Maximizing the Value of America’s Newest Resource, Low-Altitude Airspace: An Economic Analysis of Aerial Trespass and Drones

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TYLER WATSON

INTRODUCTION

Congress’s push to integrate drones into the national airspace has attracted billions in funding to explore new uses of low-altitude airspace by drones, drastically increasing the value of that airspace to society. However, current regulation significantly restricts the commercial exploitation of this airspace, and the absence of clear property rights has incited public animosity towards potentially intrusive drones. In response, there has been a flood of literature addressing, among other things, the property rights of landowners and whether those rights include the right to exclude drones from flying over their land, and if so, at what altitude does that right end. While much of this literature claims the common law doctrine of aerial trespass to be inadequate, the arguments are premised on the assumption that the goal of the traditional trespass to land doctrine is to protect landowners’ privacy rights, and therefore, the goal of aerial trespass should also be to protect these privacy rights.

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4. See Cohn et al., supra note 2 (stating that the most “vital” factor the future of drones depends on is the issue of public acceptance). “Attitudes may soften as drones become more common, but the industry has to build a lot of confidence before people will accept thousands of them flying overhead or board [drone] air taxis.” Id.
5. See generally Hillary B. Farber, Keep Out! The Efficacy of Trespass, Nuisance and Privacy Torts as Applied to Drones, 33 GA. ST. U. L. REV. 359, 380–92 (2017) (focusing on the application of legacy torts and whether they adequately protect privacy rights of
In an attempt to alleviate the public’s privacy concerns and minimize litigation between landowners and drone operators, the Uniform Law Commission (ULC) has taken it upon itself to redefine the property rights to this new, valuable resource by drafting an inflexible “bright[-]line” per se aerial trespass rule that cuts the commercially exploitable airspace in half, potentially stifling innovation if adopted. In the months following the ULC’s release of its draft Tort Law Relating to Drones Act, negative reactions by industry and commercial stakeholders led the ULC’s drafting committee to offer two alternatives in its next draft, released in October 2018. From an economic perspective, the likely side effect of such a rule is an inefficient allocation of this valuable resource, and therefore the rule—including its two proposed alternatives—should be rejected by state legislators. The economic analysis put forth in this Note is intended to provide a different perspective on the issues the ULC is responding to with its proposed rules and to highlight the potential economic side effects that might come from prematurely adopting such a rule without giving society time to adjust to an evolving drone industry that is still in its infancy.

Recognizing that tort law is a unique area of law that was judicially created by rational human beings with an innate sense of economic justice, this Note seeks to apply positive economic theory—derived from ex post analyses of tort cases—to an ex ante analysis to predict how and to what extent the existing and proposed aerial trespass rules will further economic efficiency in the context of drones and airspace rights. Part I will provide (1) an overview of the Federal Aviation Administration’s (FAA) current regulatory framework and the development of the common law aerial trespass doctrine and (2) an overview of the debate surrounding landowners’ property rights and drones by discussing the ULC’s proposed per se aerial trespass rule and the reactions of various stakeholders that led to the proposal of the two


6. See TORT LAW RELATING TO DRONES ACT prefatory note at 8 (UNIF. LAW COMM’N, Discussion Draft for Annual Meeting, 2018) [hereinafter Draft for Annual Meeting], https://www.uniformlaws.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=acc3dee9-7ab6-24e3-ee55-ad3e09a826ea&forceDialog=0 [https://perma.cc/WJL4-4NGS]. The ULC’s proposed trespass rule, Section 301, is supposedly intended to benefit both landowners and drone operators, as well as “ensure the success of the unmanned aircraft industry by helping to resolve issues related to public acceptance of this technology.” Id. at 10.

alternative rules mentioned above. Part II will attempt to clarify the property rights of landowners to the airspace above their land and argue that the ULC’s proposal is premised on a flawed assumption that aerial trespass should be treated as trespass to land. Part III will compare the economic efficiency of these proposed rules with the existing doctrine in place by applying an ex ante positive economic analysis to show that the common law doctrine of aerial trespass is economically superior to the ULC’s per se and alternative aerial trespass rules.

I. INTEGRATION OF DRONES INTO THE NATIONAL AIRSPACE & THE AERIAL TRESPASS DOCTRINE

In June 2016 the FAA concluded the first phase of its plan to integrate drones into the National Airspace System (NAS) by announcing its highly anticipated final rule for the operation and certification of small unmanned aircraft systems, more commonly known as drones. The rule, known as Part 107, establishes a framework that enables drone operations for commercial purposes without requiring an airworthiness certification or exemption. Building upon Part 107, a “foundational operating rule” that posed the least amount of public risk, the FAA will gradually develop regulations that deviate from the rule’s operational restrictions when such deviations would enable routine and safe operations.

The key provision of Part 107 that prompted questions surrounding landowners’ property rights and their ability to exclude drones from the airspace above their land is the operational height restriction. Unlike regulations for manned aircraft, which set minimum safe altitudes at 500 feet and above, Part 107 sets a maximum altitude of 400 feet above ground level (AGL)—or within a 400-foot radius of a structure—but no minimum. Because the FAA’s regulations focus on safety rather than privacy, states must determine whether their existing laws provide adequate legal remedies to landowners against intrusive drones. The technological capabilities of drones make it relatively easy for operators to capture images or videos of the inside

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11. Draft for Annual Meeting, supra note 6, prefatory note at 3, 11. For the text of the regulation, see 14 C.F.R. § 107.51(b) (2019).
12. Operation and Certification of Small Unmanned Aircraft Systems, 81 Fed. Reg. at 42,190 (“[T]he FAA notes that its mission is to provide the safest, most efficient aerospace system in the world, and does not include regulating privacy.”).
of someone’s home without physically trespassing on the property. Trespass, however, is one of the existing laws that policymakers and academics suggest should be modified to protect the privacy of landowners.

A. Aerial Trespass

Historically, airspace rights in the United States have been relatively static. The Supreme Court’s holding in United States v. Causby marked the one time in our history that these rights have been redefined. The widespread use of airplanes and the benefit of public transit that they provided necessitated further delineation of these rights.

Before Causby, airspace rights were defined by the *ad coelum* doctrine, which gave landowners, who had property rights to the surface of the land, property rights to the airspace above the land, “stretching indefinitely up to the sky,” as part of their bundle of rights to the surface. The property line boundaries determined who

14. Id. at 402.

The privacy concerns relating to drones stem from their capabilities. These aerial observers enable operators to gather information about people and places via cameras, live video-streaming capability, and sensory-enhancing technologies that can be mounted to the drone. The drones’ aerial positioning makes it difficult for anyone without prior notice to avoid being caught on their cameras. Id. at 362.

15. See infra note 38 and accompanying text.

16. See, e.g., Robert A. Hazel, Privacy and Trade Secret Law Applied to Drones: An Economic Analysis, 19 COLUM. SCI. & TECH. L. REV. 340, 363 (2018) (“[V]ertical property rights should emerge or, in this case, re-emerge below 200 feet. At this altitude, drone operations should be considered a trespass and property owners should be permitted to exclude them.”). Robert Hazel’s argument for trespass below 200 feet is entirely dependent on the assumption that drone operations below this altitude impose “much higher privacy costs while offering minimal additional economic benefits.” Id. at 362. Unfortunately, Hazel does not cite any evidence to support this assumption. Moreover, Hazel recognizes that the increasingly sophisticated cameras drones can carry are capable of capturing the same detailed images a normal camera could at thirty feet but at an altitude above 200 feet, requiring the separate tort of intrusion upon seclusion to protect the privacy of landowners. Id. at 352, 374. Thus, this leaves the “unnerving” presence of drones at lower altitudes as the only argument left to support his trespass argument. See id. at 362. However, “a cause of action that is dependent on proximity to real property is of little or no utility in the drone context.” Farber, supra note 5, at 389.

17. 328 U.S. 256, 266 (1946) (holding that the flights of various military aircraft—bombers, transports, and fighter jets—over the plaintiffs’ land constituted a taking because they were “so low and so frequent as to be a direct and immediate interference with the enjoyment and use of the land”).

18. See infra notes 25 and accompanying text.


20. The *ad coelum* doctrine is the more commonly known name for the phrase “*Cujus est solum, ejus est usque ad coelum, or “[t]o whosoever the soil belongs, he owns also to the sky . . . .”* Id. at 166 (quoting *Cujus est solum, ejus est usque ad coelum*, BLACK’S LAW
owned what column of air. This old English doctrine remained the law until 1946, when the \textit{Causby} Court held that the doctrine had “no place in the modern world.”

Recognizing that “[t]he airplane is part of the modern environment of life, and the inconveniences which it causes are normally not compensable,” the Court justified Congress’s declaration that the navigable airspace is a “public highway” because the recognition of “private claims to the airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim.” \textit{Causby} made it clear that, according to Congress’s definition of “navigable airspace,” all airspace 500 feet and above was public airspace. The Court, however, was less clear about who owned the airspace below 500 feet, stating that landowners held exclusive rights to airspace within the “immediate reaches” of their land. The Court declined to determine the precise altitude that the “immediate reaches” ended and the navigable airspace began.

Prior to the arrival of drones, the \textit{Causby} Court’s decision not to define the immediate reaches had not been problematic because FAA regulations set a minimum altitude for manned aircraft at 500 feet, excluding takeoff and landing. The aerial trespass doctrine was created against this backdrop of laws and regulations that have traditionally ensured that most manned aircraft would fly at safe distances from people and property in high-altitude airspace. For safe operations of drones, on the other hand, the FAA has determined that drones should be operated in low-altitude airspace, away from manned aircraft. In aerial trespass cases, “[f]light by [an] aircraft in the air space above the land of another is a trespass if, but only if, (a) it enters into the immediate reaches of the air space next to the land, and (b) it interferes substantially with the other’s use and enjoyment of his land.”

\begin{itemize}
  \item 21. See Rule, supra note 19, at 166 (stating that the \textit{ad coelum} doctrine “assigned airspace rights based on ownership of the surface land situated immediately below the space”).
  \item 23. \textit{Id}. at 266.
  \item 25. \textit{Causby}, 328 U.S. at 261.
  \item 26. \textit{Id}. at 260, 263, 266 (“The airspace, apart from the immediate reaches above the land, is part of the public domain.”).
  \item 27. \textit{Id}. at 264.
  \item 28. \textit{Id}. at 266.
  \item 29. Draft for Annual Meeting, supra note 6, prefatory note at 1, 11.
  \item 30. \textit{Id}.
  \item 31. See \textit{id}; see also supra note 11 and accompanying text.
  \item 32. \textit{Restatement (Second) of Torts} § 159(2) (AM. LAW INST. 1965) (emphasis added). The development of the aerial trespass doctrine by the federal courts is based primarily on \textit{Causby}, even though it was a Fifth Amendment takings case. See \textit{id}. at § 159(2) reporter’s notes to subsec. (2) (stating that aerial trespass is based primarily on \textit{Causby}) ; see also id. at § 159(2) cmt. k (stating that subsequent federal cases have limited aerial trespass to cases such
B. The ULC’s Tort Law Relating to Drones Act

The Causby decision has historically only been relevant in subsequent takings cases where a public airport, owned by a state or local government, was so close to privately occupied land that the glide path of aircraft taking off and landing at the airport was so low that it interfered with the use and enjoyment of private land.\(^\text{33}\) Today, the emergence of drones, “which operate in greater numbers and much closer to the ground than manned aircraft,” has necessitated a reevaluation of the concept of “immediate reaches” as it pertains to the common law aerial trespass doctrine.\(^\text{34}\) The proponents of the ULC’s bright-line per se aerial trespass rule argue that the existing doctrine will result in costly litigation and fail to protect landowners from intrusive drones.\(^\text{35}\)

1. Per Se Aerial Trespass

The proposed per se aerial trespass rule was discussed at the National Conference of Commissioners on Uniform State Laws in July 2018.\(^\text{36}\) The language of the rule is as follows:

A person operating an unmanned aircraft is liable to a land owner or lessee for per se aerial trespass, when the person, without consent, intentionally causes the unmanned aircraft to enter into the airspace below [200] feet above the surface of land or below [200] feet above improvements built upon the surface of land.\(^\text{37}\)

The rationale for the rule is “premised upon a conclusion that laws crafted specifically for manned aircraft do not adequately provide clarity or uniformity” needed to address “the ability of drones to enter low altitude airspace adjacent to property” and “to surreptitiously gather information in a manner that may be

as Causby, “so that, even though there is a flight below the prescribed minimum altitude, there is no trespass unless there is such interference with actual, as distinguished from potential, use” of land).

33. \textit{See}, e.g., Griggs v. Allegheny Cty., 369 U.S. 84 (1962). After \textit{Causby}, Congress enacted the Federal Aviation Act of 1958, which redefined “navigable airspace” to mean “airspace above the minimum altitudes of flight prescribed by regulations . . . and shall include airspace needed to [e]nsure safety in take-off and landing of aircraft.” \textit{Pub. L. 85-726, 72 Stat. 731, 739} (1958). In Griggs, the Supreme Court held that a taking had occurred even though the landing planes were within the navigable airspace as Congress redefined it in 1958. \textit{Griggs}, 369 U.S. at 88–90.

34. \textit{Draft for Annual Meeting, supra} note 6, prefatory note at 1.

35. For a summary of the arguments supporting this proposition, see \textit{id.} prefatory note at 3–8.

36. \textit{See id.} For a list of the drafting committee members and an archive of current and previous drafts, see \textit{Tort Law Relating to Drones Committee, UNIFORM L. COMMISSION} (2017), https://www.uniformlaws.org/committees/community-home?CommunityKey=2cb85e0d-0a32-4182-adee-e15c7e1eb20 [https://perma.cc/MNC4-JSQ9].

37. \textit{Draft for Annual Meeting, supra} note 6, § 301(a).
offensive to a reasonable person.” The drafting committee concluded that the existing aerial trespass doctrine “operates more like a nuisance suit than a right to exclude” because it requires proof of harm (a showing of substantial interference) that, when applied to drones, “will likely not allow for a right of exclusion of [drones] at nearly any altitude, thereby swallowing property rights and engendering public backlash against drone operators.”

2. Industry Reaction

The drone community, particularly companies and associations representing the drone industry, criticized the proposals in the draft act on three grounds. First, the opponents of the draft act argue that the per se aerial trespass rule, which creates a “No Fly zone” below 200 feet, would be preempted because the federal government has exclusive authority to regulate aircraft flight, including altitude. The second argument is that existing tort law doctrines—battery, intrusion upon seclusion, nuisance, and trespass—are more than adequate and the drafting committee’s deliberate choice to base the per se rule on physical trespass to land, and to give landowners an absolute right to exclude drones, creates an “inflexible line in the sky” that is ill-informed and inconsistent with existing tort law on aerial trespass. The

39. Id. at 4–5.
43. All. for Drone Innovation et al., Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, supra note 40, at 2.
committee has expressly acknowledged that drones do not cause the kind of harm (substantial interference) that traditional aerial trespass recognizes, particularly from noise.\textsuperscript{44} Rather than acknowledge the implications of the lack of harm—that there is no need for a law that restricts an activity that does not cause cognizable harm—the committee chose to redefine the law so that no interference or impact on the landowner’s use and enjoyment of the land is required; the mere presence of a drone causes per se harm.\textsuperscript{45}

Lastly, they argue that the per se rule would increase litigation rather than reduce it and fails to strike an appropriate balance between innovation and personal privacy.\textsuperscript{46} The rule will not reduce litigation because it is “premised on the flawed notion that [it] will eliminate the need for ‘a fact-specific inquiry which has historically caused uncertainty and a lack of uniformity.’”\textsuperscript{47} To the contrary, the certainty provided by a uniform “line in the sky” is illusory because any claim brought under the proposed rule would still require a fact-specific inquiry to determine whether the drone was in fact over the claimant’s property, whether consent was given, and whether the drone was at an altitude below 200 feet.\textsuperscript{48} While a fact-specific inquiry under the per se rule may at first be less costly than one that must determine whether substantial interference occurred, “the technological components of a holistic drone integration and aerospace management regime will certainly include remote ID and UAS traffic management systems, with forensic accuracy and reliability, which will make fact-finding a trivial operation” in either scenario.\textsuperscript{49} Instead, the proposed per se rule “would shift the burden of proof to drone operators,”\textsuperscript{50} increasing the likelihood that landowners will file erroneous claims.\textsuperscript{51}

\begin{itemize}
\item \textsuperscript{44} Id.; see also Draft for Annual Meeting, \textit{supra} note 6, prefatory note at 7 (stating that courts have found that noise alone is not substantial interference in aerial trespass cases).
\item \textsuperscript{46} All. for Drone Innovation et al., Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, \textit{supra} note 40, at 1–2.
\item \textsuperscript{47} Comment from Acad. of Model Aeronautics et al., \textit{supra} note 45, at 2 (citing Draft for Annual Meeting, \textit{supra} note 6, at 5).
\item \textsuperscript{48} Id.
\item \textsuperscript{50} WhiteFox Def. Techs., Inc., Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, \textit{supra} 49, at 1.
\item \textsuperscript{51} Nat’l Press Photographers Ass’n, Comment Letter on Proposed Uniform Tort Law Relating to Drones Act (July 24, 2018), https://www.uniformlaws.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=7408559f-8737-faa-7d02-7e957c2c83a9&forceDialog=0 [https://perma.cc/Q6CB-BHNM]. The difference between existing doctrine
and “eviscerate the social and commercial benefits of drones.” The existing doctrine, on the other hand, permits courts to consider both the rights of private property owners to the use and enjoyment of their property as well as the public interest in the integration of drones into the national airspace, thereby striking a balance between innovation and personal privacy.

In general, the opponents of the per se rule do not dismiss the need for regulatory and legislative reform that clarifies the responsibilities of drone operators and protects the public’s reasonable interests in privacy. Instead, they believe that Congress, and thus the FAA, should have the exclusive authority to regulate so as to avoid an unbalanced and inflexible legal landscape that stifles innovation. Although landowners have a reasonable right to ensure their property is safe from disruptive interference with their use and enjoyment of land, “the moral entitlements of a person to the enjoyment of their land (i.e. the grounds for their reasonable complaint against trespass) are technologically contextual”—that is, they depend on the technology currently available and in widespread use.

II. COMMON LAW AERIAL TRESPASS AND PROPERTY RIGHTS POST-CAUSBY

In general, the ULC’s bright-line per se aerial trespass rule is supported by two arguments. First, it is argued that there is a lack of clarity regarding landowners’ property rights due to the ambiguity of the term “immediate reaches.” Second, it is argued that the existing doctrine inadequately protects landowners’ property rights because the proof of harm requirement (substantial interference) operates more like a nuisance suit, a claim for compensation for harm suffered, rather than traditional trespass to land, which stems from the landowner’s right to exclude. The goal of Section II.A is to shed some light on the current state of landowners’ property rights and a per se rule is the per se rule will lead to more litigation because landowners would be more likely to file erroneous claims either because of their own inaccurate assessments of the drone’s location, id., or just because they can, even though the drone did not cause any harm and merely zipped across the property at an altitude just above the tree line.

54. WhiteFox Def. Techs., Inc., Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, supra note 49, at 1; see also supra note 38 and accompanying text (quoting the drafting committee’s rationale for the per se rule, which is premised on the need to protect reasonable interests in privacy).
56. See supra note 35 and accompanying text.
57. See supra notes 34, 38 and accompanying text; see RESTATEMENT (SECOND) OF TORTS § 159(2) (AM. LAW INST. 1965) (stating that aerial trespass requires a showing that the drone entered into the “immediate reaches” of private land).
58. See supra note 39 and accompanying text. But see supra note 45 and accompanying text.
after *Causby*. Section II.B will argue that the ULC’s inadequacy argument is premised on a flawed assumption that aerial trespass should be treated as trespass to land.

### A. Clarification of Property Rights Under *Causby*

Generally, landowners have the right to exclusive use and control of their land, which, prior to *Causby*, was thought to include all airspace from the surface and above.\(^{59}\) In *Causby*, the Supreme Court, by quickly dismissing the “ancient” *ad coelum* doctrine,\(^{60}\) subconsciously (if not consciously) recognized that changes in technology had given rise to a more efficient use of that airspace,\(^{61}\) and as such, the optimal level of interference with the use and enjoyment of the private land below was no longer zero.\(^{62}\) The problem, however, is that the landowners had suffered a substantial amount of harm\(^{63}\) and the Court could not compensate the landowners for that harm under traditional tort doctrines because the government is protected from tort liability under the doctrine of sovereign immunity.\(^{64}\) If it were not for the significance of the harm suffered by the landowner, the Court “could have simply allowed the government to invade the Causby’s airspace without paying any compensation” and the taking would have still been an efficient reallocation of resources.\(^{65}\)

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59. See supra notes 19–21 and accompanying text.
61. See DAVID W. BARNES & LYNN A. STOUT, THE ECONOMIC ANALYSIS OF TORT LAW 15 (1992) (stating that the reallocation of airspace in *Causby* was “almost certainly wealth maximizing” (i.e., efficient) because the landowners’ loss “was a necessary sacrifice”).
62. See infra note 149 and accompanying text (discussing the effects of changes in technology on the optimal level of harm caused by an activity).
63. See *Causby*, 328 U.S. at 259 (stating that military bombers and fighter jets flew so low over the landowners’ property that they scared the landowners’ chickens to death, literally).
64. Justice Black, in his dissenting opinion in *Causby*, made some compelling arguments that seem to support the proposition that the creation of new property rights, or the adjustment of property rights to airspace, is limited to federal regulation and that the role of common law, and the courts, is to protect, not create, property rights. See *Causby*, 328 U.S. at 271 (Black, J., dissenting). Justice Black argued that if it were not for sovereign immunity, the landowners’ remedy would have been based in tort—i.e. nuisance, a violation of statute, or negligence—and that the “future adjustment of the rights and remedies of property owners, which might be found necessary because of the . . . imminent expansion of air navigation, [should] be left where . . . the Constitution left it, with Congress.” Id.; see also Draft for Drafting Committee Meeting, *supra* note 7, prefatory note at 5 (“It was not clear whether the Court ordered compensation based on a trespass theory—because the overflights penetrated the Causbys’ airspace—or based on a nuisance theory—because the flights substantially interfered with the Causbys’ use and enjoyment of their land.”) (quoting James C. Smith, *Airspace, in NEIGHBORING PROPERTY OWNERS § 5:03* (1988)).
65. BARNES & STOUT, *supra* note 61, at 15. “A reallocation without compensation may also maximize utility and wealth. If a decisionmaker (such as a court or legislature) knows for certain which resource use generates the most utility or is valued most highly then compensation is unnecessary.” Id.
Instead, the Court tried to reach a “just” conclusion by shortening the airspace “stick” in the “bundle of sticks” that accompany ownership of land, rather than eliminating the stick altogether. The Court reasoned that “if the landowner is to have full enjoyment of the land, he must have exclusive control of the immediate reaches of the enveloping atmosphere. Otherwise buildings could not be erected, trees could not be planted, and even fences could not be run.” Thus, “[t]he landowner owns at least as much of the space above the ground as [they] can occupy or use in connection with the land.”

The Court, in providing an example of the erection of an elevated railway over private property in which none of the supports touch the land, stated this would also be a taking because it would “subtract from the owner’s full enjoyment of the property and . . . limit his exploitation of it.” The Court not only recognized that the right to exclusive control of the immediate reaches arises out of its connection to the ownership of land but also recognized that the economic use of the land depends on maintaining exclusive control. Thus, the Court redefined property rights by separating one resource, land, from another, public airspace.

After Causby, the only change to landowners’ property rights was the redefinition—from ownership of the entire sky above the property to ownership of the enveloping atmosphere—of a particular right in the bundle of rights attached to the land. Causby did not result in any changes to the legal remedies landowners have against private actors who interfere with those rights. Drones may lawfully occupy all airspace apart from the immediate reaches of private land and below 400 feet above ground level (AGL). For example, suppose that the definition of “immediate reaches” is perfectly clear and unambiguous. Drone operators would be liable under traditional trespass doctrine if the drone crosses into the immediate reaches. Similarly, drone operators could still be liable under private nuisance laws, even if the drone never crosses over into the immediate reaches.

The problem only arises because of the ambiguity of the term, which has its advantages and disadvantages. The biggest advantage is by far the opportunity to supplement the Causby holding with more flexible liability rules (as opposed to redefining property rights) in coordination with a “robust, creative, and multi-pronged solution” that includes “technological innovation, cultural change and, when

66. By asserting that the ad coelum doctrine had “no place in the modern world” and upholding Congress’s declaration that the navigable airspace is public airspace—that is, all airspace at least 500 feet AGL and above—the Court effectively shortened the airspace “stick” in the “bundle of sticks.” See supra Section I.A.
67. Causby, 328 U.S. at 264.
68. Id. (emphasis added).
69. Id. at 265 (emphasis added).
70. See supra notes 17–21 and accompanying text.
71. See supra note 11 and accompanying text. This is a general statement pertaining to property rights and is premised on an implied assumption that the drone operator is not violating any other law or regulation, including certain airspace restrictions. See 14 C.F.R. § 107.41 (2019).
72. This assumes there is a cognizable harm that amounts to substantial interference. See supra note 45 and accompanying text.
appropriate, regulation.” The biggest disadvantage is the potential exploitation of the ambiguity for the creation of inflexible and inefficient property rights.

**B. The Aerial Trespass Doctrine Is Economically Indistinguishable from Nuisance**

The ULC, citing Professors A. Michael Froomkin and P. Zak Colangelo, argues that common law aerial trespass “confla[es]” the strict liability rule of trespass to land with the rule of nuisance by superimposing the requirement of actual harm. The doctrine was created through subsequent courts’ readings of *Causby* to require actual interference with the landowner’s “actual use, as distinguished from potential use or bare possession.” The ULC, quoting Froomkin and Colangelo, suggests that “[t]here is no obvious reason why the interference requirement should be as strict in a trespass claim. If aerial trespass genuinely is to be treated like terrestrial trespass, then all that should be required is entrance into that part of the airspace that remains fully private.” This last sentence highlights a flawed underlying assumption in the ULC’s proposed aerial trespass rules—that aerial trespass should be treated the same as trespass to land.

The distinction between traditional trespass to land and nuisance is that “[a] trespass is an invasion of the interest in the exclusive possession of land,” whereas “[a] nuisance is an interference with the interest in the private use and enjoyment of the land, and does not require interference [w]ith the possession.” The ULC’s proposals rest on the assumption that landowners have, or should have, a possessory interest in the airspace above their land. However, a logical interpretation of the Supreme Court’s opinion in *Causby* suggests that the Court’s holding was an attempt to distinguish between landowners’ exclusive possessory interests in land and the airspace that is public domain. Landowners have a possessory interest in the

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73. WhiteFox Def. Techs., Inc., Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, supra 49, at 1. “For example, innovations in UAS traffic management and remote ID are critical parts of the effort to integrate drones into the national airspace, as are regulatory and legislative reform that clarify responsibility for drone operators and protect reasonable public interests in security and privacy.” *Id.* (emphasis added). For a discussion of property rights and liability rules, see *infra* Section III.A.

74. Draft for Drafting Committee Meeting, supra note 7, prefatory note at 3.

75. Pueblo of Sandia ex rel. Chaves v. Smith, 497 F.2d 1043, 1045 (10th Cir. 1974) (emphasis added); see also Draft for Drafting Committee Meeting, supra note 7, prefatory note at 4 (quoting excerpt from A. Michael Froomkin & P. Zak Colangelo, *Self-Defense Against Robots and Drones*, 48 CONN. L. REV. 1, 28 (2015)).

76. Draft for Drafting Committee Meeting, supra note 7, prefatory note at 4 (quoting Froomkin & Colangelo, supra note 75, at 69).

77. *Id.* at 2 (“This Act follows as closely as possible the existing precedents which have traditionally governed trespass to land.”); see also supra notes 38–39 and accompanying text.

78. RESTATEMENT (SECOND) OF Torts § 821D cmt. d (1979) (emphasis added).

79. See Draft for Drafting Committee Meeting, supra note 7, § 301 cmt. (emphasis added) (“The right to exclude others from one’s airspace serves . . . to protect privacy interests of possessors of land.”) (quoting James C. Smith, supra note 64, at § 5:3).

80. See *supra* notes 68–69 and accompanying text. The support for the per se rule that the ULC has included in its draft Tort Law Relating to Drones Act only incorporates specific language of the *Causby* holding that supports its argument. When the facts and circumstances
airspace above their land only to the extent that they can “occupy or use [it] in connection with the land.”\textsuperscript{81} Absent a more precise definition of “immediate reaches,” this possessory interest is indistinguishable from the right to the use and enjoyment of land. Hence the need to require actual interference with an actual use of the land.

Moreover, the substantial interference requirement in nuisance cases “operates to screen out a host of nuisance actions where the costs of the nuisance, if not necessarily lower than those of abating the nuisance, probably are lower than the sum of those costs plus the costs of using the legal system.”\textsuperscript{82} In the context of drones, the requirement of substantial interference will screen out legal claims where the cost of interference to the landowner is less than the cost of abating the nuisance—the decrease in the net benefit to drone operators through a reduction in the level of drone activity\textsuperscript{83}—plus the costs of using the legal system.

Additionally, courts have rejected a strict liability approach in favor of a cost-benefit approach to traditional land use conflicts. Private nuisance actions require a showing that the activity was unreasonable, which is “unmistakably [an] economic analysis of nuisance.”\textsuperscript{84} The First Restatement of Torts states that “an intentional invasion of another’s interest in the use and enjoyment of land is unreasonable . . . unless the utility of the actor’s conduct outweighs the gravity of the harm.”\textsuperscript{85} The Second Restatement of Torts provided an alternative test that would allow the plaintiff to “show that the cost of abatement, although it might exceed the benefits, would not drive the defendant out of business.”\textsuperscript{86} The alternative test offered by the Second Restatement of Torts is not accepted by most courts and “is inefficient, surrounding the case are also considered with the entire holding, the \textit{Causby} opinion cannot logically be interpreted to support a bright-line per se rule. \textit{See supra} Section II.A (interpreting \textit{Causby} and its implications on property rights). For example, the ULC’s draft quotes \textit{Causby} as follows: “The airspace, apart from the immediate reaches above the land, is part of the public domain. We need not determine at this time what those precise limits are.” Draft for Annual Meeting, \textit{supra} note 6, prefatory note at 1 (emphasis in original). However, the immediately preceding sentence states that “[t]he airplane is part of the modern environment of life, and the inconveniences which it causes are normally not compensable under the Fifth Amendment.” \textit{United States v. Causby}, 328 U.S. 256, 266 (1946). Moreover, the sentence immediately following the ULC’s quote states that “[f]lights over private land are not a taking, unless they are so low and so frequent as to be a direct and immediate interference with the enjoyment and use of the land.” \textit{Id.} If it would not be compensable under the Fifth Amendment if the government were doing it, then what obvious reason is there for it to be compensable under trespass if civilians were doing the very same thing? That is, why shouldn’t we interpret \textit{Causby} to mean that the “immediate reaches,” as it pertains to aerial trespass and drones, is the point at which frequent drone operations over private land would be a direct and immediate interference with the enjoyment and use of the land, thereby requiring actual interference to establish aerial trespass.

\textsuperscript{81} \textit{Causby}, 328 U.S. at 264 (emphasis added).

\textsuperscript{82} \textsc{William M. Landes} \& \textsc{Richard A. Posner}, \textsc{The Economic Structure of Tort Law} 49 (1987).

\textsuperscript{83} \textit{See infra} note 183 and accompanying text.

\textsuperscript{84} \textsc{Landes} \& \textsc{Posner}, \textit{supra} note 82, at 49.

\textsuperscript{85} \textit{Id.} at 49 n.29 (quoting \textsc{Restatement (First) of Torts} § 826 (\textsc{Am. Law. Inst.} 1939)).

\textsuperscript{86} \textit{Id.} (citing \textsc{Restatement (Second) of Torts} § 826(b) (\textsc{Am. Law. Inst.} 1979)).
because it amounts to strict liability (subject to the limitation that it not be crushing).87 Since the judicially created doctrine of nuisance was developed with economic considerations in mind, perhaps the judicially created doctrine of aerial trespass resembles nuisance because it was also created with economic considerations in mind.88 Subsequent courts’ citations to Causby might reflect nothing more than a preference to rely upon a Supreme Court decision, which “requires” them to take economic considerations (substantial interference) into account, rather than explicitly stating they are engaging in a cost-benefit analysis equivalent to that of nuisance.89

III. ECONOMIC ANALYSIS OF AERIAL TRESPASS

The method of analysis used in this Note is based on a positive economic theory of law—the theory that common law rules can best be explained as if they were designed to increase economic efficiency.90 The positive economic theory of tort law—first articulated by Richard A. Posner and William M. Landes in 1987—suggests that “the common law of torts is best explained as if the judges who created the law through decisions operating as precedents in later cases were trying to promote efficient resource allocation.”91 Posner and Landes tested this theory through an ex post review and analysis of tort cases.92 An ex post positive economic analysis seeks to explain existing common law rules “by demonstrating how and to what extent [the] existing doctrines further economic efficiency.”93 In other words, an ex post positive economic analysis seeks to explain known data.94 This Part seeks to apply an ex ante positive economic analysis—applying a theory that has been tested on known data to a new context with limited known data—to predict how and

87. Id. at 49–50 n.29 (citing several sources that support the propositions that the First Restatement’s test is still the standard and that few cases cite the alternative whereas many cite the first).
88. See supra Section II.A (arguing that the Causby Court’s redefinition of landowners’ property rights in the airspace above their land was the product of the Court’s recognition that changes in technology had given rise to a more efficient use of that airspace and the Court’s desire to compensate a landowner that had suffered a substantial loss).
89. Most would agree the Causby decision has no precedential authority in aerial trespass cases, only takings cases. See Draft for Annual Meeting, supra note 6, prefatory note at 4 (quoting Froomkin & Colangelo, supra note 75, at 69).
90. LANDES & POSNER, supra note 82, at 1. For a summarization of the numerous studies that support this theory, see RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW pt. II (9th ed. 2014).
91. LANDES & POSNER, supra note 82, at 1.
92. Landes and Posner applied their theory to the entire field of tort law by using simple economic models of alternative liability rules to predict which specific rules of tort law would be adopted to promote efficiency and comparing those predictions with the actual rules adopted in a representative sample of tort cases. See id. at 22.
94. See LANDES & POSNER, supra note 82, at 22.
to what extent the existing aerial trespass doctrine, and proposed aerial trespass rules, will further economic efficiency in the context of drones and airspace rights.\textsuperscript{95}

For the purposes of this Note, "economics" is defined as the "science of rational choice or (equivalently) as the attempt to get the most from scarce resources."\textsuperscript{96} An economic analysis reaches a conclusion as to the efficient allocation of resources among competing uses by allocating the resources to those members of society who will "get the most" out of them.\textsuperscript{97} The economic unit of measurement that economists seek to maximize to get the most out of a resource is "utility"—happiness, pleasure or satisfaction that is derived from the use of the resource.\textsuperscript{98} However, it is impossible to measure a person’s level of utility and, even if it were possible, one cannot compare the value of one person’s utility to the utility of another.\textsuperscript{99} Wealth, on the other hand, is much easier to quantify by observing an individuals’ relative willingness and ability to pay for some right(s) to a particular resource, or, conversely, what they demand in exchange for giving up some right(s) they possess in that resource.\textsuperscript{100} Thus, for the purposes of this Note, a policy change is efficient if it is wealth maximizing, that is, “if the dollar value of the gains to the winners is greater than the dollar cost of the losses to the losers.”\textsuperscript{101}

A. Property Rights v. Liability Rules

To properly analyze and compare the common law aerial trespass doctrine with the ULC’s proposed per se aerial trespass rule (and the alternatives), it is necessary to distinguish between property rules and liability rules as methods for protecting property rights.\textsuperscript{102} A property rule creates an "exclusive right to the use, control, and enjoyment of some resource—that is, a right to exclude anyone else in the world from using the resource without the consent of the owner of the right . . . ."\textsuperscript{103} Property rights give the rights holder the right to exclude, notwithstanding the argument that “the general welfare, whether defined in economic or in any other terms, would be increased by transferring the right to someone else.”\textsuperscript{104} A liability rule does not create

\textsuperscript{95} See Christine Jolls, Cass R. Sunstein & Richard Thaler, \textit{A Behavioral Approach to Law and Economics}, 50 STAN. L. REV. 1471, 1522 (1998) (stating that a positive economic analysis of law seeks to explain “what the effects of law will be and why we have the laws we do”); see also BARNES & STOUT, supra note 61, at 1 (“Applying economic principles to legal problems brings a better understanding of the implications of legal rules.”).

\textsuperscript{96} LANDES & POSNER, supra note 82, at 23.

\textsuperscript{97} BARNES & STOUT, supra note 61, at 1–2, 4.

\textsuperscript{98} Id. at 4, 11.

\textsuperscript{99} Id. at 9–10.

\textsuperscript{100} See id. at 10; see also POSNER, supra note 90, at 16 (discussing the economic concept of “wealth”).

\textsuperscript{101} LANDES & POSNER, supra note 82, at 16.


\textsuperscript{103} LANDES & POSNER, supra note 82, at 29.

\textsuperscript{104} Id.
a right to exclude; instead, it creates only a right to claim damages caused by another’s activity that damages the resource or otherwise interferes with the rights holder’s use of that resource.\textsuperscript{105} Thus, a property rule protects property rights by requiring the consent of the rights holder to permit the transfer of rights—generally through a voluntary exchange—whereas a liability rule protects the property rights by permitting the transfer of rights without the consent of the rights holder, “conditioned on the payment of government-determined compensation for the rights taken.”\textsuperscript{106}

The distinction between property and liability rules has two important implications. First, the reallocation of resources in the property-rights approach requires a voluntary market transaction; the liability-rule approach allows for the reallocation of resources through the legal system, bypassing the market.\textsuperscript{107} Second, transaction costs play an important role in determining the efficiency of the applicable legal rules.\textsuperscript{108} The property approach is economically superior to the liability approach when the costs of voluntary market transactions are low because the market is deemed a more efficient mechanism for determining the relative values each party places on a particular right in a resource.\textsuperscript{109} In contrast, when transaction costs are high the property approach is economically inferior to the liability approach because the costs of effecting a transfer of rights will prevent the reallocation of resources to their most valuable uses.\textsuperscript{110} Recognizing these implications, a basic application of the Coase Theorem—that the efficient reallocation of resources is independent of the initial assignment of rights, provided that transaction costs are zero—can be used to reliably predict the relative efficiency of a proposed rule change.\textsuperscript{111}

B. The Coase Theorem and Transaction Costs

For simplicity, the microeconomic analysis put forth in this Note is based on the examples, models, and analyses provided by Landes and Posner, whereby they explain and expand upon the Coase Theorem.\textsuperscript{112} The context for the analysis in the

\textsuperscript{105} Id. at 30.
\textsuperscript{106} Merrill & Smith, supra note 102, at S79.
\textsuperscript{107} LANDES & POSNER, supra note 82, at 31.
\textsuperscript{108} For a more detailed discussion of transaction costs, see infra Section III.B.2.
\textsuperscript{109} LANDES & POSNER, supra note 82, at 31.
\textsuperscript{110} Id.
\textsuperscript{111} See id. at 31 (discussing the predictive implications of the distinction between property and liability rules and the presence of the distinction in the Coase Theorem); see also R. H. Coase, The Problem of Social Cost, 3 U. CHI. J.L. & ECON. 1–2 (1960). For a discussion of the accuracy of simple economic models, see LANDES & POSNER, supra note 82, at 12.
\textsuperscript{112} See generally LANDES & POSNER, supra note 82, at 31–53, 62–72. The illustrations and analysis presented in Section III.B are directly modeled after the examples provided by Landes and Posner with only minor adjustments in the variables used. See id. at 31–38. Section III.C expands upon this model by adapting the cost and benefit equations to illustrate the common law aerial trespass doctrine and incorporating the concepts employed by Landes and Posner in illustrating their “Model of Liability Rules.” See id. at 62–72. Additionally, the author has made similar adjustments to adapt the model to illustrate the ULC’s proposed alternative to the per se rule discussed in Section III.D.1.
subsequent Sections of this Note is as follows. Suppose the FAA amends all the necessary provisions of Part 107 to allow unrestricted drone operations for package delivery. Amazon Prime Air knows that it may fly its package delivery drones above 200 feet above ground level (AGL) without risk of liability for trespass or interfering with the use and enjoyment of private land. However, Amazon has determined that package delivery would be more profitable if its drones operated below 200 feet AGL because such operations would not only decrease last-mile shipping costs but also open up a new revenue stream from the new, or higher quality, data the drones can collect along a flight path at a lower altitude.

113. For simplicity, this Note assumes “unrestricted drone operations” to mean all operations that the FAA has determined can be safely conducted on a widespread basis, given the technology available. In other words, the FAA has determined that the commercial use of drones for package delivery can be safely implemented nationwide.


115. Because the controversy surrounding the ULC’s proposed rules is about drone operations below (as opposed to above) 200 feet AGL, this Note assumes, for the sake of simplicity, that no drone operations conducted above 200 feet AGL will result in liability from the drone operator, Amazon, to the owner of the private land below.

116. Amazon has stated that its drone delivery service will be used primarily for “last-mile” deliveries and for distances no more than fifteen miles and packages under five pounds. See Zachary Terry, Amazon Prime Air: Drone Delivery and Profits, SEEKING ALPHA (Feb. 28, 2017, 4:06 PM), https://seekingalpha.com/instablog/3009741-msu-eli-broad-student-research/4964322-amazon-prime-air-drone-delivery-profits [https://perma.cc/K46B-YM7V]. Comparing the estimated cost per mile for delivery by drone ($0.05) with the current cost per mile using the U.S. Postal System ($2), Amazon has the potential to decrease their last mile shipping costs by 97.5%. Id. In 2017, Amazon made more than five billion deliveries (including international shipments) to its Prime customers (who get free shipping), costing the company more than $20 billion in shipping costs. Jeff Desjardins, Amazon and UPS Are Betting Big on Drone Delivery, BUSINESS INSIDER (Mar. 11, 2018, 10:47 AM), https://www.businessinsider.com/amazon-and-ups-are-betting-big-on-drone-delivery-2018-3 [https://perma.cc/2HU3-BXFE]. Since 90% of the items Amazon sells weigh less than five pounds, id., there is a potential to save upwards of $6 billion annually on its last-mile shipping costs alone. See infra note 130 (Amazon shipped approximately 3.3 billion packages in the United States in 2017). Analysts estimate that Amazon could save $1.1 billion per year if it could implement drone delivery on a wide enough scale to no longer need to rely on FedEx or UPS. Terry, supra note 116. Moreover, Amazon prioritizes capturing market share over profits and is more likely to transfer most of these savings to its customers. Id.; see also Desjardins, supra note 116 (stating that 86% of abandoned online checkout carts are due to high shipping costs).

117. See Matthew Stern, Amazon’s Drones May Collect Valuable Data on Their Fly-overs, FORBES (Aug. 28, 2017, 8:05 AM), https://www.forbes.com/sites/retailwire/2017/08/28/amazons-drones-may-collect-valuable-data-on-their-fly-overs/#539b9caa6cbe [https://perma.cc/2VBU-LQ6R] (“Amazon has patented technology that allows a drone to scan and collect data from houses it passes on its flight path.”). For simplicity, this Note assumes that the data Amazon plans to collect with its drones either cannot be collected at an altitude above 200 feet or that flying below 200 feet would increase the quality or type of data the drone can collect, resulting in increased revenue. Furthermore, the privacy implications regarding data collection are beyond the scope of this Note.
Depending on the applicable laws—in addition to aerial trespass, nuisance, and other laws that may put Amazon at risk of liability—Amazon may choose to either (1) conduct a certain quantity \((Q)\) of drone operations below 200 feet AGL,\(^{118}\) or (2) refrain from all drone operations below 200 feet AGL and invest in its next best alternative activity. The net benefit \((NB)\) Amazon receives for \(Q\) drone operations represents its economic profits (as opposed to accounting profits)—the amount that Amazon’s revenues and cost savings exceeds its opportunity costs. The opportunity costs of an activity include both the costs of the resources used to generate revenue (e.g., labor and capital)—accounting profit is the amount of revenue that exceeds such costs—and the profits that could have been made by employing those resources to their next best alternative use.\(^{119}\) Thus, Amazon’s net benefit is a function of \(Q\) drone operations \((NB(Q)\) in Table 1 below), meaning the economic profits depend on the quantity of drone operations below 200 feet AGL. The marginal net benefit \((MNB_Q)\) is the incremental net benefit Amazon receives from one drone operation.\(^{120}\) Economics assumes that the marginal net benefits are initially positive but declining (the first drone operation is more profitable than the second and so on\(^{121}\)), and that they become zero at some point and negative thereafter.\(^{122}\) Notice that Amazon’s net benefit will be maximized at four drone operations, when the marginal net benefit for doing any additional operations is zero.

Now suppose that Amazon’s use of airspace below 200 feet AGL is incompatible with the landowner’s use of that airspace because it interferes with the landowner’s

\(^{118}\) While the analysis put forth in this Note expresses \(Q\) as discrete whole numbers, the quantity of drone operations is assumed to include all possible dimensions of drone operations below 200 feet AGL such as the altitude (or extent below 200 feet), the number of drone flights below 200 feet, and the amount of time a drone (individually or in aggregate) is above the landowner’s property.

\(^{119}\) See Posner, supra note 90, at 6. For Amazon’s drone delivery service, the costs of labor and capital might include the cost of the drones (including repair and maintenance), research and development of drone technology, and the labor needed to maintain and operate the drones. The next best alternative might be investing that capital in other delivery vehicles, such as delivery trucks (or electric delivery trucks) and hiring drivers/operators for those vehicles.

\(^{120}\) The equations used for net benefit and marginal net benefit are \(NB(Q) = 4Q - \frac{1}{2}Q^2\) and \(MNB_Q = 4 - Q\). These equations are chosen for simplicity and are the equations used by Landes and Posner. See Landes & Posner, supra note 82, at 31.

\(^{121}\) Although the law of diminishing returns, see infra note 122, is generally true for most activities, this may not be the case for Amazon due to network effects. Tech companies like Amazon, Google, and Facebook collect data from their customers/users that they use for marketing, customer service, and targeted advertising (as well as a host of other potential revenue-generating uses made possible by artificial intelligence). Thus, the more data that can be collected, the more valuable the data becomes. See Irving Wladawsky-Berger, The Rise of the Data Economy Is Triggering More Powerful Network Effects, WALL ST. J. (May 26, 2017, 11:34 AM), https://blogs.wsj.com/cio/2017/05/26/the-rise-of-the-data-economy-is-triggering-more-powerful-network-effects/ [https://perma.cc/Z86Q-8AAY].

use and enjoyment of land.123 Such interference—whether it be noise, invasion of privacy, or any other reason124—results in a cost to the landowner of $C(Q)$ and a marginal cost of $MC_Q$.125 Table 1 below illustrates the net and marginal net benefits to Amazon and the cost and marginal cost to the landowner of $Q$ drone operations.

Table 1

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<th>$C(Q)$</th>
<th>$MC_Q$</th>
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1. Conflicting Uses: Coase Theorem Illustrated in the Context of Drones

In determining how and to what extent a law furthers the efficient allocation of resources, it is important to address the following questions separately. First, whether a law results in the economically efficient allocation of resources necessarily depends on the quantity of a given activity that results in the optimal use of that resource. That is, what is the optimal quantity of drone operations that maximizes society’s net wealth? The answer can be derived from an application of the Coase Theorem.126 Second, whether the economically optimal use of a resource will result depends on who bears the costs of the decision to use that resource.127 The answer to these questions will determine whether property or liability rules (or some combination) are needed. This Section will answer the first question by showing the optimal quantity is not zero. Section III.C will determine the efficiency of the aerial trespass doctrine and the ULC’s proposed rules by measuring the extent that the cost of interference to landowners is internalized to drone operators.

123. For a discussion about incompatible uses and the Coase Theorem, see generally Posner, supra note 90, at 50, § 3.5. The problem of conflicting uses (or incompatible uses) arises when one party’s use of a resource interferes with another’s use of the same or different resource, provided both uses are allowed given the parties’ respective property rights. See Steven Shavell, Foundations of Economic Analysis of Law 77–78 (2004) (discussing the notion of external effects on the use of property).

124. Although issues surrounding privacy are beyond the scope of this Note, this Note assumes that drone operations below 200 feet AGL impose at least some costs to landowners’ privacy.

125. The equations used for cost and marginal cost ($C(Q) = (1/2)Q^2$ and $MC_Q = Q$) are the equations use by Landes & Posner, supra note 82, at 32.

126. See supra note 111 and accompanying text.

127. See Lloyd R. Cohen, The Public Trust Doctrine: An Economic Perspective, 29 Cal. W. L. Rev. 239, 260 (1992) (noting the importance of not confusing “the questions of who shall make the decisions on how property shall be used, and what those uses shall be, with the entirely separate question of who shall bear the costs of those decisions”).
Now, consider the situation where both Amazon and the private land the drone is operating over have a single owner, Jeff Bezos. Although Bezos will benefit from Amazon’s drone operations, the trade-off for this benefit is the cost of the interference with the use and enjoyment of his land. As a rational decision-maker, Bezos is incentivized to maximize his overall net wealth \( W(Q) \) in Table 1 above. Bezos’s wealth maximization formula is \( W(Q) = NB(Q) - C(Q) \) because Bezos’s opportunity cost of conducting \( Q \) drone operations is increased by the cost of interference with the use and enjoyment of his land, thereby decreasing the benefit he receives after taking these costs into account. Table 1 shows that Bezos’s net wealth is maximized when the quantity of drone operations is two, even though four drone operations maximizes Amazon’s net benefit. This is the optimal quantity—where the marginal net benefit to Amazon is equal to the marginal cost of interference to Bezos—because additional drone operations will result in an incremental net benefit that is less than the incremental cost of interference.

The microeconomic principles in this example can be aggregated to the macroeconomic level\(^{128}\) by using Amazon and Jeff Bezos as proxies for society as a whole; that is, using Amazon as a proxy for all commercial drone operations\(^{129}\) and Jeff Bezos as a proxy for all private landowners. Thus, the optimal quantity of drone operations reflects the optimal quantity that maximizes the net wealth of society. But rather than two drone operations across a single tract of private land, think two million drone operations across \( N \) tracts of land per week or per day.\(^{130}\)

Up to this point, no value has been placed on Bezos’s use and enjoyment of his privately owned land. Yet, the optimal quantity of drone operations is still two, regardless of the objective or subjective value of Bezos’s use and enjoyment of his land.\(^{131}\) This is true because the analysis is only concerned with the impact (the costs)

\(^{128}\) While micro- and macroeconomics differ in many respects, the primary difference is that microeconomics is grounded in core principles used among all economists, whereas economists in the macroeconomic field disagree on how to apply these core principles to a national or global level. See G. Chris Rodrigo, *Micro and Macro: The Economic Divide*, INT’L MONETARY FUND, [https://www.imf.org/external/pubs/ft/fandd/basics/bigsmall.htm](https://perma.cc/HM23-G3WX) (last updated Dec. 18, 2018) (stating that many macroeconomic models are grounded in microeconomic principles).

\(^{129}\) For information on the current commercial uses of drones, see [FORECASTS & PERFORMANCE ANALYSIS DIV., FAA, FAA AEROSPACE FORECAST: FISCAL YEARS 2018-2038](https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/fy2018-38_faa_aerospace_forecast.pdf) [https://perma.cc/QK3S-7GEC]. For potential uses, see generally Rohit Jaggi, *Air Taxis Could Be the Next Big Thing in Aviation*, BARRON’S (July 20, 2018, 12:49 PM), [https://www.barrons.com/articles/air-taxis-could-be-the-next-big-thing-in-aviation-1532105388](https://perma.cc/CR32-XNQL); Marcontell & Douglas, supra note 3; see also Cohn, et al., supra note 2, at Exhibit 3 (illustrating potential drone applications).


\(^{131}\) This is true only if we assume the use and enjoyment of land cannot be negative. That is, the damage to land in general cannot be more than the land is worth (otherwise, a rational landowner would abandon the land—i.e., move). This differs from the example illustrated by
of the drone operations on Bezos’s right to the use and enjoyment of his land. To illustrate this point, suppose Bezos values this right at $10. Notice this is higher than the value Amazon would place on the right to freely conduct drone operations without any liability. Absent liability, for trespass or otherwise, Amazon’s net benefit is maximized at four drone operations, resulting in a net benefit of $8. Conducting any more drone operations would be inefficient from Amazon’s perspective because the opportunity cost exceeds the incremental benefit Amazon would receive, meaning Amazon would be better off employing its resources in another activity that generates a greater net benefit.

At two drone operations, if Jeff Bezos owns both Amazon and the affected land, Bezos’s net wealth is $14 ($6 in Amazon profits plus $10 of use and enjoyment of the land minus $2 for the interference caused by the drones). If Amazon is forced to shut down its drone operations, Bezos’s wealth falls to $10—the value he places on the use and enjoyment of the land. If Bezos is forced to move to allow Amazon to conduct four drone operations, Amazon’s profits would rise to $8, but it would cost Bezos $10 in the use and enjoyment of his land. On the other hand, suppose that Bezos only valued the use and enjoyment of his land at $3. Bezos’s net wealth would still be maximized at $7, if Amazon conducted two drone operations ($6 in Amazon profits, plus $3 of use and enjoyment of the land, minus $2 for the interference caused by the drones). The next best quantity, four drone operations, results in a net wealth of $5 ($8 in Amazon profits less $3 in use and enjoyment of land).

Prior to Coase, the prevailing economic thought would have been that unless Amazon and the private tract of land were under common ownership, giving Amazon the right to fly drones over private property without any liability for interference with the use and enjoyment of land below would generate an externality—shown as the deadweight loss (DWL) to society in Figure 1 below.

Landes and Posner where the conflicting uses are both commercial, and thus, the damage can be greater than the profits earned. See Landes & Posner, supra note 82, at 33–34.

132. See supra note 119 and accompanying text.

133. See Landes & Posner, supra note 82, at 33 (using the combination of two commercial enterprises, farmland, and an adjacent railroad that causes damage to the farmer’s crops when the rail cars emit sparks as they pass by to illustrate the concept: “At two trains per day the combined enterprise earns $14 in profits ($6 in railroad profits minus $2 in crop damages plus $10 in farm profits) . . .”).

134. See id.

135. This assumes, for simplicity, that either Jeff values the use and enjoyment of his new home $10 less or that moving costs are $10.

136. See supra note 133.

137. See id.; see also supra Table 1 (illustrating that net wealth, \( W(Q) \) is maximized at two drone operations).

138. See Landes & Posner, supra note 82, at 33.
Coase, however, showed that if transaction costs are zero, Amazon would conduct only two drone operations even if Amazon had the right to conduct as many as it wanted, thereby achieving economic equilibrium. Although Amazon would intend to conduct four drone operations, the landowner would offer up to $6 for Amazon to reduce that number to two (the difference in the cost of interference of $8 for four operations and $2 for two operations). Amazon would accept any offer $2 and above because $2 is Amazon’s marginal net benefit at two operations—the exact value of the net benefit Amazon would receive in excess of its next best alternative activity. This transaction would occur as long as the landowner’s willingness to pay (WTP) is greater than Amazon’s willingness to accept (WTA), provided the costs of reaching the agreement are zero. If the landowner’s WTP is less than $2, meaning the landowner places a value of less than $2 on the use and enjoyment of the land, Amazon would reject any offer made by the landowner and choose to conduct four drone operations. Alternatively, if the landowner has an exclusive

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139. See id.
140. Provided the landowner values the right to use and enjoyment of property at more than $8. See supra Table 1.
141. For an overview of the concept of willingness to pay and accept, see BARNES & STOUT, supra note 61, at 9–10.
142. See LANDES & POSNER, supra note 82, at 33.
143. Alternatively, if the landowner is using the land for a profitable activity, the landowner would not even make the offer because the net profit would still be negative. See id. at 35. Table 1 suggests that Amazon would accept $0.50 or more to reduce its operations from four to three, but the landowner would not make the offer because four drone operations causes the same amount of interference as three and two since all the landowner’s value is destroyed at just two drone operations. The presence of this external cost to the landowner is not evidence of inefficiency. Rather, the fact that it remains suggests that it was not worth internalizing, otherwise the parties would transact to maximize net wealth. Henry E. Smith, Exclusion Versus Governance: Two Strategies for Delineating Property Rights, 31 J. LEGAL STUD. S453, S462–S463 (2002) (citing Harold Demsetz, Toward a Theory of Property Rights, 57 AM. ECON. REV. PAPERS & PROC. 347 (1967)).
property right to all airspace below 200 feet AGL, the landowner would sell Amazon an air easement and the parties would negotiate until they agreed upon an easement for two drone operations at a price between $2 and $6, resulting in the maximum net wealth of $14.\footnote{144}{See Landes & Posner, supra note 82, at 33–34 (stating that both parties would be better off by reducing the activity because their net wealth is increased by $4, and thus, they would agree to the reduction).}

While transaction costs are never zero in the real world, the application of the Coase Theorem shows that property rights are economically preferable to liability rules whenever transaction costs are lower than the gains from transacting.\footnote{145}{Landes & Posner, supra note 82, at 36.} Because market valuations are generally more accurate than the legal system, it is presumed that property rights are cheaper to administer than liability rules.\footnote{146}{Id.} If transaction costs are so high as to preclude a market solution, property rights will be sufficient if, and only if, the optimal level of harm caused by an activity is zero or the optimal solution is no limitation of that activity at all.\footnote{147}{Id.} In the first case, the landowner can be given a property right against any and all interference by drones; in the second, Amazon can be given the property right to conduct as many drone operations as it wishes and at whatever altitude it chooses.\footnote{148}{See id. The second assumes Amazon is not violating any other law or regulation. See supra note 71.}

Even if the optimal level of interference is zero at first, such an assignment of property rights would be objectionable as being too inflexible if the optimal level becomes positive because changes in technology increase the value of low-altitude airspace.\footnote{149}{See Landes & Posner, supra note 82, at 36 (“It may be that at first the optimal level of damage is zero but that with changes in technology the optimal level becomes positive.”).} A more flexible alternative would be to require the active party, Amazon, to compensate the passive party, the landowner, through a liability rule.\footnote{150}{Id.} The difference is that the law is more reluctant to redefine property rights than to modify liability rules as technology changes.\footnote{151}{Id. at 37.} “Property rights, being designed as they are for settings of low transaction costs, are not supposed to be casually redefined by courts; they are meant to be traded in the market.”\footnote{152}{Id.} If transaction costs are prohibitively high and the optimal solution to a problem of conflicting uses requires some but not total restriction of the active party’s use, a more flexible regime of liability rules is preferable to the strict liability of a property rights regime.\footnote{153}{Id. at 36–38.}

In the context of drones, this Section has demonstrated that the optimal quantity of drone activity below 200 feet AGL is not zero. Thus, if transaction costs are high, the problem of conflicting uses between commercial drone operators and private landowners requires some, but not total, restriction of the use of this low-altitude airspace by drones. The next Section will argue that transaction costs are prohibitively high.
2. Transaction Costs

The Coase Theorem can be restated to say that the problem of conflicting uses will be resolved through a mutually beneficial agreement whenever one exists, given the assumption that nothing will prevent the parties from reaching it.\(^\text{154}\) A mutually beneficial agreement exists whenever the sum of the parties’ utilities (or wealth) can be raised by an agreement to change the allocation of the parties’ respective rights in a resource.\(^\text{155}\) That is, the agreement increases the net wealth of the parties, and thus, the change is efficient.\(^\text{156}\)

Transaction costs are “any hindrances to bargaining—whether literally [the] costs of bargaining, or . . . other obstacles.”\(^\text{157}\) This Section will briefly discuss some factors that suggest transaction costs are high, preventing commercial drone operators and landowners from reaching a mutually beneficial agreement. The three primary factors that explain why transaction costs are prohibitively high in any given setting are the proximity of the parties, the asymmetries of information between the bargaining parties, and the number of parties involved.\(^\text{158}\)

Sticking with Amazon as an example, the most obvious obstacle to bargaining with landowners to purchase air easements is the proximity of the parties. “If the concerned parties are not physically proximate, bargaining may be difficult to arrange.”\(^\text{159}\) If Amazon hopes to implement its drone delivery service all over the country, Amazon would have to give the local drone operator or manager the authority to bargain with each of the individual landowners, which would likely require hiring another highly paid manager for each geographic region that offers drone delivery.\(^\text{160}\)

Even if this is not enough to prevent bargaining from occurring, the probability of bargaining failure is likely high due to asymmetric information.\(^\text{161}\) The probability is likely high because Amazon does not have sufficient information to objectively calculate the subjective value the landowner places on the use and enjoyment of the land or how Amazon’s use of drones might affect that value.\(^\text{162}\) On the other side, the landowner may think Amazon’s willingness to pay is much higher than it really is and reject an otherwise mutually beneficial offer.\(^\text{163}\)

\(^{154}\) Shavell, supra note 123, at 83–84.

\(^{155}\) Id. at 84.

\(^{156}\) See supra note 101 and accompanying text.

\(^{157}\) Shavell, supra note 123, at 84 n.8.

\(^{158}\) See id. at 87–88.

\(^{159}\) Id. at 88.


\(^{161}\) See generally Shavell, supra note 123, at 89–90 (stating that the explanation for bargaining failure “involves asymmetric information between parties that leads to miscalculations in bargaining and failure to agree”).

\(^{162}\) See id. at 89–91.

\(^{163}\) See id. at 90–91 (stating that a rejection of such an offer would be rational due to asymmetric information); see also Posner, supra note 90, at 19 (discussing the “endowment effect”—we value what we have more than we would value the identical thing if we did not
The number of parties involved in the transaction is probably the most significant factor because transaction costs “tend to rise steeply as the number of parties to [the] transaction increases.”  

Nuisance cases commonly arise from settings of high transaction costs because the nuisance affects a number of surrounding parties. For Amazon, this is potentially a significant obstacle because the number of homes or businesses that a drone might fly over to deliver a single package is likely to be dozens or even hundreds, even if Amazon limits its drone delivery service to a fifteen-mile radius of each facility it operates the drones out of. Amazon may only choose to implement drone delivery in a particular location if it can get a certain number of landowners to sell an air easement, with each agreement with an individual landowner conditioned on an agreement being reached with all landowners in the area. If one landowner holds out or refuses to sell an air easement, even if Amazon values it more, then Amazon may not be able to offer its drone delivery service at all in that location. Furthermore, the holdout problem should not be dismissed simply because current regulations and technological capabilities of drones limit the number of landowners operators would have to negotiate with. State legislatures should be mindful of the more permissive regulations and technological innovations to come that will allow drones to travel greater distances in the future. More flexible liability rules may be a better alternative to prematurely drawing an inflexible line in the sky.

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164. Posner, supra note 90, at 52. “[T]he formula for the number of links required to join all members of a set of n members is suggestive: n(n-1) / 2.” Id. For example, if a transaction is conditioned on the agreement between three parties, then each party has to coordinate with the other two, requiring three different links in the negotiation. But if there are four parties, then six different links are required.

165. Landes & Posner, supra note 82, at 43 (“[T]ransaction costs are likely to be high because of the number of properties affected.”).

166. See supra note 116.


168. Most notably, current FAA regulations require drone operators to maintain visual line of sight with their drones. 14 C.F.R. § 107.51(b) (2016).

169. Professor Troy Rule, in arguing that transaction costs are not prohibitive, dismissed the potential holdout problems, stating that the number of landowners affected by a single drone operation is likely low because “drones are not designed to travel even a single mile away from their operators.” Rule, supra note 19, at 195–96.


171. See supra note 149 and accompanying text.
C. Common Law Aerial Trespass v. Per Se Aerial Trespass

The previous Section illustrated that, under the Coase Theorem, the optimal quantity (Q) of drone activity under 200 feet AGL is not zero and provided arguments for why transactions costs are likely prohibitively high, and therefore the efficient allocation of low altitude airspace is not likely achievable through the assignment of property rights and traditional market forces. The remainder of this Part addresses whether one of the ULC’s proposed rules is more efficient than common law aerial trespass, and thus preferable to the common law doctrine despite the resulting inefficiencies. The following Sections expand upon the examples discussed in the previous Section to illustrate that the ULC’s proposed rules are less efficient than the common law aerial trespass doctrine.

1. Economic Analysis of a Per Se Aerial Trespass Rule

The ULC’s proposed per se aerial trespass rule is just as economically inefficient as giving commercial drones the right-of-way to fly at any altitude above private property without subjecting them, or their operators, to any liability for harm caused to the private landowner.172 This is true when the economic model is concerned only with the use of the airspace below 200 feet AGL.173 An expanded model, which considers the use of airspace between 200 and 400 feet AGL, requires additional assumptions that cannot be defended with the information available, resulting in a less accurate model with little predictive value.174

The per se rule is equivalent to giving landowners property rights to use the airspace below 200 feet above the surface of their land.175 The analysis in Section III.B.1 showed that if transaction costs are high, giving Amazon the right to conduct unrestricted drone operations over the landowner’s private property, without the threat of liability, would generate a DWL of $4—illustrated in Figure 1.176 The same result would occur if the landowner is given the right to exclude Amazon and a voluntary market exchange is infeasible due to high transaction costs. Table 1

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172. See supra note 138 and accompanying text; see supra Figure 1.

173. For simplicity, this analysis treats the proposed rule as placing a ceiling on land at 200 feet AGL and ignores the provision prohibiting drones from coming within 200 feet of structures. See supra note 37 and accompanying text.

174. Under an expanded model, if you assume that Amazon’s NB(Q) and MNBQ in Table 1 reflect the value Amazon places on its use of all airspace below 400 feet AGL, creating a line at 200 feet that is per se aerial trespass will substantially impact Amazon’s net benefit function, making package delivery only marginally better than Amazon’s next best use. Amazon’s new net and marginal net benefit, NBQ’ and MNBQ’, can be illustrated using NBQ’ = 2Q – (1/2)Q^2, where MNBQ’ = -Q + 2, and if the landowner is given the right to exclude Amazon below 200 feet AGL, the cost of interference is reduced significantly (CQ’ = (1/4)Q^2, where MCQ = (2/3)), resulting in DWL of $3. But if instead the assumption is that Amazon’s NBQ and the landowner’s C(Q) directly correlate with the size of the “drone highway” (Q of 4 would be 0 to 400 feet AGL and Q of 2 would be 200 to 400 feet AGL), then drawing a “bright-line” at 200 feet would be perfectly efficient with a DWL of $0. Unfortunately, neither assumption can be justified due to a dearth of relevant data.

175. See supra note 144 and accompanying text.

176. See supra note 138 and accompanying text.
showed that Amazon’s willingness to pay for an air easement that allows two drone operations was $6 (Amazon’s net benefit for two drone operations) and the landowner’s willingness to accept was $2 (the cost of interference of two drone operations). If transaction costs—the costs of finding each other, valuing the air easement, and negotiating the terms and price—are greater than $4, then the transaction will not occur. The result is a DWL of $4, which is illustrated in Figure 2.

2. Economic Analysis of Common Law Aerial Trespass

This Note will focus on the common law doctrine’s requirement of substantial interference and ignore the “fact-specific inquiries into what constitutes the ‘immediate reaches’ of the airspace above the plaintiff’s parcel.” This is the dispositive element and an argument can be made that the facts needed to show substantial interference are the same for the “immediate reaches” element. The exact point at which a drone’s flight path crosses over to the immediate reaches is not within the scope of this Note; it is sufficient to assume that such point is where the drone activity results in interference with the actual use and enjoyment of the private land and property below. For simplicity, the analysis will treat aerial

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177. See supra note 157 and accompanying text.
178. Draft for Drafting Committee Meeting, supra note 6, at 4 (quoting Rule, supra note 19, at 184).
179. The argument would be that, absent a clear definition of “immediate reaches,” a drone will not be found to have entered the immediate reaches unless it causes substantial interference. See supra notes 78–81 and accompanying text.
180. This assumption works because even if we were able to parcel out mutually exclusive rights to the use of airspace—such as drawing a line at X feet AGL—“[t]ruly exclusive (absolute, unqualified) property rights would be a contradiction in terms.” Posner, supra note 90, at 50. Posner illustrates this contradiction in his discussion of incompatible uses of two adjacent but separate parcels of property—a farmer’s use of land to plant crops and a railroad that emits sparks that cross over to the farmer’s land and damage the crops. Id. “To enjoy [absolute and unqualified] exclusive use of its right-of-way, a railroad must be permitted to
trespass similar to nuisance and, accordingly, the model will incorporate the probability of harm occurring, which includes the likelihood an interference will not be litigated or will go uncompensated.\footnote{181}

Suppose that for all drone activity Amazon conducts below 200 feet AGL Amazon’s net benefit and the landowner’s cost of interference are the same as in Table 1 ($NB(Q), MNBQ, C(Q)$ in Table 2 below),\footnote{182} when Amazon’s drone operations are unrestricted (no liability). Under the common law doctrine, Amazon could potentially be liable for any interference caused by its drones if they fly too low (within the immediate reaches of the land below), are unreasonably loud, hover too long, drop too frequently to a low altitude, or are otherwise operated in a way that unreasonably interferes with the landowner’s use and enjoyment of land.

<table>
<thead>
<tr>
<th>$Q$</th>
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<th>$MNBQ$</th>
<th>$NB_A$</th>
<th>$MNB_A$</th>
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<th>$E(D)$</th>
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</table>

At $Q = 4$ Amazon operates in a way that provides the greatest net benefit without taking into consideration how the drone operations affect the landowner’s use and enjoyment of land below; Amazon is assumed to be operating carelessly. Assume that at $Q = 4$ Amazon has a 40% chance of being successfully sued by the landowner and having to pay $8. Thus, the amount of damages Amazon is expected to pay, $E(D)$, is $3.20 (40\%$ of $8$). If Amazon exercises some care by altering the way it conducts its drone operations and/or reducing the amount of operation conducted (from $Q = 4$ to $Q = 3$),\footnote{183} the probability that Amazon will face a successful lawsuit is reduced to 30\%, and thus, Amazon would have a 30\% chance of having to pay

\begin{quote}
emit engine sparks without legal limitation; the value of the [right-of-way] would be impaired otherwise. But the value of adjacent farmland would be reduced because of the fire hazard from the sparks.” \textit{Id.}
\end{quote}

\footnote{181. The actual probability of litigation or compensation does not impact the efficiency of the rule. \textit{See infra} note 185. Additionally, the model is based on Landes and Posner’s model for liability rules where nuisance is considered the equivalent of negligence. \textit{See LANDES \& POSNER, supra} note 82, at 39 (stating that a negligence rule is “essentially equivalent” to a reasonable-use nuisance rule); \textit{see also} Smith, \textit{supra} note 167, at 969 (“[I]f there is one thing upon which commentators seem to agree, it is that the standard for nuisance law should be assimilated to that of accident law.”).}

\footnote{182. \textit{See supra} notes 120–125 and accompanying text.}

\footnote{183. \textit{See LANDES \& POSNER, supra} note 82, at 66 (stating that the injuring party “is interested in any measure that would reduce his expected damage by more than the cost of the measure; it is a matter of indifference to him whether the cost results from purchasing some safety input or from forgoing the profits from a higher level of productive activity”).}
Amazon’s net benefit, however, would be reduced to $7.50 because either the altered drone operations cost more to perform (otherwise Amazon would be not doing it this way in the first place) or Amazon chooses to reduce the labor and capital invested in this activity because the expected cost of four drone operations is $1.85 more than three drone operations ($3.20 versus $1.35), which is greater than the marginal net benefit Amazon would receive from the additional operation. Similarly, as Amazon increases its level of care or reduces its drone activity to $Q = 2$ and $Q = 1$, assume the probability of facing a successful lawsuit decreases to 20% and 10%, respectively.

The common law aerial trespass doctrine forces Amazon to internalize the expected damages. Amazon’s net benefit after internalizing these costs is expressed as $NB_A = NB(Q) - E(D)$. Amazon will still continue to conduct drone operations until its $MNB_A$ is zero, which is at $Q = 2.815$ in Table 2. The result, illustrated in Figure 3, is a DWL of $0.66$. Amazon’s net benefit after paying expected damages is $6.18. The landowner will be compensated for the expected damages of $1.12, resulting in $2.85 going uncompensated. Thus, net wealth is increased by $3.34, whereas the maximum increase in net wealth that can be achieved is $4.

184. For a more detailed discussion on how to incorporate probabilities and expected damages in an economic model for liability rules, see generally LANDES & POSNER, supra note 82, at 55–73. The full equation used in the model is $NB_d = 4Q - (1/2)Q^2 - 0.1(Q)^{1/2}Q^2$, where $MNB_d = 4 - Q - 0.15Q^2$. The author has altered the equation used by Landes and Posner to reflect Amazon’s expected net benefit, $NB_a$, which is the net benefit derived from $Q$ drone operations less expected damages. See generally id. at 62–68.

185. Depending on the percentages that are attached to each level of activity, $Q$ will either be closer to 2 or closer to 3 but will always be within this range when the probability at $Q = 3$ is greater than 22.5%. The maximum DWL possible, subject to this limitation, is $1.00 (7.50 - 4.50). To illustrate the impact of percentages, assigning 3% to $Q = 3$ would result in a level of activity at 3.785 (with a respective 3.785% probability) and a DWL of $3.19.

186. Calculating net wealth from the numbers in the table will result in a DWL of $0.67 due to rounding.

187. The fact that some interference may still go uncompensated is not a sign of inefficiency but a “potential externality” that is not worth internalizing because the cost of internalizing—identifying and pursuing legal action against the drone operator—may be greater than the harm caused by the interference. See supra note 143.
Under the simple microeconomic analysis in this Section, the common law aerial trespass doctrine (DWL of $0.66) is clearly economically superior to the ULC’s per se aerial trespass doctrine (DWL of $4). This, of course, assumes that Amazon derives a significant net benefit from being able to conduct its drone operations below 200 feet AGL, as opposed to being strictly limited to the airspace between 200 feet and 400 feet AGL. Moreover, “[t]he nuisance standard illustrates the common law’s awareness that when the place, kind, or amount of activity is an important factor in bringing about the right level of damage, it should be part of the legal standard.” The alternative aerial trespass rules the ULC’s drafting committee has even incorporate these factors into the language of the rules, suggesting the committee at least acknowledges that its per se rule may be too inflexible to adequately accommodate beneficial and productive uses of commercial drones.

D. Economic Analysis of Proposed Alternatives to Per Se Aerial Trespass

On October 19, 2018, the drafting committee, in response to the negative reactions from the drone community, released a revised draft of its Tort Law Relating to Drones Act, offering two alternatives to the per se rule. The first alternative replaces the per se trespass rule with a rebuttable presumption—that a person who operates drones over private land below 200 feet AGL is presumed to have

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188. Unfortunately, there is a dearth of relevant information that is needed to determine if this assumption is correct. For evidence that Amazon may indeed derive additional benefits, see supra notes 116–117 and accompanying text.
189. LANDES & POSNER, supra note 82, at 70.
190. See infra note 194 and accompanying text.
191. See generally Draft for Drafting Committee Meeting, supra note 7; Oct. 19, 2018 Memo, supra note 7, at 2 (“Comments from observers just before and soon after the Annual Meeting indicated unease and dissatisfaction with the per se trespass concept and encouraged the development of alternatives to the initial approach.”) (emphasis in original).
committed a trespass to land—that “may be rebutted by a showing that the intrusion did not significantly intrude upon the landowner’s enjoyment or use of her property.” The rule then provides an inclusive list of nine factors for courts to consider to determine the significance of the intrusion—such as the amount of time the drone is over the land, the height at which it was operated, and the noise produced by the drone (“in the context of any other noise nearby”). The rationale for this alternative is that “while it provides less certainty than the per se trespass rule, it also provides more flexibility for drone operators across a host of circumstances,” potentially allowing “more use of the airspace above land, while still protecting landowner rights from interference.” Additionally, it may incentivize the development of “innovative uses that do not affect the use and enjoyment of the land below.”

The second alternative leaves it to each state to recognize “a right of landowners in the airspace appurtenant to their land extending to various heights depending primarily upon the use and location of the land. . . .” Specifically, it requires each state to adopt a uniform law with respect to rural, suburban, urban, and agricultural regions, as defined by the relevant state law. The provision states that the rule does “not create any new rights to landowners, but rather recognize[s] the common law and statutory rights already held by landowners.” Furthermore, the committee reasons that although this alternative would not provide a uniform height across the nation, the uniformity comes from “the requirement that the state explicitly articulate the height” under which a drone operator is liable for trespass, thereby removing all uncertainty by giving the drone community the information it needs to “develop appropriate maps and technologies to allow for drone operation within the boundaries established by each state.”

1. Rebuttable Presumption of Trespass to Land

Both proposed alternatives would only be marginally more efficient than the per se aerial trespass rule and both would still be inferior to the common law aerial trespass doctrine. For the first alternative, the probabilities in the simple economic model used for the common law doctrine can be adjusted to reflect the probability that the presumption will be rebutted. Assume the quantity of drone operations, $Q$, reflects the overall activity level of the drone operations, not just the number of overflights, including the factors suggested by the rule for determining significance of the intrusion—such as the amount of time the drone is over the land, the height at

192. Draft for Drafting Committee Meeting, supra note 7, § 301(c) (Alternative A).
193. Id.; see also Oct. 19, 2018 Memo, supra note 7, at 2 (discussing illustrative factors).
195. Id. at 2.
196. Draft for Drafting Committee Meeting, supra note 7, § 301(a)(1) (Alternative B).
197. Id. § 301(a)(2)–(5).
198. Id. § 301(a)(6). The drafting committee cites to a regulatory takings case, Penn Cent. Transp. Co. v New York City, 438 U.S. 104 (1978), stating that it “stands for the proposition that property rights include airspace rights, and that airspace rights are a part of the rights that landowners hold in their land.” Oct. 19, 2018 Memo, supra note 7, at 4.
which it was operated, and the noise created. Furthermore, assume \( Q = 4 \) represents a level of activity that will almost certainly result in liability, yielding a 100% probability that Amazon will face a successful lawsuit by the landowner and pay $8 in damages. Additionally, assume that reducing \( Q \) from four to three increases the chance that Amazon would be able to rebut the trespass presumption, thereby reducing the likelihood of liability from 100% to 75% with expected damages of $3.38 ($4.50 of 75%). Similarly, assume that the respective probabilities for \( Q = 2 \) and \( Q = 1 \) are 50% and 25%, respectively.

However, the rule is still an action for trespass and does not convey the right to operate drones below 200 feet above private property so long as the drone does not cause interference. The landowner presumably still has the right to exclude all drones up to 200 feet AGL, and thus, Amazon will likely be limited to operations closer to the 200-foot AGL line, substantially reducing the net benefit Amazon receives from drone operations below 200 feet AGL. Amazon’s expected net benefit, \( NB_A \), its net benefit from \( Q \) drone operations, \( NB(Q) \), less the damages it can expect to pay to the landowner under a trespass action.

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Although Amazon’s net benefit, \( NB(Q) \), is maximized at \( Q = 2 \), Amazon’s expected net benefit, \( NB_A \), is maximized at \( Q = 1.333 \). At this level of drone activity below 200 feet, Amazon has a 33% chance of being successfully sued by the landowner (or a 67% chance of rebutting the presumption of trespass). Amazon’s expected net benefit is $1.48. The landowner’s expected compensation for interference is $0.30, leaving $0.59 uncompensated. Thus, the net wealth generated by this rule is $0.89 ($1.48 less $0.59), whereas the maximum increase in net wealth

200. For a list of the factors, see Draft for Drafting Committee Meeting, supra note 7, § 301(d)(1)-(9).

201. If the landowner has the right to exclude, then a verbal manifestation to Amazon that its drone operations are not welcome would increase the likelihood the landowner would sue Amazon, as well as the difficulty of rebutting the presumption, resulting in a rule closely resembling strict liability.

202. Amazon’s new net benefit formula is \( NB(Q) = 2Q - (\frac{1}{2})Q^2 \), where \( MNB_0 = -Q + 2 \). The author has slightly altered the formula used by Landes and Posner to illustrate the effects of the reduction of net benefit. See generally LANDES & POSNER, supra note 82, at 62–68.

203. The full equation used in the model is \( NB_A = 2Q - (\frac{1}{2})Q^2 - (0.25)(Q^{(\frac{1}{2})})Q^2 \), where \( MNB_A = 2 - Q - (0.375)Q^2 \). See supra note 184.
that can be achieved is $4. The result is a DWL of $3.11, illustrated in Figure 4 below.

Figure 4

2. Drone Zoning

This Section will provide a normative economic analysis of the second alternative, which leaves it to each state to recognize “a right of landowners in the airspace appurtenant to their land extending to various heights depending primarily upon the use and location of the land,” based on the exclusion versus governance theory articulated by Henry E. Smith and the arguments put forth by Troy A. Rule for drone zoning. Similar to the distinction between property rights and liability rules, Smith argues that it makes sense to distinguish between exclusion and governance as proxies to measure the costs and benefits of different methods of delineating rights to a resource that is rising in value. “The resources that are the subject of [these] property rights can . . . be thought of as bundles of valued attributes, each of which is costly to measure.” Exclusion roughly measures “what collection of attributes is treated as a unit” so we can identify the resource for the purposes of regulating access to that resource, whereas governance rules regulate access to the resource by determining what range of activities are allowed. Exclusion rights are enforced through basic trespass and property law, whereas governance can use a wide range of rules, such as nuisance law and zoning regulations, to provide a higher degree of delineation of rights to resources through specification of proper

204. Draft for Drafting Committee Meeting, supra note 7, § 301(a)(1) (Alternative B).
205. See generally Smith, supra note 143.
207. See supra Section III.A.
208. See Smith, supra note 143, at S455, S467 (“[E]xclusion and governance are strategies that are at the poles of a continuum of methods of measurement . . . .”).
209. Id. at S454.
210. Id. at S454–55, S467.
activities. The “roughness” of the measurement used to define a right is referred to as precision. Further precision through exclusion “can be achieved by focusing on proxies that measure ever smaller classes of uses,” such as redefining boundary lines, making the resource more difficult to use without the right holder’s permission. Further precision through governance can be achieved by holding an actor liable for interference with another’s right to use of a resource.

The goal of the ULC’s second alternative appears to be further precision through exclusion by requiring each state to explicitly define the boundaries of private land, depending on the location of the land—location being rural, urban, suburban, and agricultural. The ULC might argue that the emergence of such exclusive, private property rights is necessary to internalize the privacy costs currently borne by the landowners to the drone operators. However, the emergence of exclusive property rights in a resource of rising value usually arises because that resource can be used more productively with exclusion rights, thereby internalizing that increase in value to the private owners. Unlike traditional uses of land, the rising value in low-altitude airspace due to the changing technologies and capabilities of drones can only be exploited by allowing commercial drones to use that low-altitude airspace; landowners can only exploit the increase in value through market transactions, which are likely prohibited due to high transaction costs. Thus, governance rules—such as specifically tailored nuisance and liability laws or drone zoning regulations—are likely preferable to giving landowners the right to exclude.

Although the second alternative proposed by the ULC may be a useful tool for increasing precision in the future—when the integration of drones into the national airspace is further along and the commercial use of low-altitude airspace is more developed—a more appropriate and efficient method for increasing precision in the delineation of airspace rights might be “drone zoning.” Professor Troy Rule argues that local regulation of drones by municipalities would allow for a greater degree of

211. Id. at S455 n.5.
212. “[P]recision itself [is] a bundle of measurable properties but not measurable itself. Precision in property rights could be termed lack of vagueness, fine grainedness, accuracy, exactness, complexity, and the like.” Id. at S472. The degree of precision correlates with the degree of specification. Id. at S473. “Rights are precise or specified to the extent that they protect attributes by preventing a range of unauthorized actions.” Id.
213. Id. at S467, S469.
214. See id. at S468 (discussing governance methods in grazing commons).
215. See supra notes 196–197 and accompanying text.
216. See, e.g., supra notes 38–39 and accompanying text.
217. See Smith, supra note 143, at S453 (“The emergence of exclusive, private property rights is said to help solve the ‘tragedy of the commons,’ because the new private owners will bear more of the changes in resource values that their activities cause.”).
218. See id. at S461 (stating that with the rising value of wool and technological changes that allowed sheep to be raised on less land, the open-field grazing commons in England eventually gave way to a trend toward private enclosure (exclusion) as the “overall attainable level of production” began to rise).
219. Zoning and neighborhood covenants are governance mechanisms for increasing precision. See id. at S456.
220. See generally Rule, supra note 206.
precision and efficiency that would not otherwise be attainable.\footnote{Id. at 176.} First, enabling municipalities to contribute to a comprehensive drone regulatory regime would be more efficient than drawing a strict line in the sky because they have greater access to firsthand, local information,\footnote{Id. at 176–77.} potentially putting them in a better position to assuage some of the concerns regarding the nuisance of drone flights and anxiety over the invasion of privacy within their communities.\footnote{See WhiteFox Def. Techs., Inc., Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, supra note 49, at 1 (“We find it plausible that, as ULC says, property owners could suffer from the nuisance of drone flights and anxiety over the invasion of privacy.”).} Second, municipalities have a long history of regulating low-altitude airspace under common municipal ordinance provisions, such as those setting building setbacks and height restrictions, which “effectively designate the low-altitude airspace near the homes involved . . . as a valuable seclusion buffer that reciprocally benefits residents below.”\footnote{See Rule, supra note 206, at 170–71.} Rule argues that local government officials are “better positioned than the FAA to determine which of these two competing airspace uses—drone activity or preservation of seclusion—to prioritize in each specific neighborhood.”\footnote{See supra text accompanying note 199.} Lastly, the advancements in drone technologies and the resulting proliferation of drones “necessitate a location-sensitive regulatory approach that only localities are equipped to effectively establish and enforce.”\footnote{See Rule, supra note 19, at 171–72; see generally Rule, supra note 19.}

Late nineteenth and early twentieth century courts and policymakers justified the emergence of municipal land use controls, including zoning laws, with similar arguments.\footnote{Id. at 179.} Rule argues that the proliferation of drones increasingly spawns conflicts that trespass, nuisance, and broad federal regulations do not adequately address; just as policymakers turned to municipal zoning to manage the growing volume of land use conflicts, “drone zoning could serve a similar function as drones increasingly compete for the use of low-altitude airspace . . . .”\footnote{Id. at 181.}

In theory, the second alternative could be used in tandem with drone zoning to provide a cause of action in trespass at a clearly specified height that the state determines is appropriate based on a broad geographic classification system of rural, urban, suburban, and agricultural airspace.\footnote{See supra text accompanying note 199.} Rule argues that state governments are best positioned to clarify landowners’ property rights through state statutes.\footnote{Id. at 171–72; see generally Rule, supra note 19.} However, Rule argues for increased precision, with respect to these rights, through exclusion rather than governance at the state level because it “would make it easier for parties to negotiate drone-related covenants and easements involving [low-altitude airspace].”\footnote{Id. at 176.} This Note, however, has presented an in-depth argument based on a positive economic analysis of the various rules proposed by the ULC that
suggests otherwise. Moreover, Rule’s argument is premised on the assumption that transaction costs are low.\textsuperscript{232} Section III.B.2 provided several arguments—in addition to the lack of information available to justify a low transaction cost assumption—that transaction costs are likely to be prohibitively high, so as to prevent mutually beneficial transactions from occurring.

Nevertheless, a combination of a state law that clarifies landowners’ property rights “by focusing on proxies that measure ever smaller classes of uses,”\textsuperscript{233} such as further delineation of landowners’ rights based on their location and governance rules through municipal drone zoning ordinances, may increase efficiency by filling in the gaps not currently addressed by the common law aerial trespass doctrine. For example, the state may find that, in general, drones should be excluded below 100 feet AGL in urban areas, where parcel sizes tend to be relatively small and closer together, because the ability of drones to capture detailed images increases the likelihood of invasions of privacy by drones.\textsuperscript{234} The statute would be efficient so long as it also gives local municipalities “broad regulatory authority” to regulate drones below this level through its zoning powers.\textsuperscript{235} This would be done by creating a cause of action in trespass for landowners, subject to the local drone zoning ordinances that may allow certain uses of that space by drones—for example, an ordinance may distinguish between commercial and recreation drone uses and allow commercial drones to operate only during business hours on weekdays but limit recreational drone activity by prohibiting it altogether or to a narrower set of places and times.\textsuperscript{236}

Returning to the Amazon example, such a combination of exclusion rules at the state level and governance rules at the local level would reduce drone delivery activity in communities by restricting drone operations in certain locations and at certain times where the drone may potentially cause a nuisance or anxiety over the intrusion of privacy. Yet it would still allow Amazon to exploit the rising value of the airspace by implementing its drone delivery services in that community, which would benefit the community as well as Amazon.\textsuperscript{237}

CONCLUSION

Perhaps the most important part of Rule’s article is that he recognizes that both “state and municipal involvement, in coordination with the federal government, is needed to facilitate the efficient evolution of drone law.”\textsuperscript{238} Drone law is still in its infancy stage. Part 107 was only the first phase in what the FAA expects to be a

\textsuperscript{232} See Rule, supra note 19, at 193–94 (arguing that new drone technologies are reducing the “cost of internalization”).
\textsuperscript{233} Smith, supra note 143, at S467; see supra text accompanying note 215.
\textsuperscript{234} See Rule, supra note 206, at 181 (discussing the ability of drones to get visual access into a secluded yard in urban areas); see also supra notes 14–16.
\textsuperscript{235} See Rule, supra note 206, at 176 n.216 (“In most cases a special enabling act . . . gives the locality the power to zone.”) (quoting WILLIAM A. FISCHEL, THE ECONOMICS OF ZONING LAWS 22 (1985)).
\textsuperscript{236} See id. at 196.
\textsuperscript{237} For the potential benefits to Amazon, as well as consumers, see supra note 116–117 and accompanying text.
\textsuperscript{238} Rule, supra note 206, at 199 (emphasis added).
fifteen-year (or more) process of integrating drones into the national airspace.\textsuperscript{239} Public perception of drones may change drastically over that period as federal regulations are amended to allow new commercial uses of drones that allow companies like Amazon to share the value of low-altitude airspace with their customers through cheaper, faster services and through the environmental benefits that come with using drones.\textsuperscript{240} Not to mention the new, transformative technology that might be introduced over the next decade “that could be as disruptive as the advent of automobiles.”\textsuperscript{241} Thus, state legislatures should reject the ULC’s proposed aerial trespass rules as presently written to avoid adopting an inefficient and inflexible solution solely to assuage public concerns about drones. Such concerns would be better addressed through more flexible liability and governance rules.

\textsuperscript{239} See FAA UAS ROADMAP, \textit{supra} note 10 (stating that integration of passenger drones and air taxis is the last phase of drone integration into the national airspace and may take another fifteen years).

\textsuperscript{240} For example, drones that replace commercial delivery trucks could help reduce urban pollution and energy consumption. Rule, \textit{supra} note 19, at 162–63 (citing Jim Lyza, \textit{Could Drones Give Your Package a Sustainable Lift?}, \textsc{GreenBiz} (May 2, 2014), https://www.greenbiz.com/blog/2014/05/02/could-drones-give-your-package-sustainable-lift [https://perma.cc/QZ7H-6DLY]).

\textsuperscript{241} Cohn et al., \textit{supra} note 2.