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# Airspace in a Green Economy

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## ABSTRACT

The recent surge of interest in renewable energy and sustainable land use has made the airspace above land more valuable than ever before. Unfortunately, a growing number of policies aimed at promoting sustainability disregard landowners' airspace rights in ways that can cause airspace to be underutilized. This Article analyzes several land use conflicts emerging in the context of renewable energy development by framing them as disputes over airspace. This Article suggests that incorporating options or liability rules into laws regulating airspace is a useful way to promote wind and solar energy while still respecting landowners' existing airspace rights. If properly tailored, such policies can facilitate renewable energy development without compromising landowners' incentives and capacities to make optimal use of the space above their lands. This Article also introduces a new abstract model to argue that policymakers should weigh the likely impacts on both rival and nonrival airspace uses when deciding whether to modify airspace restrictions to encourage sustainability.

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## TABLE OF CONTENTS

## INTRODUCTION

The sky holds some of the most promising solutions to the world's toughest energy challenges. Although power from coal, petroleum, natural gas, and enriched uranium currently fuels most economic activity around the globe,[1] there is growing concern that relying primarily on those energy sources is unsustainable and could threaten the environment.[2] Fortunately, while prospectors search even deeper underground for subsurface fuels to meet the planet's burgeoning energy demand,[3] alternative energy strategies are emerging that do not require any drilling. Wind and solar energy devices and many "green development" techniques generate or conserve power by utilizing resources found above the Earth's surface rather than by exhausting materials found beneath it. Policies that promote these sustainable energy strategies are placing unprecedented pressure on "airspace"—the invisible layer of space that envelops the Earth's surface and fills its inner atmosphere.[4]

As coal mines, oil wells, and suburban sprawl are increasingly giving way to solar panels, wind turbines, and smart growth, new conflicts are arising over the use of airspace. In cities, infill development[5] and urban tree

1. In 2008, more than 83 percent of the energy consumed in the United States was derived from fossil fuel sources. Approximately 8 percent was from nuclear electric power. *See U.S. Energy Consumption by Energy Source*, U.S. ENERGY INFO. ADMIN. (Aug. 2010), http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html (indicating that 83.532 quadrillion BTU out of 99.438 quadrillion BTU in total consumed energy originated from fossil fuel sources and that 8.427 quadrillion BTU of all consumed energy was in the form of nuclear electric power).
2. *Human and Natural Drivers of Climate Change*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-human-and.html (last visited Oct. 6, 2011) (describing dramatic increases in atmospheric greenhouse gases since the year 1750, and noting that these increases have been "due primarily to fossil fuel use and land use change" and have altered the "energy balance of the climate system").
3. Deep oil drilling garnered a significant amount of media attention after a major oil spill at a British Petroleum deep-sea oil well in the Gulf of Mexico in 2010. *See, e.g.*, Neil King Jr. & Keith Johnson, *An Oil-Thirsty America Dived Into 'Dead Sea*,*'* WALL ST. J., Oct. 8, 2010, http://online.wsj.com/article/SB10001424052748704657304575540063579696700.html (stating that the "pressures to drill deep in the Gulf water aren't going away," and noting that "Shell's newest project sits in 10,000 feet of water, twice as deep as BP's ill-fated well, and relies on innovations that regulators haven't even begun to wrestle with").
4. Airspace is also sometimes alternatively referred to as "skyspace." *See* Sara C. Bronin, *Solar Rights*, 89 B.U. L. REV. 1217, 1236 (2009) (citing NEB. REV. STAT. § 66-907 (2003); R.I. GEN. LAWS § 34-40-1(2) (1995)).
5. The literature that suggests that infill development and greater urban density are important means of reducing greenhouse gas emissions is too voluminous to catalog here. For a primer and description of recent scholarship on this topic, see generally Alice Kaswan, *Climate Change, Consumption, and Cities*, 36 FORDHAM URB. L.J. 253, 258–66 (2009) (discussing research that

programs[6] are seeking to occupy more urban airspace, while solar access laws,[7] green building incentives for natural indoor lighting,[8] and urban garden programs[9] are demanding that more of that space be kept open. In rural areas, commercial wind energy projects are continuing to face opposition due to their potential to disrupt migratory bird populations,[10] military radar systems,[11] and competing wind farms.[12] All of these clashes are ultimately disputes over scarce airspace.

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indicates that increased urban density, infill, and mixed-use development would significantly reduce automobile use and carbon dioxide emissions). Because dense infill development is often taller than sprawling development, scholars have identified building height restrictions as contributors to sprawl. *See, e.g.*, Bernard H. Siegan, *Smart Growth and Other Infirmities of Land Use Controls*, 38 SAN DIEGO L. REV. 693, 733 (2001) (noting that zoning ordinances "limiting use, density, area and height" have caused "much greater sprawl than existed previous to [their] imposition").

6. For a discussion of recent programs aimed at increasing and protecting tree populations in major cities across the globe, see Irus Braverman, *"Everybody Loves Trees": Policing American Cities Through Street Trees*, 19 DUKE ENVTL. L. & POL'Y F. 81, 82 (2008) (stating that "'[g]reening the city' is currently a hot issue in the agenda of major cities worldwide" and that "[t]rees are a significant aspect of this issue").

7. Existing solar access laws are critiqued in significant detail in Part IV.C. *See infra* notes 164–194 and accompanying text.

8. *See* U.S. GREEN BLDG. COUNCIL, LEED 2009 FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS RATING SYSTEM 77–80 (updated 2010), *available at* http://www.usgbc.org/ShowFile.aspx?DocumentID=7244 (describing requirements for earning one point toward LEED certification for specified building design criteria related to natural interior daylight illumination). LEED is a common acronym for the Leadership in Energy and Environmental Design rating system established by the U.S. Green Building Council to recognize energy efficient building and land use designs. *See* U.S. GREEN BLDG. COUNCIL, http://www.usgbc.org/DisplayPage.aspx?CategoryID=19 (last visited Oct. 6, 2011). For additional discussion of this issue, see *infra* text accompanying notes 80–81.

9. *See, e.g.*, Catherine J. LaCroix, *Urban Agriculture and Other Green Uses: Remaking the Shrinking City*, 42 URB. LAW. 225, 237 (2010) (noting that "no structures are allowed" in Cleveland's recently created urban garden districts "except for small structures associated with the permitted uses" and that fences in those districts can only be "up to six feet high").

10. *See* Hadassah M. Reimer & Sandra A. Snodgrass, *Tortoises, Bats, and Birds, Oh My: Protected-Species Implications for Renewable Energy Projects*, 46 IDAHO L. REV. 545, 564 (2010) (describing the problem of fatalities to migratory birds and other avian species from collisions with wind turbine towers, blades, and related infrastructure).

11. *See* Elisabeth Burleson, *Wind Power, National Security, and Sound Energy Policy*, 17 PENN. ST. ENVTL. L. REV. 137, 141–43 (2009) (describing how commercial wind turbines can interfere with military radar, and highlighting previous opposition to wind farms by the U.S. Department of Defense on that ground). For a full analysis of conflicts between wind energy projects and military radar systems, see *infra* text accompanying notes 149–162.

12. *See* Troy Rule, *A Downwind View of the Cathedral: Using Rule Four to Allocate Wind Rights,* 46 SAN DIEGO L. REV. 207, 209–10 (2009) (describing the problem of wind turbine wake interference between competing wind energy developers). Additional analysis of this issue also follows in Part IV.A, *infra*. *See infra* text accompanying notes 134–148.

Some policies enacted to address these new conflicts have ignored landowners' long-held airspace rights in ways that could unintentionally hinder rather than promote the efficient use of airspace.[13] As the productive value of airspace continues to expand, the effective utilization of that space grows ever more imperative. What policies are best suited to allocate airspace among its increasingly complex array of competing uses?

This Article analyzes several renewable energy development conflicts by framing them as disputes over airspace. Applying microeconomic and property theories to scrutinize these conflicts and the laws governing them, this Article suggests that policies that acknowledge landowners' existing airspace rights are best suited for facilitating renewable energy development and for promoting efficient use of the space above land.

Part I of this Article discusses the distinction between airspace and other natural resources such as wind and sunlight and describes how airspace rights have evolved over time in response to technological and cultural developments. Part II discusses the growing significance of airspace as a means of accessing renewable energy resources and as a method of combating suburban sprawl. Part III sets forth two overarching principles to guide policymaking for airspace to address conflicts that may emerge from the sustainability movement. Specifically, Part III.A argues that new airspace governance approaches should build upon the common law's longstanding property regime, fine-tuning that regime through options or liability rules to advance sustainability goals. Part III.B asserts that policymakers should weigh the potential impacts of such policies on both airspace use that hinders others' concurrent use (rival use) and use that does not (nonrival use) before adjusting bulk and height restrictions to promote sustainability. Part IV applies these two principles to examine renewable energy-related laws causing the underutilization of airspace and identifies policies that might be more tailored to govern airspace rights in the renewable energy context.

## I. PROPERTY IN AIRSPACE

Airspace is among the most ubiquitous of all natural resources, present in every corner of the globe. Nonetheless, airspace is inherently scarce. Each cubic inch of it exclusively occupies a unique spatial position in the universe.[14] The

13. The shortcomings of several recent airspace-related renewable energy policies are the focus of Part IV, *infra*. *See infra* text accompanying notes 133–210.

14. Other scholars have likewise noted the finite nature of airspace. *See, e.g.*, J. Scott Hamilton, *Allocation of Airspace as a Scarce National Resource*, 22 TRANSP. L.J. 251, 289 (1994) ("Like real

old adage "location, location, location" thus applies as much to the valuation of airspace as it does to the valuation of surface land: Ownership rights in a cube of remote, high-altitude airspace might be worth only pennies, even though rights in an equivalent volume of airspace above a city's downtown core might fetch millions of dollars.[15]

Airspace is distinct from "air"—the life-sustaining blend of mostly nitrogen and oxygen gases that circulates around the planet.[16] Because air pollutants freely course throughout the world's air supply, air is sometimes characterized as a globally shared "commons."[17] In contrast, much of the *space* through which air flows is not held in common but is separately owned or controlled.[18]

Similarly, airspace is distinct from the countless invisible waves that pass through air. Vibrating objects transmit waves through the air to deliver music, spoken words, and other sounds to our ears.[19] Modern electronic equipment can also transmit electromagnetic waves of varying frequencies through air, including waves capable of communicating information via

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estate, airspace is a finite resource."). Although one could theoretically view airspace as extending infinitely into outer space, this Article uses "airspace" to refer only to space situated within the Earth's atmosphere.

15. *See, e.g.*, Charles V. Bagli, *$430 a Square Foot, for Air? Only in New York Real Estate*, N.Y. TIMES, Nov. 30, 2005, http://www.nytimes.com/2005/11/30/nyregion/30air.html (describing two real estate developers' purchase of unused "air rights" for approximately $37 million from owners of shorter downtown buildings to erect a thirty-five-story Manhattan apartment tower).

16. Not surprisingly, other scholars have observed the important legal distinction between "air" and "airspace." *See, e.g.*, John Cobb Cooper, *Roman Law and the Maxim* Cujus Est Solum *in International Air Law,* 1 MCGILL L.J. 23, 36 (1952) ("The distinction between 'air' and 'airspace' was as clear in Roman law as it is today. The legal status of the air (or atmosphere) which men breathed was not the same as that of the space through which the air circulated."); B. Harrison Frankel, *Three-Dimensional Real Property Law: The Truth About "Air Rights*,*"* 12 REAL EST. L.J. 330, 340 (1984) ("The term 'air rights' is neither accurate nor descriptive. Air is a chemical mixture.").

17. Garrett Hardin himself cited air pollution as a primary example when first describing his famous "tragedy of the commons." *See* Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1245 (1968) (characterizing air as a commons because it "cannot readily be fenced" and is thus susceptible to tragedies of excessive pollution).

18. Hardin seemed to have overlooked the important distinction between air and airspace in his most famous article. *See id.* (referencing the placing of "distracting and unpleasant advertising signs into the line of sight" as an example of a "tragedy of the commons"). Much airspace that can be "fenced in" is usually owned as private property and is thus far less vulnerable to the "commons as a cesspool" problems that Hardin describes for water and air.

19. In fact, sound cannot travel through a vacuum of airspace. For a concise summary of how sound waves travel through liquids, solids, and gases such as air, see generally Hector Judez, *Sound*, ORACLE EDUC. FOUND., http://library.thinkquest.org/10796/ch9/ch9.htm (last visited Oct. 6, 2011) (noting that sound "cannot travel through a vacuum" and that sound waves travel faster through liquids and solids than through gases).

devices such as cellular phones, radios, and wireless computer receivers.[20] The radio spectrum itself is a highly regulated commons in the United States, subject to detailed policies from the Federal Communications Commission for allocating transmission rights at various frequencies among private and public parties.[21] Nonetheless, all of these waves are distinct from the airspace through which they commonly pass.

On a similar theory, airspace is also fully distinguishable from the wind currents and solar rays that fuel renewable energy generation. On calm evenings, airspace can be largely devoid of wind and sunlight, whereas, on blustery days, airspace serves as the medium through which these resources travel. Because wind and solar radiation are practically inexhaustible,[22] they arguably warrant no private property protection.[23] In contrast, airspace—a finite, immovable resource—has justifiably enjoyed property protection for centuries.[24]

Several of the land use conflicts arising from wind and solar energy development in recent years have essentially been clashes over competing uses of scarce airspace. Unfortunately, some well-intended laws responding to these conflicts have blurred the vital distinction between airspace and the renewable

20. Microwaves, x-rays, and gamma rays are other important forms of electromagnetic radiation. For a straightforward description of the electromagnetic spectrum, see generally *Electromagnetic Spectrum*, NASA GODDARD SPACE FLIGHT CTR., http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html (last updated Feb. 3, 2010) (comparing and contrasting radio waves, light, microwaves, x-rays, gamma rays, and other types of electromagnetic radiation).

21. Although a discussion of laws allocating transmission rights across the radio frequency spectrum falls outside the scope of this Article, there are excellent sources available on this fascinating subject. *See, e.g.*, Roscoe M. Moore, III, *Business-Driven Negotiations for Satellite System Coordination: Reforming the International Telecommunication Union to Increase Commercially Oriented Negotiations Over Scarce Frequency Spectrum*, 65 J. AIR L. & COM. 51, 55–60 (1999).

22. *See* Hannah Wiseman, *Expanding Regional Renewable Governance*, 35 HARV. ENVTL. L. REV. 477 (2011) (stating that sunlight and wind "are nondepletable and do not pose traditional commons problems" and "do not generally decline in quantity when harvested, unlike schools of fish or grass in a pasture"). It should be noted that a turbine that "harvests" the kinetic energy in wind does leave more turbulent, less energy-productive wind in its wake and can thus disrupt downwind turbines. For additional discussion of turbine wake interference, see *infra* text accompanying notes 134–148.

23. A methodology set forth by Carol Rose for determining the appropriate degree of property protection for various commons resources comes to mind in this regard. *See* Carol M. Rose, *Rethinking Environmental Controls: Management Strategies for Common Resources*, 1991 DUKE L.J. 1, 17 (arguing that a "do nothing" strategy of essentially providing no property protection or regulation for a resource "might be most appropriate" for resources for which "overuse or depletion costs" are low).

24. For a brief summary of the history of airspace law, see generally *infra* text accompanying notes 29–71.

energy resources passing through it.[25] Other laws have disregarded landowners' existing airspace rights in order to favor particular airspace uses that support renewable energy generation.[26] Both of these types of laws can unintentionally cause the underuse of precious airspace. Analyzing these renewable energy-related airspace conflicts is a critical first step toward structuring rules to effectively govern these disputes.

To what extent does the growing importance of wind and sunlight justify altering the laws governing the airspace through which those resources travel? There is strong political support for renewable energy development in the United States as a means of improving the nation's energy sustainability.[27] One could argue that this socially valuable development's heavy reliance on airspace warrants a serious revisiting of existing law in order to favor newfound airspace uses. On the other hand, the law of airspace has been shaped over hundreds of years to optimize the resource's productivity. Policymakers traditionally fine-tune rather than overhaul airspace rights laws in response to societal or technological changes. The following summary of the evolution of airspace laws and how such laws have promoted the efficient use of airspace helps put into context the substantial legal changes involving airspace today.

### A. The *Ad Coelum* Rule and the Origin of Airspace Rights

Airspace laws originally evolved much as Harold Demsetz might have predicted: through the emergence of property rights in what was a previously shared commons in response to technological innovation.[28]

25. Certain solar access laws discussed in Part IV.C, *infra*, fall within this category. *See infra* text accompanying notes 165–173.

26. For a discussion of a handful of preemptive state laws aimed at promoting small wind turbine installations that suffer from this problem, see *infra* text accompanying notes 199–203.

27. Such support is evidenced by the existence of substantial federal subsidies for renewable energy development and state incentive programs aimed at promoting renewable energy installations. *See, e.g.*, 26 U.S.C. § 48 (2006) (providing for 30 percent federal income tax credits for installations of solar panels, small wind turbines, and certain other renewable energy devices); DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY, http://www.dsireusa.org [hereinafter DSIRE] (last visited Oct. 6, 2011) (providing a database of state-by-state information on state-level incentives for renewable energy).

28. Harold Demsetz famously argued that clearer property protection for a resource was often the product of "new technology and the opening of new markets, changes to which old property rights are poorly attuned." Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 350 (1967); *see also id.* (stating that "the emergence of new private or state-owned property rights will be in response to changes in technology and relative prices"); Amnon Lehavi, *Mixing Property*, 38 SETON HALL L. REV. 137, 143 (2008) ("Harold Demsetz's *Toward a Theory of Property Rights* offers an evolutionary analysis (accompanied by vigorous normative support) of human society's shift to private property as the pressure on resources increases and

For much of recorded history, because most of the Earth's airspace was beyond the physical reach of humankind, few conflicts arose regarding its use. Out of practical necessity, the majority of the planet's airspace was merely a commons through which landowners enjoyed sunlight and views. It is true that laws in ancient Rome recognized that surface owners held rights in the airspace above their land.[29] The English common law doctrine of ancient lights also indirectly limited some building heights to protect neighbors' access to sunlight.[30] However, in early, agriculturally based societies, most landowners were primarily concerned with having rights to enough airspace to enable the growth of their crops.[31]

As construction techniques gradually improved over the centuries, airspace became an increasingly valuable resource, and rules clarifying property interests in airspace naturally followed. Legal historians have traced the beginnings of modern airspace law as far back as to the 1300s, when Cino da Pistoia pronounced the maxim: *Cujus est solum, ejus est usque ad coelum*,"[32] or, "[To] whomsoever the soil belongs, he owns also to the sky."[33] This doctrine, commonly known as the *ad coelum* rule, established simple private property rights in airspace based upon subadjacent parcel boundaries. The rule was subsequently cited in Edward Coke's influential commentaries in the seventeenth century[34] and in William Blackstone's commentaries in the eighteenth century,[35] cementing it

technological or organizational innovations enable cost-effective delineation and protection of private property.").

29. *See* Cooper, *supra* note 16, at 26 ("As early as Roman times the law recognized exclusive rights, both public and private, in [air]space in connection with the use and enjoyment of the land below.").

30. *See* Henry E. Smith, *Mind the Gap: The Indirect Relation Between Ends and Means in American Property Law*, 94 CORNELL L. REV. 959, 981 (2009) (noting that the "English common law doctrine of 'ancient lights' gave landowners whose windows had unobstructed access to sunlight for a certain period (generally twenty years) a permanent easement," but also noting that "this doctrine was firmly rejected in the United States").

31. *See* Eugene J. Morris, *Air Rights Are "Fertile Soil*," 1 URB. LAW. 247, 250 (1969) ("In an agricultural society where the surface level of the land, give or take a few feet, was the source of the value of the land, the early focus of land law was logically, on the surface of the soil.").

32. The attribution of this phrase to Cino da Pistoia is found in Stuart S. Ball, *The Vertical Extent of Ownership in Land*, 76 U. PA. L. REV. 631 (1928).

33. BLACK'S LAW DICTIONARY 453 (4th ed. 1968). The full maxim reads, "*cujus est solum, ejus est usque ad coelum et ad inferos*." *Id.* It is worth noting that the *ad coelum* maxim itself likely was not extant in ancient Rome. *See* Cooper, *supra* note 16, at 50 ("It is now generally conceded that the language of the maxim . . . was not part of Roman written law. . . . When the maxim is carefully analyzed, however, and reasonably construed, it is apparent that it must have sprung originally from principles of Roman law — though stated in a non-Roman manner.").

34. *See, e.g.*, 2 WILLIAM BLACKSTONE, COMMENTARIES ON THE LAW OF ENGLAND 8 (19th ed. 1836), *cited in* Morris, *supra* note 31, at 249.

35. *Id.*

as a fixture in English and American common law.[36] By the early twentieth century, U.S. courts were applying the doctrine to find trespass for even minor intrusions into airspace above privately owned land.[37]

Henry E. Smith has classified the *ad coelum* rule as a simple "exclusion" airspace regime because it allocates broad airspace rights to surface owners based solely on property boundary lines and without regard for how the space is used.[38] Exclusion regimes are beneficial in that they clearly segregate and define parties' respective rights and duties surrounding a given resource and can facilitate the enforcement of those rights.[39] Exclusion regimes also delegate to individual owners—who are often in the best position to determine the most productive use for the resource—the task of determining how airspace is utilized.[40] The Coase Theorem suggests that, by assigning resource entitlements among individual parties, exclusion regimes can enable those parties to bargain with each other in ways that ultimately allocate the resource to its highest valued use.[41] By establishing clear, enforceable private property rights in airspace, the *ad coelum* rule encourages Coasean bargains among neighbors and promotes allocative efficiency in airspace.

36. *See* ROBERT R. WRIGHT, THE LAW OF AIRSPACE 34 (1968) ("[T]he usque ad coelum maxim, as we have seen, was in large measure a child of Coke, as far as its incorporation into English law was concerned."); *id.* at 35 ("*Blackstone's Commentaries* . . . reiterated Coke's viewpoint on ownership of airspace. These *Commentaries* burst upon the scene practically on the eve of American independence, and were accepted as 'quasi authority' in America.").

37. *See, e.g.,* Cooper, *supra* note 16, at 60 (citing Hannabalson v. Sessions, 90 N.W. 93, 95 (1902) (holding that reaching an arm across a property was a trespass because "it is one of the oldest rules of property known to the law that the title of the owner of the soil extends . . . upward usque ad coelum")).

38. *See* Henry E. Smith, *Exclusion Versus Governance: Two Strategies for Delineating Property Rights*, 31 J. LEGAL STUD. 453, 455 (2002) ("To set up [rights of exclusion], rough proxies like boundaries and the *ad coelum* rule are used.").

39. *See* Henry E. Smith, *Exclusion and Property Rules in the Law of Nuisance*, 90 VA. L. REV. 965, 984 (2004) (noting that exclusion regimes "send a simple message to dutyholders—to keep off—and this has value"). It is worth noting parenthetically that the costs of enforcing rights to exclude in airspace are often higher than for surface land. Erecting a fence to peaceably deter trespass onto a parcel's surface is far less expensive than preventing airborne vehicles or polluted air from invading the space above the same piece of land.

40. Henry Smith has emphasized this information–cost advantage in support of the appropriate use of exclusion regimes. *See id.* (noting that "[d]elegating the information-gathering function through the exclusion strategy lowers information costs" and "frees . . . courts . . . from having to develop first-order information" about the relative values of potential uses of the resource at issue); *see also id.* at 985 (asserting that resource "[o]wners are closest to their assets" and "are likely often to be the least cost generators of information about assets").

41. *See* R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 2–8 (arguing that, if transaction costs of bargaining between parties are sufficiently low and a legal entitlement has been assigned to one of them, the parties will negotiate the transfer of the entitlement to its highest valued user).

## B. Supplementing *Ad Coelum*: The Evolution of Modern Airspace Laws

Despite the strength of the doctrine, strict private property regimes like the *ad coelum* rule have limitations. Resources sometimes reach a breaking point at which they become so valuable to society that protecting strict property rights in them is no longer cost-justified, particularly when high transaction costs threaten to prevent the bargaining necessary for their efficient allocation. In such situations, new regulations or some other forms of "governance" rules may be needed to promote those uses of the resource such that it will maximize the aggregate social welfare.[42] In Henry E. Smith's words:

> As multiple use [of a given resource] becomes more important, a governance regime of some sort should tend to emerge, either by contract, regulation, or modification of common-law rules . . . [R]ising resource values should lead to increasing precision of rights. For a given resource, this means a tendency to move to supplement exclusion with governance rules.[43]

Smith's predictions have generally proven true for airspace. As technological advancements have expanded the scope of competing uses for airspace over time, new governance strategies have emerged. The following Subparts describe how new governance rules have gradually supplemented the *ad coelum* doctrine over the past century in response to modern innovation.

### 1. Navigable Airspace as a Regulated Commons

Prior to invention of the airplane, courts rarely encountered disputes between air travelers and landowners over competing uses of airspace.[44] However, that changed abruptly in the early twentieth century when propeller-driven vehicles began soaring through the sky.[45] Airspace laws adapted to modern aviation by introducing new governance rules that clarified and built upon the *ad coelum* rule's rigid exclusion regime.

42. *See* John Edward Cribbet, *Concepts in Transition: The Search for a New Definition of Property*, 1986 U. ILL. L. REV. 1, 3 (noting that "as [a] resource becomes scarce, society's stake greatly increases, and the laws [governing it] tend to become complex").
43. Smith, *supra* note 39, at 1005–06. Smith added that a "wide range of rules, from contractual provisions, to norms of proper use, to nuisance law and public environmental regulation can be seen as reflecting the governance strategy." Smith, *supra* note 38, at 455.
44. At least one court speculated about the issue in dicta. *See infra* note 52.
45. For a fascinating summary of the debate among early twentieth century judges and scholars over how to reconcile common law rules governing airspace with the advent of modern aviation, see generally STUART BANNER, WHO OWNS THE SKY? 85–100 (2008).

A clash between airplanes and farmers gave rise to what is perhaps the best known case clarifying the scope of landowners' airspace rights.[46] The plaintiffs in *United States v. Causby*[47] owned a chicken barn situated about 2200 feet from the end of a municipal airport runway.[48] Commercial airplane flyovers had previously caused minimal problems for the Causbys' chicken farming operation, but that quickly changed when the U.S. military began leasing the airport in 1942.[49] The heavy bombers and fighter planes that began roaring overhead repeatedly startled the plaintiffs' chickens into a panicked frenzy. Several chickens per day died from frantic collisions with the barn walls.[50] Frustrated by the airplane flyovers and their effects on the farm, Mr. and Mrs. Causby sued to recover damages for what they claimed was the military's compensable Fifth Amendment taking of rights in the airspace above their land.

The U.S. Supreme Court ultimately decided the *Causby* case, upholding the lower court's ruling that Mr. and Mrs. Causby were entitled to compensation for the military's repeated flights over their land.[51] The Court refrained from literally applying the *ad coelum* rule to reach its holding, noting that landowners' airspace rights did not extend indefinitely into the sky above their land.[52] Instead, the Court cited federal legislation to declare that "navigable"[53] airspace was a "public highway" for air travel and was not under the exclusive control of surface landowners.[54] Accordingly, military over-flights could only trigger

46. The other case that would seem a likely nominee for this distinction is *Penn Central Transportation Co. v. New York City*, 438 U.S. 104 (1977), which held that no compensable regulatory taking resulted from a historic landmark ordinance's severe limitation on a landowner's rights to occupy valuable airspace above its property.
47. 328 U.S. 256 (1946).
48. *See id.* at 258.
49. *See id.* at 258–59.
50. *See id.* at 259 (noting that "[a]s many as six to ten of [the Causbys'] chickens were killed in one day by flying into the walls from fright" and that the "total chickens lost in that manner was about 150").
51. *See id.* at 266–67.
52. *See*, *e.g.,* Pickering v. Rudd, 4 Camp. 219, 171 Eng. Rep. 70 (1815), *cited in* Note, *The Air Space as Corporeal Realty*, 29 HARV. L. REV. 525 (1916). *Pickering* is an English case in the early nineteenth century wherein "Lord Ellenborough, explaining his decision by supposing a case of an aeronaut traversing the air in a balloon high over divers closes, held that trespass did not lie for a board projecting over the plaintiff's garden." Note, *supra*, at 525. Other commentators have noted the inappropriateness of literal readings of the *ad coelum* doctrine. *See, e.g.*, Cooper, *supra* note 16, at 50 ("Literally translated[,] the maxim leads to the obvious absurdity of claiming for the landowner private exclusive 'dominium' (ownership) of space above his lands up to infinity.").
53. Generally, "navigable airspace" is any airspace exceeding five hundred feet above ground level. Within six miles of airports, the scope of navigable airspace can be greater. *See* 14 C.F.R. § 77.17 (2009).
54. *Causby*, 328 U.S. at 264.

compensable takings of airspace easements in situations like the Causbys' in which the flights were "so close to the land as to render it uninhabitable."[55]

Although *Causby* placed some limits on the scope of landowners' airspace rights under the *ad coelum* doctrine, it also made clear that landowners held enforceable property interests in the usable airspace above their parcels. To quote from the opinion:

> The landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land . . . The fact that he does not occupy it in a physical sense—by the erection of buildings and the like—is not material . . . We think that the landowner, as an incident to his ownership, has a claim to it and that invasions of it are in the same category as invasions of the surface."[56]

*Causby* and related legislation clarified the scope of landowners' airspace rights to address conflicts that were arising from the introduction of modern flight. The governance rules established under *Causby* and corresponding statutory law converted navigable airspace into a regulated commons—a communally shared layer of high-altitude space that is openly accessible for air travel and reserved for that purpose.[57] Robert Ellickson has defended this vertical stratification of airspace rights on efficiency grounds, noting that it facilitates more productive overall use of airspace in the aviation age.[58]

55. *Id.*
56. *Id.* at 264–65.
57. *See, e.g.*, 49 U.S.C. § 40103(a)(2) (2006) (providing that a "citizen of the United States has a public right of transit through the navigable airspace"). Because airspace can be utilized for centuries without ever depleting or wearing out, these new governance rules created minimal risk of Garrett Hardin's famous "tragedy of the commons" afflicting navigable airspace. In contrast to the grazing lands Hardin described, airspace perpetually retains its nature regardless of how intensely it is used over time and thus suffers no risk of tragic degradation when communally shared. To review Hardin's famous article on commons tragedies, see generally Hardin, *supra* note 17, at 1243–48; *see also* H. Scott Gordon, *The Economic Theory of a Common-Property Resource: The Fishery*, 62 J. POL. ECON. 124 (1954).
58. *See* Robert C. Ellickson, *Property in Land*, 102 YALE L.J. 1315, 1363–64 (1993) ("Aviation . . . activities are generally most efficiently undertaken over an area whose horizontal scope is much larger than that optimal for agriculture, housing, and other basic land-surface operations. Groups have responded by imposing vertical limits on the standard rights and privileges conferred on surface landowners. For example, landowners everywhere are now subject to avigation easements . . . . Dividing space into layers facilitates exploitation of the varying returns to horizontal scale that are available in different layers.").

### 2. Subdividing Airspace: Modern Condominium Laws

In the late nineteenth century, improvements in construction technologies[59] and the modern elevator[60] prompted a different set of airspace governance rules to further supplement the *ad coelum* rule's exclusion regime. For the first time in history, these and other innovations enabled high-rise development to flourish, particularly near urban cores where space was already at a premium. Accordingly, builders' newfound abilities to build upward catalyzed unprecedented development of city airspace.[61]

The enhanced value of urban airspace resulting from new high-rise construction techniques in the early twentieth century prompted calls for greater precision of airspace rights among property owners. It became increasingly common during this era for structures containing dozens of separately owned suites or apartments to sit atop single surface parcels. During the period, some courts held that one must own underlying surface land in order to own the overlying airspace.[62] It would be difficult for each of a building's several unit owners to understand her rights in the supporting soil or in the cubes of airspace occupied by their respective units without new laws.

Eventually, developments in condominium law helped clarify airspace ownership rights. Although condominiums trace back to ancient times,[63] laws governing condominiums underwent dramatic expansion in the 1960s, with most ultimately providing that a single condominium unit owner could hold

59. *See* Michael R. Montgomery, *Keeping the Tenants Down: Height Restrictions and Manhattan's Tenement House System, 1885–1930*, 22 CATO J. 495, 499 (2003) (describing a "revolution in building techniques" in the 1870s "due to steel-frame construction methods, new fire-resistant technologies, and related innovations, paving the way for the construction of far taller buildings"); John R. Nolon, *The Law of Sustainable Development: Keeping Pace*, 30 PACE L. REV. 101, 109 (2010) ("By the end of the 19th century, steel-frame construction made it possible to build sky scrapers—a brand new urban form. . . . Steel-frame construction also facilitated the building of tall loft buildings . . . .").

60. *See* Montgomery, *supra* note 59, at 499 (explaining that "Otis' invention of the safety elevator" in the mid-nineteenth century eliminated the "need to climb several flights of stairs to reach one's workplace or residence," which had previously been a significant constraint on building heights).

61. New York City is a prime example of an urban center whose skyline was transformed by the development of high-rise building methods. *See id.* (noting that "[g]round rents in Manhattan were high" during the mid- to late-nineteenth century and that "[t]all-building technologies eased this problem, and during the latter part of the 1870s and early 1880s numerous structures greater than 10 stories began to appear in various sections of the city").

62. *See, e.g.*, Butler v. Frontier Tel. Co., 186 N.Y. 486, 491 (1906) (stating that the "law regards the empty space" above land as "inseparable from the soil"), *cited in* Terence Kennedy, *New York City Zoning Resolution Section 12-10: A Third Phase in the Evolution of Airspace Law*, 11 FORDHAM URB. L.J. 1039, 1044 (1983).

63. *See* Morris, *supra* note 31, at 249 (stating that the condominium "has been traced back as far as the Babylonian law of 2,000 B.C.").

title to the three-dimensional airspace occupied by her condominium unit.[64] Federal legislation enacted during the same period enabled the Federal Housing Administration to issue real estate mortgage insurance secured on condominium units.[65] The practical effect of these laws was to allow the subdivision and transfer of exclusive rights in airspace—rights totally separate from ownership of the surface land below. Like the laws for navigable airspace, these condominium laws were governance rules structured to clarify and supplement the *ad coelum* rule's exclusion regime in ways that accommodated an important new airspace use.

### 3. Open Airspace: Bulk and Height Restrictions

Although the proliferation of high-rise apartment and office tower construction in the early twentieth century increased the value of urban airspace, it provoked fear and anger in some communities. Neighborhood opposition to tall buildings arose almost as quickly as the skyscrapers themselves. City dwellers began complaining that the massive structures blocked natural sunlight[66] or that they were fire hazards because existing hoses and ladders could not reach their upper floors.[67] Some opponents even feared that lofty buildings could become havens for infectious diseases.[68]

In response to mounting political pressure in this new age of high-rise buildings, municipalities began adopting height restrictions, building setbacks, lot coverage ratio requirements, and other ordinances to limit building bulk

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64. Other scholars have noted how condominium laws responded to the increased value of airspace by recognizing it as a real property unit in the condominium context. *See, e.g.*, Bronin, *supra* note 4, at 1250 (noting that the "proliferation of dense, high-rise condominium buildings gave rise to horizontal airspace as a unit of real property—a concept in property law, which had not existed before the advent of skyscrapers" (citing Daniel P. Moskowitz, *Legal Access to Light: The Solar Energy Imperative*, 9 NAT. RESOURCES LAW. 177, 184 (1976))).

65. *See* Frank Schnidman & Cameron Roberts, *Municipal Air Rights: New York City's Proposal to Sell Air Rights Over Public Buildings and Public Spaces*, 15 URB. LAW. 347, 350 (1983) (citing the Federal Housing Administration regulations as "defin[ing] a mortgage on air space").

66. *See* Montgomery, *supra* note 59, at 502 ("Longstanding legal traditions in the common law suggested—but did not clearly indicate—that homeowners enjoyed rights to that sunlight which 'naturally' would reach a building lot they owned. Tall buildings [erected in the 1870s and 1880s] threatened this perceived right by casting huge shadows.").

67. *See id.* at 503 (noting that "[f]ireproofing technologies" in the late nineteenth century "were imperfect, and the upper stories of tall buildings could not be reached by firefighters' ladders and hoses").

68. *See id.* ("More populated buildings, it was argued, had a higher risk of spreading contagious diseases among people living or working in them.").

and height.[69] Despite their restrictiveness, such regulations have become commonplace in communities throughout the country.[70] Although bulk and height restrictions force landowners to forfeit their rights to occupy the airspace above their land, such restrictions are typically reciprocal in that they require nearly all neighboring landowners to give up those same rights and nearly all landowners get the same general benefit from the restrictions.[71] Whether adopted by municipal governments or recorded in private subdivision covenants, bulk and height restrictions that are reciprocal in nature generally respect existing airspace rights. In that sense, they are yet another example of governance rules designed to build upon rather than undermine the basic exclusion regime for airspace.

## II. SUSTAINABILITY AND THE SKY: THE GREEN MOVEMENT'S INCREASED PRESSURE ON AIRSPACE

As just described, policymakers over the past century have gradually responded to social and technological changes affecting airspace with governance rules designed to supplement the *ad coelum* rule's exclusion regime. However, new airspace uses emerging from the sustainability movement in recent years have further complicated the task of governing airspace rights. Difficult new policy questions are arising in part because, as the following Subparts describe, some sustainable land use strategies require the occupation of additional airspace, whereas others necessitate that more airspace be kept open.

### A. Growing Calls for Open Airspace

Several types of renewable energy and green development strategies require open airspace. Unoccupied airspace allows sunlight and wind to

69. *See id.* at 503–04 (explaining that "in June 1885, the New York State legislature passed a bill restricting the height of all residential buildings henceforth to be built in Manhattan to a maximum of 70 feet on the narrower streets and avenues, and 80 feet on the wider streets and normal avenues"); *see also* Welch v. Swasey, 214 U.S. 91, 106 (1909) (upholding the constitutionality of Boston city ordinances enacted in 1904 and 1905 that imposed maximum building height restrictions on designated districts within the city, and declaring that "regulations in regard to the height of buildings . . . made by legislative enactments for the safety, comfort, or convenience of the people, and for the benefit of property owners generally, are valid" if they "can be plainly seen to be not unreasonable or inappropriate").

70. A detailed analysis of when bulk and height restrictions may be warranted for particular airspace is set forth in Part III.B.3, *infra*. *See infra* text accompanying notes 127–133.

71. Other scholars have characterized zoning restrictions in this fashion. *See, e.g.*, WILLIAM A. FISCHEL, THE HOMEVOTER HYPOTHESIS 54 (2001) ("Robert Nelson [ ] and I have said for a long time and in many places that zoning is best thought of as a collective property right . . . . ").

reach plants, buildings, and renewable energy devices without interruption—a valuable function in our increasingly green economy.

One sustainability-oriented use for open airspace is to prevent the shading of solar energy devices. Commonly known as "solar access" protection, the need for contractual or legal protections against the shading of solar energy devices has been the subject of numerous statutes, ordinances, and law review articles over the years.[72] Photovoltaic solar panels[73] and passive solar energy systems[74] generate and save significant amounts of power, thereby reducing an economy's dependence on fossil fuels and other conventional energy sources. However, these and most other solar energy devices are far more productive when exposed to direct sunlight. Shade from trees or other structures in the airspace above nearby land can diminish a solar panel's productivity. The risk that trees or buildings could ultimately pop up in neighboring airspace and shade solar energy systems deters some landowners from investing in rooftop solar installations.[75]

The demand for laws to protect solar access has rapidly grown over the past few years due to an unprecedented interest in rooftop solar energy development.[76] Accordingly, government-provided incentive programs are supporting

72. Two recent law review articles provide detailed discussions of solar access laws. *See generally* Bronin, *supra* note 4, at 1226–36; Troy A. Rule, *Shadows on the Cathedral: Solar Access Laws in a Different Light*, 2010 U. ILL. L. REV. 851, 857–58, 873–80.

73. Photovoltaic solar panels are typically modules of small crystalline cells holding substances that are formulated to catalyze electricity-generating chemical reactions when struck by sunlight. *See* Bernadette Del Chiaro & Rachel Gibson, *Government's Role in Creating a Vibrant Solar Power Market in California*, 36 GOLDEN GATE U. L. REV. 347, 353 (2006).

74. "Passive" solar energy devices such as solar heat-oriented building designs and solar water heaters utilize solar radiation to directly heat water or buildings. For basic descriptions of these energy strategies, see generally *Learning About Renewable Energy: Passive Solar,* NAT'L RENEWABLE ENERGY LAB., http://www.nrel.gov/learning/re_passive_solar.html (last updated Sept. 29, 2009).

75. Initial investments in rooftop solar panels can be quite significant and take several years to be recouped from energy savings. *See* Jason Coughlin & Karlynn Cory, *Solar Photovoltaic Financing: Residential Sector Deployment*, NAT'L RENEWABLE ENERGY LAB., at v (Mar. 2009), http://www.nrel.gov/docs/fy09osti/44853.pdf (determining that the initial capital requirement for installing a residential photovoltaic system was between $12,000 and $23,000, even after taking into account all government-offered incentives).

76. The economic recession of 2008 adversely impacted solar panel installation rates. However, industry growth remains quite strong in the context of residential rooftop solar energy. *See* SOLAR ENERGY INDUS. ASS'N, US SOLAR INDUSTRY: YEAR IN REVIEW 2009, at 2 (2010), *available at* http://www.seia.org/galleries/default-file/2009%20Solar%20Industry%20Year%20in%20Review.pdf (stating that total United States photovoltaic generating capacity increased by 37 percent over 2008 but that residential installations more than doubled). For obvious reasons, solar access tends to be more relevant in the residential context than in commercial solar energy development.

solar energy more aggressively today than ever before.[77] As the cost-effectiveness of rooftop solar energy grows, so does the need for laws enabling landowners to protect their solar energy systems from shading by neighbors.

Urban gardens can also require a degree of direct solar access that only open city airspace provides. An increasing number of cities throughout the country are encouraging the cultivation of gardens on inner city lots as a means of combating blight and improving urbanites' access to fresh local produce.[78] Of course, the successful growth of many food plants requires adequate sunlight. This need for unobstructed sunlight can also potentially constrain the development of airspace above neighboring parcels.[79]

Even in the context of green building, access to sunlight via open airspace has taken on added value in recent years. The U.S. Green Building Council's 2009 Rating System rewards points toward LEED (Leadership in Energy and Environmental Design) Certification for building designs that satisfy specific natural daylight illumination requirements.[80] Natural lighting through skylights and windows conserves energy by mitigating the need for electrical light.[81] Unfortunately, shade from neighboring buildings or trees can reduce

77. For a summary of recent federal and state policies promoting solar energy development, see *id.* at 2–5.

78. *See* LaCroix, *supra* note 9, at 235–36 (citing CLEVELAND, OHIO, ORDINANCES tit. VII, ch. 336.01 (2009)) (describing urban agriculture plans in Youngstown and Cleveland in Ohio and in Detroit, Michigan, and citing portions of the Cleveland Zoning Code indicating that the city's purpose for creating its Urban Garden District was to "meet needs for local food production, community health, community education, garden-related job training, environmental enhancement, preservation of green space, and community enjoyment on sites for which urban gardens represent the highest and best use for the community").

79. Land use restrictions within Cleveland's Urban Garden District at least suggest that urban garden development can have a constraining effect on airspace. *See id.* at 237 (noting that only "small structures associated with the permitted uses" are allowed within the urban garden district and that fences within the district may not exceed six feet in height).

80. *See supra* note 8.

81. The energy-saving benefits of natural lighting designs for buildings are so great that some public utilities reward such designs alongside distributed renewable energy generation. *See, e.g.*, ARIZ. ADMIN. CODE § R14-2-1802.B.6 (providing that "[s]olar [d]aylighting," defined as the "non-residential application of a device specifically designed to capture and redirect the visible portion of the solar beam, while controlling the infrared portion, for use in illuminating interior building spaces in lieu of artificial lighting," constitutes a "[d]istributed [r]enewable [e]nergy [r]esource" together with renewable energy devices such as small wind turbines and passive solar energy systems). As a consequence, homeowners making solar daylighting improvements sometimes qualify for comparable incentives from utilities seeking to comply with state renewable portfolio standards. *See, e.g.*, *Incentives for Solar Daylighting*, APS RENEWABLE ENERGY INCENTIVE PROGRAM, http://www.aps.com/main/green/choice/choice_41.html (last visited Oct. 12, 2011) (describing eligibility of solar daylighting devices for up-front financial incentives under the Arizona Public Service Renewable Energy Incentive Program).

the degree of interior illumination achievable on a given parcel, necessitating greater reliance on electricity-dependent artificial light sources.

One other potential use for unoccupied urban airspace is to provide wind access for "small" wind turbines. Wind turbines convert the kinetic energy in wind into electric power. Small turbines are petite versions of commercial turbines and usually generate only enough power to offset a portion of a single landowner's energy consumption.[82] These devices may not require direct sunlight, but they still need a substantial amount of open airspace to function effectively. They are more productive the higher they reach into the sky[83] and can require hundreds of feet of open airspace in the upwind direction to ensure that wind flowing into them is largely undisturbed.[84] Wind access for small turbines has historically been a low priority in most jurisdictions, although this could change as these devices become increasingly cost-effective and the demand for them continues to grow.[85]

## B. Mounting Pressure to Occupy Airspace

Despite the myriad of uses for *open* airspace just described, physically occupying airspace with buildings, trees, or other structures also creates substantial value in many circumstances. The sustainability movement is also bolstering demand for this other category of airspace uses.

Filling more urban airspace with buildings has become an increasingly attractive policy option in the past few decades as the damaging effects of

82. *See* AM. WIND ENERGY ASS'N, THE U.S. SMALL WIND TURBINE INDUSTRY ROADMAP 8–9 (2002) (noting that the generating capacity of small wind turbines ranges from 400 watts "for specific small loads such as battery charging for sailboats and small cabins" to 100 kilowatts "for large loads such as a small commercial operation").

83. *See* David Mears, *Feasibility of Residential Wind Energy: The Lack of Regulatory Integration for Local Communities*, 37 REAL EST. L.J. 133, 137 (2008) ("Winds are faster at higher elevations, causing wind power to increase by a factor of three as the speed increases. This means that even a small boost in height greatly enhances a turbine's output."), *cited in* Troy A. Rule, *Renewable Energy and the Neighbors*, 2010 UTAH L. REV. 1223, 1239.

84. *See* AM. WIND ENERGY ASS'N, IN THE PUBLIC INTEREST: HOW AND WHY TO PERMIT FOR SMALL WIND SYSTEMS 6 (2008) (stating that the "bottom of the turbine rotor should clear the highest wind obstacle (rooftop, mature tree, etc.) within a 500 foot radius by at least 30 feet").

85. The total generating capacity of small wind turbine installations in the United States has grown since January 2007. *See* AM. WIND ENERGY ASS'N, SMALL WIND TURBINE GLOBAL MARKET STUDY 17 (2010), *available at* http://e360.yale.edu/images/digest/2010_AWEA_Small_Wind_Turbine_Global_Market_Study-1.pdf.

suburban sprawl have become evident.[86] Sprawling development on the suburban fringe tends to require more public infrastructure than dense urban infill projects and can also result in comparatively longer commutes and greater energy consumption.[87] As a result, some have advocated land use policies that loosen height restrictions and make more intense use of urban airspace.[88] Taller buildings provide more work and living space per acre, leaving more land available for green spaces and easing the pressure for suburban expansion. High-rise development can be particularly valuable when situated near public transit systems because of the comparatively low burden it places on traffic congestion and transportation infrastructure.[89] For these and other reasons, vertical building designs are commonly viewed as relatively eco-friendly approaches to real estate development.[90]

Cities are also seeking to enhance their environmental sustainability by filling more of their skylines with trees. In recent years, tree preservation and planting programs have begun sprouting up in major cities throughout the world.[91] In some regions, trees that shade buildings can reduce air

86. For a fascinating discussion of sprawl and of the history of efforts to identify and quantify its costs to society, see generally ROBERT W. BURCHELL ET AL., THE COSTS OF SPRAWL—REVISITED (1998).

87. *See, e.g.*, Alain Bertaud & Jan K. Brueckner, *Analyzing Building-Height Restrictions: Predicted Impacts and Welfare Costs*, 35 REGIONAL SCI. & URB. ECON. 109 (2005) (concluding that height restrictions imposed in Bangalore, India, imposed welfare costs on the city's citizenry in the range of 1.5 to 4.5 percent of household consumption); *see also* BURCHELL ET AL., *supra* note 86, at 3 (projecting that, if sprawl in South Carolina were to remain unchecked, "statewide infrastructure costs for the period 1995 to 2015 [would] be more than $56 billion, or $750 per citizen per year for the next twenty years").

88. *See, e.g.*, Stephen Sussna, *Another Look at Height Regulations and Air Rights*, 57 APPRAISAL J. 109, 117 (1989) (arguing that "[m]ore sensible use of height regulations and air rights" could "reduc[e] sprawl and encourage[e] reasonable infilling so that public improvement and service costs are reduced").

89. A recent example of a proposed high-rise building gaining favor for its proximity to a transit center is New York City's recent approval of plans for a 1216-foot-tall skyscraper at 15 Penn Plaza, just three blocks from the 1250-foot-tall Empire State Building, which was supported in part because of the project's closeness to Penn Station. *See* Charles V. Bagli, *Unwelcome Neighbor for Empire State Building*, N.Y. TIMES, Aug. 25, 2010, at A1 (noting that the 15 Penn Plaza project "had the backing of Mayor Michael M. Bloomberg, whose administration has long favored high-density development near major transit points like Penn Station" and that the developer "earned zoning bonuses that will let it construct a building 56 percent larger than what would ordinarily be allowed" because of the building's proximity to the transit hub).

90. For instance, the green benefits of vertical development have been part of the recent debate over whether to loosen height restrictions in the District of Columbia. *See* Sabrina Tavernise, *In the Capital, Rethinking Old Limits on Buildings*, N.Y. TIMES, Nov. 3, 2010, http://www.nytimes.com/2010/11/04/us/04buildings.html (noting that advocates for raising the height restriction have argued that doing so "would allow for greener construction").

91. *See* Braverman, *supra* note 6, at 85–86 (describing municipal tree planting or preservation programs in cities such as Boston, Chicago, London, New York, and Vancouver).

conditioning usage during hot summer months.[92] Trees can also help to improve stormwater drainage,[93] sequester carbon dioxide emissions from the air,[94] and improve the aesthetic ambiance of city streets.[95] In certain circumstances, trees can even reduce heating energy costs on cold days by serving as windbreaks for homes and other buildings.[96] Of course, trees must physically occupy scarce airspace to perform these valuable functions.

Unlike buildings and trees, small wind turbines are a relatively new type of structure competing to occupy urban airspace. Small wind turbines not only require open airspace for adequate wind flow, but also fill substantial airspace with their towers and rotor blades. Although wind energy devices have historically been installed primarily in rural areas, permit applications to install small wind turbines in suburban areas with heights upwards of 120 feet are increasingly common.[97]

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92. *See Energy Saving Landscapes*, SUSTAINABLE URB. LANDSCAPE INFO. SERIES, http://www.sustland.umn.edu/design/energysaving.html (last visited Oct. 12, 2011) (noting that "[a]pproximately half of unwanted heat in a house in the summer comes from the sun shining through the windows," and recommending the planting of trees to "[s]hade east and west windows in the summer, where most solar energy enters the house").

93. *See* Braverman, *supra* note 6, at 84 (citing Harold A. Perkins et al., *Inequitable Access to Urban Reforestation: The Impact of Urban Political Economy on Housing Tenure and Urban Forests,* 21 CITIES 291, 292 (2004)) (explaining that "trees' roots can capture storm runoff associated with urbanization processes").

94. *See Sequestration Rates in U.S. Forests, Urban Trees, and Agricultural Soils*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/sequestration/sequestration_rates.html (last updated June 22, 2010) (estimating that 58.7 million metric tons of carbon were sequestered from the atmosphere by urban trees in the United States in 2002, totaling approximately 8.5 percent of all carbon sequestered by plants and trees that year).

95. Braverman, *supra* note 6, at 86–87 (describing how world cities such as London, Melbourne, Tokyo, and Toronto seek to enhance their "self-image" by emphasizing their abundance of trees).

96. *See Energy Saving Landscapes*, *supra* note 92 (noting that trees strategically planted near buildings can "[c]reate windbreaks to block harsh winter winds, but allow cool summer breezes to flow through"); *see also Landscaping for Energy Savings,* SUSTAINABLE SOURCES, http://landscaping.sustainablesources.com (last visited July 31, 2011) (explaining that "[e]vergreen trees on the north and west sides [of a building] afford the best protection from the setting summer sun and cold winter winds").

97. *See* AM. WIND ENERGY ASS'N, *supra* note 82, at 22 ("For many residential applications, systems of 5 to 15 kW, turbines need to be on towers from 80 to 120 feet tall."). According to the American Wind Energy Association, small wind turbine installations in the United States increased by 15 percent in 2009. *See* AM. WIND ENERGY ASS'N, *supra* note 85, at 3.

## III. TOWARD A GREENER THEORY OF AIRSPACE RIGHTS: AIRSPACE GOVERNANCE RULES FOR AN ERA OF SUSTAINABILITY

The sustainability movement's pressures to occupy or conserve open airspace have prompted a wide range of new airspace governance rules in recent years.[98] Unfortunately, many of these novel policy strategies unjustifiably diverge from the *ad coelum* rule's valuable exclusion regime for airspace or otherwise fail to efficiently allocate airspace among its potential uses. What overarching principles should guide policymakers as they develop airspace governance rules to reflect the resource's growing role in renewable energy and sustainable land use? Parts III.A and III.B below describe two general guidelines for future policymaking involving airspace.

### A. Fine-Tuning Rather Than Replacing the *Ad Coelum* Rule

An overarching principle is that new airspace governance rules should build upon rather than deviate from the *ad coelum* rule's longstanding exclusion regime for airspace. As described in Part I above,[99] laws founded upon the *ad coelum* doctrine have helped to promote efficient airspace allocation for centuries. New laws should neither ignore landowners' existing airspace rights nor materially rearrange landowners' rights as a strategy for promoting sustainability. In situations where high transaction costs among neighbors are preventing the efficient use of airspace, governance policies involving options or liability rules are a promising means of overcoming those barriers.

Theoretically, the *ad coelum* rule itself promotes the efficient allocation of airspace rights because it plainly assigns airspace entitlements among landowners.[100] So long as transaction costs are sufficiently low, the Coase Theorem predicts that landowners holding those clear entitlements will buy and sell easements and covenants among each other to allocate each cubic inch of airspace to its highest valued use.[101]

98. Several examples of such rules are described and analyzed in Part IV, *infra*. *See infra* text accompanying notes 134–213.

99. *See supra* text accompanying notes 28–71.

100. *See supra* text accompanying notes 38–39 (describing how the *ad coelum* rule provides for clearly delineated airspace rights among landowners).

101. This is in part because *ad coelum* makes clear initial assignments of the airspace entitlements at issue, which the Coase Theorem suggests greatly enhances the likelihood for voluntary bargaining. *See* Coase, *supra* note 41, at 2–8.

However, transaction costs among neighbors are often too high to allow for successful Coasean bargaining over airspace, despite the straightforward delineations of airspace rights under the *ad coelum* rule. When airspace rights are not flowing to their highest valued use through voluntary bargaining, new governance rules may be necessary to intervene and correct the problem.

Some jurisdictions have sought to overcome high transaction costs among neighbors by enacting legislation that effectively reassigns airspace rights to landowners who employ airspace for some specific favored use. Such rules disregard landowners' long-held airspace rights and often result in suboptimal use of the airspace involved. Examples of such laws are discussed in greater detail in Part IV below.[102]

Protecting airspace rights with "liability rules" in certain defined situations is a more customized approach to the problem of high transaction costs and may encourage socially valuable airspace uses without undermining the centuries-old exclusion regime for airspace. Guido Calabresi and Douglas Melamed are credited with first recognizing the property rule–liability rule dichotomy, which has become a staple of law and economics.[103] Existing laws ordinarily protect airspace with property rules, meaning that one party can acquire airspace rights from another only by purchasing those rights in a voluntary transaction with their holder for a mutually negotiated price.[104] Liability rules, on the other hand, would give landowners options to unilaterally purchase others' nearby airspace rights for court-determined amounts approximating their value present rights holders.[105] When the option prices are determined accurately,[106] liability rule protection may promote allocative

102. *See infra* text accompanying notes 167–177 (describing prior appropriation–based solar access laws and related statutes).
103. *See generally* Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972).
104. *See id.* at 1092.
105. *See id.*
106. The risk of inaccurately determined option prices is a common criticism of liability rules. *See, e.g.*, Louis Kaplow & Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 HARV. L. REV. 713, 728–29 (1996) (describing the "frequently heard argument" against liability rules that a "court may not possess all the data necessary" to accurately estimate the harm, meaning the option price, under liability rules). A particular fear in connection with this reliance on third-party determinations is the risk that the option price will be set excessively low, leading to inefficient transfers of entitlements under the rule. *See* Richard A. Epstein, *A Clear View of* The Cathedral*: The Dominance of Property Rules*, 106 Yale L.J. 2091, 2093–96 (1997) (arguing against the use of liability rules based on an assertion that the "risk of undercompensation" under liability rules "is pervasive given the inability to determine with accuracy the losses, both economic and subjective, that follow when individuals find that someone else has plucked away from them" previously held entitlements). However, even Richard Epstein, a fairly strong critic of liability rules, has acknowledged that the rules

efficiency because rational landowners will only exercise the options if they value the airspace rights at issue more than current rights holders are deemed to value them. Further, liability rule approaches respect landowners' airspace rights under the *ad coelum* rule's existing exclusion regime because they provide for compensation to parties that relinquish those rights. Henry E. Smith has expressly noted the potential usefulness of liability rules as a way to "fine-tune basic exclusionary regimes in high-stakes contexts."[107] As illustrated in Part IV below, liability rules provide a way for landowners to purchase the airspace rights needed for government-favored renewable energy uses when landowners are unable to acquire those rights through voluntary bargaining with neighbors.[108]

## B. Viewing Restricted Airspace as a Conservation Commons

Another overarching principle for airspace governance relates to the increasing use of bulk and height restrictions to promote renewable energy. The governance strategy set forth in Part III.A of protecting certain airspace with liability rules can be useful for airspace disputes among two or three parties. However, that strategy is less suitable for addressing conflicts among large groups of landowners who intend to make several different uses of the space. Local governments have long used bulk and height restrictions to govern airspace rights in these large-number conflicts.[109] For decades, such restrictions have spared landowners from having to negotiate multiple easements or covenants in order to keep surrounding airspace open and safeguard their parcel's natural daylight, ambience, or views.[110]

may be warranted in situations of "necessity and bilateral monopoly, where holdout problems are likely to prove important." *Id.* at 2096, 2105–11. For a more detailed discussion of the pros and cons of using liability rules in the wind turbine wake interference context, see generally Rule, *supra* note 12, at 230–40.

107. *See* Smith, *supra* note 39, at 980.

108. *See infra* text accompanying notes 145–148.

109. For a basic background discussion on bulk and height restrictions, see *supra* text accompanying notes 69–71.

110. Open airspace can sometimes have substantial value as a preserver of untarnished views of lakes, oceans, waterways, mountain ranges, parks, or city skylines. *See, e.g.*, Michael T. Bond, Vicky L. Seiler & Michael J. Seiler, *Residential Real Estate Prices: A Room With a View*, 23 J. REAL EST. RES. 129, 135 (2002) (describing an empirical study of 1999 tax assessment values of 1172 lakefront and adjacent properties in Cuyahoga County, Ohio, that determined that, "after controlling for significant home characteristics, the premium added to homes with a view" of Lake Erie was $256,544.72).

As described in Part II above,[111] some land use strategies require the physical occupation of airspace while others demand that airspace be kept open. Competition between these two mutually exclusive categories of airspace uses is often evident in debates over bulk and height restrictions. The appropriate use of bulk and height restrictions theoretically builds upon the *ad coelum* rule's exclusion regime because nearly all landowners in a jurisdiction reciprocally share the burdens and benefits of such restrictions. However, such restrictions are an inflexible type of governance strategy because they effectively prohibit all trespassory uses within the restricted airspace.

What situations warrant the use of bulk and height restrictions to preserve open airspace and when should landowners instead be free to occupy the space with structures or trees? Analyzing this issue requires recognizing the distinction between rival and nonrival uses of airspace and considering how a proposed restriction might impact those two categories of uses.

### 1. Rival vs. Nonrival Airspace Uses

Airspace differs from surface land in that several common uses of it are nonrival—they neither preclude nor increase the cost of other nontrespassory uses of the same space.[112] Consider, as an illustration, a ten-square-foot cube of airspace situated fifty feet above the home of Ann, a hypothetical landowner. Suppose that Ann relied on the airspace to help deliver solar rays from the sun to her rooftop solar panel. Ann's use of the space for that purpose would neither prevent nor increase the cost of her neighbor's concurrent use of the same airspace to provide clear views of a nearby mountain range or downtown skyline. In fact, a second neighbor could simultaneously rely on the same airspace to help transmit sunlight to his strawberry patch and a third neighbor could rely on the space to deliver steady air currents to a small wind turbine situated

111. *See supra* text accompanying notes 72–97.

112. The distinction between rival and nonrival consumption is a common economics concept that is often discussed in connection with "public goods"—goods that are nonrival in consumption and nonexcludable. *See, e.g.*, HARVEY S. ROSEN, PUBLIC FINANCE 61 (5th ed. 1999) (stating that a "pure public good is nonrival in consumption," which "means that once the good is provided the additional resource cost of another person consuming the goods is zero"). Some scholars have gone further, exploring the possibility of "intermediate" or "partially" nonrival goods. *See, e.g.*, Brett M. Frischmann, *An Economic Theory of Infrastructure and Commons Management*, 89 MINN. L. REV. 917, 951 (2005) (defining "partially (non)rival goods" as "durable goods that have finite, renewable, and sharable capacity," and stating that "[w]hether these resources are consumed nonrivalrously or rivalrously" typically depends on factors such as resource management, the number of users, the types of potential uses, and the available capacity). Brett Frishmann argues that lakes and the internet may fall within this category. *See id.* at 952. Airspace seems to fit this classification as well.

downwind. All of these landowners, and numerous others,[113] could simultaneously make productive use of the same cube of airspace without raising the cost of several other nonrival airspace uses.

In contrast, some uses for airspace are highly rival,[114] preventing or increasing the cost of numerous other concurrent uses.[115] If Ann were to occupy the same cube of airspace with a tree or structure, the tree would not only shade her own solar panel but could also obstruct neighbors' views,[116] disrupt valuable wind currents, and shade nearby gardens from the sun.[117]

Bulk and height restrictions prohibit rival uses within a specified volume of airspace to ensure that it remains available for nonrival uses. Landowners often rely upon the continued existence of bulk and height restrictions when developing their parcels, expecting that the height-restricted airspace above their neighborhoods will remain clear to serve valuable nonrival uses for the relevant future.

113. For example, several landowners can simultaneously utilize the same airspace as a medium for transmitting radio waves or other forms of electromagnetic radiation at differing frequencies. The use of airspace for such transmission is often rival within a given frequency but can be nonrival vis-à-vis transmissions at other frequencies and even against some trespassory uses such as trees or buildings. *See* Moore, *supra* note 21, at 56 (stating that radio transmissions ordinarily "must be carried over different frequencies, because two or more radiowaves sent at the same frequency interfere with one another[,]" resulting in the "cancellation or degradation of the telecommunications content carried on that frequency"). The radio spectrum is thus governed as a highly regulated commons, with federal regulations allocating transmission rights among private and public parties. *See id.* at 60 (noting that the "radio frequency spectrum within a nation is normally controlled and administered by an agency of the government, such as the Federal Communications Commission (FCC) within the United States"). For purposes of this Article, which focuses mainly on land use controls, the phrase "rival uses" is not intended to encompass rivalry in use within the electromagnetic spectrum.

114. Rivalry in consumption is sometimes described as subtractability. *See, e.g.,* ELINOR OSTROM ET AL., RULES, GAMES, AND COMMON-POOL RESOURCES 6 (1994) (stating that goods and events "differ in terms of the degree of subtractability of one person's use from that available to be used by others[, and i]f one fisherman lands a ton of fish, those fish are not available for other fishermen"). Ostrom and her coauthors famously separated goods into four distinct types (public goods, common-pool resources, toll goods, and private goods) in a two-by-two diagram based upon a good's subtractability and excludability. *Id.* at 7. A given cube of airspace could theoretically fit into any one of those categories depending on its location and the uses involved.

115. The primary list of "rival" airspace uses has remained largely the same for several decades. *See* Ball, *supra* note 32, at 656 (describing, in a 1928 article, "trees," "projecting structures," "wires," "physical intrusion by man or his agents," the "[f]iring of projectiles," and the "passage of balloons, airplanes, and the like" as the chief airspace uses that "involve an invasion" into the space).

116. This highlights an important distinction relating to scenic views: Enjoying a territorial view through a cube of open airspace may qualify as a nonrival use of the space, but erecting a tall structure within airspace to *access* such a view is a categorically rival use.

117. As suggested above, use of airspace as a medium for transmitting electromagnetic waves is often rival vis-à-vis similar transmission uses within the same frequency but may be nonrival vis-à-vis transmission uses at other frequencies. *See supra* notes 20–21 and accompanying text.

### 2. Anticommons Tragedies vs. Conservation Commons

In one sense, bulk and height restrictions create a sort of airspace anticommons[118] above a community—a regime in which "everyone has the power to exclude everyone else from a resource, but nobody has the power to enter or use that resource without the permission of everyone else."[119] As Michael Heller famously observed, resources subject to these regimes are susceptible to anticommons tragedies—conditions of chronic underuse.[120] Anticommons resources tend to go underutilized because of the high transaction costs associated with attaining the numerous consents required to utilize them.[121] Similar anticommons tragedies are arguably possible in any airspace subject to bulk and height restrictions because multiple landowners and their local governments have rights to exclude trespassory uses of restricted space.

Abraham Bell and Gideon Parchomovsky might alternatively categorize much height-restricted airspace as a "conservation commons."[122] Bell and Parchomovsky defined a conservation commons as a "commons whose most efficient use is nonuse"[123] or, more precisely, one whose most efficient uses are nonrival and nontrespassory in nature.[124] This definition seems to describe aptly the open airspace created by most bulk and height restrictions. Such

118. *See generally* Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition From Marx to Markets*, 111 HARV. L. REV. 621 (1998).

119. Lee Anne Fennell, *Common Interest Tragedies*, 98 NW. U. L. REV. 907, 926 (2004).

120. *See* Heller, *supra* note 118, at 624.

121. *See* Fennell, *supra* note 119, at 928–30 (describing how holdout and free rider problems create costs that deter efficient use of resources within anticommons regimes). Hannah Wiseman has aptly characterized properties suitable for commercial-scale renewable energy projects as anticommons because landowners and multiple layers of public entities often possess the power to block their development. *See* Wiseman, *supra* note 22 (manuscript at 26) (describing the potential for individual landowners to prevent renewable energy projects by refusing to lease their land to developers, and noting that "a number of municipal, state, and federal agencies have opportunities to block the development through permitting processes, which are themselves rights of exclusion"). She has argued that anticommons tragedies, marked by underutilization of the resources at issue, are a likely result under such regimes. *See id.*

122. *See* Abraham Bell & Gideon Parchomovsky, *Of Property and Antiproperty*, 102 MICH. L. REV. 1, 39 (2003). Michael Heller also seems to recognize the potential for this sort of anticommons to be beneficial rather than tragic. *See* Heller, *supra* note 118, at 666.

123. Bell & Parchomovsky, *supra* note 122.

124. By "nonuse," Bell and Parchomovsky seem to mean "only nonrival uses." In their article, they emphasize several nonrival, noninvasive uses for a public park as examples of the benefits accruing to neighbors from a conservation commons. *See id.* at 4 (noting that property owners abutting a public park benefited from using the park as "a panoramic view, an acoustic barrier, and an air freshener"). They also referred to "conservation" as "non-building" in the context of a conservation commons. *See id.* at 58.

airspace is often heavily utilized, albeit in ways that do not require physical invasion of the space.

An implicit desire to create airspace conservation commons capable of protecting nonrival airspace use is the primary reason that many communities adopt bulk and height restrictions. Piecing together such protective arrangements through negotiated easements and covenants can be extremely difficult and costly, especially when large numbers of landowners are involved. Free riding, holdouts, and other collective action problems can prevent neighbors from successfully negotiating the private arrangements necessary to keep neighborhood airspace completely open.[125] Bulk and height restrictions are a popular means of overcoming the collective action problems that might otherwise prevent efficient conservation commons in airspace. Such restrictions conserve airspace for nonrival uses without requiring unanimous landowner support.

On the other hand, creating a conservation commons in airspace requires prohibiting any rival uses in the restricted space. Trees, buildings, and other rival uses surrendered under bulk and height restrictions are sometimes highly valuable.[126] In what situations does it make economic sense to prohibit rival airspace uses in order to protect nonrival uses of the space? The following Subpart describes a straightforward means of analyzing this question.

### 3. A Model for Analyzing Restrictions on Airspace

Using bulk and height restrictions to create conservation commons in airspace is cost-justified whenever the aggregate value of rival uses of a given space is less than the damage those uses would impose on nonrival uses. A simple abstract model helps to illustrate this principle.[127]

Suppose that planners of a newly subdivided but undeveloped neighborhood were contemplating whether to impose a 35-foot height restriction in the new

125. *See id.* at 25–29 (using the example of a city park to describe collective action problems that can impede the preservation of conservation commons in the absence of governance intervention).

126. Descriptions of several valuable rival airspace uses are set forth in Part II.B, *supra*. *See supra* text accompanying notes 86–97.

127. Although economists have empirically investigated the welfare impacts of height restrictions, their studies have not accounted for all of the costs or benefits involved. *See, e.g.*, Richard J. Arnott & James MacKinnon, *Measuring the Costs of Height Restrictions With a General Equilibrium Model*, 7 REGIONAL SCI. & URB. ECON. 359 (1977) (setting forth a general equilibrium model for residential height restrictions that focuses primarily on the impacts of residential height restrictions on property tax revenues, land rents, and individual utility based on such factors as the availability of recreational land); Bertaud & Brueckner, *supra* note 87 (analyzing the impact of height restrictions on social welfare in Bangalore based primarily on increased commuting costs). These other approaches are highly valuable, but none seems to focus on the impacts of height restrictions on airspace.

community. The restriction would prohibit landowners from erecting or growing any structures in excess of that height on any of the hundreds of parcels situated in the development. However, with the resulting conservation commons in place, lot owners could confidently invest in windows, skylights, solar panels, and gardens, and otherwise develop their land to make nonrival use of the pristine airspace above the neighborhood.

If planners opted not to impose the height restriction, lot owners would make rival uses of at least some of the airspace above the 35-foot mark. Those rival uses would disrupt some territorial views, solar access, and natural lighting, and would otherwise diminish the value of nonrival uses of the space.

Let:

$N_1$ = the aggregate social value of all potential nonrival uses of the airspace at issue when protected by the height restriction;

$R$ = the aggregate social value of all potential rival uses of the airspace; and

$N_0$ = the aggregate social value of all potential nonrival uses of the airspace when *not* protected by the height restriction.

Based on these assumptions,[128] it would be cost-efficient to adopt the proposed height restriction only if:

$(N_1 - N_0) > R$ [Equation (1)]

In instances where Equation (1) holds true, imposing the height restriction to create a conservation commons would maximize the productivity of the airspace at issue.

This concept of weighing rival and nonrival airspace uses can also be expressed in terms of the marginal social cost and benefit of increasing the height level under a basic height restriction. To demonstrate that approach, suppose that:

$MC_r$ = the incremental increase in $(N_1 - N_0)$, or marginal cost, of disruptions to nonrival users of loosening a height restriction to allow rival uses within an additional altitude inch of airspace; and

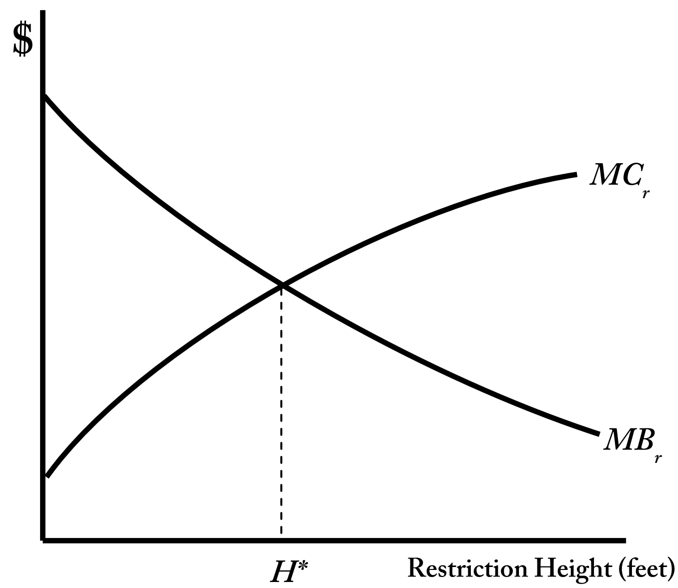
$MB_r$ = the incremental increase in $R$, or marginal benefit, to rival users of loosening the height restriction to allow rival uses within that additional inch of space.

A graph depicting these two functions appears in Figure A below. The upward slope of the $MC_r$ curve reflects an assumption that the incremental

128. This model also assumes that any additional administrative costs associated with creating and enforcing the restriction would be negligible. Such an assumption seems fairly defensible in jurisdictions that already have land use controls and enforcement infrastructures.

value of nonrival uses of protected airspace tends to grow with increasing height within the airspace at issue.[129]

**FIGURE A. Optimal Restriction Height**




$MB_r$ is shown here as a downward-sloping curve, on the assumption that $MB_r$ tends to be negatively related to restriction height. This inverse relationship seems likely given that the costs of elevators, the necessity of special building methods, and other logistical challenges add significant costs to high-rise construction as building height increases.[130]

129. This assumption seems reasonable given that this analysis focuses on relatively low-level airspace within 100–200 feet of ground level. Below those height levels, in most locations, a greater number of landowners can make nonrival uses of a given cube of airspace the higher it sits in the sky.

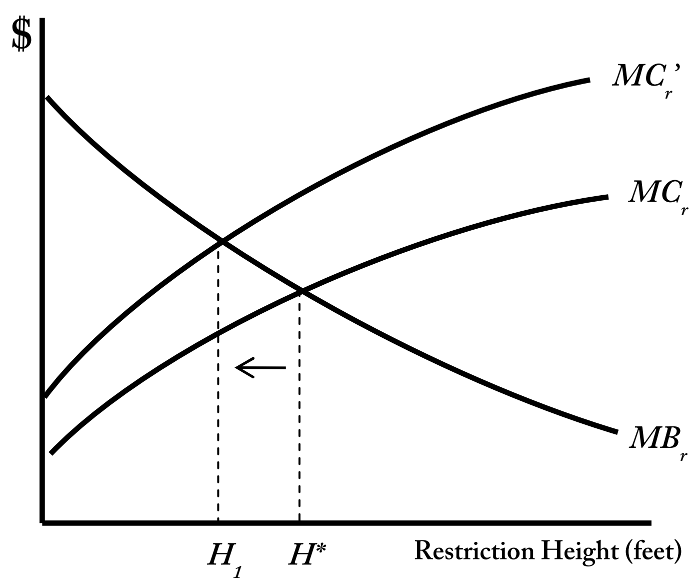
130. *See* AM. INST. OF ARCHITECTS, THE ARCHITECT'S HANDBOOK OF PROFESSIONAL PRACTICE 754 (Joseph A. Demkin ed., 14th ed. 2008) (stating that "[a]bove six or eight stories, unit costs per square foot tend to increase due to the costs of increased loads, wind bracing, elevators, and fire code requirements"). Although this assumption is reasonable in most instances, there are some noteworthy caveats and exceptions. For example, as already mentioned, wind speeds tend to increase with altitude, so wind energy productivity is usually positively correlated with turbine height. *See supra* note 83 and accompanying text. These increasing marginal benefits associated with additional turbine height are ultimately offset by escalating turbine construction as height increases, but such benefits would likely cause the

Under these assumptions, the socially optimal restriction height within a given community, shown as $H^*$ on the graph in Figure A, is the height at which:

$MC_r = MB_r$ [Equation (2)]

Although it is difficult to estimate the actual values of $N_1$, $N_0$, and $R$ in any given circumstance, it is possible to predict how various exogenous changes might affect $H^*$. For instance,[131] the invention of a valuable new, nonrival airspace use or a sudden boost in the value of an existing, nonrival use would increase the overall cost of allowing rival uses in the airspace. As shown in Figure B, such changes would shift $MC_r$ upward to $MC_r'$, thereby justifying a more stringent height restriction that prohibits rival uses below the height of $H_1$.

**FIGURE B. Effect of a New, Nonrival Use on Optimal Restriction Height**

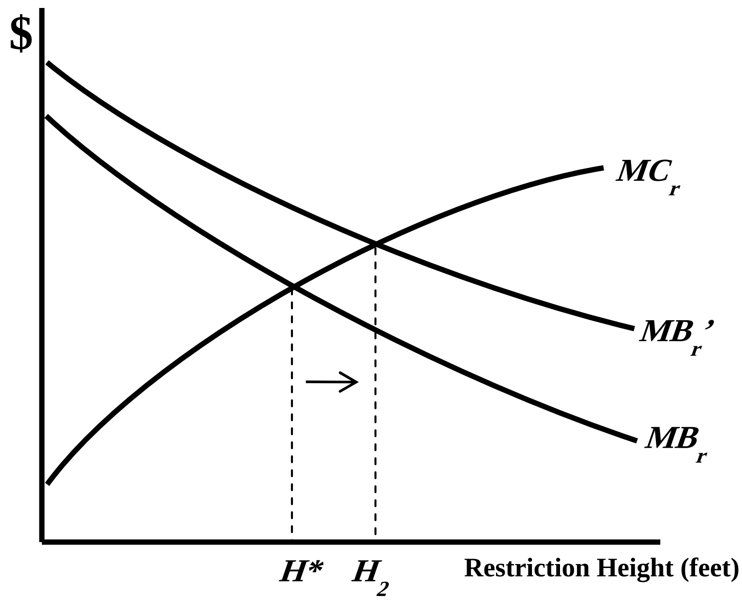



marginal benefit curve for prime wind development airspace to be flatter than the curve for airspace elsewhere—an observation that is consistent with the towering heights of many modern wind turbines. The marginal benefit curve may also flatten in the occasional instance when achieving a particular building height gives the building's upper floors particularly valuable view access over nearby structures or geographic features.

131. For a discussion of how the introduction of solar access as an increasingly important nonrival use is generating pressure to increase height restrictions, see *infra* text accompanying notes 179–181.

In contrast, the invention of a valuable new rival airspace use or a significant rise in the value of an existing rival use[132] would increase the overall benefit of allowing rival uses in the airspace at issue. As illustrated in Figure C below, either of those changes would shift the $MB_r$ curve upward to $MB_r$', thereby justifying a loosening of height restrictions to allow rival uses up to a height of $H_2$.

**FIGURE C. Effect of a New Rival Use on Optimal Restriction Height**




The preceding model provides a useful framework for analyzing the appropriateness of particular restrictions on airspace arising in the context of renewable energy. Its application requires consideration of how the proposed restriction would likely impact the values of rival and nonrival uses of the airspace at issue. Applications of the model to analyze specific, sustainability-related airspace regulations follow in Part IV below.[133]

132. It is worth noting that innovations reducing the underlying production costs associated with rival or nonrival uses often increase the net value of those uses. For instance, technological innovations that reduced the construction cost of tall buildings or reduced the manufacturing cost of wind turbines would likely increase the aggregate net social value of rival uses of airspace.

133. *See generally infra* text accompanying notes 179–187, 209–210.

## IV. CASE STUDIES IN AIRSPACE GOVERNANCE: SUBOPTIMAL AIRSPACE RESTRICTIONS AND ALTERNATIVE APPROACHES

This Article now analyzes specific examples of misguided governance rules that are causing the suboptimal use of airspace in the context of renewable energy.[134] Applying the principles set forth in Part III, the following case studies seek to highlight deficiencies in existing policies and suggest possible alternative ways of governing conflicts over airspace.

### A. Imposing Wind Access Buffers to Avoid Turbine Wake Interference

Commercial-scale wind energy development is one context in which suboptimal airspace regulations can arise.[135] A commercial wind turbine creates a "wake" of turbulent air that can reduce the wind energy productivity of other turbines behind it for up to half a mile.[136] As a result, disputes may arise whenever a developer proposes to install a wind turbine immediately upwind of a competing developer's proposed turbine site.[137] If both turbines were to be installed, the wake from the upwind turbine would reduce the energy productivity and profitability of the competing downwind turbine.[138] Unfortunately, the law is far from clear regarding who prevails in these conflicts. This legal uncertainty may deter wind energy developers on both sides from installing

134. I have published separate articles examining some of the real world examples described in this Part under different analytical frameworks. *See generally* Rule, *supra* note 12, at 207–46 (analyzing wind turbine wake interference conflicts); Rule, *supra* note 72, at 851–96 (comparing and contrasting solar access laws); Rule, *supra* note 83 (examining laws aimed at overcoming local regulatory barriers to landowners' installation of small wind turbines and rooftop solar panels).

135. To review my analysis of this issue under a different framework, see generally Rule, *supra* note 12, at 851–96.

136. *See id.* at 209–10.

137. To characterize one turbine site as "upwind" of another is to presuppose that wind tends to blow in the same general direction most of the time. Such is usually true in areas deemed most suitable for commercial wind energy development. *See* Ernest E. Smith & Becky H. Diffen, *Winds of Change: The Creation of Wind Law*, 5 TEX. J. OIL GAS & ENERGY L. 165, 186 (2010) ("A newly emerging issue is how to protect the flow of wind from adjacent, up-wind property. In any given area wind typically blows from a predominant direction.").

138. For recent articles on wind turbine wake effects, see generally R.J. Barthelmie et al., *Modelling and Measurements of Wakes in Large Wind Farms*, 75 J. PHYSICS CONF. SERIES 1 (2007), *available at* http://iopscience.iop.org/1742-6596/75/1/012049/pdf/jpconf7_75_012049.pdf (describing various models used to measure wake effects at large wind energy projects); Martin Méchali et al., *Wake Effects at Horns Rev and Their Influence on Energy Production,* EWEC (2006), *available at* http://www.dongenergy.com/SiteCollectionDocuments/NEW%20Corporate/PDF/Engineering/40.pdf (describing the measurement of turbine wake effects at a Danish commercial-scale wind farm).

turbines within the vast, wake-sensitive areas near property boundary lines, thereby effectively taking large quantities of valuable airspace out of use.[139]

In at least one state, government officials have addressed the wind turbine wake interference problem by imposing wake-based "wind access buffer" setbacks along property lines on land zoned for commercial wind energy development.[140] These buffer setbacks prohibit siting wind turbines within quarter-mile-wide bands of property along boundary lines when wind development is also occurring on the adjacent parcel.[141]

Although the setbacks prevent neighbor disputes over turbine wake interference, they can create anticommons tragedies in the affected airspace. The only conflicts that the wind access setbacks address are binary disputes between neighboring wind farm developers over a single type of use—wind energy generation. Because commercial wind energy projects are typically sited in areas specifically approved for such development, there are no third-party, nonrival uses at issue in these disputes that might warrant forming a conservation commons.[142] Laws prohibiting landowners from installing turbines in vast

139. For a more detailed description of how legal uncertainty over wind turbine wake interference can frustrate efficient turbine siting, see Rule, *supra* note 12, at 209–10.

140. *See, e.g.,* Order Establishing General Wind Permit Standards, Docket No. E,G-999/M-07-1102, at 7–8 (Minn. Pub. Util. Comm'n, Jan. 11, 2008), *available at* http://www.windaction.org/documents/14797 (establishing "wind access buffer" setbacks of five rotor diameters in the prevailing wind axis and three rotor diameters in the secondary wind axis for any wind energy project in the state of Minnesota having a total nameplate generating capacity of less than 25,000 megawatts).

141. *See id.* at 4–5 (describing Minnesota's turbine setback requirements as preventing turbine installations within five rotor diameters of "non-participating" property owners whose parcels are at least fifteen acres in size on the predominant wind axis, and stating that these setbacks will "protect wind rights and future development options of adjacent rights owners"). Modern ground-mounted commercial wind turbines often have rotor diameters in excess of one hundred meters. *See, e.g.*, *Direct Drive Wind Turbine Reduces Complexity,* SIEMENS, http://www.siemens.com/innovation/en/news/2010/direct-drive-wind-turbine-reduces-complexity.htm (last visited Oct. 12, 2011) (describing Siemens's SWT-3.0-101 turbine as having a rotor diameter of 101 meters).

142. *See, e.g.*, Katherine Daniels, N.Y. State Energy Research & Dev. Auth., *Wind Energy: Model Ordinance Options*, N.Y. STATE ENERGY RESEARCH & DEV. AUTH., Oct. 2005, at 3, *available at* http://www.powernaturally.org/programs/wind/toolkit/2_windenergymodel.pdf (describing the practice of a local government creating "wind energy overlay zone[s]" with special permitting standards in areas suitable for commercial wind energy development, and noting that "[c]areful attention to potential visual and avian impacts in defining the overlay area can greatly mitigate or even eliminate these issues when wind energy facilities are proposed"); *see also* Anne C. Mulkurn, *Wind Is the New Cash Crop in Rural Wash. Town*, N.Y. TIMES, Oct. 18, 2010, http://www.nytimes.com/gwire/2010/10/18/18greenwire-wind-is-the-new-cash-crop-in-rural-wash-town-3529.html (describing how Goldendale, Washington, "created the nation's first energy overlay zone" in 2005 to expedite wind energy development in the area, "with the county pre-approving several time-consuming studies that must be done before windmills can be installed").

areas on both sides of a property line create anticommons tragedies, relegating large amounts of land and airspace to chronic underuse.[143]

The task of governing this novel type of land use conflict is complicated by the fact that wind energy productivity is often location-specific. The strength of wind can vary greatly from location to location based on local topography,[144] meaning that one of two competing sites on either side of a property line can sometimes have significantly greater production potential than the other. Maximizing the wind energy productivity of a fixed amount of land and airspace thus requires allocating airspace rights in ways that lead to turbine installations in the most productive sites.

Theoretically, an exclusion regime that allocates the competing entitlement to either of the two neighboring landowners would enable them to engage in Coasean bargaining to allocate the airspace to its highest valued user. Laws based upon the *ad coelum* rule could allocate the entitlement by giving landowners the rights to capture wind in the airspace above their lands without liability for downwind wake effects. An owner of property downwind of potential turbine sites could then negotiate the purchase of voluntary easements or covenants from his upwind neighbors if he believed his property had greater wind energy development value than the property of his upwind neighbor. Individual landowners (or wind developers who have leased their land for development) seem to be in the best position to identify whether an upwind turbine or downwind turbine is likely to be more productive in any given circumstance and to act accordingly.

However, the success of Coasean bargaining depends on there being sufficiently low transaction costs, and transaction costs tend to be relatively high in these situations. Wind developers are often business rivals so they likely cannot rely upon social norms of neighborly behavior to motivate cooperation between them.[145] Instead, strategic behavior problems and other bounded rationality

143. Of course, the underuse of airspace in the instant case results from the absence of any wind turbines within the airspace situated immediately above the setbacks in a general geographic area that local officials and developers have already deemed suitable for wind energy development.

144. *See, e.g.*, *Wind Energy*, AUSTL. GOV'T, http://www.ga.gov.au/energy/other-renewable-energy-resources/wind-energy.html (last updated Feb. 1, 2011) (stating that "[l]ocal topography and other variability in the local terrain such as surface roughness exert a major influence on wind speed and wind variability").

145. Robert Ellickson suggests that social norms among tight-knit neighbors might help to promote bargaining for solar access and other common neighbor conflicts. *See* ROBERT C. ELLICKSON, ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES 273 (1991). However, such norm-based governance is far less likely among commercial wind developers who have merely entered into wind energy leases in adjacent lands.

problems threaten to preclude successful bargaining in many instances.[146] The fact that the parties are in a "bilateral monopoly" bargaining position over a unique, scarce entitlement also tends to raise transaction costs.[147] Whenever Coasean bargaining fails due to high transaction costs, turbines are installed in suboptimal locations or not at all and valuable potential wind energy productivity is lost.

Assuming that there is significant public policy interest in promoting the optimal use of wind energy resources, a new governance approach may be warranted to help overcome the high transaction costs associated with neighbor bargaining over turbine wake interference. As described in Part III above,[148] liability rule protection is a potentially useful way to supplement the *ad coelum* rule's exclusion regime in response to this relatively new sort of conflict over airspace for wind turbine use.

A liability rule–based governance strategy for wind turbine wake interference could take the form of "waivable" wake setbacks in areas zoned for commercial wind energy development.[149] Under such an approach, landowners would be free to install turbines within ordinary safety and aesthetics-based restrictions anywhere in the airspace above their parcels without any risk of liability for downwind wake effects. Setbacks sufficient to prevent wake interference would be imposed on the downwind-most portions of each parcel. Landowners who applied for permits to install turbines within those setback areas would be required to send written notice to their neighbors immediately downwind, who would have an option to pay the upwind landowners to make the setback permanent. The option price would equal the economic value of the upwind setback area for wind energy development, as determined by some preappointed governmental body. Such price determination could be made relatively easily based on submitted information regarding the current wholesale pricing for wind-generated power and wind study reports for the setback area. So long as the option price was not excessively low, rational downwind neighbors would only elect to pay it and make the setback permanent, believing genuinely

146. *See* Rule, *supra* note 12, at 235–36 (describing the potential for strategic behavior problems leading to higher transaction costs in interdeveloper negotiations over wind rights).

147. *See* Herbert Hovenkamp, *Rationality in Law & Economics*, 60 GEO. WASH. L. REV. 293, 298 (1992) (describing a bilateral monopoly as a situation where opposing parties' "previous investment in their present position [is] sufficiently substantial and irreversible" and where bargaining with each other is "a better solution than simply picking up stakes and moving elsewhere"). The common rivalry between competing wind energy developers could also encourage strategic behavior, which could further increase transaction costs.

148. *See supra* text accompanying notes 103–108.

149. For my own more detailed description of a potential waivable setback program, see generally Rule, *supra* note 12, at 242–45.

that the value of the potential wind energy preserved in their airspace justified the expenditure.

This governance strategy would present its own challenges,[150] but it would be far less detrimental to aggregate wind farm productivity than an outright prohibition on development under ordinary wind access setback requirements. This approach would also help to address the problem of high transaction costs that cause inefficiency in wind turbine siting decisions. It is an example of tailored use of liability rule protection to fine-tune landowner airspace rights under the *ad coelum* rule's exclusion regime.

### B. Restricting Wind Energy to Protect Military Interests

Another type of airspace conflict arising in commercial wind energy development is the increasingly common clash between wind farms and military bases. The current approach of the U.S. Federal Aviation Administration (FAA) to these disputes overlooks landowners' airspace rights and diverges from the principles set forth in *United States v. Causby*.[151] The FAA's rules effectively reassign the airspace rights involved from individual landowners to the U.S. Department of Defense (DOD), thereby enabling the DOD to acquire valuable airspace easements without compensation. As the discussion below suggests, such reassignments sometimes lead to underuse of the airspace at issue.

Most onshore commercial wind projects do not encroach into "navigable airspace" because navigable airspace generally begins at five hundred feet above ground level[152] and is a regulated "public highway" for general air travel.[153] In the United States, commercial-scale wind turbines are typically sited in rural areas where the turbines usually do not exceed heights of about 450 feet.[154] Because wind farms tend to stay out of navigable airspace, they typically raise no major conflicts in that regard.

150. Specifically, there would be additional administrative costs relating to the valuation of waivable setback areas. There would also be the potential for inefficient transfers of rights in cases where valuations were too low. *See supra* note 106 (describing the undercompensation problem sometimes associated with liability rules).

151. 328 U.S. 256 (1946). A detailed discussion of *United States v. Causby* is set forth in Part I, *supra*. *See generally* text accompanying notes 46–57, *supra*.

152. *See supra* note 53. It should be noted that the navigable airspace boundary for parcels of land within six miles of some airport runways may be between two hundred and five hundred feet. *See* 14 C.F.R. § 77.17(a)(2) (2009).

153. *Causby*, 328 U.S. at 264.

154. For a diagram and information comparing heights of some commercial wind turbines to other tall structures, see *Wind Turbine Technology Overview*, N.Y. STATE ENERGY RESEARCH & DEV. AUTH., Oct. 2005, at 6–7, *available at* http://www.powernaturally.org/programs/wind/toolkit/9_windturbinetech.pdf.

However, the U.S. military makes nonrival use of a large amount of rural airspace *below* the 500-foot level in connection with its radar systems. To protect the DOD's use of that additional space, FAA regulations allow the DOD to delay or prevent wind turbine installations even when those installations are dozens of miles away from any military base and would not penetrate navigable airspace.[155] The regulations require wind energy developers to notify the FAA prior to installing any turbines exceeding two hundred feet in height. Upon receipt of such notices, the FAA gives the DOD an opportunity to object to the installation. Based on a DOD objection, the FAA can issue "a notice of presumed hazard,"[156] which can greatly hinder the development of wind farms.

According to the American Wind Energy Association, nearly half of the generating capacity of all proposed wind energy development nationwide in 2009 was either "abandoned or delayed because of radar concerns raised by the military and the [FAA]."[157] Evidence suggests that many of those delays or losses could have been avoided had the military updated its radar systems, some of which were decades old.[158] According to empirical studies the cost of such equipment updates would have been much smaller than the cost imposed on the wind energy industry from failed or postponed projects.[159]

Should the U.S. military be entitled to take the equivalent of airspace easements in vast stretches of non-navigable airspace for its own singular use without compensating landowners? Or should such actions trigger an obligation to pay just compensation to affected landowners who may consequently lose lucrative streams of income they would have received under commercial wind leases?

155. *See* Kate Galbraith, *Gulf Coast Wind Farms Spring Up, as Do Worries,* N.Y. TIMES, Feb. 11, 2011, at A23 (suggesting that the "Navy would like wind farm construction to stay outside a 30-mile radius of its facilities").

156. Procedures for Handling Airspace Matters, FAA Order No. JO 7400.2H (Mar. 10, 2011), *available at* http://www.faa.gov/air_traffic/publications/atpubs/AIR/air0701.html.

157. Leora Broydo Vestel, *Wind Turbine Projects Run Into Resistance*, N.Y. TIMES, Aug. 26, 2010, http://www.nytimes.com/2010/08/27/business/energyenvironment/27radar.html?scp=1&sq=Leor%20Broydo%20Vestel,%20Wind%20Turbine%20Projects%20Run%20Into%20Resistance,&st=cs.

158. *See id.* (stating that "many radar systems in use in the United States date back to the 1950s and have outdated processing capabilities—in some cases, less than those of a modern laptop computer").

159. Empirical studies of this issue have suggested that radar system replacement is often the most cost-effective option. *See, e.g.,* Michael Brenner et al., *Wind Farms and Radar*, FED'N AM. SCIENTISTS, Jan. 2008, at 8–9, *available at* http://www.fas.org/irp/agency/dod/jason/wind.pdf ("The cost of a single radar installation was said to be in the range of $3–8M, to be compared with the $2–4M cost of a single wind turbine, and the roughly $0.5M annual electric production of a single turbine (5×106 kWh, at $0.10/kWh retail). A wind farm can have hundreds of turbines.").

The question in these conflicts is not whether a conservation commons is warranted to protect nonrival airspace uses but whether one particular airspace use should be given universal precedence over another. In that sense, these conflicts are materially different from conflicts over the potential aesthetic or health impacts of wind farms[160] or their effects on migratory birds.[161] Here, typically only two parties are involved in the disputes at issue: a military entity and a wind energy developer. Nonetheless, FAA regulations can prohibit development in massive stretches of non-navigable airspace—a governance approach ordinarily reserved for cost-justified conservation commons—to protect a single entity's use of that space. Such rules result in underutilization of the airspace at issue whenever the DOD is the "cheapest-cost avoider"[162] and is capable of updating its equipment at an expense far lower than the detriment to the wind project.

Congress's delegation of regulatory authority to the FAA expressly requires that the FAA's activities promote the "efficient use of navigable airspace."[163] Unfortunately, the FAA's well-intended rules governing wind farms deviate from their stated objective, regulating non-navigable airspace and doing so in ways that can undermine its efficient use. By reassigning airspace entitlements to the military, these FAA regulations enable the DOD to block wind farms

160. The most commonly reported conflicts over wind farms' use of airspace relate to their alleged effects on neighboring residences or businesses. Neighbors have opposed wind farms based on concerns over aesthetic impacts, flicker effects, noise, and other concerns. Under the abstract model set forth in Part III, allowing commercial wind energy development in spite of these impacts makes economic sense whenever the value created by allowing development in the relevant airspace ($R$) exceeds the value of protecting neighbors' nonrival uses of the space ($N_1 - N_0$). Of course, measuring these variables is difficult, and overcoming local political opposition to allow siting of wind farms in cases where $R > (N_1 - N_0)$ can also be challenging. Exploring possible solutions to these conflicts is outside the narrow scope of this Article, but recent articles by other scholars propose inventive means of potentially mitigating the difficulties of commercial wind energy siting. *See, e.g.*, Ashira Pelman Ostrow, *Process Preemption in Federal Siting Regimes*, 48 HARV. J. ON LEGIS. 289 (2011) (advocating a system of process preemption for wind project siting similar to the system used for siting telecommunication towers); Garrick B. Pursley & Hannah J. Wiseman, *Local Energy*, 60 EMORY L.J. 877 (2011) (proposing an approach that involves federal minimum standards for wind energy siting).

161. *See* Reimer & Snodgrass, *supra* note 10 (describing conflicts between migratory birds and wind farms).

162. Initially conceived by Guido Calabresi, the concept of a least cost avoider has become commonplace in law and economics literature. Generally speaking, the cheapest-cost avoider is the party who can most cheaply avoid the conflict between the parties at issue. *See* Guido Calabresi, *The Costs of Accidents: A Legal and Economic Analysis* 135 (1970); *see also* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 190 (7th ed. 2007) (stating that the "lower-cost accident avoider" should take precautions necessary to avoid an accident); STEVEN SHAVELL, ECONOMIC ANALYSIS OF ACCIDENT LAW 17 (1987) (using the term "least cost avoider").

163. 49 U.S.C. § 40103(b) (2006).

for little to no cost, thereby incentivizing in the DOD an excessive willingness to obstruct these valuable projects.

A more efficient governance approach would be to require the DOD to exercise its eminent domain power to acquire airspace easements when necessary to prevent wind energy development below the 500-foot level that might interfere with its radar equipment. As some scholars have aptly noted, affording eminent domain authority to government entities is in itself an example of liability rule protection.[164] Such an approach would allow rural landowners to retain their long-held legal entitlements in the non-navigable airspace above their land. Under this strategy, developers could still be obligated to send notice to the FAA for proposed structures exceeding heights of two hundred feet. However, the DOD would have to respond to such notice by either updating its radar equipment as needed or by exercising its eminent domain authority to take an easement in or title to a sufficient amount of airspace to protect the equipment from interference by wind turbines and to provide affected landowners with just compensation. If operating under such a policy, the DOD would purchase airspace rights above rural land for that purpose only when it determined that doing so would be cost-efficient. The availability of the eminent domain power in this situation is another example of how liability rules can supplement the *ad coelum* rule in furtherance of particular policy objectives.

## C. Overregulating Airspace Under Solar Access Laws

Another context in which conflicts over airspace use are becoming more common is rooftop solar energy development. Below are critiques of two types of solar access laws that can cause the underutilization of airspace and a description of an alternative governance strategy better suited to protect solar access while respecting airspace rights.

### 1. Prior Appropriation–Based "Solar Rights" Statutes

As described in Part II above, legislation promoting the protection of direct sunlight access for solar energy devices has existed for decades.[165] Although most solar energy devices require access to direct solar radiation to operate at

164. Calabresi and Melamed specifically cited eminent domain as a type of liability rule. *See* Calabresi & Melamed, *supra* note 103, at 1106 (citing the eminent domain power as a "good example" of a liability rule approach).

165. For recent analyses of solar access laws in the United States, see generally Bronin, *supra* note 4, at 1226–35; Rule, *supra* note 72, at 878–80 (similarly criticizing the blanket nature of shade-based zoning setbacks).

maximum capacity, landowners possess no inherent right to unobstructed sunlight under prevailing common law.[166] In response, many state and local governments have enacted laws aimed at promoting solar access for users of solar energy devices.

Some laws seek to protect solar access by seizing private airspace rights from individuals without solar energy devices and then granting those rights to landowners with solar energy devices. Neighbors who lose airspace rights under these laws neither receive compensation from the government nor receive compensation from the benefited parties. Laws in New Mexico and Wyoming allow landowners to acquire the equivalent of a restrictive easement across their neighbors' airspace without compensating their neighbors by being the first to make "beneficial use" of the space for solar access.[167] In these states, a landowner who installs a qualifying solar collector,[168] records a specific document with the county clerk,[169] and satisfies specific neighbor notice requirements acquires a "solar right."[170] A solar right is a legal entitlement to an "unobstructed line-of-sight path from a solar collector to the sun" that "permits radiation from the sun to impinge directly on the solar collector."[171] Solar rights are essentially easements in neighboring airspace that prevent any rival uses capable of disrupting solar access on a solar right holder's property.[172]

Based upon water law's prior appropriation doctrine,[173] the New Mexico and Wyoming solar access statutes purport to provide landowners with "priority in time" as to sunlight with the "better right" vis-à-vis their

166. The preservation of building access to sunlight was historically a primary reason for regulating open airspace, as evidenced by the English doctrine of ancient lights. However, United States courts resisted adopting the doctrine in the twentieth century when artificial electric light became commonplace. For a more detailed summary of the evolution of laws regarding rights to light, see Rule, *supra* note 72, at 865–66.

167. Under the statutes in both states, "beneficial use" is the "basis, the measure and the limit of the solar right." *See* N.M. STAT. ANN. § 47-3-4.B (1995); WYO. STAT. ANN. § 34-22-103(b)(i) (West 2011).

168. *See* N.M. STAT. ANN. § 47-3-4.A; WYO. STAT. ANN. § 34-22-102(a)(i).

169. *See* N.M. STAT. ANN. § 47-3-9; WYO. STAT. ANN. § 34-22-106.

170. N.M. STAT. ANN. § 47-3-3.B.

171. *Id.*; WYO. S TAT. ANN. § 34-22-102(a)(ii).

172. Language in New Mexico's statute expressly requires that a solar right be "considered an easement appurtenant." N.M. STAT. ANN. § 47-3-8.

173. The prior appropriation doctrine is a common law doctrine embraced in several western states that established and prioritized water rights among landowners based on landowners' beneficial use of water resources. *See* Arizona v. California, 373 U.S. 546, 555 (1963) ("Under [the prior appropriation doctrine,] the one who first appropriates water and puts it to beneficial use thereby acquires a vested right to continue to divert and use that quantity of water against all claimants junior to him in point of time. 'First in time, first in right' is the shorthand expression of this legal principle.").

neighbors.[174] In reality, the resource at issue in these conflicts is not sunlight but airspace—and subadjacent landowners have already been assigned rights in that resource under common law. These statutes are transferring airspace rights from neighbors to landowners with solar energy devices, overlooking existing airspace rights and misapplying the prior appropriation doctrine.[175] Statutes in other jurisdictions do not expressly analogize to the prior appropriation doctrine but give rise to the same practical consequences as those in New Mexico and Wyoming.[176]

Although such statutes may be a relatively low-budget way for state and local governments to promote solar access, they can impose heavy costs on landowners and the rest of society. Like the FAA regulations discussed above,[177] these solar access laws do not seek to create valuable conservation commons to protect multiple landowners' nonrival uses of airspace. Instead, they offer property interests in neighboring airspace as an incentive for landowners to install solar energy devices. Airspace reserved for solar access under these laws is no longer available for valuable rival uses such as buildings or trees, and landowners installing solar panels on their property are not required to pay anything to their neighbors to induce them from abstaining from those uses. Whenever those rival airspace uses are of greater social value than conserving the space for solar access protection and other nonrival uses, Equation (1) above would not hold true.[178] In such instances, a solar panel user's exercise of rights under one of these statutes results in suboptimal airspace use.

### 2. Solar Access–Based Setbacks and Height Restrictions

Imposing blanket airspace restrictions to protect solar access can also cause the underutilization of airspace. Solar access laws applying this approach

174. N.M. STAT. ANN. § 47-3-4.B(2); WYO. STAT. ANN. § 34-22-103(b)(ii).

175. For my more detailed critique of prior appropriation–based solar access laws, see Rule, *supra* note 72, at 876–78 (criticizing prior appropriation–based solar access laws). Other commentators have also challenged the use of the prior appropriation doctrine to promote solar access. *See, e.g.*, GAIL BOYER HAYES, SOLAR ACCESS LAW: PROTECTING ACCESS TO SUNLIGHT FOR SOLAR ENERGY SYSTEMS 187–92 (1979).

176. Examples of such statutes include laws in Massachusetts and Wisconsin allowing municipalities to adopt ordinances granting solar access "permits" that effectively preclude landowners from occupying their airspace to the extent that doing so would shade a solar panel on neighboring property. *See* MASS. GEN. LAWS ANN. ch. 40A, § 9B (LexisNexis 2006); WIS. STAT. ANN. § 66.0403(2) (West 2003).

177. *See supra* text accompanying notes 149–162.

178. To review Equation (1) and related concepts, see *supra* text accompanying notes 127–129.

can inadvertently create anticommons tragedies in airspace because they protect solar access for solar energy systems that usually do not exist.

The model for airspace conservation commons set forth in Part III[179] illustrates how the increased importance of solar access can create pressure for local governments to adopt stricter bulk and height restrictions. Solar access is a relatively new type of nonrival airspace use and is becoming increasingly important due to generous government incentives and improving solar energy technologies.[180] As shown in Figure B,[181] the growing value of this nonrival use shifts $MC_r$ upward and thus theoretically justifies at least somewhat more stringent restrictions on airspace.

It is therefore no surprise that some communities seeking to encourage solar energy development have adopted special ordinances restricting additional airspace to better protect solar access. For example, an ordinance adopted in Ashland, Oregon, imposes "solar setbacks" on much of the private property within that jurisdiction.[182] The solar setbacks aim to protect access for and investment in solar energy devices by prohibiting any new structure that would cast shadows above a certain height at the north property line. The practical effect of this ordinance is that structure heights near the southerly boundary of a given parcel are permitted to be taller than those in the northernmost portions. Municipal ordinances in jurisdictions such as Boulder, Colorado,[183] and Soldier's Grove, Wisconsin, have a similar effect.[184]

However, it seems doubtful that the upward shift in $MC_r$ resulting from the increasing value of solar energy is sufficiently large to dominate setback height determinations in most communities. Solar access–based bulk and height

179. *See supra* text accompanying notes 126–132.
180. *See, e.g.*, 26 U.S.C. § 25D (2006) (providing for 30 percent federal income tax credits for installations of solar panels); DSIRE, *supra* note 27 (providing a database of state-by-state information on state-level incentives for renewable energy, including rooftop solar energy development).
181. *See supra* text accompanying note 130.
182. *See* ASHLAND, OR., MUN. CODE § 18.70.040 (2009). Language in the Ashland ordinance makes clear that the ordinance was adopted to protect "the economic value of solar radiation falling on structures, investments in solar energy systems, and the options for future uses of solar energy." *Id.* § 18.70.010.
183. *See* BOULDER, COLO., REV. CODE 1981 § 9-9-17(d) (Supp. 2009) (establishing "solar fences" in particular zone areas of the city).
184. *See* SOLDIERS GROVE, WIS., ORDINANCES § 2.06 (1980), *available at* http://www.smartcommunities.ncat.org/codes/soldiers.shtml ("Solar Access shall be protected in the following manner. No structure, whether Principal Use or Accessory Use; and no plant materials, whether trees, shrubs or other; and no permanently fixed equipment shall be of such a height that it would cast a shadow during daylight between 9 A.M. and 3 P.M. of the winter solstice on any portion of another building or the buildable area of a parcel if no building exists. Compliance with this standard must be graphically shown in Application for Zoning Permit.").

restrictions are blanket restrictions that prohibit rival uses in all of the restricted airspace within an area—not just above those lots situated near solar panels. Given that there are currently solar panels on less than 1 percent of the residential rooftops in the United States,[185] the nonrival use specially protected by the restrictions is not even in existence more than 99 percent of the time.[186] Rooftop solar panels will need to become far more prevalent and cost effective before one can reasonably assume that $(N_1 - N_0) > R$ enough of the time to warrant blanket restrictions for this purpose.[187] In most instances, such restrictions are likely to create anticommons tragedies and might lead to underuse of the incrementally restricted airspace.

### 3. A Better Way: Solar Access Protection Built Upon the *Ad Coelum* Rule

Solar access laws in at least one jurisdiction strike a decent balance between protecting solar access and promoting efficient allocations of the airspace rights involved. Rather than unilaterally shuffling landowners' airspace interests or imposing blanket restrictions that would create anticommons tragedies in airspace, Iowa's approach[188] respects and largely preserves landowners' long-held airspace rights.

Under Iowa's solar access statute, landowners who desire to prevent structures on neighboring land from shading their solar energy devices may do so only by purchasing airspace easements or covenants from their neighbors. In that sense, Iowa's statute mirrors the existing laws for view and ordinary land easements and is consistent with the *ad coelum* rule's exclusion regime.

Of course, solar energy advocates would rightly be dissatisfied if Iowa's statute only went that far because the statute would provide no guaranteed means for landowners to obtain enforceable solar access rights. In all cases in which easement negotiations with neighbors fail, landowners under such a

185. *See* Debbie Arrington, *Seeds: Sun's Again Rising for Area Solar Industry*, SACRAMENTO BEE, June 20, 2009, at D1.

186. For additional discussion of these arguments, see Rule, *supra* note 72, at 878–80 (similarly critiquing the blanket nature of shade-based zoning setbacks).

187. Other commentators have noted the potential inefficiencies of too aggressively protecting solar access. *See, e.g.*, Peter C. Hoffman, *Mandating Solar Hot Water by California Local Governments: Legal Issues*, 1 UCLA J. ENVTL. L. & POL'Y 71, 101 (1981) ("In attempting to guarantee solar access for new construction in existing neighborhoods, a very difficult balance must be struck between the recognized need to protect the solar user's right to meaningful use of his solar hot water system and the neighboring homeowners' rights to use their property in a reasonably unrestrained fashion.").

188. *See* IOWA CODE ANN. § 564A.4–.5 (West 1992).

regime would have no way of acquiring solar access protection and could therefore be deterred from installing solar energy devices on their property. Much like for the wind turbine wake interference disputes described above, negotiations over solar access often take the form of bilateral monopoly bargaining,[189] which can sometimes involve significant transaction costs. Imperfect information, bounded rationality, and other factors can further thwart Coasean bargaining for solar access rights.[190] Inefficiency results whenever high transaction costs frustrate neighbor negotiations that could have reallocated airspace rights to their highest and best use.

Fortunately, Iowa's law has provisions enabling landowners to obtain solar access protection despite failed neighbor negotiations for a solar access easement. Providing the equivalent of liability rule protection for airspace in the narrow context of solar access,[191] Iowa's statute tweaks the *ad coelum* doctrine's exclusion regime to better facilitate solar access protection. In Iowa, a landowner who is unable to strike a reasonable, voluntary bargain with a neighbor for the purchase of a solar access easement can compel the neighbor to sell the easement for its fair market value, as determined by the locally appointed governmental board.[192] Assuming that those valuations are accurate,[193] rational landowners would only choose to compel such sales when the neighboring airspace at issue is best suited for solar access protection and other nonrival uses.[194] Iowa's strategy

189. *See supra* note 145 and accompanying text.

190. For a detailed discussion of the potential obstacles to voluntary bargaining among neighbors over solar access, see generally Rule, *supra* note 72, at 891–94 (mentioning administrative and legal costs, the parties' bilateral monopoly bargaining position, imperfect information, holdout problems, and the bounded rationality of the parties involved as potential impediments to successful Coasean bargaining in the solar access context).

191. *See generally id.* (explaining that Iowa's approach corresponds to "Rule Four" of Calabresi and Melamed's famous model of property rules and liability rules because it gives polluters—neighbors who would shade the solar panels—the scarce entitlement at issue but protects the entitlement with a liability rule.) To review Calabresi and Melamed's own description of their model, see generally Calabresi & Melamed, *supra* note 103, at 1115–16.

192. *See* IOWA CODE ANN. § 564A.5.

193. As mentioned in connection with the use of liability rules in the wind turbine wake interference context, the risk of undervaluation of entitlements under such rules is a commonly cited weakness of liability rule-based policies. *See supra* note 105. However, despite the potential for occasional undercompensation, Iowa's approach at least includes some sort of compensation requirement in connection with the transfer of airspace rights to protect solar access. Although Iowa's approach will not produce perfect efficiency every time, its compensation requirement does make it more efficient and fair than prior appropriation-based approaches that provide no compensation to landowners who are forced to forfeit valuable airspace rights under those laws.

194. Although landowners could potentially manipulate such a statute by using its provisions to purchase their neighbors' airspace rights to protect nonrival uses other than solar access, careful statutory drafting could largely prevent such strategic abuse. For a discussion of how Iowa's solar access

is yet another example of how liability rules can supplement existing airspace rights laws so as to further a broader public policy goal.

### D. Preemption of Local Laws to Accommodate Small Wind Turbines

Another type of airspace conflict arising in recent years involves the growing number of state statutes that preempt local land use controls in order to allow small wind turbine installations in suburban neighborhoods.[195] Small wind energy devices can generate significant amounts of renewable electric power and do not require new, costly transmission lines.[196] As a result, state and federal lawmakers have enacted programs aimed at aggressively promoting landowners' installation of small wind devices.[197] However, the turbines often must rise well above local height restrictions to be fully effective, which creates legal barriers to their installation in many communities.[198] In a few jurisdictions, local land use controls expressly prohibit small wind turbine installations because of their potential impacts on views, aesthetics, and property values.[199]

Recent technological innovations and government incentives for small wind turbines that have bolstered the significance of this rival use arguably justify loosening suburban height restrictions in some areas. This effect was illustrated in Figure C above,[200] in which the invention or increased value of a rival use shifted the marginal benefit curve upward to $MB_r$' and shifted the optimal restriction height to $H_2$.

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law is structured to prevent opportunistic behavior and for ideas on how to improve upon Iowa's law in that regard, see generally Rule, *supra* note 72, at 891–94.

195. *See infra* notes 202–206 and accompanying text.

196. For a discussion of the private and social costs of transmission infrastructures needed to support commercial-scale renewable energy projects in remote areas, see generally Sara C. Bronin, *Curbing Energy Sprawl With Microgrids*, 43 CONN. L. REV. 547, 553–57 (2010) (describing the recent studies on the impacts of energy sprawl).

197. Not surprisingly, these incentive programs are often grouped together with those for solar panels. *See, e.g.*, 26 U.S.C. § 25D (2009) (providing for 30 percent federal income tax credits for installations of solar panels); DSIRE, *supra* note 27 (providing a database of state-by-state information on state-level incentives for renewable energy, including rooftop solar energy development).

198. Small turbine heights can be as high as 120 feet above ground level. *See supra* note 97 and accompanying text. Suburban height restrictions are often set at approximately 35 feet.

199. *See, e.g.*, SARATOGA, CAL., CODE OF ORDINANCES § 15-52.050 (2002) (restricting locations within the jurisdiction where small wind turbines may be installed), *cited in* Ernest Smith, *Wind Energy: Siting Controversies and Rights in Wind*, 1 ENVTL. & ENERGY L. & POL'Y J. 281, 298 (2007); BLOWING ROCK, N.C., TOWN CODE § 16-149(C)(3) (prohibiting the "installation, erection, or use of a wind energy system, wind turbines, and/or associated towers for wind energy conversion" in all of the municipality's zoning districts), *referenced in* Jennifer R. Andriano, *The Power of Wind: Current Legal Issues in Siting for Wind Power*, 61 PLAN. & ENVTL. L., no. 5, 2009, at 3, 7.

200. *See supra* text accompanying note 132.

However, many benefits of small wind turbine installations—such as reduced carbon dioxide emissions and diminished reliance on fossil fuel-generated energy—do not accrue at the local level.[201] Because the potential costs borne by localities from allowing small wind turbine installations often exceed locally enjoyed benefits, many local jurisdictions are reluctant to revise their land use controls to accommodate the devices.

Several state statutes seek to overcome local resistance to small wind turbines by invalidating local land use controls that restrict small wind turbine installation. Laws enacted in Delaware,[202] Florida,[203] New Hampshire,[204] Vermont,[205] and Wisconsin[206] prohibit or significantly limit the ability of local governments to restrict small wind turbine installations. Statutes that preempt local height restrictions or setbacks to allow a particular rival airspace use are prone to inefficiency. Such laws effectively dissolve airspace conservation commons and ignore officials' localized cost–benefit determinations regarding airspace regulation within those jurisdictions.

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201. For a recent description of some of the broad benefits of wind energy and other renewable energy development, see generally Joshua P. Fershee, *The Rising Tide of Climate Change: What America's Flood Cities Can Teach Us About Energy Policy, and Why We Should Be Worried*, 39 ENVTL. L. 1109, 1137–39 (2009) (describing climate change, jobs, and other benefits of renewable energy development). The benefits of warding off climate change through greenhouse gas reductions are shared worldwide, and many of the economic stability and job opportunity advantages available through greater reliance on renewable energy also often accrue beyond a single municipality.

202. *See* DEL. CODE ANN. tit. 29, § 8060 (Supp. 2003) (prohibiting a "county or municipal government" in Delaware from adopting any land use regulation more restrictive than a specific statutory standard that "prohibits or restricts the owner of a property from using a system for obtaining wind energy for a residential single family dwelling unit").

203. *See* FLA. STAT. ANN. § 163.04(1) (West 2006) (forbidding any local "governing body" in Florida from adopting an ordinance that "prohibits or has the effect of prohibiting the installation of . . . energy devices based on renewable resources").

204. *See* N.H. REV. STAT. ANN. § 674:63 (Supp. 2010) (providing that "[o]rdinances or regulations adopted by municipalities to regulate the installation and operation of small wind energy systems shall not unreasonably limit such installations or unreasonably hinder the performance of such installations," and describing certain restrictions that constitute "unreasonable" limits).

205. *See* 27 VT. STAT. ANN. tit. 27, § 544 (Supp. 2010) (providing that no municipality, by ordinance, resolution, or other enactment, "shall prohibit or have the effect of prohibiting" the installation of "energy devices based on renewable resources," with exceptions made for patio railings in condominiums, cooperatives, and apartments).

206. *See* WIS. STAT. ANN. § 66.0401(1m) (West 2003) (prohibiting political subdivisions in Wisconsin from imposing "any restriction, either directly or in effect, on the installation or use of . . . a wind energy system" that is more restrictive than a specific state-enacted standard or from placing restrictions on any "wind energy system" unless the restriction (a) "[s]erves to protect the public health or safety," (b) "[d]oes not significantly increase the cost of the system or significantly decrease its efficiency," or (c) "[a]llows for an alternative system of comparable cost and efficiency").

Advocates for preemption statutes in this context might argue that such laws are necessary to overcome the "positive externality" problem inherent in renewable energy development.[207] Local governments tend to discount the benefits accruing outside their own jurisdictions when regulating land use. Unless incentivized otherwise, a rational local official desiring reelection can be expected to discount the broader social benefits of reduced carbon dioxide emissions or less burdened regional electric power grids when deciding whether to accommodate small wind turbines and will thus excessively restrict their installation. Some type of state government intervention is arguably warranted to correct this problem.[208]

However, indiscriminately preempting local land use controls throughout a state is an imprecise method of addressing the positive externality in this context. Analysis of this issue can be framed within the conservation commons model set forth in Part III.[209] Suppose that the airspace restriction at issue is a suburban community's existing ordinance prohibiting small wind turbines and other structures in excess of thirty-five feet and that the ordinance is at risk for preemption by a state statute. Accounting for the positive externality problem requires distinguishing the value of preempting the local ordinance that would be captured by local citizens who installed small turbines from the broader social value accruing outside of the jurisdiction.

Let:

$R_l$ = the aggregate value of small wind turbine installations resulting from the preemption statute that would accrue to citizens within a given local jurisdiction; and

$R_s$ = the aggregate *social* value of the turbines, comprising the sum of $R_l$ and any additional benefits accruing outside of the jurisdiction.

Because local governments tend to be most concerned about costs and benefits within their localities, they are likely to focus on $R_l$ rather than $R_s$ when deciding whether to allow small wind turbines in their neighborhoods.

207. An externality exists when "the activity of one entity . . . directly affects the welfare of another in a way that is not transmitted by market prices." Rosen, *supra* note 112, at 86. Generally, a "positive" externality problem exists when the activity at issue benefits at least one other party in a way that is internalized through market forces by the party or group engaged in the activity.

208. Other scholars have noted the potential need for government intervention to address externality problems relating to sustainability. *See, e.g.*, Carl J. Circo, *Does Sustainability Require a New Theory of Property Rights?*, 58 U. KAN. L. REV. 91, 116 (2009) (suggesting that "subsidies and regulations calculated to influence economic decisions" may be warranted "in circumstances in which natural market forces are inadequate to assure that the externalities of an economic decision properly figure into the cost-benefit analysis" (citing STEVEN SHAVELL, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW 108 (2004))).

209. *See supra* text accompanying notes 127–133.

However, responding to that problem by invalidating local land use restrictions on small wind turbines in every community in an entire state is only justified if, in most local jurisdictions:

$R_s > (N_1 - N_0)$ [Equation (3)]

Equation (3) surely holds true in some communities but likely does not describe many other neighborhoods where small turbines would significantly damage valuable views and other nonrival uses. Thus, a blanket preemption approach that forces all communities to allow small wind devices is an imprecise and inefficient form of government intervention. In all local jurisdictions where $R_s < (N_1 - N_0)$, such an approach would generate a deadweight loss equal to the difference between $R_s$ and $(N_1 - N_0)$.

Options-based rules that help communities internalize more of the social benefits of accommodating small wind turbines are a more promising governance approach in this context. State governments could address the issue through a program that awarded annual property tax credits to qualifying landowners in all jurisdictions that had voluntarily amended their land use controls to reasonably exempt small wind turbines or certain other renewable energy devices. The state government would set the tax credit amount under such a program based on its willingness to pay for ordinances in cities and towns that welcomed small wind energy. An optimal tax credit amount would equal the difference between $R_s$ and $R_l$ for each eligible community.[210]

A property tax credits program would better respect landowners' reciprocal airspace rights arrangements under existing land use restrictions compared to the blanket preemption approach. Specifically, the tax credits would compensate landowners in jurisdictions that had voluntarily forfeited their rights to exclude in height-restricted airspace by amending local controls to allow small wind turbines. This approach would also be less likely to undermine airspace conservation commons in neighborhoods where it would not be cost efficient to do so.[211]

210. It is worth noting that a rational, self-interested state government setting the tax credit amount would only consider social benefits of gentler land use controls that would accrue within *state* boundaries, which would equal some amount less than $R_s$. A tax credit amount fixed by the federal legislature would probably more closely approximate $R_s$ but would still likely be less than $R_s$ because some of the benefits of renewable energy—such as reduced carbon dioxide emissions and reduced demand for fossil fuels—are globally shared. Still, providing at least some tax credit amount would help overcome some of the externality problem without supplanting local land use decisionmaking and thus seems superior to existing policy strategies.

211. For example, allowing small wind turbines in the backyards in a neighborhood with highly valuable views may not be cost efficient. For a detailed discussion on the disadvantages of a blanket preemption approach in this context, see generally Rule, *supra* note 83, at 1252–54 (describing how a blanket preemption statute invalidating local restrictions on small wind turbines might impact a hypothetical beachfront town).

So long as the local democratic process worked properly, only those communities that placed a particularly high value on protecting nonrival airspace uses such as views and aesthetics would opt to retain existing land use restrictions and forgo receiving the tax credits.[212] By paying proportionately higher property taxes, those communities would effectively purchase the right to contribute less than their fair share toward statewide renewable energy goals.[213]

## CONCLUSION

Renewable energy development and sustainable land use are causing airspace to become more valuable than ever before. Innovative laws are needed to govern the new airspace conflicts arising from these changes and to prevent them from unnecessarily hindering sustainable development. This Article advances two general principles to help guide policymaking aimed at allocating airspace among its increasingly complex web of uses.

First, new laws responding to the escalating value of airspace will be most effective and efficient if they are structured in ways that acknowledge landowners' long-held airspace rights. The exclusion regime founded under common law's *ad coelum* doctrine is beneficial in that it clearly delineates among landowners' respective interests in airspace. By assigning unambiguous legal entitlements among landowners, this regime enables landowners to bargain with each other more freely and thereby allocate airspace rights to their highest valued use.

When high transaction costs prevent the reallocation of airspace to important uses such as wind energy or solar access, policymakers should not ignore or radically alter existing airspace rights. An alternative approach that builds more firmly upon the *ad coelum* rule's valuable exclusion regime is to

212. Tax credit programs can be susceptible to strategic abuse, but carefully structuring the programs can reduce the likelihood of such opportunistic behavior. For a more in depth discussion of these risks and possible ways of mitigating them, see *id.* at 1272–73.

213. The concept of requiring each neighborhood in a jurisdiction to host its own "fair share" of locally undesirable land uses (LULUs) is not new. *See* Vicki Been, *What's Fairness Got to Do With It? Environmental Justice and the Siting of Locally Undesirable Land Uses*, 78 CORNELL L. REV. 1001, 1077 (1993) (describing New York City's charter provisions aimed at ensuring that "each of its neighborhoods bears its fair share of the burden of LULUs"). Programs allowing some communities to purchase the privilege not to host LULUs in such contexts have proven controversial in the affordable housing context. *See* ROBERT C. ELLICKSON & VICKI L. BEEN, LAND USE CONTROLS 778 (2005) (describing the scholarly debate over the merits of programs that allowed communities to sell their statutory obligations to host affordable housing projects to other jurisdictions through "[r]egional contribution agreements"). However, arguments against such arrangements are less compelling when the LULUs at issue are merely renewable energy devices restricted for aesthetic reasons.

merely protect airspace rights with a liability rule rather than a property rule when some socially important use, such as wind or solar access, is at issue. If appropriately tailored, policies providing for liability rule protection in these settings can facilitate efficient airspace rights transfers among landowners that might otherwise be thwarted by high transaction costs.

Second, before adjusting bulk and height restrictions in response to a new airspace use, policymakers should weigh the potential impacts of such actions on both rival and nonrival uses of the space. Some airspace is most valuable to society as a conservation commons in which physically occupying the space is prohibited so that it can better serve nonrival uses. Sustainability-driven uses of airspace, such as wind and solar energy development, can create political pressure to loosen or tighten height restrictions and to alter existing conservation commons. However, the discovery of a single new airspace use often does not justify sweeping changes in airspace regulation. Before acting on such pressure by implementing a broad law aimed at promoting a particular use of airspace, policymakers should recognize and weigh the law's likely effects on both rival and nonrival uses of the airspace at issue.

Renewable energy and sustainable land use are rapidly gaining importance in local and national policy, so even greater competition for airspace will likely develop in the years to come.[214] Innovative new policies built firmly upon the centuries-old property rights regime for airspace are the most promising means of promoting the efficient use of this precious resource well into the future.

214. For example, NASA's recent interest in the development of airborne wind turbines that would be tethered to the ground and float thousands of feet above the ground suggests the potential for new kinds of airspace conflicts involving wind energy in future years. *See An Answer to Green Energy Could Be in the Air*, NASA (Dec. 10, 2010), http://www.nasa.gov/topics/technology/features/capturingwind.html (describing new research on airborne wind turbine designs funded through a $100,000 grant from the federal government to NASA's Langley Research Center).