www.fs.usda.gov/about-agency/news

government acquired nearly 11.3 million acres of sub-marginal lands under the Bankhead-Jones Farm Tenant Act and other emergency relief statutes, providing relief to distressed occupants.[305] These lands are now leased for grazing and other public purposes. Similarly, public acquisition authority—voluntary and by eminent domain—has been used to create national parks, monuments, and recreation areas.[306] Hardly a relic of conservation era programs, some of these initiatives are recent. For instance, Golden Gate National Recreation Area was created in the 1970s through a combination of voluntary acquisitions and the use of eminent domain.[307] In areas where the federal government already has some land holdings, targeted acquisition programs could be used to consolidate the pore space resource and remove fragmentation.

Public acquisition of pore space for designated sequestration reserves would secure the nation's future carbon removal efforts. The existence of established contractual frameworks and preliminary market valuations for these rights provides a foundation for transactions by which such rights could be acquired. Given the national interest in carbon storage, the program and funding should be federal. The federal government is already paying for storage through the 45Q program, the value of which is being used by private companies to acquire land rights from pore space owners. This does not mean, however, that the reserves need to be federally owned and managed. States with suitable storage resources and interest in sequestration projects could apply for funds that could be administered within a cooperative federalism model, not unlike recent funds provided to states through the Bipartisan Infrastructure Law's state orphan well program.[308] A cooperative model could address potential state concerns about federal control, giving states

room/releases/us-forest-service-celebrates-100th-anniversary-weeks-act [On File with Columbia Journal of Environmental Law].

305. H.H. Wooten, U.S. Dep't of Agric. Econ. Rsch. Serv., Agric. Econ. Rep. No. 85, The Land Utilization Program 1934 to 1964: Origin, Development, and Present Status, at v (1965); Sidney Baldwin, Poverty and Politics: The Rise and Decline of the Farm Security Administration 107–08 (1968).

306. In fact, author Tara Righetti's own family ranch was condemned to create the Golden Gate National Recreation Area.

307. Hal K. Rothman, Nat'l Park Serv., U.S. Dep't of the Interior, The Park That Makes Its Own Weather: An Administrative History of Golden Gate National Recreation Area (2002), https://www.nps.gov/parkhistory/online_books/goga/goga_admin_history.pdf [https://perma.cc/KE85-3P7A].

308. 42 U.S.C. § 15907 (2021).

an opportunity to determine the location and appropriateness of carbon storage preserves while assuring that national objectives are met through co-management arrangements.

VI. Conclusion

Following enactment of new economic incentives for sequestration, private parties have only recently begun to undertake pore space acquisition at scale. This article engages in the first empirical examination of pore space acquisition agreements, providing transparency to landowners and practitioners. It reveals the emergence of common approaches regarding the contracts' duration, extent, and compensation. Though bearing similarity to other exhaustible resource contracts, these agreements present key differences—distinctions without analog in any other natural resource market. The nascent nature of the sequestration industry introduces a variety of economic, legal, and geological considerations that contribute to high project risk and information asymmetry. Moreover, unresolved questions about trespass and the nature of pore space property rights leave lingering uncertainty about the extent of rights required. These factors, along with subeconomic incentives for capture from the majority of industrial point sources, reduce the value of pore space and operate as a barrier to contracting.

The contracting challenges for pore space acquisition reveal the deeper problem with the commodification of carbon removal. The same challenges that make contracting for pore space difficult also encourage landowners to wait until markets are more developed and capture costs are lower. While doing so may impede expeditious progress towards U.S. net-zero ambitions, with little opportunity cost for inaction, delaying contracting could increase the potential value of their subsurface property. This incentive, however, creates a policy problem: if Congress increases the 45Q credit to encourage capture at higher-cost point sources, the land value surrounding those point sources increase with it. This will have the impact of increasing the ultimate costs of emissions reductions to the public. This reality warrants reconsideration of the mechanisms available to acquire pore space, and with it, the commercial and regulatory models for carbon sequestration.

VII. APPENDIX I

A. Methodologies

The data underlying this article was collected over the course of two years, between March 2023 and May 2025. Our data collection efforts took the form of real property record searches as well as public record requests, the latter of which utilized state, county, and municipal record request laws and platforms to collect relevant agreements.

B. Real Property Record Searches

Pore space contracts are contracts related to real property. Accordingly, either the agreement or a memorandum of the agreement is customarily recorded in the records of the clerk of the county where the real property is located. Over two years, we conducted extensive online records searches in counties where CCS projects have been announced or where permit applications have been filed. We identified potential project areas where we would expect to find pore-space agreements by reviewing news articles, searching SEC records for public announcements of CCS projects in EDGAR, and examining EPA's permit tracker. Using these results, we developed a list of counties and potential names of grantees (project developers) to search. We searched the property records in each of the following counties:

- Baldwin County, Alabama
- Mobile County, Alabama
- Kern County, California
- Larimer County, Colorado
- Weld County, Colorado
- Polk County, Florida
- Christian County, Illinois
- Ford County, Illinois
- Macon County, Illinois
- Montgomery County, Indiana
- Randolph County, Indiana
- Vermillion County, Indiana

- Vigo County, Indiana
- Russell County, Kansas
- Pratt County, Kansas
- Allen Parish Louisiana
- Ascension Parish, Louisiana
- Plaquemines Parish, Louisiana
- Morrill County, Nebraska
- San Juan County, New Mexico
- Lorain County, Ohio
- Bosque County, Texas
- Chambers County, Texas
- Deaf Smith County, Texas
- Ector County, Texas
- Galveston County, Texas
- Glasscock County, Texas
- Harris County, Texas
- Jasper County, Texas
- Jefferson County, Texas
- Kleberg County, Texas
- Liberty County, Texas
- Loving County, Texas
- Midland County, Texas
- Campbell County, Wyoming
- Goshen County, Wyoming
- Laramie County, Wyoming
- Lincoln County, Wyoming
- Sweetwater County, Wyoming
- Uinta County, Wyoming

County real property records can be searched online through portals on local county clerk and recorder websites or through other document requests. Most record search interfaces allow search by property location, by grantor or grantee, or by keyword. Because the lands included in projects most often have not been announced, we used grantee searches and keyword searches. We used the following keywords: "carbon," "storage," "sequestration," "CCS," "pore space," "CCS," "CO2," "Injection," "Carbon Lease," "low carbon," "Seismic," and "carbon capture." We searched only for records filed after January 1, 2019. For each search, we maintained a log as to the date, county, keywords, and results the search yielded. These search efforts were only moderately successful. In many cases we could not locate any recorded documents. The most common form of record filed were 'Memorandums of Pore Space Lease and Carbon Dioxide Storage Easement Agreement.' These memoranda reflect that an agreement has been executed for the pore space but does not include commercial terms.

C. Public Records Request

Although our search of county property records yielded hundreds of results, relevant agreements were rarely recorded in full. Instead, public records indicated only a memorandum of lease or agreement. Most of the publicly available agreements for pore space or injection rights are on state-owned land. We located copies of these agreements by searching the websites for state land offices and through public records requests. Through these avenues, we obtained copies of six agreements with Louisiana state agencies, two agreements with the Wyoming Office of State Lands and investments, one agreement with the Texas General Land Office, and one agreement with a Texas county. The State of Colorado has issued four exploration agreements with lease options. The State of Montana, conversely, reported no agreements presently exist. Additional public records requests to the state land offices in California, Illinois, Kansas, Nebraska, New Mexico, and North Dakota—as well as numerous additional county offices across numerous states—yielded no responsive data.

Uniquely, Louisiana's Department of Energy and Natural Resources publishes on its website all carbon sequestration agreements to which the state is a party.[311]

311. State of Louisiana Department of Energy and Natural Resources, *supra* note 193.