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HOW SCIENCE CAN IMPROVE REGULATION: NOISE CONTROL IN URBAN AREAS

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The issue of noise is becoming increasingly problematic in urban areas. Research has revealed that it not only contributes to hearing loss, but also to cardiovascular disease, psychiatric disorders, and even slower language development and learning in children. Preventing these effects would require a significant decrease in noise levels. However, experts report that community noise levels are actually increasing. Moreover, zoning in many cities and towns is shifting to a model in which different types of land uses tend to be closer to one another, which increases the potential for conflict over noise.

This Article draws on the scientific literature on noise to argue that cities can alleviate this problem by improving noise ordinances and proposes a non-exhaustive list of measures aimed at reaching this goal. First, adjusting noise standards to reflect citizens' varying tolerance for noise at different times of the day would make noise ordinances more efficient. Second, measuring noise levels where the harm is caused, rather than where the noise is produced, would add flexibility to noise control frameworks. Third, by accounting for noise characteristics—frequency and impulsiveness—that play an important role in determining how unpleasant a particular type of noise is, municipalities would be able to more adequately evaluate the harm that noise can cause.

While this list focuses on what municipalities can do to improve their noise ordinances, these recommendations can be applied to regulation by other levels of government. This Article is mainly concerned with noise in mixed-use districts, and therefore focuses on improving regulatory frameworks in the municipal context. However, because this Article's suggestions are aimed at making noise control frameworks more effective and efficient, states and the federal government can also incorporate them into their noise-control statutes and regulations.

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INTRODUCTION

Noise, which has been defined as a "disagreeable or undesired" sound,[1] is a very serious problem in urban areas.[2] Its potential health effects are diverse and some of them

1. Colin H. Hansen, *Fundamentals of Acoustics*, *in* OCCUPATIONAL EXPOSURE TO NOISE: EVALUATION, PREVENTION AND CONTROL 23 (Berenice Goelzer et al. eds., 2001).

2. In 2002, for example, New York City's former Mayor Michael R. Bloomberg adopted the so-called "Operation Silent Night" to reduce excessive noise. Jennifer Steinhauer, *It Never Sleeps, But City Does Demand Quiet*, N.Y. TIMES (Nov. 25, 2002), http://www.nytimes.com/2002/11/25/nyregion/it-never-sleeps-but-city-does-demand-quiet.html.

are unknown to many. While the most common consequences of noise are sleep disturbance, hearing loss, and reduction in performance, experts have also identified other more serious effects, such as cardiovascular disease, abnormal endocrine responses, and psychiatric disorders.[3] Researchers have even shown that noise causes children to have slower language development and learning.[4] These problems affect a not insignificant portion of the American population. Hearing loss, for example, affects fifteen percent of Americans.[5]

Preventing some of these effects would require a decrease in noise levels of ten decibels.[6] This is a very significant reduction: given the nature of this unit of measurement, a ten decibel decrease results in a sound that is only half as loud.[7] Meanwhile, despite the technological advances in the field of noise control, noise levels keep rising. Community noise levels experienced an eleven percent increase in the United States between 1987 and 1997.[8] One author explains that noise levels in cities may be increasing at a rate of 0.5 decibels per year.[9]

This is particularly troubling for many urban areas in the United States, given the growing interest in mixed-use districts, that is, areas where different types of land uses (e.g., residential, commercial, and industrial) coexist.[10] Under a more traditional zoning approach, which tended to segregate uses to avoid conflict, the issue of noise was often minimized by merely separating noise-producing activities from areas with high sensitivity to noise.[11] As the United States Supreme Court framed it in a landmark zoning decision, "[a] nuisance may be merely a right thing in the wrong place."[12] In mixed-use districts, however, where the separation of potentially conflicting uses is not desired, local governments must find other types of solutions.

The existing legal literature on noise control has mostly focused on regulation at the federal level,[13] new formulas under tort law,[14] new regulatory frameworks to tackle the

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3. Stephen A. Stansfeld & Mark P. Matheson, *Noise Pollution: Non-Auditory Effects on Health*, 68 BRIT. MED. BULL. 243, 244–49 (2003).

4. Charlotte Clark & Stephen A. Stansfeld, *The Effect of Aircraft and Road Traffic Noise on Children's Reading*, LITERACY TODAY, September 2005, at 24, 25.

5. Hendi Crosby Kowal, *Millions of Americans Need Hearing Aids. Why Don't They Have Them?*, ALTARUM INST. (Jan. 14, 2016), http://altarum.org/health-policy-blog/millions-of-americans-need-hearing-aids-why-don%E2%80%99t-they-have-them.

6. Jonathon Keats, *20 Things You Didn't Know About. . . Noise*, DISCOVER (May 23, 2014), http://discovermagazine.com/2014/june/24-20-things-you-didnt-know-about-noise.

7. DB ENGINEERING, *Four Ways to Quiet a Noisy Machine*, http://800nonoise.com/tutorials/four-ways-to-quiet-a-noisy-machine (last visited July 24, 2017).

8. Susan L. Staples, *Public Policy and Environmental Noise: Modeling Exposure or Understanding Effects*, 87 AM. J. PUB. HEALTH 2063, 2063 (1997).

9. WORLD SOUNDSCAPE PROJECT ET AL., HANDBOOK FOR ACOUSTIC ECOLOGY: NOISE POLLUTION (Barry Truax ed., SIMON FRASER UNIV. 1999), http://www.sfu.ca/sonic-studio/handbook/Noise_Pollution.html (last visited July 24, 2017).

10. *See* sources cited *infra* note 24.

11. Roderick M. Hills, Jr. & David Schleicher, *The Steep Costs of Using Noncumulative Zoning to Preserve Land for Urban Manufacturing*, 77 U. CHI. L. REV. 249, 255, 272 (2010) (explaining that one of the justifications for separating residences from industry under the noncumulative zoning approach was to deal with nuisance problems).

12. Village of Euclid v. Ambler Realty Co., 272 U.S. 365, 388 (1926).

13. Sidney A. Shapiro, *Lessons from a Public Policy Failure: EPA and Noise Abatement*, 19 ECOLOGY L.Q. 1, 20 (1992).

14. Jason A. Lief, *Insuring Domestic Tranquility Through Quieter Products: A Proposed Product-Nuisance Tort*, 16 CARDOZO L. REV. 595, 628 (1994).

noise caused by mobile sources,[15] and the nuisance/regulation dichotomy.[16] This Article claims that noise problems in urban environments, and in mixed-use districts in particular, can be alleviated by improving noise ordinances to better accommodate the different interests at stake—i.e., citizens' need for low noise levels and society's need for commercial and industrial activities. Although municipal regulation has improved greatly since the first known ordinance enacted in Greece in the sixth century B.C.—which required roosters and tinsmiths to be outside the city limits[17]—many good practices in the area of noise control are not applied uniformly, even in major cities.[18]

This Article draws on empirical scientific literature and the experience that municipalities have acquired during the past decades to suggest a set of improvements to noise ordinances. First, adjusting noise standards to reflect citizens' varying tolerance for noise at different times of the day would make noise ordinances more efficient. Second, measuring noise levels where the harm is caused, rather than where the noise is produced, would add flexibility to noise control frameworks. Third, by accounting for noise characteristics, such as frequency and impulsiveness, both of which play an important role in determining how unpleasant noise is, municipalities would be able to more adequately evaluate the harm that different types of noise can cause.

While this list focuses on what municipalities can do to improve their noise ordinances, these recommendations can be applied to regulation by other levels of government. This Article is mainly concerned with noise in mixed-use districts, and therefore focuses on improving regulatory frameworks in the municipal context. However, because the suggestions this Article makes are aimed at making noise control frameworks more effective and efficient, states and the federal government can also incorporate them into their noise-control statutes and regulations.

This Article proceeds as follows. Part I explains why mixed-use districts are becoming increasingly popular, as well as why this increases the need for improved noise control frameworks. Part II provides an overview of noise regulation. Noise can be tackled at the federal, state, and local level. In turn, states can rely on the doctrine of nuisance or create their own regulatory framework to supplement it. Municipalities generally have authority to enact noise ordinances, which can adopt a variety of forms and have different degrees of sophistication.

Part III lays out a series of features that noise ordinances should include to control noise effectively and efficiently. This includes incorporating the teachings of psychoacoustics to ensure that ordinances are correctly accounting for the harm that different types of sounds cause.[19] Moreover, ordinances can be more efficient when they have multiple

15. *See, e.g.*, Steven N. Brautigam, *Rethinking the Regulation of Car Horn and Car Alarm Noise: An Incentive-Based Proposal to Help Restore Civility to Cities*, 19 COLUM. J. ENVTL. L. 391, 419 (1994); David B. Torrey & Jeffrey R. McCulley, *Limiting Motorcycle Exhaust Noise Through Amendment of the Motor Vehicle Code and Its Regulations*, 25 TEMP. J. SCI. TECH. & ENVTL. L. 49, 51 (2006).

16. Aaron C. Dunlap, *Come on Feel the Noise: The Problem with Municipal Noise Regulation*, 15 U. MIAMI BUS. L. REV. 47, 49 (2006) ("The Article will concentrate on the dichotomy between a zoning approach of restrictive noise ordinances and common law regulation through nuisance actions.").

17. Keats, *supra* note 6.

18. *See infra* Part II.C.3; *supra* notes 144, 185, and accompanying text.

19. Psychoacoustics is the study of how certain features of sound—e.g., temporal structure or timbre—affect the annoyance it can cause on people. *See* YOSHIHARU SOETA & YOICHI ANDO, NEURALLY BASED MEASUREMENT AND EVALUATION OF ENVIRONMENTAL NOISE 167 (2015).

noise standards to reflect people's varying tolerance to noise at different times of the day. Local regulators can also control noise more efficiently by measuring noise at the location of those who are affected by it, instead of measuring the noise at the source's location. Part IV examines the issue of whether existing activities should be exempt from amendments to ordinances that incorporate these types of measures, as well as the potential takings implications of changing noise control frameworks.

I. BACKGROUND: MIXED-USE DISTRICTS AND THE PROBLEM OF NOISE

Planning theory has long supported the idea that different land uses should be categorized (e.g., residential, commercial, agricultural, and industrial) and kept apart from each other.[20] Originally, the main reason justifying this separation of uses in large urban areas, such as New York City, was the need to address safety issues—mostly fire and health concerns.[21]

More recently, however, land-use segregation has been subject to many criticisms, and, as a result, there has been a "gradual but dramatic shift in planning thinking" towards mixing land uses.[22] This is an ongoing process, and today we still see debates over what the right mix of uses (e.g., light industrial or commercial with residential) is optimal for a particular area.[23] What seems clear at this point is that the interest in mixed-use districts is growing and that these configurations are becoming increasingly popular in many cities.[24] As the discussion below shows, the notions of cumulative zoning and performance zoning provide a good framework to further explore the recent support for mixed-use districts.

A. The Cumulative Zoning/Noncumulative Zoning Distinction

The evolution of the debate about whether cumulative zoning is more appropriate than its noncumulative counterpart, or vice-versa, is helpful to understand why mixed districts are becoming more and more popular. The distinction between these two types of zoning is premised on the theory that there is a hierarchy of uses, in which residential is generally the highest use, followed by commercial, and industrial.[25] The first zoning ordinances adopted a cumulative approach, i.e., they allowed, in areas dedicated to lower uses (less restrictive zones), these lower uses plus any other use that was higher, but the reverse

20. Sonia Hirt, *The Mixed-Use Trend: Planning Attitudes and Practices in Northeast Ohio*, 24 J. ARCHITECTURAL & PLANNING RES. 224, 225 (2007).

21. Chad Lamer, *Why Government Policies Encourage Urban Sprawl and the Alternatives Offered by New Urbanism*, 13 KAN. J.L. & PUB. POL'Y 391, 393 (2004).

22. Hirt, *supra* note 20, at 225.

23. Chelsea Davis, *DeSmet School Seeks to Address Lack of Housing, Mixed-Use Zoning in District*, MISSOULIAN (Jan. 10, 2017), http://missoulian.com/news/local/desmet-school-seeks-to-address-lack-of-housing-mixed-use/article_5215055e-00a1-5c87-868e-6661831a585d.html.

24. *See* JANNA BLASINGAME CUSTER, NEW URBANISM AND EUCLIDIAN ZONING: CAN THEY CO-EXIST? 5 (2007) (explaining how "[i]n metro Atlanta . . . counties and cities have been revising their ordinances in recent years to encourage mixed-use developments" and that "Georgia city manager Kathy Brannon noted, 'The change [in her city's ordinances to allow for mixed-use communities was] market driven.'"); Hirt, *supra* note 20, at 225 (stating that "[t]he mixed-use principle has become a key tenet of the most influential current planning paradigms"); Lamer, *supra* note 21, at 391 (advocating for the amendment of zoning ordinances to allow mixed-use neighborhoods).

25. Lamer, *supra* note 21, at 395.

did not hold true.[26] In other words, while residences—the highest use—were allowed in industrial or commercial districts—i.e., lower uses—, this form of zoning excluded industrial or commercial uses from residential areas.[27]

Later, after World War II, noncumulative zones started becoming more widespread.[28] Noncumulative zoning, in addition to excluding lower uses from higher-use areas, as cumulative zoning did, also excluded higher uses from lower use zones.[29] Thus, under a noncumulative approach, industries cannot be located in residential areas but, unlike with cumulative zoning, residences are not allowed in industrial zones. As some authors have noted, one of the main reasons that justified that shift was that "lower uses . . . also required protection from higher uses . . . if zoning legislation was to be effective."[30] This idea, coupled with the willingness to retain industry after the shipping revolution had made cities less attractive to industry, led New York City and other major cities to adopt some form of noncumulative zoning to prevent other uses from pricing out factories.[31]

More recently, scholars have questioned the validity of these two arguments in support of noncumulative zoning.[32] The first argument in favor of noncumulative zoning has been that residences in manufacturing areas are a threat to industries because they may subject the latter to nuisance complaints.[33] In response to this argument, scholars have pointed out that keeping non-industrial uses out of manufacturing zones is too drastic a measure to deal with this situation.[34] As this Article explains in Part II.A, there are other ways of addressing the nuisance-type problems that may arise in mixed-use districts.[35] The second argument in support of noncumulative zoning is that allowing residential uses in manufacturing districts—as cumulative zoning would permit—would drive up the price of the land, pushing industrial users out of the city.[36] In response to that claim, some commentators have argued that using noncumulative zoning for such purposes—i.e., as a subsidy aimed at maintaining industry within city limits—is inefficient and lacks transparency because it makes it very complicated for the public to know the actual cost of the subsidy.[37]

In addition to challenging the arguments supporting noncumulative zoning, scholars have also noted the problems that this form of zoning can lead to. One author concludes

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26. *See* 12 N.Y. JUR. 2d *Buildings* § 217 (2016).
27. *Id.*
28. David Schleicher, *City Unplanning*, 122 YALE L.J. 1670, 1681 (2013).
29. *Id.*
30. 12 N.Y. JUR. 2d *Buildings* § 217 (2016).
31. Hills & Schleicher, *supra* note 11, at 254. In New York City, for example, the statement of general purposes in the Zoning Resolution shows the concern for maintaining industrial uses in New York City: "These general goals include, among others, the following specific purposes: (a) To provide sufficient space, in appropriate locations, to meet the needs of the City's expected future economy for all types of manufacturing and related activities, with due allowance for the need for a choice of sites." N.Y.C., N.Y., ZONING RESOLUTION § 41-00 (1961). There are three types of manufacturing districts: M1 (Light Manufacturing Districts), M2 (Medium Manufacturing Districts), and M3 (Heavy Manufacturing Districts). *Id.* §§ 41-11 to -13. Consistently with this idea of protecting industry, the Zoning Resolution adopts a noncumulative zoning approach which excludes residential completely from M2 and M3. *Id.* §§ 41-12 to -13.
32. Hills & Schleicher, *supra* note 11, at 255, 272.
33. *Id.*
34. *Id.*
35. *See infra* Part II.A.
36. Hills & Schleicher, *supra* note 11, at 255.
37. Schleicher, *supra* note 28, at 1724.

that "[w]hat started out as a noble intention to protect the health of citizens and improve the quality of life in the urban environment may have done just the opposite by fostering the sprawling pattern of today's cities."[38] Sprawl, in turn, can harm the environment, create automobile dependence, and cause racial segregation in inner cities.[39] In light of these criticisms, it is not surprising to see a surge in initiatives seeking to increase the creation of mixed-use districts.[40]

B. Performance Zoning

Another concept that is closely tied to the notion of mixed-use districts is performance zoning. As noted above, conventional zoning, which divides the territory into use districts to ensure that uses deemed incompatible are physically separated from each other, has been criticized on various grounds.[41] Commentators have argued that conventional zoning inflates the price of housing, creates delays, and imposes excessive costs on developers.[42] A potential alternative to conventional zoning that has been acquiring momentum is performance zoning, which instead of limiting the uses in a particular district, focuses on the impacts of the different activities.[43] In other words, whether a certain use may be located in a particular district depends on the impact that it will cause on the area, rather than on its use category, such as residential or manufacturing.

It is worth noting that, while some municipalities have eliminated conventional zoning completely and replaced it with performance zoning, others have adopted a hybrid system.[44] The so-called "Kendig model," for example, still separates incompatible uses into different districts, but, within each mixed-use district, it employs performance standards to limit the negative impacts of certain uses upon others.[45] In the Kendig model, one way of separating incompatible uses that are located in the same district are "bufferyards," which place a barrier between the two or more potentially conflicting uses.[46] Regardless of whether we are talking about a "pure" or a hybrid system, performance zoning schemes have two common traits: (1) they give a landowner more leeway when deciding to what use she can dedicate the land, and (2) they place the emphasis on performance standards.[47] In the noise context, performance standards generally adopt the form of maximum noise levels with which activities must comply.[48]

Different authors have praised the virtues of performance zoning. From the perspective of the landowner, performance zoning allows a broader range of uses for the land,

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38. Lamer, *supra* note 21, at 395.

39. Wayne Batchis, *Enabling Urban Sprawl: Revisiting the Supreme Court's Seminal Zoning Decision* Euclid v. Ambler *in the 21st Century*, 17 VA. J. SOC. POL'Y & L. 373, 375 (2010).

40. *See* sources cited *supra* note 24.

41. As explained above, this feature of conventional zoning is more salient in the case of noncumulative zoning, but it also applies to some extent to cumulative zoning, which still prohibits industrial uses in residential zones. *See infra* Part II.A. *See also* Frederick W. Acker, Note, *Performance Zoning*, 67 NOTRE DAME L. REV. 363, 366 (1991).

42. *Id.* at 366–67.

43. ARDEN H. RATHKOPF ET AL., RATHKOPF'S THE LAW OF ZONING AND PLANNING § 21:67 (4th ed. 2016).

44. 1 ZONING & PLANNING DESKBOOK § 2:13 (2d ed. 2016).

45. Acker, *supra* note 41, at 372.

46. *Id.* at 373.

47. 1 ZONING & PLANNING DESKBOOK § 2:13 (2d ed. 2016).

48. Further detail on the nature of performance standards is provided *infra* in Part II.B.

which in turn may increase its value.[49] Further, commentators have noted that municipal governments also benefit from performance zoning because, by permitting landowners to use their land in a more flexible and economically efficient way, the tax base increases.[50]

In short, mixed-use districts—regardless of whether they are created under a cumulative zoning or performance approach, or not—are becoming increasingly popular.[51] While this Article does not take a position on the desirability of these types of districts, it does claim that areas that are following this approach should have regulatory systems that are well suited to dealing with some of the problems that mixed-use districts can generate. As different studies have shown, one challenge that mixed-use districts present is the issue of noise.[52] Performance standards offer one possible avenue.[53] However, for standards of performance to be a good solution, they must have the necessary sophistication to control noise both effectively and efficiently. The next sections will examine the different ways in which noise in urban areas can be addressed, as well as some of the potential avenues for improving the existing local frameworks.

II. NOISE REGULATION AT THE LOCAL LEVEL

A. Noise and Federalism

1. Federal Noise Regulation

The only significant attempt by the federal government to regulate noise was through the Noise Control Act of 1972.[54] The Environmental Protection Agency created the Office of Noise Abatement and Control to carry out "a full and complete investigation and study of noise and its effect on the public health and welfare."[55] The goals that the statute entrusted to the Office were the following:

> (1) identify and classify causes and sources of noise, and (2) determine—(A) effects at various levels; (B) projected growth of noise levels in urban areas through the year 2000; (C) the psychological and physiological effect on humans; (D) effects of sporadic extreme noise (such as jet noise near airports) as compared with constant noise; (E) effect on wildlife and property (including values); (F) effect of sonic booms on property (including values); and (G) such other matters as may be of interest in the public welfare.[56]

A few years later, Congress enacted the Quiet Communities Act of 1978, which amended the Noise Control Act and was directed at providing more tools to state and local governments.[57] The federal noise program, however, was short-lived. In 1982, the federal government decided that state and local governments were in a better position to handle noise

49. 1 ZONING & PLANNING DESKBOOK § 2:13 (2d ed. 2016).
50. *Id.*
51. *See* sources cited *supra* note 24.
52. Dana L. Brown & Lee White, *Noise: A Land Use Dilemma? A Case Study of the City of Jacksonville*, FLA. B.J., Nov. 2009, at 52, 53.
53. Lamer, *supra* note 21, at 403.
54. Pub. L. No. 91-604, 86 Stat. 1234 (1972); Brautigam, *supra* note 15, at 425.
55. 42 U.S.C. § 7641(a).
56. § 7641(a).
57. Paula P. Bentley, Comment, *A Line in the Sand: Florida Municipalities Struggle to Determine the Line*

issues.[58] As a result, while the provisions of the Noise Control Act of 1972 remain in place, the EPA progressively reduced the Office of Noise Abatement and Control's funding.[59] States and local governments reacted by taking the lead and creating ways to address noise pollution.[60]

2. Noise Control at the State Level: Nuisance and Regulation

Tort law has traditionally dealt with noise through the doctrine of nuisance.[61] This doctrine dates back to, at least, the twelfth century,[62] but its basic principles had been recognized in Roman law long before that time.[63] In addition, states have also enacted various types of regulations to address noise problems.[64] A detailed explanation of how these regulations operate is provided in Part II.C. For the purposes of this discussion, however, suffice it to say that noise control frameworks generally incorporate one of two types of standards.[65] First, emission standards limit the level of noise that a source generates, and compliance is measured in close proximity to the source.[66] Second, immission standards address the noise levels to which people are exposed, and, thus, are generally measured farther away from the source and near where the potentially affected people are located.[67] The next two sections explore the principles of nuisance, as applied to noise, and the debate over whether regulation or tort is a more adequate way to deal with this problem.

a. Nuisance

The doctrine of nuisance finds its "modern incarnation" in the Restatement (Second) of Torts.[68] Section 821A lays out the two types of nuisance: public nuisance and private nuisance.[69] While, theoretically, both are potentially relevant when examining the issue of noise pollution, plaintiffs tend to use the doctrine of public nuisance less frequently because it presents some additional hurdles to those bringing the action.[70]

The Restatement defines private nuisance as "a nontrespassory invasion of another's

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Between Valid Noise Ordinances and Unconstitutional Restrictions, 35 STETSON L. REV. 461, 468–69 (2006).

58. ENVTL. PROT. AGENCY, *EPA History: Noise and the Noise Control Act*, https://www.epa.gov/history/epa-history-noise-and-noise-control-act (last visited June 17, 2017) [hereinafter *EPA History*].

59. Shapiro, *supra* note 13, at 20; *EPA History*, *supra* note 58.

60. Brautigam, *supra* note 15, at 425.

61. *Id.* at 417.

62. RESTATEMENT (SECOND) OF TORTS § 821D cmt. a. (AM. LAW INST. 1979).

63. *See* Melius De Villiers, *Nuisances in Roman Law*, 13 L. Q. REV. 387, 387 (1897) (explaining that "[t]here is no term in Roman Law corresponding to the English word 'nuisance' [but] there are certain rules of law in the legislation of Justinian that to a considerable extent are in agreement with the principles of English law relative to the subject indicated by that word.").

64. *See, e.g.*, OR. ADMIN. R. 340-035-0005 (2015). For more examples, see *infra* Part II.C.

65. In some cases, they use both. *See, e.g.*, OR. ADMIN. R. 340-035-025, -35 (2015) (imposing limitations on the noise generated by automobiles while also requiring "industrial or commercial sources" not exceed the "ambient statistical noise levels.").

66. *See infra* Part II.B.

67. *See infra* Part II.B.

68. *See* Thomas W. Merrill, *Is Public Nuisance a Tort?*, 4 J. TORT L. 1, 4 (2011).

69. RESTATEMENT (SECOND) OF TORTS § 821 et seq. (AM. LAW INST. 1979).

70. Dunlap, *supra* note 16, at 68. However, there are some cases in which plaintiffs have brought public nuisance lawsuits in the noise context and have been successful at obtaining relief. *See, e.g.*, New York v. Waterloo Stock Car Raceway, Inc., 409 N.Y.S.2d 40, 45 (Sup. Ct. 1978).

interest in the private use and enjoyment of land."[71] For liability for private nuisance to arise, the invasion must be "intentional and unreasonable."[72] An intentional invasion is unreasonable if any of the following two factors are present. First, if "the gravity of the harm outweighs the utility of the actor's conduct," which courts determine using a multi-factor balancing test.[73] Even if this balancing favors the actor, a court may still find a nuisance under the second factor. The second factor, which applies to serious harms only, is met when "the [actor's] financial burden of compensating for this and similar harm to others" would not jeopardize the continuation of the activity.[74] In other words, even if the utility of the actor's conduct is greater than the harm, the Restatement still favors imposing liability in cases in which a certain activity is causing a harm that is serious, as long as requiring the owner of such activity to compensate the aggrieved party would not affect the viability of the activity.[75]

While both factors lead to a finding that a certain activity is a nuisance, it is important to stress that the remedy that a court could provide to the plaintiff in these two scenarios is different. In the first case—where the gravity of the harm exceeds the utility of the conduct—the court could grant an injunction.[76] In the second scenario, however, the default remedy would be for the court to impose damages on the offending party.[77] The reason that supports this different approach is that, while an injunction has the purpose and effect of stopping the activity, the award of damages would merely "place on the activity the cost of compensating for the harm it causes."[78]

In the case of disputes related to noise pollution, the balancing test that determines whether a court should grant an injunction may ultimately hinge upon how socially valuable the activity causing the annoyance is perceived to be. Two examples illustrate how this balancing test operates in practice. In the case of an airport, the decision to grant an injunction will depend on "the social value of aviation and the need for air transportation," and how it compares to the harm derived from such activity.[79] It is possible to see how a large airport, given its social value, could justify granting the plaintiffs damages instead of an injunction. However, some recreational activities such as a racetrack have been

71. RESTATEMENT (SECOND) OF TORTS § 821D (AM. LAW INST. 1979).

72. *Id.* § 822. If it is unintentional, it is actionable if it meets the requirements for negligence or strict liability. *See id.*

73. *Id.* §§ 827, 828.

74. *Id.* § 826.

75. *Id.* § 826 cmt. f.

76. RESTATEMENT (SECOND) OF TORTS § 826 cmt. f (AM. LAW INST. 1979).

77. *Id.* § 826. The original rule in some states was that once a nuisance had been found, and the harm caused was substantial, the activity would be enjoined even if the economic effects of the injunction on its owner were greater than those caused by the activity upon the plaintiff. Boomer v. Atlantic Cement Co., 257 N.E.2d 870, 872 (N.Y. 1970). The problem with this approach was illustrated by the situation in *Boomer v. Atlantic Cement*, where the sum of the damages to all plaintiffs was approximately $185,000, *id.* at 874, while granting an injunction would have stopped a plant that cost in excess of $45 million and employed over 300 people, *id.* at 874 n.*. In that case, the Court of Appeals of New York decided to adopt a rule consistent with that currently in the Restatement and granted an injunction that would be vacated upon payment by the plaintiff of permanent damages to the defendants. In sum, under the rule in the Restatement and *Boomer v. Atlantic Cement*, the burden that the plaintiff must bear to obtain damages—that the harm is serious and compensation would not be fatal for the activity—is lower than that required for an injunction—that the balance between harm and utility tips in favor of the former.

78. *Id.*

79. *Id.*

treated differently by the case law—and therefore enjoined—based on the argument that the harm they created was greater than their social value, which was perceived to be relatively low.[80]

b. Nuisance v. Regulation

Noise control has not been left out of the debate over whether tort liability or regulation is better suited to deal with potentially harmful activities.[81] This question is especially relevant at the state level, where legislatures have the opportunity to favor one alternative over the other.[82] One theoretical framework that is particularly useful when examining this dichotomy in the context of noise is the model created by Steven Shavell.[83] It starts by describing tort as private in nature and explaining that it relies on the deterrent effect of a potential future legal action for damages after the harm has occurred, and contrasts it with regulation, which is public in character and attempts to prevent the occurrence of the harm in the first place.[84] It then provides four factors to aid in determining the "relative desirability" of liability or regulation.[85]

The first factor relates to "the possibility of a difference in knowledge about risky activities as between private parties and a regulatory authority."[86] In other words, if private parties have better knowledge of their benefits, the probability of occurrence of harm, its severity, and the costs of preventing it, then liability should be favored over regulation.[87] Private parties will have more information thereby allowing them to set the risk at the level that maximizes social welfare, and the threat of being sued will serve as an incentive to act consistently with such information.[88] In the case of noise-generating industrial facilities, their operators may have a better knowledge of their benefits and the costs of reducing

80. In *New York v. Waterloo Stock Car Raceway*, for example, a New York court enjoined the operation of a racetrack and distinguished *Atlantic Cement* based on the fact that the benefits in this case were lower—the facility only employed "a few people." New York v. Waterloo Stock Car Raceway, Inc., 409 N.Y.S.2d 40, 45 (Sup. Ct. 1978).

81. One author suggests creating a new "product-nuisance" tort which would allow courts to impose liability upon a manufacturer regardless of whether there is physical harm and even if the manufacturer does not control the instrumentality. Lief, *supra* note 14, at 642. Another author, however, proposes to provide a solution for car "horn use and abuse" based on a new regulatory framework under which the government would create a metering system that would allow enforcement officials to "measure actual horn use." Brautigam, *supra* note 15, at 434.

82. The federal government is mostly limited to creating new regulatory frameworks, as are the municipalities, due to the fact that nuisance is primarily a matter of state law. *See* JEFFREY MILLER ET AL., INTRODUCTION TO ENVIRONMENTAL LAW: CASES & MATERIALS ON WATER POLLUTION CONTROL 19, 21 (2008) (explaining, in the context of the common law of nuisance, that "common law is a creature of state law," although there are some limited areas in which the Supreme Court has recognized the existence of federal nuisance law).

83. Steven Shavell, *Liability for Harm Versus Regulation of Safety*, 13 J. LEG. STUD. 357, 357 (1984). Other authors have focused the analysis on whether courts or agencies are better positioned to deal with certain risks. *See* Clayton P. Gillette & James E. Krier, *Risk, Courts, and Agencies*, 138 U. PA. L. REV. 1027, 1061 (1990); Peter Huber, *Safety and the Second Best: The Hazards of Public Risk Management in the Courts*, 85 COLUM. L. REV. 277, 331 (1985).

84. Shavell, *supra* note 83, at 357.

85. *Id.* While the framework that this scholar developed to determine "the relative desirability" of liability or regulation refers specifically to "safety" and not the annoyance or inconvenience that noise typically causes, some of the factors that he considered in his analysis are also useful when examining the issue of noise pollution, as the following discussion will show.

86. *Id.* at 359.

87. *Id.*

88. *Id.*

noise, but a regulator may know more about the harm that the noise is causing to third parties or the likelihood of its occurrence. Still, while a regulator may have less information on the benefits of the activity and the cost of certain noise-reduction devices applied to a particular facility, the regulator may know the general costs of the noise control technologies that are available in the market. This factor does not clearly favor one system over the other.

The second factor to consider is the notion that "private parties may be incapable of paying for the full magnitude of the harm done."[89] In the noise context, this part of the analysis is not particularly relevant. As explained above, the most common effects of noise are annoyance and inconvenience, rather than latent or catastrophic harm.[90]

The third factor that may influence the assessment of whether regulation or liability is a more appropriate way of dealing with noise is "the chance that parties would not face the threat of suit for harm done," and that, therefore, the reduced deterrence would lead the operator to set the risk level too high.[91] With noise pollution, the threat of being sued is likely related to the magnitude of the harm to each particular person. Thus, if an industrial facility is preventing people living in the vicinity of the plant from sleeping at night, carrying out other important activities, or causing high blood pressure, then the likelihood that they will sue the industrial operator will be high.[92] If, on the other hand, as a result of the zoning in a particular locality, the facility is located far away from residences, each affected person may be receiving some moderate inconvenience not worth suing over. If the number of affected people is high, the total magnitude of the harm would be important. However, the owner of the plant may not take into account the harm that it is causing because the likelihood of a suit is low. In these situations, liability may lead to suboptimal results.

The last factor is "the magnitude of the administrative costs incurred by private parties and by the public in using the tort system or direct regulation."[93] As Shavell notes, this factor will generally weigh in favor of liability because, under that system, costs are only incurred when there is a harm.[94] In the case of regulation, the costs are sustained even if there is no harm at all.[95]

This analysis—where two factors point in a different direction and the other two are inconclusive—suggests that neither liability nor regulation is clearly superior to the other alternative. In light of this, it is important to point out that the two systems are not mutually exclusive, and that, in fact, some balance between the two—which will vary depending on the nature of the risk—may be the optimal solution.[96] This is consistent with the current state of affairs in many jurisdictions: many states have noise-control statutes or regulations

89. Shavell, *supra* note 83, at 360.

90. However, it is not impossible to envision a scenario under which the award of damages for past disturbances would be too high for an industrial operator to afford, especially if there are multiple affected parties.

91. Shavell, *supra* note 83, at 363.

92. This risk of being sued, however, will not be high if those harmed do not have the necessary resources to bring a lawsuit.

93. Shavell, *supra* note 83, at 364.

94. *Id.*

95. *Id.*

96. *Id.*

that give agencies enforcement authority, as well as common law causes of action available to those aggrieved by noise who find it appropriate to take the issue to court.[97]

3. Local Regulation

States may delegate to municipalities, through express grants or home rule provisions, the authority to enact ordinances to regulate noise.[98] These ordinances generally rely on the local government's authority to protect the public health, welfare, and safety of its citizens.[99] Many municipalities in the United States, major cities in particular, have enacted noise control ordinances of some sort.[100]

While, as explained above, states have different and powerful tools to deal with noise pollution, this Article will focus on noise control at the local level. This Article is particularly concerned with the noise problems that the creation of mixed-use districts can bring about, which partly results from the potential for certain uses to cause negative impacts on others. This is more likely to occur in some municipalities more than in others, depending on whether they encourage the creation of mixed-use districts. In other words, although the recommendations contained in Part III of this Article can be used for any kind of noise ordinance or even state statute, municipalities interested in promoting mixed-use districts will be able to benefit from these improvements to a greater extent. As a result, the decision on how necessary it is to improve the current noise control framework to advance the goal of creating more mixed-use districts is one that each municipality will make independently, based on its own needs and preferences.

In any event, it is important to point out that ordinances will, in many instances, have to coexist with state common law and, in some cases, with statewide noise control regulatory frameworks. This can create two types of tensions. First, some state statutes limit local government's ability to set its own noise standards freely. This can occur, for example, when a state statute only allows the local government to set standards that are at least as stringent as those contained in the statute.[101] The extent to which this will be a problem depends on how stringent these state standards are. Second, nuisance suits could undermine certain positive features of noise ordinances. Modern noise ordinances tend to have numerical noise standards—generally expressed in decibels— which provides certainty to all the regulated community.[102] However, someone could bring a nuisance suit against a party whose activities are generating noise, even though that noise complies with the standards in the ordinance. Fortunately, courts have already been dealing with this issue by

97. *See* ROBERT C. CHANAUD, NOISE ORDINANCES: TOOLS FOR ENACTMENT, MODIFICATION AND ENFORCEMENT OF A COMMUNITY NOISE ORDINANCE A-2 (2014), https://www.noisefree.org/Noise-Ordinance-Manual.pdf (providing several examples of states that have enacted noise control statutes and regulations). For examples of state courts recognizing the cause of action for nuisance in noise cases, see Schneider Nat'l Carriers, Inc. v. Bates, 147 S.W.3d 264, 269 (Tex. 2004); Toyo Tire North Am. Mfg., Inc. v. Davis, 299 Ga. 155, 162, 167–68 (2016); New York v. Waterloo Stock Car Raceway, Inc., 409 N.Y.S.2d 40, 45 (Sup. Ct. 1978).

98. Brautigam, *supra* note 15, at 427.

99. *See, e.g.*, LOS ANGELES COUNTY, CAL., CODE OF ORDINANCES § 12.08.20.B (1978); PORTLAND, OR., CODE § 18.02.020 (2001).

100. *See infra* Part II.C.

101. *See, e.g.*, N.J. STAT. ANN. § 13:1G-21 (West 1971).

102. *See infra* Part II.C. For a discussion about the ways in which less modern ordinances framed noise limitations and the legal problems that this generated, see Bentley, *supra* note 57, at 484–85.

taking into account regulatory limits when applying the doctrine of nuisance,[103] which limits the magnitude of the problem.[104]

B. The Basic Principles of Noise Regulation

Noise-control regulatory frameworks are similar to regulations that address other forms of pollution in many ways.[105] Thus, when analyzing noise-control frameworks, it is helpful to keep in mind the basic principles and traditional categories of regulatory tools that are generally found in most types of pollution-control regulations. Two of these classifications are of particular relevance in the context of noise pollution control: (1) the difference between design and performance standards, and (2) the emission/immission dichotomy.

Regulatory standards can be divided into design standards and performance standards.[106] Design standards specify the particular technology that an industry must use to reduce pollution.[107] In other words, with a pure design standard, the operator meets the standard by merely using that technology, regardless of the final degree of pollution reduction that it achieves. A performance standard, on the other hand, requires an "emission rate or other measure of performance to be attained," leaving the decision of what technology to employ to the regulated entity.[108] Initially, zoning regulations subjected industries to design standards, such as maximum heights for smokestacks and provisions regulating building materials.[109] During the 1950s and 1960s, however, manufacturing district regulations started exploring a different approach focused on the result rather than on the means: industrial performance standards.[110] Noise regulations can potentially incorporate both types of standards. A requirement that certain motor vehicles be equipped with specific devices to attenuate noise would fit into the design standard category, while limiting the number of decibels that a certain activity can generate would be an example of a performance standard. Given that this Article's primary concern is minimizing the impacts of activities in mixed-use districts, the following discussion will focus on performance standards, which are results oriented.[111]

The other useful distinction is between regulations that attempt to control pollution by measuring emission and those that focus on immission. As one author explains, the difference between emission and immission is that the latter focuses on the reception.[112] Stated differently, pollution is emitted by a source, it is then transmitted (through the air),

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103. *See, e.g.*, Smith v. Tennessee Valley Auth., 436 F.Supp. 151 (E.D. Tenn. 1977).

104. For a discussion of the problem with nuisance suits in areas in which municipalities would allow high levels of noise, see Hills & Schleicher, *supra* note 11, at 257–60.

105. For example, they have to take into account the competing interests at stake and consider the health impacts of industrial activities on people and the environment.

106. Timothy F. Malloy & Peter Sinsheimer, *Innovation, Regulation and the Selection Environment*, 57 RUTGERS L. REV. 183, 196 (2004).

107. *Id.*

108. Timothy F. Malloy, *The Social Construction of Regulation: Lessons from the War Against Command and Control*, 58 BUFF. L. REV. 267, 284 (2010).

109. Acker, *supra* note 41, at 370.

110. *Id.*

111. The connection between zoning and standards of performance is addressed in more depth in Part I.B.

112. TJEERT TEN WOLDE, THE EUROPEAN POLICY AND LEGISLATION ON ENVIRONMENTAL NOISE 2 (2005), http://www.ince-j.or.jp/old/05/05_page/05_doc/policyEU.pdf.

and it finally reaches a particular receiver.[113] Emission standards address what happens at the source (by, for example, requiring that an air pollutant not exceed a certain concentration when it exits a smokestack), whereas immission limitations are concerned with the levels of pollution that will be experienced by the receivers (by, for instance, monitoring the concentration of an air pollutant in the middle of a park).[114] This distinction originated in the context of air pollution and was later borrowed by noise regulations.[115] Determining in which of these two categories a particular regulation should be included can be tricky in certain situations, as will be explained below.[116] In other cases, however, it is easier to make that differentiation. The New York City Noise Code, for example, employs both. Sound produced by refuse vehicles, for example, is measured at a distance of thirty-five feet or more from the source, i.e., where the receiver of that noise could be situated.[117] In the case of machinery such as air compressors, the New York City Noise Code requires that the sound be measured at a distance of one meter from the compressor, i.e., where the source, rather than the potential receiver, is located.[118]

C. Types of Noise Ordinances

The following examples are intended to illustrate common types of frameworks and provisions that are found in noise control ordinances of cities across the United States. The first part of the analysis will examine immission ordinances—i.e., those limiting the noise that reaches receivers—by describing its two main types: (1) matrix and (2) non-matrix frameworks. The second set of examples will focus on emission-control provisions—i.e., those controlling the noise at the location of the source.

1. Immission Ordinances: Matrix System

The City of Portland, Oregon, has a very sophisticated noise ordinance that sets noise standards in decibels, which is the unit that is generally employed to measure sound pressure.[119] By way of reference, rustling leaves generate twenty decibels, a quiet room in your home is forty decibels, a conversation in an unusually loud background is around sixty decibels, and a jackhammer or noisy factory can cause noises of ninety decibels.[120]

The ordinance includes noise standards for each of the four land-use zone categories: (1) residential, (2) open space, (3) commercial, and (4) industrial.[121] What makes this system a matrix, however, is that the maximum sound level that these zones can receive also

113. *Id.*

114. The Clean Air Act provides examples of these two types of frameworks. Limitations on hazardous air pollutants under section 112 focus on the emission generated by a specified source. 42 U.S.C. § 7412(c)(2) (2010). Ambient air quality standards, on the other hand, set maximum immission levels for certain pollutants. § 7412.

115. WOLDE, *supra* note 112, at 2.

116. *See infra* Part II.C.3.

117. N.Y.C., N.Y., NOISE CODE § 24-225 (2005).

118. N.Y.C., N.Y., NOISE CODE § 24-226 (2005).

119. PORTLAND, OR., CODE § 18.10.010.A (2010) (using the A-weighting network); Hansen, *supra* note 1, at 30–33.

120. ENGINEERING TOOLBOX, *Sound Pressure*, http://www.engineeringtoolbox.com/sound-pressure-d_711.html (last visited July 26, 2017).

121. PORTLAND, OR., CODE § 18.10.010. A (2010).

varies depending on the zone in which the *source* is located.[122] The following figure shows the different noise limits expressed in matrix format.

Zone Categories of Source	**Zone Categories of Receiver (measured at property line)**			
	Residential	**Open Space**	**Commercial**	**Industrial**
Residential	55	55	60	65
Open Space	55	55	60	65
Commercial	60	60	70	70
Industrial	65	65	70	75

Table 1[123]

It is important to note that, while this framework takes into account the location of the source, it is still an immission-type regulation. What determines whether an ordinance limits emission or immission is the location where noise levels are *measured*.[124] In the case of Portland's ordinance, even though the location of the source is taken into account to determine which standard will apply, compliance with these standards is always measured on the property of the receiver, as opposed to that of the source.[125]

The ordinance also includes a series of adjustments that can modify these maximum sound levels. The values in Table 1 apply from 7 a.m. to 10 p.m. During the so-called "night hours" (after 10 p.m. and before 7 a.m.), the sound levels are reduced by five decibels.[126] Moreover, sounds that present frequency characteristics that could threaten the public health, welfare, or safety of the city's citizens are subjected to a maximum decibel level that is more stringent than that in Table 1.[127]

2. Immission Ordinances: Non-Matrix System

The noise control ordinance of the County of Los Angeles provides a good example of a non-matrix immission system. Similar to the Portland noise ordinance, the Los Angeles local regulations create four noise zones: (1) noise-sensitive areas, (2) residential properties, (3) commercial properties, and (4) industrial properties.[128] Because it is an immission framework, compliance with the noise standards is measured on the receiver's property.[129] Unlike in Portland, however, there is one maximum noise level per noise zone; the standards do not change based on the type of source it comes from.[130] Thus, the resulting maximum noise level table is simpler, as shown below.

Designated Noise Zone Land Use	**Exterior Noise Level (dB)**
Noise-Sensitive Area	45
Residential Properties	45

122. § 18.10.010. A.
123. § 18.10.010. A.
124. *See supra* Part II.B.
125. PORTLAND, OR., CODE § 18.10.010. A (2010).
126. § 18.10.010. B.
127. §§ 18.10.010. B, G.
128. LOS ANGELES COUNTY, CAL., CODE OF ORDINANCES § 12.08.390 A (1978).
129. § 12.08.390 A.
130. § 12.08.390 A.

Commercial Properties	55
Industrial Properties	70

Table 2[131]

3. Emission Ordinances

While pure emission noise ordinances are not very common, some large cities in the United States do have noise control provisions that predominantly focus on emission. New York and San Diego offer examples of this.

New York City has a wide variety of noise regulations. They can be grouped into three main categories: the provisions in the New York City Zoning Resolution, the New York City Noise Code, and the New York City Environmental Quality Review.[132] The most relevant regulations for the purposes of this discussion about the emission/immission dichotomy are those found in the New York City Zoning Resolution.[133] The Zoning Resolution limits the noise caused by activities located in manufacturing districts, which can include different types of uses, including commercial and residential.[134] The specific standards vary slightly for each manufacturing district (M1, M2, or M3) and take into account not only the decibels of the noise, but also its frequency.[135] The applicable limits are the following:

Octave Band	**Maximum Sound Pressure Level Permitted (in decibels)**		
(cycles per second)	**M1**	**M2**	**M3**
20 – 75	79	79	80
75 – 150	74	75	75
150 – 300	66	68	70
300 – 600	59	62	64
600 – 1200	53	56	58
1200 – 2400	47	51	53
2400 – 4800	41	47	49
Above 4800	39	44	46

Table 3[136]

The question of whether a particular provision controls emission or immission depends on the language used to specify where—location of the source or of the receiver—the compliance with the noise maximum level is to be determined. Section 42-213 of the Zoning Resolution limits the maximum decibels generated by any activity, measured "at any point *on* or *beyond* any lot line."[137] This wording would suggest that this is both an emission and an immission provision. If the noise is measured on the property line, it is

131. § 12.08.390.

132. WEIXIONG WU, UPDATED NOISE REGULATIONS IN NEW YORK CITY 1 (2008), http://www.bowery-yevents.com/wp/wp-content/uploads/2010/04/NYC-Noise-Regulations.pdf.

133. N.Y.C., N.Y., ZONING RESOLUTION §§ 42-21 to -214 (1961).

134. §§ 42-02, -213. The zoning resolution also contains other miscellaneous provisions dealing with noise, such as section 123-32, which requires new dwelling units located in a Special Mixed Use District to meet certain window wall attenuation requirements.

135. § 42-213.

136. § 42-213.

137. § 42-213 (emphasis added).

being evaluated at the source, and therefore it is looking at emission. If, however, compliance with the maximum sound level is measured at some point beyond the source's property boundary, and where a receiver may potentially be located, the provision would be limiting immission.

The reason why this is predominantly an emission provision is that the emission standard is the most restrictive one. Except in very rare circumstances, the noise measured beyond the property line will be lower than the noise level on the property line.[138] Thus, if a receiver takes issue with the noise generated by an activity, what will ultimately determine whether the source is violating the standard or not is the noise level on the property line. Even if this receiver is experiencing a noise that is below the limit set by the Zoning Resolution, she may still be able to have local authorities intervene, as long as the noise level on the source's property line exceeds the noise standard.

As another author has pointed out, the provisions of the San Diego Municipal Code dealing with noise abatement and control also adopt an emission approach.[139] However, as with the New York City Zoning Resolution, it is rather a mixed system in which the emission component predominates. The relevant section of the San Diego Municipal Code reads "[i]t shall be unlawful . . . to cause noise . . . [that] exceeds the applicable limit . . . at any location in the City of San Diego *on or beyond the boundaries* of the property on which the noise is produced."[140] Again, the "*on or beyond*" language is consistent with both immission and emission frameworks but, for the reasons explained in the previous paragraph, the emission component will be the one ultimately determining whether a source is complying with the standards in the ordinance or not.

III. DESIRABLE FEATURES OF NOISE ORDINANCES

Part II.C proposed a classification of noise ordinances—emission and immission, with matrix and non-matrix approaches—and identified some features that serve to further differentiate these frameworks, such as adjustments based on frequencies or times of the day. Against this background, Part III seeks to examine the desirability of these different options. The ultimate goal is to evaluate which of these features can make the coexistence of diverse uses in the same district more viable, considering the needs of all the parties involved. The following sections will compare different types of ordinances and assess whether an ordinance with a certain feature, such as adjustment of noise standards to account for annoyance, would lead to a better outcome than one without it.[141]

A. Varying Noise Limits Depending on Time and Day

One feature that some noise ordinances have but that others—even in big cities—do

138. Noise decreases with distance. *See* ENGINEERING TOOLBOX, *Inverse Square Rule*, http://www.engineeringtoolbox.com/inverse-square-law-d_890.html (last visited July 26, 2017) ("A doubling of the distance from a noise source will reduce the sound pressure level with 6 decibel.").

139. CHANAUD, *supra* note 97, at A-17.

140. SAN DIEGO, CAL., MUNICIPAL CODE § 59.5.0401 (1973).

141. One metric that has been used to determine the desirability of certain measures in the context of risk producing activities is Steven Shavell's definition of social welfare. Shavell, *supra* note 83, at 358–59 (Social welfare "equal[s] the benefits parties derive from engaging in their activities, less the sum of the costs of precautions, the harms done, and the administrative expenses associated with the means of social control.").

not always incorporate is different maximum noise levels depending on the time of the day. The City of Portland, Oregon, for example, has a set of noise standards that apply from 7 a.m. to 10 p.m., but which are reduced by five decibels during the night hours, after 10 p.m. and before 7 a.m.[142] Other ordinances even divide the day into three different periods: day, evening, and night, with decreasing maximum noise levels.[143] Surprisingly, not all noise control ordinances in big cities in the United States make this type of adjustment.[144]

The rationale for this difference in maximum noise levels depending on the time of the day is simple: the effect that noise has on people tends to vary throughout the day. During the so-called "day" hours, which generally start at around 7 a.m. for most ordinances, people are more active, and their tolerance for noise is higher.[145] After work, people tend to reduce their activity and, with it, their willingness to accept noise intrusions diminishes, reaching a minimum at night.[146] It is not surprising, in light of this, that experts have advised, as a 'best management practice,' to reduce the impact of noise produced by industrial sources by "scheduling the use of noisy equipment at the least-sensitive time of the day."[147]

From an efficiency perspective, an ordinance that accounts for these variations will also be superior to one that does not. As under the doctrine of nuisance, policymakers who set noise standards in ordinances often strike a balance—between the harm caused to the people who will suffer the consequences of the noise and the costs of noise-reducing measures that different activities will have to implement—to reach a figure that will account for the interests of both sources and receivers.[148] Because the harm that a certain level of noise causes on people changes throughout the day, a framework that does not consider these differences will not be as efficient as one that does.[149]

The reason why this leads to inefficiency is that an ordinance with one noise standard for the entire day will have set this standard at a particular level. This level will be either closer to the optimal balance between harm and cost at daytime or closer to the optimal

142. PORTLAND, OR., CODE § 18.10.010. B (2010).

143. *See, e.g.*, SAN DIEGO, CAL., MUNICIPAL CODE § 59.5.0401 (1973).

144. One significant example is New York's Zoning Resolution, which applies to industrial sources—even if the receivers of the sound are not industrial. N.Y.C., N.Y., ZONING RESOLUTION §§ 42-21 to -214 (1961). Section 42-214, in particular, makes an adjustment when industrial noise could affect residences—a six decibel reduction—but makes no differentiation depending on the time of the day. *See* § 42-214.

145. CHANAUD, *supra* note 97, at A-2, 3-17.

146. QUALITY PLANNING, NOISE MANAGEMENT IN MIXED-USE URBAN ENVIRONMENTS 5 (2013), http://www.qualityplanning.org.nz/images/documents/plan_topics/Noise/Noise_management_in_mixed_use_urban_environments/Noise_Management_in_Mxed_Used_EnvironmentsGN.pdf.

147. ENV. PROT. AUTH., NSW INDUSTRIAL NOISE POLICY 38 (2000), http://www.epa.nsw.gov.au/resources/noise/ind_noise.pdf.

148. *See supra* Part II.A.2.a; *see also* HUIB VAN ESSEN ET AL., SOUND NOISE LIMITS 13 (2005), http://ec.europa.eu/transport/sites/transport/files/modes/air/studies/doc/environment/2005_01_sound_noise_limits.pdf. For similar considerations in the context of noise abatement measures, see FED. HIGHWAY ADMIN., DEP'T OF TRANSP., HIGHWAY NOISE AND ABATEMENT GUIDELINES 14 (2016), https://hidot.hawaii.gov/highways/files/2016/06/hwy_l-2016-Noise-Policy-and-Approval-Letter.pdf.

149. In this Article, the term "efficiency" is used to illustrate this balancing between the benefits and costs of a noise-reducing initiative or regulation. One ordinance is more efficient than another one if it is closer to the optimal point where benefits are maximized and harm from noise is minimized. The specific value of this optimal point will depend on local conditions.

level at nighttime, but not both.[150] This will make it overprotective or underprotective during at least part of the day. For example, in a particular city, considering the varying susceptibility to noise and the benefits generated by noise-producing activities, the efficient noise limits could be sixty decibels during the day, fifty-five decibels in the evening, and forty-five decibels at night. A noise ordinance that has only one noise standard of fifty-five decibels for day and night will be overregulating during the day and underregulating at nighttime.

Even though incorporating different maximums for different times of the day will improve the ordinance, it is important to note that there are certain scenarios in which this will not necessarily be the case. If we are considering an immission ordinance, and therefore, the sound limits are set based on the use categories of the receiver, not all receivers will benefit from the night reduction of noise to the same extent.[151] Given that nighttime values are lower to account for the fact that people need a reduced noise level to sleep, lower night standards will not be adequate in areas where people are either not present or are not sleeping, such as in industrial buildings.[152] A good solution is one where, as the City of Lincoln has done, the ordinance has different noise standards for day and night in residential and other noise-sensitive areas, but has only one standard for the entire day for business and industrial uses.[153]

This same analysis can be applied to similar adjustments to noise standards. While ordinances that have varying noise standards depending on the time of day are not uncommon,[154] provisions taking into account whether the noise is produced during the week or on the weekend are less frequent.[155] This can include, for instance, modifying the times that are considered 'day' and 'night,' as Orlando's noise ordinance does by modifying the definition of 'day' hours to extend it two additional hours during the weekends.[156] While this distinction between weekdays and weekends may not be as relevant as that between day and night—after all, people tend to sleep at night regardless of the day of the week—taking into account these variations may still make a particular framework more efficient, depending on the particular mix of uses in the district.

In short, unfortunately, not all cities have different noise standards for different times of the day and days of the week. However, regulations that incorporate varying maximum noise levels for different times of the day and days of the week—based on people's tolerance to noise—are in a better position to adequately balance the interests of noise-producing activities and the people affected by noise. For this to be true, however, local governments should only apply this principle to receiving uses that are likely to have varying

150. Even if the benefits of noise stay the same, the optimal maximum noise level will vary between day and night hours. This is due to fact that the harm that a given level of noise causes on receivers is higher at night.

151. *See* CHANAUD, *supra* note 97, at 6-57.

152. QUALITY PLANNING, *supra* note 146, at 5. In the case of an emission ordinance, which focuses on the source, leaving only one noise standard would not solve the problem, since the industrial source could be having an impact on residential receivers.

153. LINCOLN, NEB., MUNICIPAL CODE § 8.24.090 tbl.1 (1979).

154. *See, e.g.*, PORTLAND, OR., CODE § 18.10.010. B (2010); LOS ANGELES COUNTY, CAL., CODE OF ORDINANCES § 12.08.390 (1978); SAN DIEGO, CAL., MUNICIPAL CODE § 59.50401 (1973).

155. Portland's ordinance, for example, only takes it into account for particular kinds of sources. *Compare* PORTLAND, OR., CODE § 18.10.010 (2010), *with* § 18.10.035.B.

156. ORLANDO, FLA., CODE OF ORDINANCES § 42.03 chart 1 (2009) (adjusting its Class B standards based on the day of the week).

sensitivities to noise depending on the day or time—residential—but not to those in which the tolerance to noise is more likely to remain constant, such as with industrial or certain commercial uses.

B. Emission v. Immission

While most ordinances set their noise limits for each land use category based on immission levels—focusing on the noise that reaches the receiver—there are still some ordinances that are mostly emission-based—setting maximum noise levels which are to be measured at the location of the source.[157] Some of these emission-based ordinances contain language stating that the maximum noise levels must be met on the property line of the source or beyond.[158] The existence of both immission and emission frameworks begs the question of which of these approaches is preferable.

1. The Case for Immission Frameworks

Immission systems have one major advantage over those based on emission: they allow for a better balance between noise-reduction costs and harm to potential receivers of the noise. This results from the fact that emission systems cannot, due to how they operate, adequately take into account the magnitude of the harm.

Emission provisions require that sound levels be measured at the lot line, but this is not necessarily a good proxy for the noise level that the receiver will perceive, which is the basis to correctly determine the magnitude of the harm.[159] In emission frameworks, if the closest sensitive receiver is far away or protected by a sound barrier, an industrial facility that complies with the standard may be reducing the sound level more than is necessary—the receiver is being exposed to a level of noise much lower than the standard requires. Conversely, if the factory is located across a narrow street from an apartment building, the level of noise that this residence is suffering may be too high even if the industry meets the appropriate noise limits on the lot line.[160] By not accounting for these variations, an emission standard deviates from the optimal level of reduction—which, to correctly capture the actual harm, would have to account for the noise level that is reaching the receiver, rather than the noise on the source's lot line. As a result, an emission standard is very likely to be too lenient or too stringent, and in any case, inefficient.

As explained earlier, immission ordinances can be further divided into matrix and non-matrix frameworks, based on whether they include one maximum sound level per receiving category or several—one for each source type.[161] As the example below shows, matrix models allow regulators to find a better compromise between the needs of noise-generating sources and the wellbeing of citizens.[162]

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157. *See supra* notes 137 and 140 and accompanying text.

158. *See supra* notes 137 and 139 and accompanying text.

159. There is no harm unless the noise reaches a receiver, and the magnitude of the harm will depend on the particular level of noise that the receiver is experiencing (not on the noise level that exists on the property line of the source).

160. If there is no buffer or enough distance, the residences in question could be exposed to a decibel level very similar to limits prescribed in the Zoning Resolution, which may still be too high.

161. *See supra* Part II.C.1.

162. CHANAUD, *supra* note 97, at A-9.

Zone Categories of Source	Zone Categories of Receiver (measured at property line)			
	Residential	**Open Space**	**Commercial**	**Industrial**
Residential	55	55	60	65
Open Space	55	55	60	65
Commercial	60	60	70	70
Industrial	65	65	70	75

Table 4[163]

Non-matrix provisions have one maximum noise level for each type of receiver, regardless of the noise source's location. Matrix systems, however, by considering the type of source and the needs of the different receivers, allow local governments to carefully set their noise limits based on the importance that the different types of sources have in a particular municipality. Depending on the local priorities, some locations may, for example, allow commercial uses to be the loudest, whereas others may give this privilege to industrial facilities.

2. Addressing the Criticisms to Immission Frameworks

Although immission ordinances present the major advantage of allowing for a better balance of the different interests at stake, at least one author has pointed out that immission frameworks have a drawback: they make the noise measurement more complicated as compared to emission ordinances.[164] For example, when multiple sources are generating noise in an area, determining which source is causing the violation of the standard at the location of a particular receiver can be trickier than simply measuring emission on the lot line of the source. This problem is not exclusive to noise pollution. In the water context, for example, courts have established that a state that receives pollution from an upstream state may only succeed in having such state reduce its discharges if the contribution of the upstream state's pollution is "detectable."[165] Another context in which this issue is frequent is soil pollution; in particular when multiple industrial activities pollute the same parcel of land.[166] Both examples illustrate the complexity of attributing pollution to a particular source, which is also present in the area of noise pollution.

This issue, however, is not insurmountable and can be, and, in fact, has been, effectively addressed in at least two different ways in the noise context. The first solution is to use the background noise level as a reference.[167] The background level can be defined as the noise immission without the contribution of the source being evaluated.[168] This level can be measured by requiring the source to stop certain equipment temporarily or by waiting and making the measurement at a time or day in which such machinery is not operating

163. PORTLAND, OR., CODE § 18.10.010 A.

164. CHANAUD, *supra* note 97, at 6-5.

165. Arkansas v. Oklahoma, 503 U.S. 91 (1992).

166. *See* Luis Inaraja Vera, *Compelled Costs Under CERCLA: Incompatible Remedies, Different Statutes of Limitations, and Tort Law*, 17 VT. J. ENVTL. L. 394, 395 (2016) (explaining the legal issues that arise in cases of land contamination with multiple potentially responsible parties).

167. Catalan noise control regulation, enacted under the umbrella of EU DIRECTIVE 2002/49 provides a good example of this. Decree Implementing the Provisions of Acoustic Pollution Act Preamble (D.O.G.C. 2009, 176) (Spain) [hereinafter *Noise Decree*].

168. *Id.* at Annex 3.4.

or is undergoing regular maintenance. Once the total noise levels with and without the source have been determined, the inspectors can establish the source's contribution to the violation.[169] The second solution is to use techniques that allow those in charge of enforcement to create a map of sources based on the different frequencies of the sounds of each source contributing to the total noise level.[170]

3. Conclusion: Immission Frameworks with Specific Emission Provisions

For the reasons explained above, immission noise ordinances that set limits based on receiving land use categories are superior to those that rely on emission levels. However, local governments may also want to add an additional layer of emission standards for certain types of sources. As one expert notes, "good ordinances also regulate emission levels . . . of a number of sound sources."[171] For example, emission standards are particularly useful to control the noise of mobile sources, given that the impact on a particular receiver can only be measured during a very brief period of time. In conclusion, in order for an ordinance to be able to strike an appropriate balance between the interests of noise-generating activities and receivers, it should include a general immission framework—with a matrix system being more desirable—and a set of specific provisions addressing mobile noise sources or particular types of equipment.[172]

C. Annoyance

One of the main effects of noise is annoyance, which is defined in the field of psychoacoustics as "any feeling of resentment, displeasure, discomfort, and irritation occurring when noise intrudes into someone's thoughts and moods or interferes with activity."[173] Surprisingly, there is not necessarily a direct relationship between loudness, measured in decibels, and annoyance. This direct relationship will only hold true when other features of the sound, such as frequency and duration, are equivalent.[174] Given the variety of sounds to which people are exposed—which have various durations and frequencies—an ordinance that effectively takes into account the effects of noise on people

169. Under the Catalan regulation, if the difference between the noise when the source is operating and the background noise is between three and ten decibels, the latter is subtracted to determine the contribution of the source that is being evaluated. *Id.* If the noise when the industrial facility is operating is more than ten decibels greater than the background noise, no correction is necessary. *Id.* The likely reason for this rule is that, given the significant increase in sound pressure that ten decibels represents, the contribution of the background noise to the final immission is negligible. *See* Hansen, *supra* note 1, at 35 (explaining that, in cases in which the difference between the loudness of two sources is of ten decibels or more, "the sound source with the lower level is practically not heard."). In cases where the difference is smaller than three decibels, the Catalan Noise Regulation provides that the inspectors need to make new measurements or attempt to determine the contribution of the multiple sources in a different manner. *Noise Decree*, *supra* note 167, at Annex 3.4.

170. One of these techniques is called beamforming. *See* BRUEL & KJAER, *Acoustic Beamforming Software*, http://www.bksv.com/Products/analysis-software/acoustics/noise-source-identification/beamforming-8608 (last visited Feb. 2, 2017).

171. CHANAUD, *supra* note 97, at 6-5.

172. *See, e.g.*, N.Y.C., N.Y., NOISE CODE §§ 24-225, 226 (2005) (setting emission standards for refuse collection vehicles and air compressors).

173. W. Passchier-Vermeer & W.F. Passchier, *Environmental Noise, Annoyance and Sleep Disturbance*, *in* ENVIRONMENTAL HEALTH IMPACTS OF TRANSPORT AND MOBILITY 28 (P. Nicolopoulou-Stamati et al. eds., 2005); ENVIRONMENT PROTECTION AUTHORITY, *supra* note 155, at 28.

174. SOETA & ANDO, *supra* note 19, at 167.

must consider the impact of these sound attributes when setting maximum noise levels. The following discussion deals with how regulators should factor in frequency and impulsiveness, which is tied to sound duration, when drafting noise ordinances.

1. Frequency and Tonal Noise

The human ear is more sensitive to certain frequencies than others.[175] To account for this, many ordinances express the maximum noise levels based on some form of frequency weighting. The Los Angeles noise ordinance, for example, uses an 'A-weighted' sound level network—expressed as 'dBA,' instead of merely 'dB'—for certain noise sources.[176] This means that the sound-measuring equipment will make an adjustment and disregard the frequencies that an average person cannot perceive and instead focus on those that are audible to the human ear.[177] New York City's Zoning Resolution, on the other hand, requires that measurements be made under the "C" network,[178] which makes a similar correction but includes more low-frequency sounds than the A-scale.[179]

While requiring measurements under a particular weighting scale is not unusual for noise ordinances, there are other issues relating to frequency that are not adequately addressed in many ordinances.[180] The most salient example is tonal noise, a type of sound that has "a narrow sound frequency composition," with usually only one or two frequencies, and tends to have a specific pitch.[181] Loudness—i.e., decibels—being equal, tonal noise is more unpleasant than broadband noise—which contains many different frequencies.[182] The problem with the regulation of tonal noise is that the weighting systems that ordinances commonly require, such as A-scale, do not adequately account for the annoyance that this type of noise can produce.[183] Further, tonal noise is commonplace in sounds emitted by various types of industrial equipment, which makes it a serious issue in the context of mixed-use districts.[184]

Some ordinances have addressed tonal noise specifically, by including some adjustments in their provisions dealing with sound standards. The City of Portland, for example, has a provision under which maximum sound levels must be decreased by 5 dBA if tonal

175. NOISE METERS INC., *Frequency Weightings: A-Weighted, C-Weighted or Z-Weighted?*, https://www.noisemeters.com/help/faq/frequency-weighting.asp (last visited Feb. 2, 2017).

176. LOS ANGELES COUNTY, CAL., CODE OF ORDINANCES § 12.08.070 (1978).

177. NOISE METERS INC., *supra* note 175.

178. N.Y.C., N.Y., ZONING RESOLUTION § 42-212 (1961).

179. BACOU-DALLOZ HEARING SAFETY GROUP, *A- and C-Weighted Noise Measurements*, SOUND SOURCE, Feb. 2005, at 1, http://www.howardleight.com/images/pdf/0000/0260/Sound_Source_4_AC_WeightedMeasure.pdf.

180. *See, e.g.*, LOS ANGELES COUNTY, CAL., CODE OF ORDINANCES § 12.08.070 (1978); N.Y.C., N.Y., ZONING RESOLUTION § 42-212 (1961); PORTLAND, OR., CODE § 18.10.010. A (2010); SALT LAKE CITY, UTAH, CITY CODE § 9.28.060 C (2001).

181. EARTHWORKS, *Noise Resources: Types of Noise*, http://nf-hrup.si/pdf_files/EARTHWORKS_NoiseResource.pdf (last visited Feb. 3, 2017); ENVIRONMENT PROTECTION AUTHORITY, *supra* note 155, at 28.

182. Hansen, *supra* note 1, at 45.

183. H.G. Leventhall, *Low Frequency Noise and Annoyance*, 23 NOISE & HEALTH 52, 70 (2004); SOETA & ANDO, *supra* note 19, at 167.

184. SOETA & ANDO, *supra* note 19, at 167.

noise is present.[185] In other words, in addition to requiring the use of the A-scale—evidenced by the fact that the units used are dBA instead of merely decibels—it corrects for tonal noise. Unfortunately, many ordinances—some of which require the use of a weighting scale—still do not correct for the impact of tonal noise on receivers.[186] These ordinances will not be as efficient as those that take into account the additional annoyance caused by tonal noise, because they will not be correctly accounting for the actual harm that this type of noise is causing.

2. Sound Impulsiveness

Impulse or impulsive sound presents similar challenges to those raised by tonal noise. This type of noise "consists of one or more bursts of sound energy, each of a duration less than about 1 s[econd]"[187] and is sometimes described as "'clicks,' 'squeaks,' 'rattles,' and 'pops.'"[188] The problem with impulsive sound is that it is a noise attribute to which the human ear is particularly sensitive.[189] Stated differently, it causes a higher degree of annoyance than a steady noise of the same intensity.[190]

As with tonal noise, some ordinances correct for sound impulsiveness, while others do not. Salt Lake City's ordinance provides that "[f]or any stationary source of sound which emits a . . . repetitive impulsive sound, the limits set forth in subsection A of this section shall be reduced by five (5) dBA."[191] However, other ordinances do not incorporate these types of provisions, which can lead to undesirable situations in which sounds with the same loudness are being treated alike, even though one could be substantially more annoying than the other one due to the presence of impulsive attributes.[192] The result, again, is that the ordinance will not adequately characterize the harm to the noise receivers, and, therefore, it will not be able to accurately balance the interests of noise-generating activities and receivers needing lower noise levels.

IV. TRANSITIONAL ISSUES: GRANDFATHERING AND REGULATORY TAKINGS

A. New Noise Ordinances and Grandfathering of Existing Facilities

One of the central issues surrounding the decision to modify a regulatory regime is whether existing uses and activities should benefit from some form of transitional relief or grandfathering.[193] This is a relevant issue when modifying a noise regulation in a way that could affect existing noise sources. In some cases, the recommendations in Part III could

185. PORTLAND, OR., CODE § 18.10.010. B.2 (2010) (requiring that "the sound levels of Figure 1 be decreased 5 dBA for narrow band," i.e., tonal noise).

186. *See, e.g.*, SAN DIEGO, CAL., MUNICIPAL CODE § 59.50401 (1973); ORLANDO, FLA., CODE OF ORDINANCES §§ 42.01–.09 (2009); N.Y.C., N.Y., ZONING RESOLUTION §§ 42-21 to -214 (1961).

187. Hansen, *supra* note 1, at 48.

188. Andrew M. Willemsen & Mohan D. Rao, *Characterization of Sound Quality of Impulsive Sounds Using Loudness Based Metric*, 20 INT'L CONGRESS ACOUSTICS 1, 2 (2010).

189. *Id*.

190. EARTHWORKS, *supra* note 181.

191. SALT LAKE CITY, UTAH, CODE § 9.28.060.

192. *See, e.g.*, SAN DIEGO, CAL., MUNICIPAL CODE § 59.50401 (1973); N.Y.C., N.Y., ZONING RESOLUTION §§ 42-21 to -214 (1961).

193. Richard L. Revesz & Allison L. Westfahl Kong, *Regulatory Change and Optimal Transition Relief*, 105 NW. U. L. REV. 1581, 1582 (2011).

lead to similar noise standards. In other cases, however, their implementation could result in, for example, more stringent noise limits at nighttime or regulators accounting for certain characteristics of the sound that the previous version of the ordinance did not consider. The question this raises is whether noise sources currently operating should be required to meet the same exigencies as those built after the new rules take effect.

There are two categories of transitional relief: temporal relief and financial relief.[194] Temporal relief provides a certain period of time for old sources to meet the new requirements that the regulation imposes or, in other cases, simply excludes these existing activities from those requirements entirely.[195] The Clean Water Act is an example of the first subcategory—it included a transitional period for existing sources to comply with more stringent discharge standards of performance.[196] Other statutes such as the Clean Air Act completely exempt some existing sources from certain requirements that are applicable to facilities built after the enactment, or amendment, of the statute or regulation.[197] Financial relief, on the other hand, provides grants, subsidies, or other financial assistance to facilitate compliance with the new requirements.[198]

Even though there are supporters of the idea that there should be no transition relief at all, several authors have laid out the main justifications for grandfathering.[199] First, the notion of fairness, which argues that "it is unfair to change the rules in the middle of the game; changes should only impinge on those who have not yet begun to play."[200] Second, a variant of the fairness argument that focuses on the idea of reliance: the government should not diminish the value of existing investments.[201] Last, some commentators claim that grandfathering is appropriate on economic efficiency grounds because installing state of the art equipment in a facility that is being built will generally be cheaper than requiring that the owners of existing facilities retrofit them to meet the new standard.[202]

As noted earlier, a key question in these cases is the appropriate treatment of existing sources. The fairness arguments explained above could lead to an expansive approach on grandfathering. However, some authors have warned against the dangers of a transition rule that is too lenient, pointing out that "[i]f the grandfathering rule is so generous that all of the existing plants continue to operate, there may be no demand for additional plants, and no new plants (or few new plants) may actually come into existence."[203] If that were to happen, the new rule would not be very useful. One scholar argues that the analysis for new and existing uses should be the same.[204] More specifically, if the government uses cost-benefit analysis for new uses, the same analysis should be employed for existing

194. Bruce R. Huber, *Transition Policy in Environmental Law*, 35 HARV. ENVTL. L. REV. 91, 95 (2011).
195. *Id*.
196. *See* 33 U.S.C. § 1311(b).
197. *See* 42 U.S.C. §§ 7475(a), 7476(3) (providing that only major emitting facilities that are constructed after August 7, 1977 require a prevention-of-significant-deterioration permit that, in turn, mandates a particular technological standard).
198. Huber, *supra* note 194, at 95.
199. Revesz & Kong, *supra* note 193, at 1587.
200. Huber, *supra* note 194, at 107.
201. *Id.* at 108.
202. *Id.* at 109.
203. Revesz & Kong, *supra* note 193, at 1587.
204. Christopher Serkin, *Existing Uses and the Limits of Land Use Regulations*, 84 N.Y.U. L. REV. 1222, 1288 (2009).

uses.[205] Thus, if the reduction costs for the latter are higher, the regulator should adopt some form of grandfathering.

In light of this, the inquiry about whether grandfathering is appropriate at all, as well as what form it should adopt, will hinge upon the cost-benefit analysis in the particular case being examined, and, possibly, on fairness considerations that the regulator may deem appropriate to take into account. As the following discussion addresses, however, the extent to which no—or very limited—grandfathering will be viable in a specific instance may also depend on whether the new requirements could affect some noise sources to the point of constituting a taking under the Fifth or Fourteenth Amendments.

B. Could Amending a Noise Ordinance Constitute a Taking?

The debate over grandfathering is closely tied to the issue of regulatory takings. As one author put it, "[r]egulatory takings claims are fundamentally conflicts over legal transitions. They arise when rules change, those changes are costly (in economic or other terms), and the people bearing the costs believe that they are being unfairly singled out."[206] Legal transitions, thus, present this tradeoff: a generous grandfathering rule will lower the likelihood of success of a takings claim, but will make the new regulation less effective, and vice versa.[207] Therefore, it is fair to say that the duty to compensate will generally tend to hinder change to some extent, mainly because it adds a budgetary constraint.[208] Establishing the circumstances under which a modification of a municipal noise scheme could give rise to the right of certain existing uses to obtain compensation requires we examine the particular tests that courts have adopted to draw the line between legitimate exercises of police power and compensable takings of property.[209]

1. The Takings Framework Relevant to New Regulations

Courts analyze regulations that do not have the character of a physical invasion under either the *Lucas v. South Carolina Coastal Council* or the *Penn Central Transport Company v. City of New York* frameworks.[210] Nothing in the previous section suggests that a noise ordinance should be modified to allow anything or anyone to physically occupy private property. Having excluded tests dealing with physical invasions, both the *Lucas* and the *Penn Central* frameworks could potentially be relevant. However, the *Lucas* test is limited to a very specific set of circumstances: "when the owner of real property has been called upon to sacrifice all economically beneficial uses in the name of the common

205. *Id.*

206. Holly Doremus, *Takings and Transitions*, 19 J. LAND USE & ENVTL. L. 1, 3 (2003). Takings and the resulting duty to pay compensation are also frequently described as a tool to redistribute economic losses. *See* Luis Inaraja Vera, *Instream Flows in California and Spain: The Thorny Issue of Compensation*, 27 GEO. INT'L ENVTL. L. REV. 199, 208 (2015).

207. *See* Revesz & Kong, *supra* note 193, at 1587 (explaining the perils of broad grandfathering).

208. *See* Doremus, *supra* note 206, at 11; Katrina Wyman, *The Measure of Just Compensation*, 41 U.C. DAVIS L. REV. 239, 246 (2007).

209. Thomas W. Merrill, *The Economics of Public Use*, 72 CORNELL L. REV. 61, 70 (1986).

210. Those which do would be examined under the principles of *Loretto v. Teleprompter Manhattan CATV Corp.*, 458 U.S. 419 (1982). Lucas v. South Carolina Coastal Council, 505 U.S. 1003 (1992); Penn Cent. Transp. Co. v. City of New York, 438 U.S. 104 (1978).

good, that is, to leave his property economically idle."[211] It is important to note that a court's finding of a complete deprivation of property derived from a noise control ordinance is extremely unlikely—unless manufacturing is the only permitted use for that property and the noise limit is set to a level that would make any industrial use inviable.

Therefore, the next subsections will focus on the *Penn Central* framework. The *Penn Central* test, which is used to determine if a governmental action constitutes a taking, has three relevant factors: (1) the "economic impact of the regulation on the claimant," (2) its degree of interference with investment-backed expectations, and (3) the character of the governmental action.[212] Unfortunately, the Supreme Court has not provided adequate guidance on the precise meaning of these factors or the weight that courts should afford them.[213]

a. Diminution in Value

Courts have interpreted the first factor to mean that "a regulation is a compensable taking if it reduces the value of the property by too much."[214] Stated differently, one of the key factors in any takings analysis is "the severity of the burden that government imposes upon private property rights."[215] Although the percentage of reduction that is required is unclear,[216] the U.S. Court of Federal Claims, for example, has noted that reductions in value have to be "well in excess of 85 percent before finding a regulatory taking."[217] This analysis of the diminution in value of the property, however, should be done by reference to "the parcel as a whole," not to smaller parts of it.[218] This will be relevant in cases where only part of the property has been affected by the governmental action. In the particular case of existing uses, one commentator has pointed out that, in situations where this existing use does not contribute significantly to the value of the underlying property, this prong will not be very useful to protect the owner against a takings claim.[219]

b. Investment-Backed Expectations

As its name suggests, the investment-backed expectations prong is particularly relevant when examining whether a regulation that affects existing uses may constitute a taking of private property. Before delving into the meaning of this prong, however, it is appropriate to stress that the purpose of this section is to examine how the regulatory takings doctrine may complicate the implementation of a noise regulation with limited or no

211. *Lucas*, 505 U.S. at 1019.
212. *Penn Cent. Transp. Co.*, 438 U.S. at 124.
213. Doremus, *supra* note 206, at 7.
214. Serkin, *supra* note 204, at 1253–54.
215. Lingle v. Chevron U.S.A. Inc., 544 U.S. 528, 539 (2005).
216. Serkin, *supra* note 204, at 1253–54.
217. Walcek v. United States, 49 Fed. Cl. 248, 271 (2001) (quoted in John D. Echeverria, *Making Sense of* Penn Central, 23 UCLA J. ENVTL. L. & POL'Y 171, 178 (2005)).
218. Penn Cent. Transp. Co. v. City of New York, 438 U.S. 104, 131 (1978) ("'Taking' jurisprudence does not divide a single parcel into discrete segments and attempt to determine whether rights in a particular segment have been entirely abrogated. . . . [T]his Court focuses rather both on the character of the action and on the nature and extent of the interference with rights in the *parcel as a whole*.").
219. Serkin, *supra* note 204, at 1254.

grandfathering at all. Therefore, the focus of this discussion is on the impact of a retroactive regulation, a notion that has different possible meanings that are worth clarifying. Scholars differentiate between the so-called "strongly and weakly" retroactive laws.[220] The first type—strong (or "primary") retroactive laws—provides consequences for actions that occurred prior to the enactment of the law or regulation, while the second type—weak (or "secondary") retroactive laws—"are forward-looking [but] . . . change the legal consequences . . . only from the date of the creation of the rule."[221] A noise ordinance that imposes new requirements on industrial users would fall under the second category; it would typically not allow the imposition of penalties for conduct preceding its enactment but would prospectively affect activities initiated before the issuance of the new standard. Once the type of retroactivity that one may attribute to this kind of ordinance has been clarified, the next step is to examine the meaning that courts have attached to the expression "investment-backed expectations."

Penn Central offered some guidance on how to interpret this prong.[222] The issue in that case was whether New York City's designation of the Grand Central Terminal as a "landmark," which hindered the owner's future development plans, constituted a taking.[223] As one scholar pointed out, the *Penn Central* court gave substantial weight, when discussing this prong, to the fact that the governmental action at issue did not affect the landowner's existing use but only the desired expansion of that use.[224] It has also been suggested that the content of this factor has become particularly confusing, especially after the Court's rulings on later cases.[225] Even if that is the case, the language in the decision makes it clear that the Court in *Penn Central* considered existing uses as the quintessential investment-backed expectation. The Court did not find a taking, but in reaching its conclusion it stressed how "the [New York City] law d[id] not interfere with . . . Penn Central's primary expectation concerning the use of the parcel" and that "[m]ore importantly, . . . the New York City law [permitted] Penn Central not only to profit from the Terminal but also to obtain a 'reasonable return' on its investment."[226]

Thus, this prong of the regulatory takings test would seem to tip in favor of an industrial or commercial user who has been negatively affected by a newly enacted regulation that imposes new requirements upon its operation. The next subsection will address the relevance of the government's justification for enacting such a regulation.

c. The Character of the Regulation

The third prong, the character of the regulation, is probably the most elusive of all three. One scholar has explained that the Supreme Court, when analyzing this prong, has

220. *Id*. at 1263 & n.202.

221. Jill E. Fisch, *Retroactivity and Legal Change: An Equilibrium Approach*, 110 HARV. L. REV. 1055, 1071 (1997) (citing Stephen R. Munzer, *Retroactive Law*, 6 J. LEGAL STUD. 373, 383 (1977)).

222. *Penn Cent. Transp. Co*., 438 U.S. at 108.

223. *Id*. at 107.

224. Serkin, *supra* note 204, at 1250.

225. Christopher Serkin explains that "the test today focuses more on the reasonableness of a property owner's expectations, not on her investments, and therefore focuses on future uses and not existing ones." *Id.* at 1251–52.

226. *Penn Cent. Transp. Co.*, 438 U.S. at 136.

examined a variety issues.[227] First, whether the governmental action fits more into the category of invasion or regulation.[228] Second, the Court has looked at nuisance law to see if the regulation was pursuing the same end.[229] Third, the Court has inquired as to whether the action confers a reciprocal advantage—which occurs where the regulation "impose[s] burdens and confer[s] benefits on all property owners"—as opposed to government action that burdens some property owners while benefiting others.[230] Last, courts have looked upon retroactive regulation less favorably than those regulations that are only forward-looking.[231]

According to some commentators, lower courts have been focusing primarily on the second interpretation of the character-of-the-regulation prong, which overlaps with the so-called "nuisance exception" to regulatory takings.[232] In the context of a noise control ordinance, the relevant inquiry would be whether the activity that is being regulated is a nuisance. Under this doctrine, the government may regulate a hazardous activity—to the point where the activity is no longer permitted—without having the duty to compensate the owner.[233] This principle goes back to at least the nineteenth century, when the Supreme Court, in *Mugler v. Kansas*, validated "[t]he exercise of police power [involving] the destruction of property which [wa]s itself a public nuisance, or the prohibition of its use in a particular way."[234] The Supreme Court recognized the nuisance exception in several instances after *Mugler*, for example, in a case involving a brick mill situated in a residential area,[235] or a quarry in a similar location.[236]

More recently, in *Lucas*, the Court dealt with the nuisance exception in the context of a regulation that deprived the landowner of all beneficial use of his land.[237] The Court explained that, in these cases, to escape compensation, the government must point to specific "background principles of nuisance and property law that forbid the use[]."[238] In other words, the government may only regulate away an existing use without having to pay compensation when the property is being used for a purpose that had always been unlawful.[239] An example of this, according to the Court, would be a situation where the government requires the owner of a nuclear plant located on a fault line to remove it.[240] This does not mean, however, that the justification for the governmental action would have to meet

227. Thomas W. Merrill, *The Character of the Governmental Action*, 36 VT. L. REV. 649, 672 (2012).
228. *Id*.
229. *Id*.
230. *Id*. at 664, 672.
231. *Id*. at 672. It is worth pointing out that the case cited by this author is one of weak retroactivity. *See id*. at 669–70.
232. *See* ROBERT C. ELLICKSON, VICKI BEEN, RODERICK M. HILLS, JR. & CHRISTOPHER SERKIN, LAND USE CONTROLS: CASES AND MATERIALS 156 (2013) (citing Steven J. Eagle, "*Character of the Governmental Action" in Takings Law: Past, Present, and Future*, SJ052 ALI-ABA 459 (2004)).
233. Serkin, *supra* note 204, at 1240.
234. Mugler v. Kansas, 123 U.S. 623, 669 (1887). In that case, the state had enacted legislation prohibiting the manufacture, sale, bartering, or gifting of "intoxicating liquors" and treating these activities as a nuisance. *Id*. at 670.
235. Hadacheck v. Sebastian, 239 U.S. 394 (1915).
236. Goldblatt v. Hempstead, 369 U.S. 590 (1962).
237. Lucas v. South Carolina Coastal Council, 505 U.S. 1003, 1027 (1992).
238. *Id*. at 1031.
239. *Id*. at 1030.
240. *Id*. at 1029.

this high standard to avoid having to compensate the property owner. First, this is only one of three factors in the *Penn Central* test, and, second, the other possible interpretations of this prong could still lead the court to conclude that the "character-of-the-regulation prong" weighs in favor of the government.[241]

2. Applying the Framework to Noise Regulations

Based on the above analysis, it cannot be ruled out that a takings claim could succeed, under certain circumstances, when a new noise ordinance imposes new obligations on existing activities. Given that the regulation would only be limiting the noise level coming from the facility, it is hard to imagine a plausible situation where that would automatically lead to a deprivation of all economically viable use of a property—the predicate for a *Lucas*-type analysis. This would occur in the extreme circumstance where the noise limit is set so low that no other industry can be located on a parcel, and that same land cannot be used for any non-industrial purpose. Leaving aside this possibility, courts will generally examine the impact of this type of regulation on existing facilities under the *Penn Central* framework.[242] The following discussion will examine *Penn Central's* three prongs in the noise context starting with the second and third prongs, and then addressing the first one, which may operate in some cases as a tiebreaker.

For the reasons stated above, the second prong—degree of interference with investment-backed expectations—tends to favor landowners that are merely trying to protect an existing use.[243] This is particularly so if what once was an expectation has already materialized into a tangible investment such as a factory.[244]

As for third prong, the character of the regulation, it is complicated to determine whom—the government or the landowner—it would favor. Assuming that a court adopts the most frequent interpretation of this prong, whether the use is a nuisance, the government would have a reasonable argument that enacting the first noise ordinance "do[es] no more than duplicate the result that could have been achieved in the courts—by adjacent landowners (or other uniquely affected persons) under the State's law of private nuisance."[245] As pointed out earlier, if the industrial facility in question was already subject to lower noise limits, however, it would be harder for the government to convincingly argue that it is the new regulation, not the previous one, that is addressing the nuisance problem. Why should the new version of the ordinance be the reference point to determine whether the use "was always unlawful"?[246] However, some courts have recently adopted, in the specific context of noise ordinances, an interpretation of this standard that is even more beneficial to government: there is no taking "when interference [with property rights] arises from some public program adjusting the benefits and burdens of economic life to

241. *See supra* note 227 and accompanying text.

242. *See, e.g.*, Kabrovski v. City of Rochester, 149 F. Supp. 3d 413, 424 (W.D.N.Y. 2015) (analyzing several challenges to a noise ordinance and employing the multi-factor *Penn Central* test to evaluate the takings claim).

243. *See supra* Part IV.B.1.b.

244. *See supra* Part IV.B.1.b.

245. Lucas v. South Carolina Coastal Council, 505 U.S. 1003, 1030 (1992); *see supra* note 231 and accompanying text.

246. *Id*.

promote the common good."[247]

In light of the fact that the second and third prongs may potentially weigh in favor of different parties, the first prong—diminution in value—can be critical. While there is no bright-line rule for determining what degree of decrease in the value of the land is necessary to meet the standard under this prong, vague and conclusory allegations of economic loss will generally not suffice.[248] In the context of municipal noise regulations, there are situations where the diminution in value to the landowner could be important because the costs of installing noise reduction systems on an existing facility can be very high.[249] If the cost of the noise reduction equipment necessary to meet the new performance standard makes the enterprise no longer economically beneficial, the economic loss to the landowner would be very significant.[250] Moreover, this prong of the test would also tip in favor of the industrial landowner if the new regulation dramatically reduces the profitability of the business, given that this would result in the value of the parcel being substantially diminished.

In short, as one scholar pointed out, the current takings doctrine focuses on the effects of a regulation on a particular landowner rather than on the regulation itself.[251] Consequently, it is not possible to draw a general conclusion about whether a newly enacted noise control ordinance may require the government to compensate particular industrial users for the effects that the new requirements impose on them. Old factories for which compliance with the required reduction in noise level is very costly may have to shut down. In these cases, the owner could have a colorable claim for compensation from the government, especially if the activity complyied with previous, more lenient standards. On the other hand, industries that can comply with the new standards somewhat more cheaply will not be likely to persuade courts that current takings law entitles them to compensation as a result of the burden that the new ordinance imposes on them.

CONCLUSION

This Article addresses the serious problem of increasing noise levels in urban areas, which is especially concerning at a time when districts with multiple land uses are becoming more popular. The Article draws on the scientific literature on noise pollution to make a contribution to the existing legal literature in the form of a set of measures to improve noise control frameworks at the local level. Some of these improvements are based on a deeper understanding of noise and which of its attributes can increase the disturbance that it causes on the human ear. Other suggestions try to inject flexibility into these regulations to better accommodate the interests of citizens who need low noise levels and the economic activities whose operation inevitably generates noise. Although the recommendations provided in the Article focus on municipalities, these same principles can also be applied to noise control frameworks enacted by states and the federal government.

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247. *Kabrovski*, 149 F. Supp. 3d at 424 (citing Sherman v. Town of Chester, 752 F.3d 554, 565 (2d Cir. 2014)).

248. Serkin, *supra* note 204, at 1254 n.158; *see, e.g.*, *Kabrovski*, 149 F. Supp. 3d at 424.

249. HYDROTECH, *Reducing Noise in the Manufacturing Industry*, https://www.hydrotech.com/whitepapers/reducing_noise_in_the_manufacturing_industry (last visited on Feb. 6, 2017) (noting that "[a]ctions taken after the fact are always expensive!").

250. As Professor John Echeverria points out, "[g]enerally speaking, the greater the economic impact of a government action the greater the likelihood of a taking." Echeverria, *supra* note 217, at 178.

251. Doremus, *supra* note 206, at 11.