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THE PUBLIC PORE SPACE: ENABLING CARBON CAPTURE AND SEQUESTRATION BY RECONCEPTUALIZING SUBSURFACE PROPERTY RIGHTS

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INTRODUCTION

The growing threat of global climate change[1] presents perhaps the soundest contemporary case for comprehensive national action to mitigate future inter-jurisdictional environmental effects. A coherent national legislative response to environmental change is often seen as necessary to effectively respond to the widespread nature of climate change's effects and sources.[2] In this way, climate change, and the concurrent concern over increasing carbon dioxide ("CO_2") emissions,[3] presents a striking opportunity for government action on behalf of the public good. Indeed, the threat of climate change represents perhaps the perfect example of the "tragedy of the commons."[4] As Garrett Hardin explained, "we are locked into a system of 'fouling our own nest,' so long as we behave only as independent, rational, free enterprisers."[5] To prevent the harmful effects of continued rational, independent action, some move towards collective, public action is required to prevent unprecedented environmental harm across jurisdictions.

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[1] *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT (R.K. Pachauri & A. Reisinger, eds., 2007) (stating that "warming of the climate system is unequivocal" and that anthropogenic carbon dioxide emissions are the "most important" cause) [hereinafter IPCC].

[2] *Cf.* COMM. ON ENERGY AND COMMERCE, 110TH CONG., CLIMATE CHANGE LEGISLATION DESIGN WHITE PAPER: APPROPRIATE ROLES FOR DIFFERENT LEVELS OF GOVERNMENT 1–2 (Comm. Print 2007), *available at* http://www.fws.gov/southeast/climate/policy/Climate%20Dingell%20Third%20Paper%20Govt%20Roles%20022508.pdf (noting that a comprehensive national strategy would prevent the creation of an ad hoc state-based system that may discourage private investment and fail to address trans-border concerns).

[3] *See* IPCC, *supra* note 1, at 36 (noting that annual CO_2 emissions grew by seventy percent between 1970 and 2004).

[4] *See* Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968).

[5] *Id.* at 1245.

In light of this, carbon capture and storage ("CCS") has been increasingly proffered as a potential temporary solution to the climate change riddle—continued individual demand for CO_2 emitting energy sources coupled with collective anxiety over that demand—as it allows "the continued use of inexpensive fossil fuels while dramatically reducing accompanying greenhouse gas emissions."[6] To do this CCS, in its most popular form, would inject the offending anthropogenic CO_2 (in liquid "supercritical" form) into underground storage spaces ("pore spaces"), which are most commonly found in old natural gas and oil reservoirs, unmineable coal beds, and deep saline aquifers.[7] Doing so would effectively remove vast amounts of man-made CO_2 (the primary greenhouse gas ("GHG") culprit) from the atmosphere, forestalling climate change while providing breathing room for the development of alternative energy sources.[8] CCS is not a permanent solution, as both carbon reserves[9] and potential storage spaces are limited,[10] but the temporary benefits would be vast, as the United States generates roughly fifty percent of its energy from coal, producing 1.5 billion tons of CO_2 annually.[11] Widespread CCS may be the only "currently available technology that allows very deep cuts to be made—at the scale needed—in

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[6] Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change and Carbon Sequestration: Assessing a Liability Regime for Long-Term Storage of Carbon Dioxide*, 58 EMORY L. J. 103, 107 (2008).

[7] Thomas R. Decesar, Comment, *An Evaluation of Eminent Domain and a National Carbon Capture and Geologic Sequestration Program: Redefining the Space Below*, 45 WAKE FOREST L. REV. 261, 263 (2010).

[8] Will Reisinger et al., *Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage*, 11 VT. J. ENVTL. L. 1, 2–3 (2009) (noting that as a "bridge technology" to cleaner alternative sources, CCS could remove as much as ninety percent of coal-fired plant CO_2 emissions).

[9] *See generally* WORLD ENERGY COUNCIL, 2010 SURVEY OF ENERGY RESOURCES (A.W. Clarke & J.A. Trinnaman, eds., 2010) (noting world energy reserves are finite, and listing current estimates).

[10] *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CARBON DIOXIDE CAPTURE AND STORAGE 221 (Bert Metz, et al. eds., 2005), *available at* http://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf [hereinafter IPCC CARBON DIOXIDE CAPTURE]. Estimates of CCS storage capacity are imprecise and vary by the type of formation and methodology used. The IPCC estimates that at the low end, 1690 gigatons of CO_2 ("$GtCO_2$") may be sequestered, with a possible upper limit of 101,100 $GtCO_2$ of storage. This broad range of storage estimates is largely due to uncertainty surrounding the potential capacity of deep saline formations, which can fluctuate by an order of magnitude. *Id.* at tbl.5.2. The IPCC concludes that as "potential storage sites are likely to be broadly distributed," underground CCS storage is "likely to be adequate to store a significant proportion of [CO_2] emissions well into the future." *Id.* at 197.

[11] THE FUTURE OF COAL: OPTIONS FOR A CARBON CONSTRAINED WORLD ix (James R. Katzer et al., eds., Mass. Inst. of Tech. 2007), *available at* http://web.mit.edu/coal/The_Future_of_Coal.pdf [hereinafter THE FUTURE OF COAL].

atmospheric emissions of CO_2 from fossil fuels," and should be intensely, and widely, pursued to forestall climate change.[12]

Ahead of an anticipated boom in CCS investment[13] states have begun to prepare the necessary legal groundwork to facilitate private development, and have established rules relating to property interests in the "pore space" and the resulting liability for the stored CO_2. Three states, Wyoming,[14] Montana,[15] and North Dakota,[16] have statutorily defined the property interest in the pore space estate and have granted it to the surface estate owner. Illinois, Louisiana, Oklahoma, and Texas have addressed ownership of the sequestered CO_2, but have not dealt with the pore space.[17] By placing the pore space estate with the owners of the surface estate, Montana, North Dakota, and Wyoming are setting up future CCS as a largely private venture,[18] a potentially incongruous, atomistic response to a fundamentally collective, public threat. This legislative grant of CCS control to individual land owners threatens to Balkanize what should be a nationally coherent policy for carbon sequestration.[19] The potential creation of fifty separate pore space property regimes, which would effectively require the cooperation of adjacent pore space owners and jurisdictions, would have deleterious effects upon the implementation of a coherent national CCS plan. Further, as some state laws (such as Montana's and North Dakota's) allow pore space owners to transfer ownership and liability to the state after a set period of years,[20] outright

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[12] WORLD ENERGY COUNCIL, *supra* note 9, at 5.

[13] States are anticipating a share of the roughly $8 billion in federal money that has been allocated for CCS projects, including $3.4 billion in the American Recovery and Reinvestment Act. *Flurry of U.S. State, Federal Policies Advance CCS*, CARBON CAPTURE J., Feb. 20, 2009, *available at* http://www.carboncapturejournal.com/displaynews.php?NewsID=344&PHPSESSID=1043389bcbaec9b35c510344a0524b43&PHPSESSID=1043389bcbaec9b35c510344a0524b43.

[14] WYO. STAT. ANN. § 34-1-152 (2009).

[15] MONT. CODE ANN. §§ 82-11-180, 82-11-182 (2009).

[16] N.D. CENT. CODE §§ 47-31-02, 47-31-03, 47-31-04, 47-31-05 (West 2009).

[17] *See State CCS Policy—Sequestration*, CCS REG., http://www.ccsreg.org/billtable.php?component=Sequestration (last visited Oct. 11, 2011). The majority have granted ownership of the sequestered CO_2 to the storage site operator. *Id.*

[18] JERRY R. FISH & ERIC L. MARTIN, CALIFORNIA CARBON CAPTURE STORAGE REVIEW PANEL, TECHNICAL ADVISORY COMMITTEE REPORT: APPROACHES TO PORE SPACE RIGHTS 2 (2010), *available at* http://www.climatechange.ca.gov/carbon_capture_review_panel/meetings/2010-08-18/white_papers/Pore_Space_Rights.pdf.

[19] COL. CCS TASK FORCE, BRIEFING PAPER FOR DISCUSSION: OWNERSHIP OF PORE SPACE 1 (2010) *available at* http://dnr.state.co.us/SiteCollectionDocuments/CCS%20DOCS/PoreSpaceOwnership-041610.pdf.

[20] MONT. CODE ANN. § 82-11-183 (2009) (allowing transfer of title and liability to the state after fifteen years if certain conditions are met); N.D. CENT. CODE § 38-22-17 (2009) (allowing

and infinite[21] public ownership of vast underground carbon pools may become a reality despite the public having little say on the front end.

Recognizing the complications inherent to private control over an essentially public action, this Note aims to demonstrate that pore space ownership should be vested in the public. As climate change and the resulting attempts at mitigation through CCS are public dilemmas of a national scope, the deep pore space rightly belongs to the public trust. Granting public ownership will simplify issues of regulation, liability, and permitting across jurisdictions, while lessening issues related to the exercise of eminent domain and storage basin unitization. Public ownership of the pore space will legally clear the road for national implementation of a CCS regime to address increasing carbon emissions. Indeed, as CCS moves from the relatively sparsely populated West to the more densely populated East, the establishment of public pore space ownership would proactively remove significant private property hurdles to effective collective action.[22] The ad hoc, state-by-state implementation of distinct pore space property regimes will only slow the maturation of a national CCS plan. CCS is unlike traditional subsurface extractive pursuits in that ownership largely involves maintenance and liability long after the initial injection,[23] removing any profit incentives related to continued private ownership. The impoundment of a harmful substance for the public good should be the province of the public trust.

ROADMAP

Part I of this Note will cover the present state of CCS, detailing how it may be applied to mitigate climate change and carbon emissions. Part II

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transfer of title and liability to the state ten years after injection ceases if certain conditions are met).

[21] Reisinger et al., *supra* note 8, at 25 ("To be effective as a climate mitigation strategy, CO_2 storage must be near infinite, and thus contract, tort, and statutory liability will extend long after the injection ends.").

[22] The reservoirs that are amenable to carbon sequestration underlie vast areas of land, commonly crossing not only private boundaries, but state lines as well. The surface estates that lay above these formations include private, state, federal, and tribal lands. *See* NAT'L ENERGY TECH. LAB., U.S. DEP'T OF ENERGY, 2010 CARBON SEQUESTRATION ATLAS OF THE UNITED STATES AND CANADA 23–33 (3d ed. 2010) [hereinafter CARBON SEQUESTRATION ATLAS]. The Department of Energy has identified over 22,564 billion tons of storage potential and more than forty years of storage spread across twenty-nine states and four provinces. *Id.* at 27–29.

[23] Reisinger et al., *supra* note 8, at 25.

will examine how the legal treatment of the airspace may be applied to pore spaces and CCS, how potential takings claims may be addressed, and how the pore space is currently treated at common law. Part III will examine how the pore space has been treated by the three states (Montana, North Dakota, and Wyoming) that have passed statutes concerning pore space ownership.[24] Part III will also examine the inadequacies and potential pitfalls related to these statutory definitions. Lastly, this Note will conclude by summarizing the public policy rationales and normative recommendations for public pore space ownership.

I. CARBON SEQUESTRATION, GREENHOUSE GASES, AND CLIMATE CHANGE

A. Carbon Dioxide Emissions and Global Warming

Carbon capture and sequestration ("CCS") is largely advanced as a method of permanently locking away anthropogenic carbon dioxide gas ("CO_2") to reduce or eliminate the effects associated with increased emissions of greenhouse gases ("GHG").[25] GHGs such as CO_2 negatively affect the global climate system by altering the natural energy flow, affecting the "absorption, scattering and emission of radiation within the atmosphere and at the Earth's surface," ultimately leading to a global "warming."[26] This energy imbalance ("positive radiative forcing" in the literature) can lead to higher average global temperatures, higher sea levels, reduced snow and ice coverage, an increased frequency of extreme weather, and changes in precipitation patterns.[27] Scientists have linked the post–Industrial Revolution increase in anthropogenic GHG emissions to these negative climate effects and label CO_2 as the "most important anthropogenic GHG."[28]

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[24] The Interstate Oil and Gas Compact Commission ("IOGCC") has developed a model act that largely mirrors these three states. INTERSTATE OIL & GAS COMPACT COMM'N, STORAGE OF CARBON DIOXIDE IN GEOLOGIC STRUCTURE: A LEGAL AND REGULATORY GUIDE FOR STATES AND PROVINCES (2007), *available at* http://www.gwpc.org/e-library/documents/co2/IOGCC%20Master%20CO2%20Regulatory%20Document%209-2007.pdf [hereafter IOGCC].

[25] *See* IPCC, *supra* note 1, at 60 tbl.4.2. Admittedly, CCS is not the only mitigation strategy that should be pursued. Alternative forms of energy, energy conservation, and even new methods of land use planning and building design should all be utilized to reduce the effects of climate change. *Id.*

[26] IPCC, *supra* note 1, at 37; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, 2–9 (Susan Solomon, et al., eds., 2007) *available at* http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm [hereinafter IPCC Physical Science].

[27] IPCC, *supra* note 1, at 26–33.

[28] *Id.* at 36.

Reducing anthropogenic GHG emissions is thus central to mitigating the ill effects of climate change.[29]

Of the man-made GHGs, CO_2 gas emissions are by far the largest source.[30] CO_2 accounts for over eighty percent of American GHG emissions, making a strategy for substantially reducing CO_2 emissions particularly necessary.[31] The energy and transportation sectors are the most noxious emitters of CO_2, as the combustion of fossil fuels (such as coal and petroleum derivatives) produces over 5.8 billion metric tons of CO_2 annually, the lion's share of national GHG output.[32] Further, CO_2 emissions are expected to continue to grow as emerging economies, namely India and China, "fuel economic development with fossil energy."[33] Facing an increased global reliance on fossil fuels, greater CO_2 emissions, and the related negative effects on the global climate change, CCS may be an effective mitigation strategy.[34]

B. Carbon Capture and Sequestration as a Mitigation Strategy

CCS has seen increased attention and investment[35] largely because it represents a "bridge technology"[36] that may effectively mitigate increased CO_2 emissions while allowing for the continued use of established, cheap,[37] and prevalent fossil fuels in energy generation and transportation.[38] In

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[29] *Agriculture and Climate Change*, OECD AGRIC. MINISTERIAL MEETING (Feb. 25, 2010), http://www.oecd.org/document/18/0,3746,en_2157136_43892445_44437010_1_1_1_1,00.html (stating that in order to limit a global temperature increase to two degrees Celsius anthropogenic GHG emissions must decrease globally by at least fifty percent).

[30] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, GREENHOUSE GASES, CLIMATE CHANGE, & ENERGY POLICY (2008), *available at* http://www.eia.doe.gov/bookshelf/brochures/greenhouse/Chapter1.htm.

[31] *Id.* The other significant national sources of GHGs are methane at nine percent and nitrous oxide at five percent. *Id.*

[32] *Id.* at fig.4.

[33] *Id.* The Department of Energy ("DOE") expects world CO_2 emissions to increase by 1.9 percent annually. *Id.* Similarly, the IPCC labels income growth and population change as "drivers" of increased CO_2 emissions. IPCC, *supra* note 1, at 37.

[34] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 200.

[35] *See* PETER FOLGER, CONG. RESEARCH SERVS., RL 38801, CARBON CAPTURE AND SEQUESTRATION 2–5 (2009) (detailing Congressional interest and $14.5 billion in recent federal funding).

[36] Reisinger et al., *supra* note 8, at 2–3.

[37] THE FUTURE OF COAL, *supra* note 11, at ix.

[38] Reisinger et al., *supra* note 8, at 2; *see also* Donna M. Attanasio, *Surveying the Risks of Carbon Dioxide: Geological Sequestration and Storage Projects in the United States*, 39 ENVTL. L. REP. NEWS & ANALYSIS 10,376, 10,381 (2009) ("GS is intended to be a transitional

this way, CCS technology would allow for continued use of the extensive infrastructure[39] already in place for using fossil fuels while mitigating their effects in hopes that long-term, alternative mitigation strategies will be developed.[40] Of the fossil fuels to which CCS may be applied, coal is the cheapest, and its broad global distribution ensures that it will be a readily available, and widely used, energy source for years to come.[41] The United States is the second largest global producer of coal,[42] using it to provide about fifty percent of national energy generation[43] along with 1.9 billion metric tons of CO_2 annually.[44] CCS tied to commercial coal-fired energy generation presents the readiest, and perhaps most effective, application of the technology.[45]

While coal-fired energy plants are the likeliest candidates for CCS, the process may be utilized to mitigate CO_2 emissions from a variety of fixed-point sources.[46] Capturing the CO_2 output from all fossil-fuel-based electricity generation would remove forty-one percent of annual American carbon emissions, the largest single source proportion of CO_2 emissions.[47] Applying the process to other large industrial emitters, such as cement manufacturing, could remove a further 12.8% of annual CO_2 emissions.[48] The removal of such a large amount of emissions would require large underground storage spaces,[49] and the Department of Energy

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mechanism to facilitate continued use of fossil fuels while cleaner methods of energy production are developed.").

[39] For instance, there are the equivalent of more than five hundred, 500 megawatt coal-fired power plants in the United States, largely concentrated in the East. THE FUTURE OF COAL, *supra* note 11, at ix & 5. The United States had 486 billion short tons of coal in demonstrated reserves as of January 1, 2010. *Coal Reserves Current and Back Issues*, U.S. ENERGY INFO. ADMIN. (Mar. 22, 2011), http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html.

[40] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 3. These alternative strategies include increased energy efficiency, alternative fuel sources, and conservation. *Id.*

[41] THE FUTURE OF COAL, *supra* note 11, at ix–x.

[42] WORLD ENERGY COUNCIL, *supra* note 9, at 3.

[43] *Id.* at ix.

[44] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DOE/EIA-0573 (2007), EMISSIONS OF GREENHOUSE GASES IN THE UNITED STATES 20 tbl.11 (2008).

[45] *Id.* at 17.

[46] *Id.* Ninety-eight percent of anthropogenic CO_2 emissions come from fossil fuel combustion, and all fossil fuel electric power plants are candidates for carbon capture. *What is Carbon Capture?*, NAT'L ENERGY & TECH. LAB. (Nov. 13, 2010), http://www.netl.doe.gov/technologies/carbon_seq/FAQs/carbon-capture.html.

[47] U.S. ENVTL. PROT. AGENCY, NO. EPA 430-R-11-005, INVENTORY OF U.S. GREENHOUSE EMISSIONS AND SINKS: 1990–2009 9 & tbl.es-3, *available at* http://epa.gov/climatechange/emissions/usinventoryreport.html.

[48] *Id.*

[49] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 204.

has estimated that the United States and Canada collectively possess enough "pore space" to sequester over 22,564 billion tons of CO_2.[50] Thus, a large-scale, national CCS program could potentially remove sixty percent of annual CO_2 emissions, while allowing for current fossil-fuel-based technologies to remain viable long enough for alternative sources to be developed. To be effective as a mitigation strategy, such a program would need to eventually sequester the CO_2 emissions from the equivalent of over 600 large (>1,000 megawatts ("MW")) coal-fired plants, a massive undertaking.[51]

C. CCS Generally

CCS generally involves three steps: capturing the CO_2 produced by either a power plant or industrial source, transporting the CO_2 via pipeline to the injection site, and injecting the CO_2 in liquid form into geological formations deep underground.[52] The candidate geologic formations include deep saline formations,[53] unmineable coal seams,[54] oil and gas reservoirs,[55] and basalt formations.[56] Essentially, CO_2 is captured before it is emitted into the atmosphere by either a power plant or industrial source, shipped via pipeline to a well-site, and pumped deep underground for storage.[57] This process theoretically removes the harmful effects of fossil fuels while forestalling their obsolescence. As the CO_2 is pumped into the earth in a "supercritical" liquid state, the geological pressures exerted below 800 meters will act to keep it confined beneath impermeable layers of rock in a dense, largely immobile state.[58] Once in the ground, ninety-nine percent of the injected gas is expected to stay sequestered for at least 100 years, and likely for more than 1000.[59]

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[50] CARBON SEQUESTRATION ATLAS, *supra* note 22, at 27–29.
[51] THE FUTURE OF COAL, *supra* note 11, at 43 (noting that global CO_2 emissions stand at 2.5 gigatons of carbon ("GtC"), and CCS at six hundred 1000 MW plants would cover 1 GtC).
[52] FOLGER, *supra* note 35, at 8–9.
[53] Most sequestration will occur in saline formations because of their large capacity and broad distribution. THE FUTURE OF COAL, *supra* note 11, at 44.
[54] *Id.* at 44.
[55] *Id.*
[56] *Introduction to Geologic Storage*, NAT'L ENERGY TECH. LAB. (May 22, 2011), http://www.netl.doe.gov/technologies/carbon_seq/corerd/storage.html.
[57] FOLGER, *supra* note 35, at 1.
[58] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 197.
[59] THE FUTURE OF COAL, *supra* note 11, at 44.

The technologies required to implement CCS either currently exist or are in development,[60] and various demonstration projects have been developed to test the method and prove its viability.[61] Further, fluids have been injected into underground pore spaces for years "on a massive scale" as a part of chemical disposal, enhanced oil recovery, or natural gas storage.[62] However, large scale CCS has not been pursued, and previous instances where CO_2 was pumped underground, such as enhanced oil recovery ("EOR") projects,[63] were not concerned with permanent sequestration, monitoring, and storage.[64]

CO_2 capture has been practiced by various industries for decades, and CO_2 has been captured from industrial streams for over eighty years.[65] While it has not been applied to energy plants on a wide scale[66], CO_2 capture, whether post-combustion, pre-combustion, or by oxy-fuel combustion capture, could theoretically operate at eighty-five to ninety-five percent capture efficiency when applied to these sources.[67]

Similarly, the technology needed to pump carbon dioxide deep into the earth, including the transportation and injection of the liquefied CO_2, has previously been developed for EOR.[68] EOR originated in Texas in the 1970s, and seventy-three EOR projects currently exist in the United States.[69] In EOR, gas is pumped into under-producing wells to aid in oil recovery, but the CO_2 is not kept permanently underground, as would be the case with CCS.[70] Currently, 32 million tons of CO_2 are pumped into the ground annually to aid EOR in the United States.[71] This CO_2 flows through

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[60] *Id.* at 43 (However "there do not appear to be unresolvable open technical issues underlying these questions . . . [and] the hurdles to answering these questions well appear manageable and surmountable.").
[61] Attanasio, *supra* note 38, at 10,378–79.
[62] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 200.
[63] Jerry R. Fish & Thomas R. Wood, *Geologic Carbon Sequestration, Property Rights and Regulation*, 54 ROCKY MTN. MIN. L. INST. 3-1, 3-19 (2008) (noting that with EOR, CO_2 either returns with the recovered oil or is vented to the atmosphere).
[64] *See id.*
[65] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 108.
[66] *Id.* at 107.
[67] *Id.*
[68] Philip M. Marston & Patricia A. Moore, *From EOR to COS: The Evolving Legal and Regulatory Framework for Carbon Capture and Storage*, 29 ENERGY L. J. 421, 426–27 (2008).
[69] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 203.
[70] Victoria B. Flatt, *Paving the Legal Path for Carbon Sequestration from Coal*, 19 DUKE ENVTL. L. & POL'Y F. 211, 213 (2009).
[71] Attanasio, *supra* note 38, at 10,378.

over 2500 kilometers of pipelines, showing the viability of liquefied CO_2 transportation to wellheads.[72] Essentially, CCS "uses many of the same technologies that have been developed by the oil and gas industry,"[73] and three large-scale storage projects are currently underway.[74] Thus, the technical components of CCS, capture, transportation, and injection, have been demonstrated to varying degrees, albeit in limited and largely experimental ways. While a true CCS program would require thousands of full-scale projects beyond what has been previously demonstrated,[75] technology will not likely be an impediment to future CCS development. The technology to implement CCS, while untested on such a large scale, exists, though ahead of the necessary legal structures.

D. Legal Impediments to CCS

The U.S. Department of Energy estimates that CCS may eventually capture ninety percent of coal-fired plant emissions.[76] While CCS may therefore represent a vital and viable climate change mitigation strategy, major impediments to the creation of a national CCS system exist. First, such a project would be massive in scale. The volume of liquid CO_2 potentially produced would be roughly equivalent to the total volume of oil consumed by the United States, equaling almost twenty million barrels of liquid CO_2 per day, all of it requiring capture, transportation, and storage.[77] A national CO_2 transportation network would therefore need to be created to deliver liquefied CO_2 from the various emission sources to the injection points,[78] as the largest clusters of emissions sources in the United States are found in the East and Midwest,[79] while many storage basins and pore space ownership regimes are found in the West.[80] The scale and cost of such

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[72] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 5.
[73] *Id.* at 6.
[74] Attanasio, *supra* note 38, at 10,378–79 (noting the Sleipner project in Norway, the Weybrun EOR project in Canada and the United States, and the In Salah project in Algeria).
[75] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 204.
[76] *Technologies: Carbon Sequestration*, NAT'L ENERGY TECH. LAB. http://www.netl.doe.gov/technologies/carbon_seq (follow "Read more" at bottom of page) (last visited Oct. 11, 2011).
[77] THE FUTURE OF COAL, *supra* note 11, at ix.
[78] INT'L RISK GOVERNANCE COUNCIL, REGULATION OF CARBON CAPTURE AND STORAGE 9 (2008), *available at* http://www.irgc.org/IMG/pdf/Policy_Brief_CCS.pdf (noting that a 1000 MW coal-fired plant produces five to eight million tons of CO_2 annually).
[79] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 83.
[80] *See id.* at 181.

a network is uncertain, and "[a]s CO_2 pipelines get longer, the state-by-state siting approval process may become complex and protracted, and may face public opposition."[81]

Second, and most importantly for the purposes of this Note, "[i]t is unlikely that CCS will flourish as long as there is legal uncertainty surrounding the acquisition of storage space, the injection process, and liability for post-injection incidents."[82] Specifically, legal issues regarding ownership of the underground pore spaces must be resolved before significant investment in CCS occurs. These pore spaces exist over 800 meters below the surface and are commonly found at depths of over one kilometer.[83] Potential carbon "storage basins" can cover vast tracks of land, crossing property borders, state lines, and national boundaries, complicating efforts to coordinate the large numbers (potentially thousands) of surface landholders over a single reservoir.[84] Although the storage basins that CO_2 will be pumped into are vast, the stored supercritical gas can be expected to migrate laterally through the pore spaces for over 100 kilometers,[85] making any adherence to traditional property boundaries, or even differing state regulatory or statutory regimes, difficult at best.[86] Complicating matters, the property rights governing these pore spaces, the focus of this Note, have been infrequently and indecisively treated by courts, and may vary by jurisdiction.[87] As Federal regulations, and most state laws, currently "do not contemplate the infinite geologic storage of gas," the most likely "major impediments to the widespread deployment of CCS are not scientific or technological, but legal and regulatory."[88]

The sort of large-scale CCS needed to mitigate continued and increased reliance on fossil fuels cannot begin without a clear delineation of the legal property interests involved.[89] Thus, the major barriers to CCS are legal, not technical, and involve issues of liability, storage field unitization,

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[81] PAUL W. PARFOMAK & PETER FOLGER, CONG. RESEARCH SERV., RL 34316, PIPELINES FOR CARBON DIOXIDE (CO_2) CONTROL: NETWORK NEEDS AND COST UNCERTAINTIES SUMMARY (2008), *available at* http://opencrs.com/document/RL34316.
[82] Reisinger et al., *supra* note 8, at 4.
[83] THE FUTURE OF COAL, *supra* note 11, at 44.
[84] *See id.* at 54–55; Fish & Wood, *supra* note 63, at 3-11 (explaining that as thousands of owners may overlay any one storage basin, obtaining the requisite property rights or exercising eminent domain to secure use of the entire field may be extremely difficult).
[85] Jeffrey W. Moore, *The Potential Law of On-Shore Geologic Sequestration of CO_2 Captured from Coal-Fired Power Plants*, 28 ENERGY L. J. 443, 454 (2007).
[86] *Id.* at 477.
[87] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 256.
[88] Reisinger et al., *supra* note 8, at 4.
[89] *See* Fish & Wood, *supra* note 63, at 3-16.

trespass, and takings.[90] To enable this massive undertaking, "future CCS operators must be able to access millions of acres of deep subsurface 'pore space' roughly a kilometer below the earth's surface to sequester the CO_2 for hundreds to thousands of years."[91] This raises questions of extraordinarily long-term liability for the pore space owner, creating a situation where governments may be "the only entities that can make credible commitments over such long storage time periods."[92] Further, as the gas migrates laterally underground, trespass or nuisance claims could arise among thousands of surface property owners.[93] If the pore space is considered to be part of the private surface estate, ownership of these massive storage basins will accordingly need to be combined. This pore space unification presents a daunting proposition, both economically and procedurally, given the physical expanse and potential thousands of surface owners. The likelihood that gas plumes will migrate across individual state lines post-injection has even prompted one commenter to declare that state regulation of CCS is illogical, as the "pore space, especially saline aquifers, does not stop at state borders."[94] Additionally, takings claims may rise from efforts to site pipelines and wellheads or from the eventual migration of government-owned (or mandated) sequestered gas into neighboring pore spaces.[95]

These swirling legal questions need to be clarified to allow for the rapid and expansive development of CCS. The ownership of the pore spaces needs to be clearly defined to enable investment and development on a large scale.[96] Unhelpfully, the common law has infrequently and incoherently addressed the subject of pore space ownership, leaving developers, property owners, regulators, and states largely in the dark when it comes to pore space ownership.[97] To rectify this, this Note proposes that the pore

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[90] Reisinger et al., *supra* note 8, at 4 ("While scientists are confident that it will soon be possible to build or retrofit 'capture-ready' power plants that can safely store vast quantities of CO_2 underground, there is no consistent legal framework to regulate these projects.").
[91] Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. ILL. L. REV. 363, 363 (2010) [hereinafter Klass & Wilson 2010].
[92] INT'L RISK GOVERNANCE COUNCIL, *supra* note 78, at 7.
[93] Moore, *supra* note 85, at 477–79.
[94] Decesar, *supra* note 7, at 266.
[95] *See* Moore, *supra* note 85, at 479 (noting that as "government could not operate if it had to pay for every encroachment," ownership rights of the subsurface pore spaces need to be clarified).
[96] Reisinger et al., *supra* note 8, at 4.
[97] *See* Owen L. Anderson, *Geologic CO_2 Sequestration: Who Owns the Pore Space?*, 9 WYO. L. REV. 97, 99 (2009) (applying the common law doctrine of *cujus est solum, ejus est usque*

space should be seen as a public resource, similar to the navigable airspace. To facilitate this, existing common law and statutory conceptions of private pore space ownership will need to be adjusted to account for the contemporary social and environmental demands surrounding climate change, freeing the heretofore atomized pore space for public use.

II. DEFINING THE PORE SPACE RIGHTS

A. Reconfiguring Subsurface Pore Space Rights at Common Law

As noted above, CCS raises important legal questions that must be answered before a national, widespread program capable of effectively sequestering and mitigating large amounts of CO_2 emissions can begin. Most significantly, the legal status of the subsurface pore space estate must be clarified, as constitutional takings issues,[98] as well as trespass-related torts,[99] may be implicated if a "protectable property interest in subsurface pore space" is either found to exist at common law or statutorily established.[100] Uncertainty over the rightful ownership of the deep pore spaces results from both inconsistent treatment by the courts[101] and from

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ad coelum et ad inferos and deciding the surface estate owns the pore space); Flatt, *supra* note 70, at 233 ("There is no clear consensus on whether the ownership of the pore space lies with the surface estate or the mineral estate."); Moore, *supra* note 85, at 477 (noting that "there is no case law addressing sequestered CO_2" and applying the common law by analogy); Reisinger et al., *supra* note 8, at 19 (noting that the cases that have dealt with subsurface storage "illustrate the lack of a consistent national view of pore space ownership . . . [v]arious courts . . . have awarded gas storage rights to surface and mineral holders alike."); IOGCC, *supra* note 24, at 16–19 (showing the variety of treatment of pore space ownership in the relevant case law, but noting that the surface owner generally wins).

[98] *See* U.S. CONST. amend. XIV, § 1; Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419, 434–35 (1982) ("[O]ur cases uniformly have found a taking to the extent of the [physical] occupation, without regard to whether the action achieves an important public benefit or has only minimal economic impact on the owner.").

[99] RESTATEMENT (SECOND) OF TORTS § 159 (1965) (declaring that trespass may be committed "on, beneath, or above the surface of the earth."). However, subsection 2 of the Restatement recognizes the limits placed by *United States v. Causby* (discussed below), as flights by aircraft are excepted from the rule if they do not invade the "immediate reaches" of the land or substantially interfere with the owner's "use and enjoyment." *Id.*

[100] Alexandra Klass, *Federal Task Force on Carbon Capture and Sequestration Will Need to Grapple With Property Rights Law*, CTR. FOR PROGRESSIVE REFORM BLOG (May 11, 2010), http://www.progressivereform.org/CPRBlog.cfm.

[101] *See supra* note 97 and discussion *infra* Part II.C.1.

traditional common law conceptions of private property ownership. Pore space ownership must be clarified, as CCS depends upon a clear delineation of the subsurface property interests involved.[102] Courts[103] and scholars[104] have infrequently and inconsistently treated the pore spaces, which has driven individual states to legislatively define pore space ownership rights,[105] potentially Balkanizing its legal and regulatory development at the outset.[106] To get ahead of this atomistic state-led development,[107] the difficulties presented by the common law, in both its assumed preference for private ownership of the subsurface and disjointed treatment of subsurface rights, must be addressed.

The legal uncertainties hindering effective CCS implementation are therefore twofold, and each must be addressed before CCS can flourish. First, the outdated property law maxim of *cujus est solum, ejus est usque ad coelum et ad inferos* (roughly translated as "whoever owns the soil owns up to heaven and down to hell")[108] must be refined to render CCS economically feasible. Second, the inconsistent treatment[109] of underground storage in the case law must be replaced with a clear legislative standard,[110] as a handful of states have attempted to do, albeit imperfectly.[111] Ultimately, there is widespread recognition that subsurface property rights must be

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[102] FISH & MARTIN, *supra* note 18, at 1 (noting that while "[c]arbon sequestration cannot occur absent the right to inject and store carbon dioxide" in pore spaces, this right is ill-defined).

[103] Reisinger et al., *supra* note 8, at 19 ("The various holdings . . . illustrate the lack of a consistent national view of pore space ownership . . . . Various courts, utilizing various factors, have awarded gas storage rights to surface and mineral holders alike.").

[104] Those scholars that have analyzed the issue have often viewed CCS as analogous to natural gas storage and have granted pore space ownership to the surface owner. Marston & Moore, *supra* note 68, at 475. However, there is a lack of consensus on whether the surface owner retains the pore spaces as well. *See supra* note 97 and accompanying text.

[105] *See also* discussion *infra* Part II.B (detailing and critiquing state definitions of pore space ownership). *See generally* MONT. CODE ANN. § 82-11-183 (2009); N.D. CENT. CODE § 47-31-03 (West 2009); WYO. STAT. ANN. § 34-1-152 (West 2009); TEX. NAT. RES. CODE ANN. § 120.002 (West 2009).

[106] *See* Decesar, *supra* note 7, at 266 ("[H]aving fifty different programs . . . would lead to unnecessary confusion and delay.").

[107] Klass & Wilson 2010, *supra* note 91, at 382.

[108] BLACK'S LAW DICTIONARY 1834 (9th ed. 2009).

[109] Underground property rights are respected to varying degrees. CCSREG PROJECT, CARBON CAPTURE AND SEQUESTRATION: FRAMING THE ISSUES FOR REGULATION 57 (2009), *available at* http://www.ccsreg.org/pdf/CCSReg_3_9.pdf.

[110] *See* Reisinger et al., *supra* note 8, at 14.

[111] *Id.* at 29–31.

clarified,[112] and unified,[113] before truly effective CCS can begin. As this Note attempts to show, the "unity" (addressed through a reconfiguring of the *cujus est solum* doctrine) and "clarity" (addressed through legislation) hurdles facing CCS will be most ably addressed through public ownership of the pore spaces.

1. Limiting the Subterranean Reach of Property: Applying *United States v. Causby* to the Pore Spaces

The primary common law impediment to CCS is the traditional property law maxim *cujus est solum, ejus est usque ad coelum et ad inferos* ("*cujus est solum*"), which declares that the surface fee simple owner's control stretches from the outer reaches of the heavens to the center of the earth.[114] Specifically, this questionably ancient doctrine[115] must be revised through analogy to navigable airspace rights to enable modern technology (in the form of CCS) to address contemporary climate change and provide a necessary public benefit. While seemingly old (and in such weighty Latin), the *cujus est solum* doctrine is far from absolute, and may be limited, as the United States Supreme Court revealed in *United States v. Causby*.[116] By applying the analysis in *Causby* to the deep pore space, private subsurface rights may be bounded just as the vertical reach of

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[112] Delissa Hayano, *Guarding the Viability of Coal & Coal-Fired Power Plants: A Road Map for Wyoming's Cradle to Grave Regulation of Geologic Cosequestration*, 9 WYO. L. REV. 139, 143 (2009) ("[T]he determination of the ownership of subsurface pore space is an essential step in creating a statutory and regulatory framework for the development of [CCS] projects."); Anderson, *supra* note 97, at 98 ("There are no technical or physical barriers to [geologic sequestration]. . . . The only thing that stands in the way of progress at the moment is policy.") (quoting THE PETROLEUM ECONOMIST, LTD., FUNDAMENTALS OF CARBON CAPTURE AND STORAGE TECHNOLOGY 38–39 (Tom Nicholls ed., 2007)).

[113] The IOGCC, which has developed a model CCS statute for states, believes that "the amalgamation of property rights is absolutely necessary to properly permit, construct and operate a carbon dioxide storage project." IOGCC, *supra* note 24, at 33 n.3.

[114] BLACK'S LAW DICTIONARY at 1834. Interestingly, BLACK'S further notes that this doctrine encompasses ownership of "hard" minerals like coal, but not "fugacious" minerals like oil or gas. *Id.*

[115] John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 983 (2008) ("[The principle] was not a principle of Roman law—despite the Latin phrasing of the maxim—nor was the theory recognized in early common law.") (citation omitted). There is "surprisingly little scholarship concerning the downward extent of a surface owner's property rights as a general matter," leading one author to believe "that the center of the earth approach is mere poetic hyperbole, not law." *Id.* at 980 n.1, 981.

[116] 328 U.S. 256, 260 (1946) (Congress declared airspace above "minimum safe altitudes" of flight to be "subject to a public right of freedom" under the Air Commerce Act of 1926. *See* Air Commerce Act of 1926, ch. 344, 44 Stat. 568, 574 (1926) (codified amended at 49 U.S.C. § 40103(a)(2) (1994))).

ownership was limited to provide for the exigencies of air travel.[117] Indeed, modern CCS faces many of the same private property challenges that the nascent air travel industry faced in *Causby*, where "every transcontinental flight would [have] subject[ed] the operator to countless trespass suits," threatening the economic and legal feasibility of an eminently public good.[118] To further the development of CCS as a public good providing national benefits, traditional property conceptions must give way to modern realities, just as they did in *Causby*.

In *Causby*, Justice Douglas upheld a takings claim by a private citizen against low-flying military aircraft, but also found an upper limit to the plaintiff's property interest in light of the Air Commerce Act.[119] The plaintiffs claimed that their chicken farm was rendered useless by incessant low-level flights, while the government argued that flights within the navigable airspace were not a physical invasion, and therefore not a taking.[120] Directly addressing the *cujus est solum* doctrine in the context of technological innovation and the modern development of air travel, the Court found that the public desire to facilitate air travel (as expressed though the Air Commerce Act) limited the upward reach of property.[121] The Court chipped away at the formerly infinite vertical bounds of private property, holding that *cujus est solum* "has no place in the modern world," because "[t]he air is a public highway, as Congress has declared."[122] Therefore, *Causby* represents the proposition that the common law tradition of unbounded vertical property limits may (literally) be brought to Earth by way of technological change and modern necessity, if the public desires it. The analogy to climate change is clear, as contemporary technological innovation (in the way of CCS) and social interests (mitigating climate change) have conspired to make the need for widespread access to the deep pore spaces a necessary public good at least equivalent to air travel.

For a salutary reconfiguring of subsurface property rights to occur, private ownership of the deep pore space must therefore be reexamined by applying the lessons of *Causby*. Private trespass suits threatened the economic and practical viability of air travel if the court did not find an upward limitation of property rights.[123] Analogously, unitization

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[117] *Causby*, 328 U.S. at 261.
[118] *Id.*
[119] *Id.* at 266–67.
[120] *Id.* at 258–60.
[121] *Id.* at 261 ("Common sense revolt[ed] at the idea" of private property claims encumbering the public use of the airways.).
[122] *Id.*
[123] *Causby*, 328 U.S. at 261.

of the requisite pore space estates (if found to belong to the surface owner), or potential liability related to subsurface trespass claims,[124] could render CCS economically infeasible.[125] Indeed, "absent unrealistically high electricity prices or . . . subsidy, pore space currently has no net-positive, intrinsic economic value . . . [that can] be passed along to property owners."[126] This would seemingly refute the prospect of private pore space development, or the presence of some incentive to privately unitize the space. Therefore, amalgamation of pore space rights though either private purchase or the exercise of eminent domain represents a fundamental obstacle to CCS development.[127] Traditional application of the *cujus est solum* doctrine would likely cripple private development of CCS, as the economic incentive,[128] or even ability,[129] to privately develop the pore space would be extremely limited, or nonexistent. The states that have addressed pore space ownership—Montana, Wyoming, and North Dakota—have effectively conceded the lack of a continuing profit motive (and heavy burden of infinite liability) by allowing for the transfer of future site ownership and liability to the state.[130] As private development of CCS

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[124] *See* Owen L. Anderson, *Subsurface "Trespass": A Man's Subsurface is Not His Castle*, 49 WASHBURN L.J. 247, 255 (2010) [hereinafter Anderson, *Subsurface "Trespass"*] (noting that while subsurface trespass should be limited, the surface and mineral estate owners have a right to protect against subsurface trespass that causes "actual and substantial damages regarding their right of subsurface use.").

[125] R. Lee Gresham, Geologic CO_2 Sequestration and Subsurface Property Rights: A Legal and Economic Analysis iv (Dec. 1, 2010) (unpublished Ph.D. dissertation, Carnegie Mellon University), *available at* http://repository.cmu.edu/dissertations/8.

[126] *Id.* at 169. Even leasing the required pore space would bring exorbitant costs, as fields may incur $13 million in rent per year, if priced similarly to current natural gas storage rates. Fish & Wood, *supra* note 63, at 3-17. When this is multiplied by the likely infinite term of storage, the costs quickly mount.

[127] Private industry is "naturally risk adverse," and may balk at the unsettled economic and legal circumstances surrounding the pore space. Reisinger et al., *supra* note 8, at 4. Furthermore, "the cost of acquiring pore space rights could significantly limit economically available sequestration capacity" if the pore space is privately owned. Gresham, *supra* note 125, at 135.

[128] Hayano, *supra* note 112, at 155 ("[W]ithout further development of carbon markets and monetization of carbon credits or increased demand for CO_2 as a commodity, revenue generation via sequestration remains uncertain.").

[129] Fish & Wood, *supra* note 63, at 3-16 ("We question whether . . . individual landowner negotiations, and subsequent myriad condemnation proceedings can be completed quickly enough to allow for rapid deployment of [CCS]."). Further, individual CCS projects may underlie thousands of square miles of thousands of individual surface owners, creating thousands of atomized holdings in storage basins. *Id.* at 3-15.

[130] *See supra* note 20. Both Montana and North Dakota allow transfer of the storage basin title to the state without payment or compensation, perhaps conceding their true value. *Id.*

is likely impractical due to the extreme economic and contractual burdens inherent in unitizing thousands of property interests,[131] *cujus est solum* should be limited with regard to the deep subsurface.

Importantly, the *Causby* decision established limits upon the *cujus est solum* doctrine with regard to airspace.[132] However, the Court's decision did not completely eviscerate the property owner's interests in the airspace. Justice Douglas created a private use boundary, holding that "[t]he landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land," even if it was not currently physically occupied.[133] Public uses above a certain regulatory threshold (here minimum altitudes of safe air travel) would not be considered a taking if they were not "so immediate and direct as to subtract from the owner's full enjoyment of the property and to limit his exploitation of it."[134] This private "full enjoyment" limiting principle is clearly applicable by analogy to the prospective public use of pore spaces, which may be more than one kilometer beneath the earth's surface.[135] Indeed, "virtually all subsurface activities by humans—such as building foundations, mines, and water wells—occur in the very shallow crust within 1000 feet of the surface."[136] Thus, the majority of full human exploitation of the subsurface ends well above the depths of the pore spaces,[137] potentially avoiding conflicts with beneficial private use of the subsurface. As a result, the public may have access to the deep pore space where that public use does not interfere with the owner's full enjoyment of the subsurface.[138] This reconfiguring of the subsurface rights is suggested by *Causby*, as the Court recognized that the right to exclusive private control would cede at some point

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[131] *See* Michael A. Heller, *The Boundaries of Private Property*, 108 YALE L. J. 1163, 1165 (1999) (noting that excessive private property fragmentation can inhibit contractual collectivization due to "high transaction costs, strategic behaviors, and cognitive biases").
[132] Klass & Wilson 2010, *supra* note 91, at 388 ("The Court . . . not[ed] that the airplane is 'part of the modern environment of life,' the inconveniences it causes are not normally compensable under the Fifth Amendment, and the airspace . . . is part of the 'public domain.'").
[133] United States v. Causby, 328 U.S. 256, 264 (1946).
[134] *Id.* at 265.
[135] THE FUTURE OF COAL, *supra* note 11, at 44.
[136] Sprankling, *supra* note 115, at 994.
[137] Gresham, *supra* note 125, at 18; Sprankling, *supra* note 115, at 994 ("Productive human activity is possible only within the shallowest portion of the earth's crust."). Mineral and resource extraction could be protected as well. *See infra* notes 142–45 and accompanying text.
[138] *See* Anderson, *Subsurface "Trespass*," *supra* note 124, at 281 (advocating for limitation of subsurface trespass, and noting that if traditional subsurface trespass law is applied to the pore space, CCS could be "greatly hindered").

(to be legislatively determined) beyond which the private owner could beneficially use.[139] Modern property owners do not require exclusive control of the pore space to extract all reasonable economic benefit.

The *cujus est solum* maxim, founded upon ancient, inaccurate notions of the deep subsurface's utility to the surface owner, may be downwardly constrained just as it was limited above.[140] Beneficial deep subsurface uses almost uniformly involve mineral extraction and storage or chemical waste disposal,[141] and private subsurface uses could be legislatively prioritized as part of a state CCS regime.[142] However, such public/private use conflicts may be avoided, as the subsurface spaces most amenable to CCS, unmineable coal seams, saline aquifers and old oil and gas fields, are attractive partly because conflicts with resource extraction would be minimized.[143] These spaces were previously beneficially used,[144] or may not be able to be put to a productive use,[145] perhaps clearing the way for CCS without infringing upon private use and enjoyment. Public use of the pore spaces may therefore be bounded in a way that preserves private economic interests, reducing conflicts with the surface owner's "full enjoyment" of the land.

The *cujus est solum* doctrine creates a fragmentation problem, revealed by *Causby*, where "millions of long, narrow subsurface parcels—somewhat like pieces of string— . . . interfere with new technologies such as [CCS] . . . that would occupy large subsurface regions."[146] The deep pore space may be effectively used only through the unification of the pore space through public ownership. As the discussion has shown, this may be achieved by placing a lower boundary on protectable private

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[139] *Causby*, 328 U.S. at 264.
[140] Sprankling, *supra* note 115, at 993.
[141] *Id.* at 994.
[142] *See* WYO. STAT. ANN. § 34-1-152 (West 2009) ("Nothing in this section shall be construed to change or alter the common law as of July 1, 2008, as it relates to the rights belonging to, or the dominance of, the mineral estate.").
[143] IPCC CARBON DIOXIDE CAPTURE, *supra* note 10, at 215 ("Depleted fields will not be adversely affected by CO_2 (having already contained hydrocarbons) and if hydrocarbon fields are still in production, a CO_2 storage scheme can be optimized to enhance oil (or gas) production.").
[144] *Id.* at 221 (noting that it is assumed CCS can occur after oil and gas reserves have been depleted in the reservoir).
[145] Deep saline aquifers, one of the largest potential CCS storage formations, contain briny water "unsuitable for agriculture or human consumption." *Id.* at 217.
[146] Sprankling, *supra* note 115, at 1029.

property interests in the subsurface.[147] This conforms not only with our advancing conceptions of subsurface geology and public necessity, but with the limits of private utility.[148] The physical and practical constraints intrinsic to deep subsurface private ownership were simply not contemplated by the *cujus est solum* doctrine,[149] and need to be reconsidered. Recognizing this, the government may indeed be the "most useful manager" of the pore space in the CCS context, as private ownership could create a market where the owners were both too numerous and too small to effectively operate and allocate the storage resource.[150] Relying upon antiquated notions of the earth's interior would irrationally hamper a socially beneficial use of the subsurface pore space, just as ancient conceptions of airspace ownership would have grounded air travel.[151] As the pore spaces have been shown to largely fall below the reach of private enjoyment and use of the subsurface,[152] the effects of public pore space ownership would not

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[147] *See supra* Part II.A.

[148] Sprankling, *supra* note 115, at 1024 (noting that "the deep subsurface is largely incapable of possession in the traditional sense" due to the fluid nature of the mantle, and extremes in heat and pressure).

[149] Indeed, the doctrine even fails in the comparable context of resource extraction ("The principles of private ownership which involve dominion on the part of the landowner over all substances from the center of the earth to the heavens were *inadequate* to solve the problems of a substance under the earth, which would migrate to points of lower pressure caused by punctures of the reservoir by drilling."). Nunez v. Wainoco Oil & Gas Co., 488 So.2d 955, 962 (La. 1986) (citing H. DAGGETT, MINERAL RIGHTS IN LOUISIANA 415 (1949)).

[150] Carol Rose, *The Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U. CHI. L. REV. 711, 719 (1986). Economic utility is not the sole right that inheres in private property; others include the "right to possess, use and dispose of it." United States v. Gen. Motors Corp., 323 U.S. 373, 378 (1945). However, as the above discussion notes, private "possession" and "use" without unification of the deep pore space may be infeasible due to physical and geological realities. *See supra* Part I.

[151] *See* Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 11 (Tex. 2008). ("Wheeling an airplane across the surface of one's property without permission is a trespass; flying the plane through the airspace two miles above the property is not. Lord Coke, who pronounced the maxim, did not consider the possibility of airplanes. But neither did he imagine oil wells. The law of trespass need no more be the same two miles below the surface than two miles above.").

[152] In the deepest subsurface trespass litigation in the United States, the plaintiff complained about "4 or 5 feet" of a drill's intrusion into his subsurface property at a depth of 11,000 ft. *Nunez*, 488 So. 2d at 957. Using facts similar to CCS, the Supreme Court of Louisiana found that the required unitization of common mineral pools did not permit an individual landowner "to rely on a concept of individual ownership to thwart the common right to the resource as well as the important state interest in developing its resources fully and efficiently." *Id.* at 964.

unduly burden private property rights.[153] Rather, unifying the pore space through public ownership would put it to an eminently productive public use that would otherwise be unavailable.[154] The overly fragmented pore space must be "[re]-scaled for productive use," and granted to the public to enable the expeditious and widespread development of CCS.[155]

B. Reconciling Public Ownership of the Pore Space with Takings Claims

Granting the pore space to the public through a reconfiguring of the *cujus est solum* doctrine raises the specter of takings, specifically with regards to the *per se* physical takings rule elucidated by the Court in *Loretto v. Teleprompter Manhattan CATV Corp*.[156] While this Note argues that the pore space, like the navigable airspace, is inherently public due to deficiencies in the common law's anachronistic conception of property, the issue must be addressed. In fact, at first blush, public ownership of the pore space and the seemingly innocuous requirement that a television cable must be installed on a building raise similar issues. Both deal with ostensibly public goods, climate change and cable television (though not equally "good"), and effect a physical appropriation that "has only minimal economic impact on the owner."[157] However, as argued above, the subsurface pore space physically falls below the limits of private beneficial use, and should not be considered to be part of the private surface estate amenable to a takings claim.[158] Thus, this Note supposes that a takings claim would

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[153] Indeed, courts have found that similar subsurface activities, such as EOR, underground waste disposal, and water storage and recharge, do not rise to the level of subsurface trespass as the property owner could not demonstrate actual harm or interference with the use and full enjoyment of the land, echoing the limitation set by *Causby*. Gresham, *supra* note 125, at 111–12.

[154] The public trust doctrine has similarly been expanded from public ownership of navigable waterways to include "parks, historical areas, cemeteries, archeological sites and remains, and works of art." William D. Araiza, *Democracy, Distrust, and the Public Trust: Process-Based Constitutional Theory, the Public Trust Doctrine, and the Search for a Substantive Environmental Value*, 45 UCLA L. REV. 385, 402 (1997). This doctrine allows resources to be preserved through public ownership to further a public good. *See generally* Joseph L. Sax, *The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention*, 68 MICH. L. REV. 471 (1970).

[155] *See* Heller, *supra* note 131, at 1166.

[156] Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 417, 434–35 (1982).

[157] *Id.* at 435.

[158] The Fifth Amendment "protects rather than creates property interests," and the "existence of a property interest is determined by reference to 'existing rules or understandings that stem from an independent source.'" Phillips v. Wash. Legal Found., 524

fail as no protectable, useable private property has been taken. Flawed doctrines alleging private property ownership of infinite vertical reach must give way to evolving realities and social necessities.[159] The *cujus est solum* doctrine wrongly supposed infinite subterranean utility to a private owner,[160] a takings claim that rests upon this outdated notion should not succeed. Ideally, this reconfiguring of the pore space would be instantaneously and universally applauded, but in reality, any such grant of the pore space to the public would surely raise a takings challenge.

In deciding an equivalent takings claim based on public use of the navigable airspace, the *Causby* Court seemingly viewed the Air Commerce Act's creation of the public airspace as determinative, and consequently endorsed limits to the vertical reach of private property.[161] An equivalent grant of the pore space to the public should be seen as equally valid, as it furthers a public good while avoiding conflict with the private owner's use and enjoyment of the subsurface. Despite the apt analogy, a takings challenge is likely to accompany any such grant of the pore space. Yet, even if a taking of the pore space is successfully asserted under *Loretto*, it may not be compensable.[162] Private, atomistic ownership of the pore space has little inherent economic utility,[163] and takings claims demanding pore space-based compensation may perhaps best be compared to previous challenges to IOLTA (Interest on Lawyers Trust Accounts) programs. In these cases, the Supreme Court recognized that while individual client trust accounts may not generate sufficient interest to be of an "economically realizable value to its owner," forced collectivization and public use of the aggregated

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U.S. 156, 164 (1998). If that understanding changes, as it did with airspace and should with pore space, the Constitution could accommodate it.

[159] In the context of subsurface trespass, Professor Owen Anderson has advanced a similar theory, stating that subsurface "[t]respass is a wrong that should continue to evolve to meet the needs of modern society, including more extensive subsurface land use." Anderson, *Subsurface "Trespass," supra* note 124, at 253.

[160] *See* Sprankling, *supra* note 115, at 992.

[161] United States v. Causby, 328 U.S. 256, 261 (1946) ("The air is a public highway, as Congress has declared.").

[162] A regulatory taking claim is unlikely, as the economic value in a limited slice of a subsurface storage basin is negligible, failing to rise to the level required by *Lucas*. Lucas v. South Carolina Coastal Council, 505 U.S. 1003, 1029 (1992). The limited utility may also deny the prospect of interference with any reasonable "investment-backed expectations" under the *Penn Central* balancing test. *See* Penn. Cent. Transp. Co. v. City of New York, 438 U.S. 104, 124 (1978); Brown v. Legal Found. of Washington, 538 U.S. 216, 234 (2003) ("Under such an analysis, however, it is clear that there would be no taking because the transaction had no adverse economic impact on petitioners and did not interfere with any investment-backed expectation.").

[163] *See supra* notes 125–28 and accompanying text.

interest may still be a taking.[164] Despite this, the Court deemed the taking to be non-compensable.[165] Real value and utility could be realized only through a unification of private property through IOLTA programs.[166] However, this increased collective value was not the basis for compensation. In determining the "just compensation" owed for the taking of negligibly valuable private property to further a public good, the Court instructed that "the question is what has the owner lost, not what has the taker gained."[167] Following this rationale, the compensation required with regard to private pore space ownership may indeed be zero.[168] Aggregation of fractionated private interests can therefore confer previously unavailable utility,[169] facilitating socially productive activity while perhaps not incurring takings-related compensation.

Therefore, potential takings claims related to the public ownership of the pore space may fail for two reasons: either the pore space falls below any protectable private property interest (following *Causby*), or it does not represent a compensable private property interest in its disaggregated state. If the *Causby* analogy is accepted, and the *cujus est solum* doctrine is accepted as an archaic formulation, the downward reach of private property may be limited. Further, if the unification of the property interest is what confers value and utility,[170] the private owner has not lost a compensable property interest. The underlying motivation for unifying the pore space flows from these rationales, and attempts to prevent fragmented private ownership from negating the pore space's central role in CCS and climate change mitigation.[171] The unity of the pore space confers its

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[164] Phillips v. Wash. Legal Found., 524 U.S. 156, 170 (1998).
[165] *Brown*, 538 U.S. at 237.
[166] *Id.* at 230.
[167] *Id.* at 236 (quoting Boston Chamber of Commerce v. Boston, 217 U.S. 189, 195 (1910)).
[168] *See supra* notes 125–28 and accompanying text (noting that the economic value of privately owned pore space may be minimal).
[169] Scholars have termed the loss of utility through excessive private property fragmentation the "tragedy of the anticommons." Heller, *supra* note 131, at 1166 ("If too many people gain rights to use or exclude, then bargaining among owners may break down. With too many owners of property fragments, resources become prone to waste either through overuse in a commons or through underuse in an anticommons.").
[170] *See* Sprankling, *supra* note 115, at 1025.
[171] This concept of valid, forced unitization in the face of private property is not new to the subsurface, where gas or oil reservoir unitization is often required to protect the public resource. While traditional conceptions of property suggest dominion and exclusive control, forced pool unitization "infringe[s] on the usual rights of ownership" to prevent the "tragedy of the commons" from engendering excessive waste of a finite resource. Nunez v. Wainoco Oil & Gas Co., 488 So.2d 955, 961–69 (La. 1986).

utility,[172] and private ownership may be incapable of unitizing the pore spaces on a scale large enough to advance meaningful climate mitigation through CCS.[173] Therefore, just as the law has recognized the validity of publicly mandated unitization of private property interests to enable resource extraction,[174] air travel,[175] and the provisions of legal services,[176] it may do so to promote CCS as well.[177]

C. Common Law Uncertainty and the Inapplicability of Available Examples

1. Legal Uncertainty

Limiting the *cujus est solum* doctrine through a legislative grant of the pore spaces to the public provides a possible solution to the "unity" problem facing CCS development. However, the "clarity" problem, born of the inconsistent legal treatment of the pore space across jurisdictions, must be examined as well. As courts have variously granted the pore space to the surface or mineral estate, while inconsistently enforcing the *cujus est solum* doctrine with regard to subsurface trespass, legal uncertainty faces prospective CCS developers. This uncertainty should be clarified through a clear legislative definition of pore space ownership. The inconsistencies in the case law with regard to subsurface ownership have been examined before, more ably and in more detail than will be done here.[178] However, examining the inconsistency is not important for what it reveals about subsurface ownership,[179] but rather to show that without a clear legislative

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[172] *See* discussion *supra* Part I.A.

[173] *See* THE FUTURE OF COAL, *supra* note 11, at 43 (noting that CCS may be the only current technology capable of reducing emissions at the level needed, and would need to sequester the equivalent of the emissions from over six hundred 1000 MW coal-fired plants); Heller, *supra* note 131, at 1165 (noting property collectivization bargaining difficulties); Fish & Wood, *supra* note 63, at 3-15 ("It is possible that thousands of individual owners will overlie the CO_2 plume from each facility."). Some proposals have even focused on developing CCS only under state-owned lands to avoid private unitization issues. Lydia Gonzalez Gromatzky & Peter T. Gregg, *Carbon Storage: Texas Stakes Its Claim*, 25 NAT'L RESOURCES & ENV'T 21, 23 (2010).

[174] *See* Heller, *supra* note 131, at 1165–66.

[175] *See* Brown v. Legal Found. of Wash., 528 U.S. 216, 233 (2003).

[176] *See id.* at 221.

[177] *See id.* at 237.

[178] *See generally* Anderson, *supra* note 97; Anderson, *Subsurface "Trespass," supra* note 124; Fish & Wood, *supra* note 63; Klass & Wilson, *supra* note 6; Reisinger et al., *supra* note 8.

[179] The available analogies may not be apt comparisons to CCS. *See infra* notes 190–99 and accompanying text.

definition placing the pore space in the public trust, subsurface ownership rights will vary arbitrarily by jurisdiction.

Specifically, the common law has inconsistently dealt with both whether the surface owner retains ownership of the pore spaces when the mineral estate has been severed (revealing whether they are an intrinsic part of the surface estate),[180] and whether the surface owner possesses a right to excludability when the alleged pore space trespass has produced no real harm.[181] As the various holdings reveal,[182] states have inconsistently applied the *cujus est solum* doctrine in the context of subsurface property rights, removing even the limited utility of this bright line rule.[183]

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[180] *Compare* Ellis v. Ark. La. Gas Co., 450 F. Supp. 412, 421 (E.D. Okla. 1978) (noting that mineral rights are "an incorporeal interest analogous to a profit to hunt and fish" and do not "convey the stratum of rock containing the pore spaces"), *and* Int'l Salt Co. v. Geostow, 878 F.2d 570, 574 (2d Cir. 1989) ("International Salt has a fee simple interest in the salt only and does not have a separate fee interest in the excavation cavity or containing chamber."), *with* Lillibridge v. Lackawanna Coal Co., 143 Pa. 293, 301 (1891) ("How could the defendant own the coal absolutely and in fee-simple, and not own the space it occupied? Or how is it possible to conceive of such a thing as the ownership of the space independently of the coal?"), *and* Mapco, Inc. v. Carter, 808 S.W.2d 262, 274 (Tex. Ct. App. 1991) *rev'd on other grounds*, 817 S.W.2d 686 (Tex. 1991) ("Thus, the fee mineral owners retain a property ownership, right and interest after the underground storage facility—here, a cavern—had been created.").

[181] *Compare* Nunez v. Wainoco Oil & Gas Co., 488 So.2d 955, 963 (La. 1986) ("Like the Oklahoma Supreme Court, we conclude that the established principles of private ownership, already found inadequate in Louisiana to deal with the problems of subsurface fugacious minerals . . . need not necessarily be applied to other property concepts, like trespass."), Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 11 (Tex. 2008) ("The law of trespass need no more be the same two miles below the surface than two miles above."), *and* Chance v. BP Chemicals, Inc.,670 N.E.2d 985, 992 (Ohio 1996) ("[Appellant's] subsurface ownership rights are limited. As the discussion in *Willoughby Hills* makes evident, ownership rights in today's world are not so clear-cut as they were before the advent of airplanes and injection wells."), *with* Columbia Gas Transmission Corp. v. An Exclusive Nat'l Gas Storage Easement, 620 N.E.2d 48 (Ohio 1993) (finding just compensation is due if there is sufficient recoverable subsurface interest), *and* OKLA. STAT. ANN. tit. 60, § 64 (West 2010) ("The owner of land in fee has the right to the surface and to everything permanently situated beneath or above it.").

[182] *See supra* notes 180–81 and accompanying text.

[183] The Supreme Court has held that "[t]he power to exclude has traditionally been considered one of the most treasured strands in an owner's bundle of property rights." Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419, 435 (1982). However, this bright line seemingly blurs the deeper one that delves into the subsurface, as physical harm and interference with full enjoyment becomes remote. *See* Coastal Oil & Gas Corp., 268 S.W.3d at 11 ("It is important to note, however, that [Plaintiff]'s claim of trespass does not entitle him to nominal damages (which he has not sought). He must prove actual injury."); W. Edmond Salt Water Disposal Ass'n v. Rosecrans, 226 P.2d 965, 970 (Okla. 1950) (finding

Therefore, developers in Oklahoma may find they can purchase the pore space as part of the mineral estate,[184] while storage basins across the border in Texas may be controlled by the surface estate.[185] Similarly, the enforcement of subsurface trespass may stop[186] and start[187] randomly at jurisdictional boundaries. Thus, even though most jurisdictions place the pore space with the surface estate,[188] presumably granting surface owners the right to exclude, various courts have declined to find liability for subsurface trespass where no harm has occurred.[189] As a result, potential liability for laterally migrating sequestered CO_2 could vary arbitrarily as the gas crossed state lines. CCS developers would be hard pressed to determine uniform property rules that applied from field to field, as ownership and exposure to liability seemingly vary at random. In light of these inconsistencies, the legal environment surrounding the pore space may not provide a solid footing for private development.[190] A grant of the pore space to the public would rectify this by providing needed clarity.

Clearly, the ownership of the pore space cannot vary across geologically arbitrary jurisdictional lines. Widespread development requires legal consistency.[191] *Causby* should therefore be applied to the pore space through legislative action to promote uniformity. Disappointingly, legislative definitions of the pore space have been attempted in only a few states,[192] leaving potential CCS storage basins at the inconsistent whim of state subsurface common law. Legislation clearly granting the pore space to the public

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no liability for subsurface trespass where injected saltwater merely mingled in an abandoned well with other saltwater, causing no actual damage). *See generally* Anderson, *Subsurface "Trespass," supra* note 124, at 248 (arguing that subsurface trespass claims should be limited similarly to airspace claims, and only allowed where actual harm has occurred).

[184] *Ellis*, 450 F. Supp. at 421.

[185] *Mapco, Inc.*, 808 S.W.2d at 274.

[186] *Chance*, 670 N.E.2d at 991 (limiting subsurface trespass under the *Causby* rationale).

[187] OKLA. STAT. ANN. tit. 60, § 64 (West 2010) (embracing the *cujus est solum* doctrine).

[188] Anderson, *Subsurface "Trespass," supra* note 124, at 255 ("[I]n most jurisdictions, title to subsurface pore spaces rests with the surface owner, not the mineral owners.").

[189] *Chance*, 670 N.E.2d. at 993 ("Even assuming that the injectate had laterally migrated . . . we find that some type of physical damages or interference with use must have been demonstrated for appellants to recover for a trespass."); FPL Farming, Ltd. v. Texas Nat'l Resource Conservation Comm'n, No. 03-02-00477-CV, 2003 WL 247183, at *4 (Tex. Ct. App. Feb. 6, 2003) ("[S]ome measure of harm must accompany the migration for there to be impairment.").

[190] *See* Reisinger et al., *supra* note 8, at 4 (noting that "[i]ndustry is naturally risk-averse," and will perhaps balk at subsurface legal uncertainty).

[191] *Id.* at 43.

[192] *See infra* Part III.

would rectify the inconsistency problem, statutorily reinforcing and clarifying a downward limit to surface ownership that has been heretofore inconsistently recognized by courts. Enigmatically, decisions denying instances of subsurface trespass show that *Causby* has indeed infected judicial conceptions of subsurface property,[193] and the formerly bright line rule of "heaven to earth" ownership is clearly eroding.[194] While this development may support the thesis of this Note, it has bred inconsistency across state lines with regard to pore space ownership. An ad hoc, judicial reconfiguring of the pore space would be detrimental to CCS, and uniform legislative definitions are needed to promote consistency in the law. If subsurface storage basins do not stop at state borders, the relevant property rights and legal regulatory regime should not either.[195]

2. Potential Inapplicability of Available Examples

While this Note argues that the airspace example provided by *Causby* is a more fitting analogy with regard to pore space ownership, subsurface property rights are vastly more encumbered than airspace rights, and may present a different set of problems.[196] They should therefore be addressed to determine the extent that prior subsurface litigation may inform CCS. Significantly, the vast majority of subsurface property right litigation involves resource extraction, waste injection, or natural gas storage, implicating the removal or storage of a commodity rather than long term sequestration of a substance for public benefit.[197] Thus, not only are the aforementioned holdings inconsistent with regard to their treatment of the subsurface, but their instructive or predictive value in the context of CCS may be limited. Disputes involving EOR, natural gas storage, or underground waste storage often center upon interference with mineral rights or reserves, and are not directly applicable to CCS.[198] These claims largely focus on forms of subsurface trespass that have "generally been accompanied by removal of minerals, with the attendant damages consisting of the

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[193] *See* Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W. 3d. 1, 11 (Tex. 2008); Raymond v. Union Tex. Petroleum Corp., 697 F. Supp. 270, 274 (E.D. La. 1988) ("[T]raditional property concepts like trespass, must yield to the important interest of conserving the natural resources of the state."); *Chance*, 670 N.E.2d at 991 (following *Causby's* rationale).

[194] Sprankling, *supra* note 115, at 1004 (2008) ("Broadly speaking, the deeper the dispute, the less likely courts are to recognize the surface owner's title.").

[195] *See* Decesar, *supra* note 7, at 266.

[196] Klass & Wilson 2010, *supra* note 91, at 388–89.

[197] *Id.* at 393.

[198] *See generally* Anderson, *Subsurface "Trespass," supra* note 124, at 256–81.

value of the extracted minerals."[199] Conversely, CCS involves the infinite sequestration, over potentially thousands of square miles, of vast amounts of a substance that both science and society have deemed to be harmful to humanity.[200] Any actual damages incurred due to CCS (through surface leakage, resource displacement, or blowout) could be legally remedied, but absent actual economic or physical harm, there is no similar basis for subsurface damages related to CCS.[201] CCS, as a noneconomic pursuit aimed principally at climate mitigation, cannot be comfortably wedged into the Procrustean bed of prior subsurface litigation.[202] Because of this, *Causby* and the airspace example, which created an upward property boundary delineated by the limit of the owner's full enjoyment and exploitation, may be a more fitting analogy for purposes of CCS.[203]

CCS, as a transitional method of climate mitigation, should be conceived as a public action taken in the interest of society, not as a fundamentally private economic endeavor, as profit incentives are lacking, or at least of secondary importance.[204] Thus, disputes involving EOR, mineral extraction, or temporary natural gas storage focus on the extractive nature, and inherent value, of the substance, and may not be adequate guides in determining the proper ownership of the pore space.[205] Indeed, if conflict

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[199] Nunez v. Wainoco & Gas Co., 488 So. 2d 955, 959 (La. 1986); *see also* Klass & Wilson 2010, *supra* note 91, at 392–93 ("[I]nstead of involving the use of space in the subsurface, these cases involve the use of valuable resources to be taken from the subsurface for commercial gain."); Sprankling, *supra* note 115, at 1005 ("[D]ecisions concerning the right to use and enjoy subsurface lands address only five main topics: (a) groundwater; (b) oil and gas; (c) hard rock minerals; (d) objects embedded in the soil; and (e) waste disposal. In fact, these are the only economically productive uses of the subsurface currently possible.").

[200] *See supra* Part I.C.

[201] *See* Anderson, *Subsurface "Trespass," supra* note 124, at 281 ("Although [CCS] can lead to the physical migration of substances beneath neighboring property, [it] should not give rise to actionable trespass without a showing of actual and substantial harm other than drainage."). This limitation of subsurface private property rights absent physical harm or interference with the surface owner's reasonable enjoyment is in some respects similar to the dichotomy presented by the "property" and "liability" rules as explained by Calabresi and Melamed. Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1092 (1972). This Note argues that the "property" rule surrounding subsurface storage spaces should be abolished, making them publicly owned.

[202] Klass & Wilson 2010, *supra* note 91, at 393 ("[T]he cases focusing on ownership of the space for the resource, commodity, or development may be more helpful than cases focusing on ownership of the resource, commodity, or development itself, although the latter group of cases may still be instructive in some circumstances.").

[203] *Id.*

[204] *See* Gresham, *supra* note 125, at iv.

[205] Anderson, *Subsurface "Trespass," supra* note 124, at 282.

existed between CCS projects and subsurface uses, mineral extraction rights could be legislatively prioritized, and any incidental oil and gas removal that accompanied the use of old fields could be allocated to the owner of the mineral estate.[206] Ultimately, a review of subsurface litigation reveals that it has limited instructive application to CCS, while adherence to the *cujus est solum* doctrine can vary by jurisdiction. Potential CCS developers would rightly view the current subsurface legal landscape as confused, and would find few adequate guides or analogies in the case law. Uniform statutory definitions of the pore space property interest, consistent across jurisdictions, would rectify this "clarity" problem. Accordingly, Montana, Wyoming, and North Dakota have statutorily granted the subsurface pore space to the surface owner,[207] providing clear definitions of subsurface property in anticipation of future CCS development.

III. STATE PORE SPACE REGULATIONS

To address the uncertainty in the common law, Montana, Wyoming, and North Dakota have enacted legislation regulating CCS and defining pore space ownership.[208] While these state CCS legal regimes are meant to kick-start state-specific CCS investment,[209] their inconsistent nature, insufficient provisions, and finite jurisdiction may prove unsuited for a national CCS program.[210] Certainly, these states[211] initially appear to be

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[206] *See id.* at 249 ("Such situations should be rare and may not arise at all if the subsurface injection project is subject to a robust regulatory permitting system whose purpose, in part, should be to prevent these situations from arising in the first place. In general, whether a particular subsurface invasion should be prohibited or stopped should be left to environmental regulatory agencies, not to courts.").

[207] *See supra* notes 14–16 and accompanying text (detailing Wyoming, Montana, and North Dakota laws, respectively, granting pore space ownership to the surface owner).

[208] Klass & Wilson 2010, *supra* note 91, at 382. Several other states have passed CCS regulations, but only the three covered here have defined pore space ownership rights. *See State CCS Policy—Sequestration*, *supra* note 17. The IOGCC has developed model legislation on CCS, which largely tracks what Montana, North Dakota, and Wyoming have done. The model statute "propose[s] the required acquisition" of pore space rights and "contemplate[s] use of state natural gas eminent domain powers or oil and gas unitization processes" to unify the storage area. IOGCC, *supra* note 24, at 27.

[209] Wyoming Governor Dave Freudenthal declared that the law would put Wyoming in the vanguard of clean energy production. State Rep. Tom Lubnau was even more optimistic, declaring future generations will look back and say "that's the day they did something." Bill McCarthy, *House OKs Clean Coal Bills*, WYOMING TRIB.-EAGLE, Feb. 14, 2008, at A8.

[210] Klass & Wilson 2010, *supra* note 91, at 382.

[211] Congress has seen legislation relating to CCS as well, but the bills largely continue to languish in committee. The legislation uniformly seeks to enable CCS development, and

on the right track, as general state regulation of CCS should be applauded. However, these states have granted the pore space to private owners,[212] gaining legal clarity while preventing pore space unity. Paradoxically, the supposedly clarifying grant of private pore space has instead resulted in an inconsistent patchwork of state regulation as states attempt to lessen the burdens of private pore space ownership. Thus, state regulations concerning field unitization,[213] liability transfer,[214] and pre-injection permit requirements,[215] ostensibly enacted to spur safe development, should rather be seen as means of working around the burdens inherent to privatized pore space. Therefore, while Montana, North Dakota, and Wyoming have set up superficially similar private pore space ownership regimes, ad hoc state-level attempts to deal with private ownership have resulted in regulatory inconsistency.[216] Thus, by committing the initial misstep of private pore space ownership in the name of legal clarity, Montana, North Dakota, and Wyoming have been forced to inconsistently tweak the bounds of private ownership to actually enable CCS.[217] Public pore space ownership would remedy this.

Most unhelpfully, Montana, North Dakota, and Wyoming have granted pore space ownership to the surface estate,[218] statutorily embracing

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a sampling of proposed bills includes provisions to make the Secretary of Energy the "long-term steward" of closed storage sites (transferring liability to the Federal government), set up DOE CCS demonstration projects, and give CCS projects and retrofitting power plants tax breaks and loan guarantees. *See* Coal Energy Bridge Act of 2010, S. 3714, 111th Cong. § 1 (2010); Carbon Capture & Sequestration Deployment Revenue Act of 2010, S. 3590, 111th Cong. § 48E (2010); Dep't of Energy Carbon Capture & Sequestration Program Amendments Act of 2009, S. 1013, 111th Cong. § 963A (2009); Carbon Storage Stewardship Trust Fund Act of 2009, S. 1502, 111th Cong. § 2 (2009).

[212] *See supra* notes 14–16 and accompanying text.

[213] *See infra* note 216 and accompanying text.

[214] *See infra* note 232 and accompanying text.

[215] *See, e.g.*, MONT. CODE ANN. § 82-11-123 (2009); N.D. CENT. CODE § 38-22-08 (West 2009); WYO. STAT. ANN. § 35-11-313 (West 2010).

[216] For example, Montana, North Dakota, and Wyoming all allow for storage field unitization within their CCS statutes, helpfully alleviating some of the problems created by private ownership of the pore space. However, the states differ as to unitization procedures and the percentages of owner approval required, even though the states all border each other and will likely share some cross-border storage basins. *See* MONT. CODE ANN. § 82-11-204 (2009) (*allowing* unitization if sixty percent of owners approve, but not requiring as part of site permit); N.D. CENT. CODE § 38-22-08(5) (West 2009) (*requiring* the storage owner to acquire the "consent of persons who own at least sixty percent of the storage reservoir's pore space" as a condition of site permitting); WYO. STAT. ANN. § 35-11-316(c) (West 2009) (allowing unitization of the pore space if eighty percent of the pore space owners approve).

[217] *See infra* notes 226–41 and accompanying text.

[218] *See supra* notes 14–16 and accompanying text.

the problems that private ownership of the pore space engenders.[219] Sequestered gas is likely to spread,[220] and it will be stored indefinitely in pools that extend across state lines and below hundreds, if not thousands, of surface land owners.[221] State mandated private ownership of the pore space directly conflicts with this physical reality. The legal challenges raised in managing a national CCS system while contending with the thousands of overlying private property owners that these laws create would undoubtedly prove to be "daunting."[222] While certainly providing clarity, private ownership of the pore space fails to solve the "unity" problem, instead carving up potential CO_2 storage basins into thousands of pieces.[223] Montana, North Dakota, and Wyoming should be lauded for taking the initial steps to legally prepare for CCS development, but embracing private pore space ownership is misguided. These states have perhaps realized the incongruity of private pore space ownership, and have taken steps to mitigate the burdens.

Following this, the CCS laws in Montana, North Dakota,[224] and Wyoming have addressed the private ownership barrier to pore space unitization, and each state provides for field unitization in some way.[225] Thus, initial private ownership may be abrogated by collective field unitization action, preventing individual pore space owners from exercising the right to excludability.[226] However, each state views unitization differently, as Montana envisions it as a voluntary act, North Dakota makes it a permit requirement, while Wyoming sees it as a means of gaining efficiency while statutorily escaping charges of monopoly.[227] Despite these unitization allowances, default private pore space ownership still remains an obstacle to widespread CCS development in the short term,

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[219] Problems would include difficulties with unitization of the pore space rights, potential trespass liability due to subsurface migration, and a lack of private economic incentives for development. *See supra* Part II.
[220] *See* Moore, *supra* note 85, at 454.
[221] Fish & Wood, *supra* note 63, at 3-6 to 3-7.
[222] Gromatzky & Gregg, *supra* note 173, at 23.
[223] Hayano, *supra* note 112, at 154 ("[The] legislation leaves unanswered how these rights are to be amalgamated so that the storage space can be acquired on a scale sufficient to allow GCS.").
[224] Uniquely, North Dakota does not allow for severance of the pore space from the surface estate, raising concerns over the unitization of subsurface pore space. N.D. CENT. CODE § 47-31-01 (West 2009).
[225] *See supra* note 216 and accompanying text.
[226] FISH & MARTIN, *supra* note 18, at 3.
[227] *See supra* note 216 and accompanying text.

as the provisions would still require the cooperation of a significant majority of pore space owners.[228] As storage fields would likely cover large expanses and hundreds of owners, unitization may become necessary, as no one storage operator would own the entire field.[229] Thus, these unitization provisions may become de facto requirements if operators are to gain access to large storage fields, as effective CCS would require.[230] Field unitization provisions essentially admit that private ownership may inhibit CCS development, but do not fully correct the problem. Allowing field unitization after a supermajority of the pore space owners consent may therefore lessen the burdens inherent to amalgamating hundreds of potential pore space interests,[231] but significant barriers remain due to the sheer scale of CCS development required.

Additionally, Montana and North Dakota lessen private CCS development costs by rightly providing for a conditional transfer of future storage site liability and ownership to the state.[232] This is likely due to a recognition of the infinite timescale of CCS and the greater ability of states to shoulder such a burden.[233] Montana and North Dakota would allow transfer of the site to the state after a set period of years if the operator demonstrates the integrity of the storage site and meets statutory requirements, and the state assumes ownership and liability without compensating the operator.[234] This allowance concedes a central limitation to private pore space ownership and CCS development: as CO_2 sequestration must be infinite, monitoring and liability responsibilities

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[228] Sixty percent in Montana and North Dakota, and eighty percent in Wyoming. *Id.* These requirements could raise the prospect of holdouts.

[229] *See* Klass & Wilson, *supra* note 91, at 365 (noting that future CCS operators would need access to millions of acres of storage space to be truly effective).

[230] *Id.*

[231] *See* Fish & Wood, *supra* note 63.

[232] MONT. CODE ANN. § 82-11-183(1) (2009) (allowing transfer of title and liability to the state after fifteen years if certain conditions are met); N.D. CENT. CODE § 38-22-17(1) (West 2009) (allowing transfer of title and liability to the state ten years after injection ceases if certain conditions are met).

[233] SONJA NOWAKOWSKI, MONT. LEGIS. ENERGY & TELECOMM. INTERIM COMM., CARBON SEQUESTRATION STUDY: AN ANALYSIS OF GEOLOGICAL & TERRESTRIAL CARBON SEQUESTRATION REGULATORY & POLICY: A REPORT TO 61ST LEGISLATURE 32 (Legis. Servs. Div. 2008), *available at* http://leg.mt.gov/content/Publications/committees/interim/2007_2008/2008carbonsequestration.pdf (noting that uncertainty surrounding carbon sequestration and length of liability may deter private development).

[234] *See supra* note 20 and accompanying text. Conversely, and regrettably, Wyoming does not allow private CCS operators to transfer liability to the state after site closure, and the state merely takes on prospective monitoring responsibilities while expressly denying future state liability for sequestration. *See* WYO. STAT. ANN. § 30-5-104(d)(vii) (West 2011).

post-closure may prove overwhelming for private actors,[235] perhaps dissuading private parties from initiating development. Transfer to the state would certainly alleviate this concern, but it raises questions as to why the state does not own the pore space, and control the project, at the outset. Where transfer of liability is not allowed by states that envision private development and ownership, such as in Wyoming,[236] CCS development faces a significant hurdle.[237]

If states regulate the beginning of CCS projects through permitting requirements,[238] allow field unitization to overcome private ownership,[239] and permit transfer of liability and ownership post-closure,[240] the public will be intimately involved in CCS development. The commingling of private and public functions may unnecessarily complicate CCS development, and may be a recognition of the challenges of private pore space ownership. Indeed, current CCS legal regimes are overly complex insofar as they cling to private pore space ownership at the outset while tempering (or removing) the impact throughout the development process. This discordant system, sandwiching private ownership and injection between public permitting and eventual public ownership, would be simplified through outright public ownership of the pore space. Under current guidelines, the relevance of private pore space ownership is largely confined to the initial development and injection process, with the public regulating permitting, allowing unification to override minority owner rights, and ultimately becoming the storage site owner. Where private development and injection may not be economically viable absent subsidy, even this private function is eroded.[241] Indeed, it is likely that private development would be infeasible without these "workarounds," revealing the shortcomings of private pore space ownership. The state, and public, are thus inexorably involved in CCS development. Insofar as the private ownership system is only enabled by

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[235] ELIZABETH ALDRICH, ENERGY POL'Y INST., ANALYSIS OF EXISTING AND POSSIBLE REGIMES FOR CARBON AND SEQUESTRATION: A REVIEW FOR POLICYMAKERS 12–17 (2011), *available at* http://epi.boisestate.edu/media/6079/epi ccs pore space regimes.pdf.
[236] *Id.*
[237] *See* Karl Puckett, *Bill Would Give Board Carbon Storage Control*, GREAT FALLS TRIB., Mar. 6, 2009, at M3. At hearing on the Montana legislation, a representative for PPL Montana, which owns several coal plants in the state, stated that "without that [state assumption of] liability, we don't believe sequestration will occur." *Id.*
[238] MONT. CODE ANN. § 82-11-111(5)(a) (2009), *amended by* Mont. Laws ch. 19, S.B. 31 (2011); N.D. CENT. CODE § 38-22-04 (West 2009).
[239] *See supra* note 194 and accompanying text.
[240] *See supra* note 20 and accompanying text.
[241] Gresham, *supra* note 125, at iv.

these sorts of public ownership-esque allowances, clarity, unity, and simplicity should be achieved through a universally public system.

Lastly, state-based pore space property regimes, and the related reliance upon private property ownership of the pore space, threaten just the sort of Balkanization of regulations that Judge Wilkinson warned of in *North Carolina v. TVA*.[242] In *TVA*, the Fourth Circuit rejected the use of public nuisance standards to bypass the Clean Air Act, fearing that such a situation would create "a confused patchwork of standards, to the detriment of industry and the environment alike."[243] Montana, North Dakota, and Wyoming are rightly attempting to address the inconsistent treatment[244] of the pore space at common law. However, such an important national, public program as large-scale as CCS should not be hindered by the constraints of fifty separate state property regimes and the subsequent negotiations with thousands of prospective owners.[245] Pore spaces and storage fields do not stop at state borders,[246] and regulations should be crafted consistently across jurisdictions to provide a clear legal foundation for CCS to begin mitigating climate change in the near future.[247]

CONCLUSION

Climate change is a growing concern[248] that will not wait for new, or as yet undeveloped alternative technologies to reduce anthropogenic CO_2 emissions. CCS represents perhaps the best available "bridge" technology that can effectively mitigate CO_2 emissions until non-carbon dependant energy generation is developed on a sufficiently broad scale.[249] To enable the sorts of widespread CCS that would actually effect CO_2 emissions, CCS developers will need access to "millions" of acres of underground storage fields.[250] Private ownership of this storage space—the pore spaces—will

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[242] *See* North Carolina ex rel. Cooper v. Tenn. Valley Auth., 615 F.3d 291 (4th Cir. 2010).
[243] *Id.* at 296.
[244] *See supra* note 97 and accompanying text.
[245] *See generally* Fish & Wood, *supra* note 63, at 3-15.
[246] Decesar, *supra* note 7, at 266.
[247] Importantly, the EPA has begun to address CCS, and recently finalized rules protecting drinking water near CCS sites and setting GHG reporting requirements for facilities that engage in CCS. *See* Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geological Sequestration (GS) Wells, 75 Fed. Reg. 77,230 (Dec. 10, 2010) (to be codified at 40 C.F.R. pts. 124, 144–47); Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 75 Fed. Reg. 75,060 (Dec. 1, 2010) (to be codified at 40 C.F.R. pts. 72, 78, 98).
[248] IPCC, *supra* note 1, at 36.
[249] *See* Attanasio, *supra* note 38, at 10,380; WORLD ENERGY COUNCIL, *supra* note 9, at 5.
[250] Klass & Wilson 2010, *supra* note 91, at 365.

fundamentally frustrate this endeavor. If CCS is going to be effective as a tool to combat climate change, a clear, uniform delegation of the pore space to the public may be necessary.[251] States may ably do so following the Supreme Court's rationale in *Causby*,[252] as the pore spaces lay below the limits of private property or private enjoyment.[253] Public ownership will reduce regulatory variation across jurisdictions, create storage field unitization, and allow for the public development of a project that is potentially lacking traditional private economic incentives.[254] Dividing the pore spaces into millions of narrow tubes of private ownership will greatly inhibit CCS development and fundamentally misunderstands subsurface geology and private utility.[255]

States should uniformly grant the subsurface pore space to the public. This would allow the state permitting agency to be a "one-stop shop[]" for CCS development, removing the need for statutory concessions such as unitization requirements or liability transfers.[256] Just as the state is the only entity capable of managing the infinite post-closure monitoring and liability burdens inherent to CCS, the state, and therefore the public, should be recognized as the legitimate owner and manager of this valuable resource.[257] The public trust doctrine has been previously expanded to encompass important public resources,[258] and insofar as CCS is envisioned as a valuable climate change mitigation strategy, the pore spaces must be publicly owned to prevent a "tragedy of the commons."[259]

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[251] *See* Puckett, *supra* note 237. The State of Montana originally supported state ownership of the pore space, believing that it would simplify the process. *Id.* Mike Volesky, a representative of the governor's office, questioned the propriety of private ownership, asking industry, "would you . . . like to deal with a majority of those landowners? . . . Or would you rather simply go to the state and get your permit[?]" *Id.* Granting ownership of the pore space to the surface owner was seen as the second-best option, but ultimately won out due to resistance from interest groups. Email from Mike Volesky, Governor's Pol'y Advisor for Natural Res., to James Zadick (Sept. 23, 2010) (on file with author).

[252] United States v. Causby, 328 U.S. 256 (1946); Legislation to grant the pore space to the State under the public trust doctrine was proposed in Montana, but was tabled in committee. H.B. 502, 61st Leg. (Mont. 2009) ("Under the public trust doctrine, the state of Montana owns the exclusive right to use all pore space in all strata below the surface of this state, with the exception of lands owned by or under the jurisdiction of the United States . . . .").

[253] *See supra* discussion, Part II. The pore spaces are not a protectable private property interest, just as the navigable airspace is not. Further, takings claims would likely be avoided. *Id.*

[254] *See* Gresham, *supra* note 125, at iv.

[255] *See* Sprankling, *supra* note 115, at 1029.

[256] Puckett, *supra* note 237.

[257] Reisinger et al., *supra* note 8, at 25.

[258] *See supra* note 154 and accompanying text.

[259] Heller, *supra* note 131, at 1166.