

LOST IN THE NOISE: A COMPARISON OF INTERFERENCE IN RADIO SPECTRUM TO WATER AND NUISANCE LAW

ALEXANDER KORAL

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INTRODUCTION

Anyone who has ever used a wireless device has dealt with the problem of radio signal interference. Whether it has manifested itself in a dropped call, poor wireless internet connection, or a garbled version of your favorite Top 40 hit, interference causes numerous problems in the transmission of data through the radio spectrum—a serious issue for a society that is becoming increasingly dependent on wireless communication. For businesses based on radio transmission, interference can be much more devastating. This is because use of the radio spectrum is a valuable commodity, one which companies pay billions of dollars to access.¹ When interference is strong enough, it impedes their right to use

1. See, e.g., Philip J. Weiser & Dale Hatfield, *Spectrum Policy Reform and the Next Frontier of Property Rights*, 15 GEO. MASON L. REV. 549, 549 (2008) (describing a 2008 transaction where 62 MHz of spectrum in the 700 MHz band was auctioned off for \$ 20 billion).

something they have paid dearly for. Companies will not develop and utilize an industry when their assets are at risk of being infringed. In this way interference presents a clear threat to the future development of the wireless industry and the overall progress of society.

What makes dealing with interference complex, however, is that much of the law and policy behind the use of radio spectrum remains unsettled. Radio spectrum is, at present, a highly regulated market, with the Federal Communications Commission (FCC) granting licenses for access and dictating rules of use.² This, however, is a legacy from the 1930s, which seems misaligned with the technological development and social needs of today.³ Within the industry, a sense of dissatisfaction with the status quo runs deep. The current model seems insufficient to foster the anticipated future of radio spectrum use. The solution to these problems is unclear.

The biggest divide among commentators in recent years is between those who advocate a pure Property Rights scheme, in line with the ideas of the late, eminent property rights scholar, Ronald Coase,⁴ and those who believe that spectrum use would be better served under a Commons approach, where access to the resource is unrestricted.⁵ A key discrepancy between the two approaches is their different estimations of future technology and whether they can create abundant access while also limiting interference.⁶ However, determining which approach should govern depends greatly on their ability to manage and control interference.

It is necessary, then, to evaluate how the Property and Commons systems work, and how they have managed other resources with interference problems. To that end, this note will examine the schema in two different areas of property law: water and nuisance. Water presents an able parallel to radio because it also is a vital and utile resource that people and companies pay to access,

2. *Id.*

3. Ellen P. Goodman, *Spectrum Rights in the Telecosm to Come*, 41 SAN DIEGO L. REV. 269, 312 (2004).

4. See, Thomas W. Hazlett & Evan T. Leo, *The Case for Liberal Spectrum Licenses: A Technical and Economic Perspective*, 26 BERKELEY TECH. L.J. 1037, 1043 (2011); Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 HARV. J.L. & TECH. 335, 405 (2001).

5. Gigi Sohn, *The Gore Commission Ten Years Later: Reimagining the Public Interest Standard in an Era of Spectrum Abundance*, 17 COMMLAW CONSPECTUS 657, 674 (2009); Daniel Sineway, *What's Wrong With Wireless?: An Argument For a Liability Approach to Electromagnetic Spectrum Regulation*, 41 GA. L. REV. 671, 678 (2007); Stuart Minor Benjamin, *Spectrum Abundance and the Choice Between Private and Public Control*, 78 N.Y.U. L. REV. 2007, 2033 (2003).

6. Goodman, *supra* note 3, at 359.

and because it is susceptible to interference-like effects. Nuisance law, on the other hand, describes interference situations in general and has a long history of determined solutions. Most importantly, these two areas demonstrate the necessity of establishing workable *ex ante* and *ex post* rules in order to properly govern any property system.

This note will describe the interference problem that plagues the development of future radio spectrum, and examine parallel systems that can possibly provide answers. A strong, technocratic regulatory body is necessary, one which can properly assign rights to fit users while also providing an able dispute resolution system for when conflicts between users inevitably arise. The first part of this note will consist of a brief examination of radio spectrum and the problems of dealing with interference. The second part will discuss water and nuisance law, and how they have developed asset allocation and protection schemes. Finally, this note will conclude with how the lessons from water and nuisance law can be applied to radio spectrum.

I. RADIO AND THE PROBLEM OF INTERFERENCE

Before delving into the legal questions surrounding radio spectrum, it is beneficial to have a thorough understanding of the technical background and the history of how the existing regulatory system has evolved. This section starts with an overview of the science of the radio spectrum and interference issues. The FCC's regulatory structure and how it was designed to mitigate interference follows, leading to a final discussion of Coase's theories of property and externalities, and how they would compare to a Commons scheme.

A. *The Physics of Radio Waves*

Radio is a natural phenomenon that pervades the universe. It is a form of energy like light and microwaves, though radio is the weakest form of such electromagnetic energy. Its spectrum comprises the lowest end of the entire electromagnetic spectrum, from below 3 Hz (the aptly named Tremendously Low Frequency) to 3,000 GHz where microwaves exist.⁷ Radio has been divided into bands corresponding to its frequency based on a log scale. Every increase by a factor of ten in the frequency corresponds to a new

7. Radio, like all electromagnetic energy, is measured in Hertz (Hz), a unit measuring the frequency of the radio waves per second. Hertz measurements, thus, also indicate the length of the wave, with higher Hertz levels having smaller wavelengths.

band. VHF (Very High frequency) radio, which is used primarily for FM radio and TV broadcasting, exists in the range between 30 and 300 MHz, while the next highest band, UHF (Ultra High frequency), which is one of the most useful bands for wireless communication, begins at 300 MHz and goes to 3 GHz.⁸

The electromagnetic spectrum is ideal for transmitting information across space. This can be very basic information, such as the shape of an object (our eyes are natural receivers of visible light, a tiny sliver on the entire electromagnetic spectrum), or it can be more complex data, like a movie streaming wirelessly. Radio is just one section of the entire electromagnetic spectrum, but it is easy to manipulate and utilize, giving it great value. Humans have only recently developed the means of utilizing radio, but have applied it to numerous ways of improving our lives, from media broadcasting to person-to-person wireless communication.

Although radio waves are invisible, they still react with the physical world. They interact with objects, such as buildings, mountains, rain, and other electromagnetic waves, which results in interference.⁹ Interference affects different bands in different ways. For instance, Extremely, Super, and Ultra Low Frequency waves (the three bands from 3-3,000 Hz) have long, undulating wavelengths, which are able to resist the effect of water and so are used primarily for communication with submarines.¹⁰ Lower end bands are better suited to resist weather, although they require longer transmission antennae in order to broadcast, all of which must be considered when planning a broadcast.¹¹ UHF, for instance, is affected by weather and geography more than VHF, but it is a preferred band because it allows for a smaller antenna, and is still powerful enough to penetrate buildings.¹²

Radio waves also degrade as their transmission spreads. The range of a radio broadcast stems largely from the power level of the transmission, with the signal diminishing as it gets farther from the source. Transmitters can be configured to physically direct the transmission,¹³ but this would be impractical for transmitters seeking a wide transmission area, such as radio media and TV broadcasters. As the power level of the waves dissipates, and the transmission is affected by interferers, the signal fades and

8. Weiser & Hatfield, *supra* note 1, at 578.

9. *Id.* at 575.

10. *Id.* at 575-76.

11. Goodman, *supra* note 3, at 279.

12. Weiser & Hatfield, *supra* note 1, at 578.

13. *Id.* at 584.

eventually is lost.¹⁴

Viewing radio waves as bits of physical matter coursing through the air, bumping up against buildings and mountains is misleading though. Interference should not be thought of as radio waves being impeded mid-flight, but as the inability of the receiver to overcome the degradation that affects the transmission as it spreads.¹⁵ Radio transmissions require two things: a transmitter to broadcast a signal, and a receiver to catch and interpret that signal. While increasing the transmission's power level or focusing its direction can make the signal stronger or more locally targeted,¹⁶ it is ultimately the job of the receiver to make sure the end user heard the message. Thus interference problems are really receiver problems. A weak receiver will fail to clearly receive even a strong signal if there's too much interference.

Better receivers could reduce interference by more effectively isolating the desired transmission from the background noise; theoretically, they could do so perfectly, eliminating interference problems.¹⁷ In order to regulate interference, the FCC could look to receiver manufacturers and impose technical standards for transmission identification. While this is a possible course, the FCC has focused only on radio transmitters, primarily because they are a more concentrated industry which the FCC has historically managed to control through the application process transmitters must go through to gain broadcast rights.¹⁸

Interference can also occur among neighboring transmitters (like if everyone at your table talks at once), or when a transmission's broadcasting power becomes too great (like when shouting from across the restaurant silences conversation at your table). In either case, the receiver cannot distinguish the transmission it wants. Better receivers can better isolate specific transmissions, but none are perfect.¹⁹ Greater transmission power could eliminate interference, but only at the cost of inflicting interference on other transmissions.

Radio is even affected by background noise, which results from added transmissions.²⁰ Every new transmission creates more

14. Goodman, *supra* note 3, at 280.

15. *Id.* at 328.

16. While early AM transmitters broadcast in power ranges up to 500 kW, allowing worldwide transmission, they are restricted today to below 50 kW, which only gives city-wide range and is restricted to only a few dozen stations nationwide.

17. Weiser & Hatfield, *supra* note 1, at 572.

18. *Id.* at 561.

19. See Christopher S. Yoo, *Beyond Coase: Emerging Technologies and Property Theory*, 160 U. PA. L. REV. 2189, 2197 (2012).

20. *Id.* at 2194.

background noise, which affects the probability that a transmission will reach its destination, up to a theoretical maximum described by Shannon's law of channel capacity. At that point, the total background noise caused by all transmissions would become so great that the probability of any data transmission ever reaching its intended receiver decreases to zero.²¹ Shannon's law implicates an inescapable fact in radio spectrum: not even improved technology can eliminate interference. Thus interference cannot be wished away, it can only be managed.

B. Developing a Regulatory Framework

Since its creation, the FCC has been charged with regulating radio spectrum in order to limit the detrimental harm of interference. Interference is legally defined as "unwanted energy" in a given band.²² For as long as the radio spectrum has been utilized by humanity, there has been a problem with interference. When Guglielmo Marconi first began his experiments with wireless over a century ago, he believed that only a single transmission could be intelligible in a region at a time.²³ While this belief was soon found false, interference remained a problem in the development of wireless communication. When the Titanic sank in 1912, the US Congress passed the first regulatory scheme of the airwaves based on the popular belief that interference from amateur broadcasters hampered the rescue efforts.²⁴ In order to broadcast, one had to get a license from the government that restricted access to only a certain frequency band and limited power emission levels.²⁵

These early regulations were insufficient to deal with the chaos of radio noise that followed the triumph of radio as a popular medium in the 1920s. This led Congress to draft new legislation in 1927. After deciding that radio spectrum was a public utility that should be regulated by the government for the "public interest," Congress passed the 1927 Radio Act.²⁶ In 1934, Congress acted again and passed the Federal Communications Act, which established the FCC as the regulating body to "license radio stations, prevent chaos, and ensure public safety."²⁷

With this language guiding it, the FCC developed a policy called

21. *Id.* at 2194-95.

22. 47 C.F.R. § 2.1(c) (2013).

23. Hazlett, *supra* note 4, at 487.

24. Goodman, *supra* note 3, at 280-81.

25. *Id.* at 281.

26. *Id.* at 282.

27. *Id.* (quoting Frank Bartholomew 254 Sugar Road RRI Box 254 Fredericksburg, Pennsylvania, *Memorandum Opinion & Order*, 14 FCC Rcd. 4046, 4047 (1999)).

the public trust doctrine, whereby it would freely allocate broad swaths of the spectrum to private entities with the expectation that these private entities would serve as public beneficiaries.²⁸ Not only would they avoid interfering with other broadcasters, but they would provide public interest programming including educational shows, local news coverage, and the general promotion of public discourse.²⁹ These policies, though, were based on the conception of radio spectrum as a very limited resource constantly beset by interference. The only way to productively utilize it was to place users far apart from each other in bands so no interference would occur, and assign them to private entities who would use them for public benefit.³⁰ The overall effect of these policies was to create a system of spectrum scarcity, where the amount of broadcasts was limited by the fear of causing interference.

The FCC was ostensibly given this authority to prevent the degradation of a valuable public resource. Some modern scholars have taken a more conspiratorial approach, though, and claim that the true reason was to effect governmental control over the new medium, and to protect the interests of incumbent broadcasters.³¹ Regardless of the reason, the FCC quickly assumed control of the radio spectrum and began licensing it out to interested parties.

The FCC based its allocations on the belief that interference was a virus that needed to be cleansed from the system.³² The private parties who received allotments of spectrum were assigned to specific channels for specific geographic areas, with limits on power emission levels in order to ensure that transmissions were kept within their assigned geographic range.³³ Large white spaces were created between channels to provide maximum protection. These policies created severe constraints on the entire broadcast industry that continue today.³⁴ For instance, in broadcast television, the FCC limits broadcasts to every other channel in a given geographical area.³⁵ Throughout the entire radio spectrum, hundreds of megahertz remain under or even completely unutilized. Nevertheless the courts have upheld the FCC's general policies when they have been challenged.

28. Sohn, *supra* note 5, at 662.

29. *Id.*

30. *Id.* at 663.

31. Goodman, *supra* note 3, at 282 n.34.

32. Weiser & Hatfield, *supra* note 1, at 559.

33. *Id.*

34. Kevin Werbach, *The Wasteland: Anticommons, White Spaces, and the Fallacy of Spectrum*, 53 ARIZ. L. REV. 213, 215 (2011).

35. Weiser & Hatfield, *supra* note 1, at 561.

For instance, in the 1943 case *NBC v. United States*, the Supreme Court upheld the FCC's Chain Broadcasting rules, which limited the networks' control over their affiliates. The Court said that strict regulation was needed because "[t]here is a fixed natural limitation upon the number of stations that can operate without interfering with one another."³⁶ The Court found that strict FCC regulation was the only way to maximize the public benefit, though it seemed to blindly accept the claim that interference was so pernicious. This was upheld twenty-five years later in *Red Lion v. FCC*, which reaffirmed the FCC's right to limit interference, though the Court also noted the FCC's ability to regulate the content of broadcasts for its public interest.³⁷

However, the basis for these rulings came from a 1930s understanding of radio spectrum and technology. Only in 1984, in *FCC v. League of Women Voters*, did the Court, for the first time, acknowledge that technology may adapt enough to limit the effects of interference and lessen the need for spectrum scarcity, although it only did so in a footnote.³⁸ Moreover, the Court was still unwilling to reconsider the longstanding approach of the FCC without a signal from the agency or Congress as to what action should be taken.³⁹ So far neither the FCC nor Congress has attempted to reexamine the policy of spectrum scarcity.⁴⁰ Thus the policies that the FCC relies on are based on an outdated understanding of spectrum and technology.

The FCC allocates spectrum through a system akin to notice and comment rulemaking.⁴¹ The FCC receives applications from potential new users of radio spectrum, such as broadcasters and wireless telecommunications providers, assesses them for feasibility, and assigns rights based on its mission to foster the public's beneficial use of spectrum. The FCC also requires the applicants to guarantee that their use will not adversely affect any incumbent user by causing new interference.⁴²

Broadcasters are limited by 47 C.F.R. § 2.102(f), which states that "stations of a service shall use frequencies so separated from the limits of a band allocated to that service as not to cause harmful interference to allocated services in immediately adjoining

36. *NBC v. United States*, 319 U.S. 190, 213 (1943).

37. *Red Lion v. Fed. Commc'ns Comm'n*, 395 U.S. 367, 375 (1969).

38. *Fed. Commc'ns Comm'n v. League of Women Voters*, 468 U.S. 364, 376 n.11, 377-78 (1984).

39. *Id.*

40. Sohn, *supra* note 5, at 665.

41. Hazlett, *supra* note 4, at 385.

42. *Id.*

frequency bands.”⁴³ Applicants are also confined to certain power levels, so as to limit the geographic range their broadcasts will cover.⁴⁴ Incumbents have great power in this model, as the FCC asks for comments from the public before assigning spectrum rights to an applicant.⁴⁵ This prompts incumbents to exaggerate the impact that new licenses will have on their transmissions.

As such, the current model severely limits new users from entering into the spectrum market. This has led to great social costs as new technologies are prohibited from spreading.⁴⁶ For instance, the FCC blocked the entry of cellular communication services for 20 years, at an estimated cost to society of \$33.5 billion in lost potential productivity.⁴⁷ And even if current owners were willing to sell their license rights to new users, FCC rules would stop them. Licensees only have limited property rights, such as the right to exclusion, but their right to alienability and severability are explicitly prohibited.⁴⁸

When determining the geographic range and signal strength of a broadcaster’s rights, the FCC relies on predictive modeling. However, these models vary in their complexity and the amount of data they can rely on. “Site general” models, in particular, are unreliable as they are based off of the general principle that transmissions degrade consistently with distance.⁴⁹ As such they fail to account for the end users’ devices, which may be insufficient, or geographic impediments that can drastically affect the predicted models.⁵⁰ This all means that the rights the FCC assigns to broadcasters may not accurately reflect the conditions that broadcasters face.

But broadcasters must still comply with the allocations the FCC makes or risk a claim for causing “harmful interference,” defined as interference that “seriously degrades, obstructs, or repeatedly interrupts” another’s service.⁵¹ As such they must take pains to ensure their equipment is not only suited to their allocation, but is also sufficient to reach less capable receivers. Engineers designing radio systems must also calculate the likely degradation their transmissions will face and make adjustments accordingly.⁵² This is

43. 47 C.F.R. § 2.102(f) (2013).

44. Hazlett, *supra* note 4, at 385.

45. *Id.*

46. Weiser & Hatfield, *supra* note 1, at 555.

47. *Id.*

48. Goodman, *supra* note 3, at 287.

49. Weiser & Hatfield, *supra* note 1, at 584.

50. *Id.* at 584. *See also id.* at 585 (describing the variances between predictive models and reality that can arise in the context of a TV broadcaster in the Denver, CO region).

51. 47 C.F.R. § 2.102(c) (2013).

52. Weiser & Hatfield, *supra* note 1, at 583-84.

affected by the different meanings of “interference.” In engineering, it refers to an energy level, while in law, it refers to the impact on system performance that the energy causes.⁵³ Engineers and regulators thus look at the problem from disparate viewpoints—the phenomenon versus its impact. To ameliorate this situation, the FCC does not give clear, absolute boundaries for broadcasters, but instead determines a percentage of end users that should be reachable by a transmission a certain percent of the time.⁵⁴ It is up to the broadcasters to take advantage and maximize their probability of reaching all of their allocated range without also causing harmful interference. But this is based on a 1930s understanding of radio technology, which is increasingly unsuited for a modern, wireless society.

C. Proposed Changes to the System

Many commentators have suggested that the FCC must change its allocation schemes. These comments have largely focused on two different schemes: a Property Rights system, and a Commons approach. They differ in how they would assign rights and how they would confront interference, and are both based on more general principles of property ownership.

Property Rights advocates assert that the FCC must do a better job of accurately describing spectrum owners’ property. They base their beliefs on work by Ronald Coase in the 1950s. Coase’s argument, for which he later won a Nobel Prize in economics, was that transaction costs hamper efficient dealings between owners. By clearly defining property rights, transaction costs decrease, allowing property owners to recognize what their rights are and then deal efficiently with each other.

This efficiency declines, though, when externalities (like interference) affect the properties.⁵⁵ Without well-defined property rights, owners cannot discern their property boundaries and cannot recognize when interference occurs. This severely complicates any interference dispute because neither side can recognize the other’s claim. But if each property owner knows where their rights lay, they can efficiently make deals concerning those externalities. This facilitates negotiations over interference disputes, as all parties can readily understand where the interference occurred, and what

53. *Interference Definition*, ALLIANCE FOR TELECOMM. INDUS. SOLUTIONS: TELECOM GLOSSARY, <http://www.atis.org/glossary/definition.aspx?id=4638> (last visited Jan. 25, 2015).

54. Weiser & Hatfield, *supra* note 1, at 586.

55. R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 13 (1960).

effects it had.

For Coaseans, the current system is failing because radio broadcasters' property is insufficiently described by the predictive modeling used by the FCC, their rights as transmitters are improperly defined (is it the right to transmit or the right not to be interfered with?), and the remedies for interference are poorly designed.⁵⁶ If radio properties could be delineated more accurately and understandably, more like how real estate is clearly delineated, then regular property laws could be more readily applied. As such the current system fosters inefficiency and poor dealings among radio broadcasters.

However, the problems with the system have not been ignored by the academic community. In the late 1960s, Arthur De Vany led an effort to have spectrum rights described in terms of a specified time, over a specified area, in a specified frequency range, which would better account for the wide variations in signal strength that can occur.⁵⁷ More recently, Robert Matheson suggested adding measurements of a transmission's direction of arrival in order to better describe the actual signal that a receiver will have, and to distinguish it from nearby, but less direct, transmissions.⁵⁸

Neither the De Vany nor the Matheson approach has been adopted yet. For one thing, their models would require much better predictive modeling along with actual, on-the-ground measurements in order to work.⁵⁹ And it is still unlikely that they could fully describe all of the interference that exists, so unaccounted for externalities would still be present. However, taking some action to develop better models would be a step forward for Coaseans, in their effort to create efficient markets, especially if spectrum licensees were permitted to deal among themselves for the right to interfere in each other's licensed spectrum.⁶⁰

Beyond assigning property rights and allowing negotiations between broadcasters, liability rules for dealing with a harmed user are also necessary. This is because any and all users of spectrum should get restitution if their ability to transmit is truly impeded. However, to make a claim for restitution, they should have clear rules for what constitutes actual harm and how much that harm would be compensated. A focus on only relieving actual harm could also limit the waste caused by holdouts who refuse to develop their properties as their ability to enjoin harmless trespassers would be

56. Hazlett, *supra* note 4, at 344.

57. Weiser & Hatfield, *supra* note 1, at 569.

58. *Id.* at 573-74.

59. *Id.* at 570.

60. *Id.* at 574.

restricted.⁶¹ Liability rules, though, are still subject to improper valuations—particularly in technical fields where judges may lack the expertise to accurately measure harm.⁶² Like other immaterial rights, it can be difficult to determine if and how a radio broadcaster has been harmed by interference, and then decide on a sufficient damages award.⁶³

Currently, the FCC defines “harmful interference” as “[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service.”⁶⁴ This standard gives the FCC wide discretion in determining harmful interference, but leaves everyone else with only a vague conception of what actual harm would be. A clearer definition of harmful interference, one that incorporates actual measurable levels, along with rules governing compensation for harm, can mitigate the potential error costs that may occur in a liability ruling. Regardless of the ultimate scheme that is developed, there is ample room (and room for improvement) for the FCC to exert its regulatory power in assigning property rights and describing what harmful interference is.

An alternative to the Property Rights model is the Commons model, where the property is not held in private hands but is accessible to all. For radio spectrum, that would mean an end to licensing and the allocation of radio bands to private entities. Instead, everyone with the technical ability to make radio transmissions would have free rein to become a broadcaster. However, developing a Commons in radio spectrum relies on technology to mitigate interference issues.⁶⁵ New technologies like spread spectrum transmission, and receivers that act as relays for transmissions may indeed help to minimize the effects of interference, allowing a Commons approach to develop.⁶⁶ A Commons would allow individuals to freely access radio and could spur even more new technology and public benefit as individuals, and not just entities willing to deal with the FCC, can utilize radio.⁶⁷ However, the feasibility of creating an actual pure Commons in radio is doubtful.

61. Mark A. Lemley & Philip J. Weiser, *Should Property or Liability Rules Govern Information?*, 85 TEX. L. REV. 783, 793 (2007).

62. *Id.*

63. *Id.* at 794.

64. 47 C.F.R. § 2.102(c) (2013).

65. Sineway, *supra* note 5, at 688.

66. *Id.* at 676.

67. *Id.* at 688-89.

The ever-present danger of the “Tragedy of the Commons” must be dealt with.⁶⁸ If a resource is freely available with no restrictions, unscrupulous users will abuse the freedom and ruin the resource for everyone through pollution and over consumption. In radio, a broadcaster would maximize their signal strength in order to drown out rivals. This is what occurred in the early days of radio use, leading up to the 1927 Radio Act and ultimately the creation of the FCC.

While new technology may help to mitigate the tragedy through more efficient use of the resource, it will probably never be sufficient. For one thing, there is still considerable doubt regarding the ability of new technology to actually accomplish what it claims.⁶⁹ The technology is still new and undeveloped, and for it to work it would have to be widely implemented, requiring most of society to update their equipment, which cannot be assured.⁷⁰ But perhaps most important is the matter of Shannon’s Law, discussed above in Part II(a).⁷¹ As long as Shannon’s Law holds true, then no matter how capable technology becomes, there is a maximum amount of radio transmissions that can exist without drowning out the entire spectrum. And as long as there is the risk that radio will be overused, then a pure Commons system remains untenable. Radio is too important a resource to abandon to the Tragedy of the Commons.

That is not to say that radio is completely unsuited to a Commons approach. Even if regulation and private ownership of spectrum endure, the FCC could allocate some bands for Commons use. In other words, the FCC could create certain unregulated bands where individuals would have free access. Some have argued that where scarcity is low and transaction costs are high, in the upper frequencies of radio where few broadcasters now transmit, a Commons approach could work, while in the frequencies below, private property would still govern.⁷² This would allow the benefits of a Commons—more public transmissions and greater ability for innovators to freely experiment with spectrum—without allowing a possible tragedy to spread through the spectrum bands that society currently relies on.

68. The “Tragedy of the Commons” was first coined by the ecologist Garrett Hardin to underscore Malthusian problems of overconsumption. Garrett Hardin, *The Tragedy of the Commons*, SCIENCE, Dec. 13, 1968, at 1243.

69. Sineway, *supra* note 5, at 689.

70. Hazlett & Leo, *supra* note 4, at 1089.

71. See *supra* Part II.a.

72. Sohn, *supra* note 5, at 672.

II. PROPERTY AND LIABILITY IN OTHER AREAS

Examining how other areas of law have dealt with interference problems can help in creating a new scheme for radio spectrum. This section will first discuss water rights as a usufructuary resource beset with potential interference from overuse and pollution. The second part of this section will deal with nuisance law in general, focusing on how the work of Guido Calabresi and A. Douglas Melamed has shaped when and how damages should be awarded for infringements. These areas of law provide applicable parallels when determining how to restructure the radio spectrum control scheme. Specifically water describes what is needed for ex ante regulation and property boundaries, while nuisance describes the ex post rules required for assigning and assessing damages when property rights are violated.

A. Water Rights

Water, like radio spectrum, is an extremely useful resource that modern society depends upon, not only to sustain life but also for agriculture, recreation, and many industries. However, it is subject to interference through overuse and pollution, which both depletes and degrades water, affecting its value. Users have property rights in water, such as the right to exclude others from access. These property rights are limited in that water is seen as a public resource that should not be completely exploited for personal gain. This is because water is a usufructuary resource. This means that the resource is renewable and non-exclusive; it cannot be captured or held onto forever. To quote Blackstone, "water is a movable, wandering thing, and must of necessity continue common by the law of nature; so that I can only have a temporary, transient, usufructuary property therein."⁷³ Once an owner has finished utilizing the resource, it returns to common property; ownership only grants access, not the absolute right to exclude.

Water thus closely resembles radio. They are both key natural resources on which society depends. Individuals can own both resources and receive property rights, though those rights are limited by public policy concerns. Moreover, they are both usufructs, as owners only receive the right to access them, but cannot absolutely exclude others from accessing it later.

Water rights developed differently in the Western and Eastern United States because of scarcity.⁷⁴ In the East, where water is

73. 1 WILLIAM BLACKSTONE, COMMENTARIES *18.

74. John L. Fortuna, *Water Rights, Public Resources, and Private Commodities*:

relatively abundant, water rights are based on riparian rights, where owners of land abutting watercourses have access rights running into the watercourse, and can use the water in any way that does not unreasonably affect other riparian owners.⁷⁵ In the West, water rights are based on the doctrine of prior appropriation (also known as the Colorado Doctrine), where whoever first managed to capture and put the water to a useful purpose has senior claim.⁷⁶ This has created two different systems, where Eastern water rights are based on a Commons-like system with liability rules for unreasonable use, while the Western system more resembles a Property Rights system, with prior users having exclusionary rights, as long as they fully utilize the water allocated to them.⁷⁷

The Western system of prior application appears to closely resemble a property system as described in the late 1960s by Harold Demsetz, where decreased costs of defining and enforcing rights in a valuable resource leads to parcelization and strict exclusion of access.⁷⁸ Congress first embraced the rights of prior appropriation in the Mining Act of 1866, which recognized that utilizers of valuable resources in the West were performing a vital good to society, and their rights needed to be protected.⁷⁹ Prior appropriation was established further in the 1882 case *Coffin v. Left Hand Ditch Co.*, where the Colorado Supreme Court explicitly rejected the notion that riparian owners would have superior rights to a non-riparian appropriator who had first put the water to beneficial use.⁸⁰ In *Coffin*, a drought-stricken owner of land that abutted the St. Vrain River demolished a dam used by an irrigating company to divert water away. The land owner, however, was found to have violated the irrigating company's prior right to the water. Though the court acknowledged that under the common law of riparian rights, the St. Vrain-abutting owner would have a valid claim, due to the "[i]mperative necessity" that existed in the West, a break from the common law rule of riparian rights was justified.⁸¹ Irrigation, necessary for agriculture in the arid West, would be impossible if riparian owners who moved to a stream could freely tap it; thus

Examining the Current and Future Law Governing the Allocation of Georgia Water, 38 GA. L. REV. 1009, 1012 (2004).

75. *Id.* at 1013.

76. Eric T. Freyfogle, *Water Rights and the Common Wealth*, 26 ENVTL. L. 27, 28 (1996).

77. Henry E. Smith, *Governing Water: The Semicommons of Fluid Property Rights*, 50 ARIZ. L. REV. 445, 449 (2008).

78. *Id.* at 452.

79. *Id.*

80. *Coffin v. Left Hand Ditch Co.*, 6 Colo. 443, 447 (1882).

81. *Id.*

prior users required a greater claim to water than later riparian owners.⁸²

In the West where water was scarce, it made sense that once a user had taken a certain amount of water and put it to beneficial use (limited to agriculture, industry, and domestic use), he continued to have the right to use that amount of water because it was unlikely there would be another available source.⁸³ This creates a detrimental situation where users have little reason to limit their use: they gain no benefit by maintaining in-stream flows in the rivers from which they withdraw (legally, only a single drop needs to remain in the river or aquifer),⁸⁴ and may actually lose out in the future if they allow others to expect greater return flows.⁸⁵ In turn, this leads to deficiencies in in-stream flows, which harm wildlife and secondary users with return flow expectations.⁸⁶ As a result, governance and regulation have become increasingly important in judging users' rights and their ability to fully exploit water resources.⁸⁷

The kind of considerations that became more important in the West, such as prioritizing domestic use of water and maintaining flow for ecological good, made the Western system adopt more of the Eastern model's reasonable use doctrine. Beneficial uses by third-parties who utilize water resources can diminish the exclusionary rights that prior users rely on.⁸⁸ Indeed, as Henry Smith argues, water rights, particularly in the East, actually more closely resemble a semicommons, where private and community property overlap.⁸⁹ As such, liability rules play an important role in determining reasonable use.

Governmental regulation is also necessary in determining rights, as there needs to be clear definition of what levels of pollutants are acceptable, and how much water needs to be reserved for return flows that can sufficiently support vital ecologies.⁹⁰ Various acts by Congress, including the Wilderness Act (1964), the National Environmental Protection Act (1969), the Clean Water Act (1972), and even the Endangered Species Act (1973), have created mandates for regulators to ensure that water resources are properly maintained.⁹¹ Studies by experts are relied upon to make

82. *Id.* at 446.

83. *See* Smith, *supra* note 77, at 454.

84. Freyfogle, *supra* note 76, at 41-2.

85. Smith, *supra* note 77, at 454.

86. *Id.* at 476-77.

87. *Id.* at 453.

88. *Id.* at 454.

89. *Id.* at 449.

90. *Id.* at 459.

91. PETER D. NICHOLS, MEGAN K. MURPHY & DOUGLAS S. KENNEY, WATER AND GROWTH IN

determinations of what are acceptable amounts of water use and pollution. However, there do not seem to be any hard and fast rules as to what constitutes inappropriate degradation. Instead regulatory decisions are made on a case-by-case basis.⁹²

As with radio spectrum, many in the academic community have advocated for a Property Rights-based marketplace for water. This would aim to clearly define the rights in water and account for externalities in order to maximize efficient dealings among water rights owners.⁹³ By allowing owners of water rights to freely trade among themselves, market advocates argue, society can ensure that water is being used by those who properly value it, as demonstrated by their willingness to pay for access.⁹⁴ Water rights are already transferable, particularly in the West, but such transfers are inhibited by rules requiring users to get approval from state boards by demonstrating that the transfer will not affect historic return flows, or injure any other lawful appropriator of water.⁹⁵

The need for regulatory approval runs counter to the free market ideals espoused by advocates of Coasean marketplaces.⁹⁶ However, there is good reason to maintain regulation of water transfers, as water rights owners are less likely to consider the public good when deciding how to utilize their resources. If water rights were allowed to be freely transferable, downstream users, such as riparian owners, recreational users, and wildlife ecosystems would suffer.⁹⁷ Water rights owners would lack incentive to consider the effects of their use on other users, especially those without property rights who would lack standing in court to argue their cause. As such, despite the economic efficiencies that a free marketplace in water would create, regulations and restrictions are still necessary to secure the public's interest in protecting a vital natural resource. For water, not only has it been necessary to decide what rights an owner has in the resource they have purchased, but also what constitutes acceptable use. Only then are private owners' expectations and the public's interest able to commodiously align.

COLORADO 47 (2001), available at http://www.colorado.edu/geography/geomorph/envs_5810/Water_and_Growth.pdf.

92. See, Smith, *supra* note 77, at 448.

93. See, e.g., Freyfogle, *supra* note 76, at 28; see generally Steven J. Eagle, *A Prospective Look at Property Rights and Environmental Regulation*, 20 GEO. MASON L. REV. 725 (2013).

94. John S. Harbison, *Waist Deep in the Big Muddy: Property Rights, Public Values, and Instream Waters*, 26 LAND & WATER L. REV. 535, 543 (1991).

95. *Id.*

96. See *id.* at 545.

97. *Id.* at 537-38.

B. Nuisance Law

Nuisance law developed to govern reasonable use and determine when interference between property owners reaches unacceptable levels. Nuisance law parallels trespass law, in that it relates to controlling one's property and enjoying it as one sees fit.⁹⁸ However, nuisance law is a more complicated area than trespass because it involves governing property uses even when there has been no actual physical invasion.⁹⁹ Nuisance law is concerned with the effects that a property owner's use will have on others nearby, primarily by judging the harm caused and seeking to ameliorate it. However, unlike trespass, this evaluation of harm is much more attenuated when the harm is non-physical, like noxious gas¹⁰⁰ or noise.¹⁰¹ It is also necessary to determine how harmful the nuisance actually was, potentially leaving the claimant without relief when the other user can argue their use was reasonable or non-harmful.¹⁰² Historically, injunctive relief was the normal remedy for a harmed party, though in the last half-century there has been a push to expand nuisance law from a purely exclusionary system to valuations of reasonable use—much of which is a result of Coase's work and the development of the bundle of sticks view of property rights.¹⁰³

It is vital for nuisance law that property boundaries and use rights are well established, and Coase's research noted the unfair outcomes that can occur when information costs in determining specific property boundaries become too high.¹⁰⁴ The cost of determining where property boundaries lie is particularly high in insubstantial and usufructuary resources, like intellectual property, water, and radio spectrum. In these situations, Coase argued that legal rules should not rely on determining who has the right to exclude whom from what, but instead on finding a balance of use

98. Henry E. Smith, *Exclusion and Property Rules in the Law of Nuisance*, 90 VA. L. REV. 965, 990 (2004).

99. *Id.* at 992.

100. See generally *Morgan v. High Penn Oil Co.*, 77 S.E.2d 682 (N.C. 1953) (finding that the defendant's release of noxious gasses from its oil refinery unreasonably impaired the plaintiff's ability to reside nearby).

101. See generally *Estancias Dallas Corp. v. Schulz*, 500 S.W.2d 217 (Tex. App. 1973) (granting injunctive relief to plaintiffs, whose ability to quietly enjoy their property was unreasonably harmed by defendant's neighboring AC system).

102. See generally *Boomer v. Atl. Cement Co.*, 257 N.E.2d 870 (N.Y. 1970) (denying relief to residents of a town near the defendant's cement factory because the great public value the plant generated outweighed the harm caused).

103. Smith, *supra* note 98, at 969.

104. *Id.* at 978.

between two incompatible users.¹⁰⁵ Limiting the bundle of property rights in such a way, Coase argued, would lead to better resource allocation not dependent on who owned what, but instead on the ability to productively utilize the resource.¹⁰⁶ A truly productive user would be allowed to continue their use, or at least be free from injunctions that would cause an end to their activity, in exchange for only having to pay damages for harm caused.

However, such a system would severely limit the traditional rights of property owners, who relied on the ability to completely exclude others from access. Exclusionary rights, in contrast, provide clear rules as to who has access to a resource: the property owner. If an owner had cause to sue an interferer, she would receive an injunction forcing the interferer to immediately cease all interfering activity. She could also sue for supracompensatory damages,¹⁰⁷ which makes all interference prohibitively costly.¹⁰⁸ Exclusion is a low cost way for property owners to protect their right, but at the same time this system can be far too expansive and restricts non-harmful interference even when it would have public benefits.¹⁰⁹ When boundaries between property owners are hard to distinguish (as they are in radio where conditions on the ground can vary wildly from the theoretical conditions that dictated the allocation) reliance on exclusionary rights becomes insupportable.

C. Revolutionizing Nuisance Analysis: Calabresi and Melamed

In 1972, Guido Calabresi and A. Douglas Melamed drastically changed nuisance analysis with the development of a new framework for evaluating and protecting entitlements.¹¹⁰ They conceptualized resource utilization as a series of entitlements balanced between how protected the entitlement should be, and who owns the entitlement in the first place.¹¹¹ This led to four different possible outcomes for a ruling depending on whether the interfering use is proper and which owner has the duty to compensate for the interference.

In the first, the interfered-upon owner has the right to exclusive access, allowing him an injunction with possible extra compensation

105. *Id.*

106. R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 38 (1960).

107. Like punitive damages, payment above and beyond mere compensation intended to cause the interferer to fully internalize the harm he caused.

108. Smith, *supra* note 98, at 980.

109. *Id.* at 983.

110. Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1090.

111. Smith, *supra* note 98, at 1008.

for great harm. This is the situation in most nuisance cases where the harmed party has greater claim and can enforce a right to exclude others from inhibiting his free use of his property. Second, the interfered-upon party is entitled to be free from interference, but is only given the right to compensation for damage. This is seen in the classic case of *Boomer v. Atlantic Cement Co.*, where the defendant cement company was found to be a harmful nuisance, but, because of its extreme economic value, was allowed to compensate the harmed parties instead of being shut down.¹¹² This occurs when the interfering use is found to have great public value and can continue, but should still compensate for the disruption it has caused. Third, the interferer is privileged with the right to continue their interfering use and can enjoin others from even seeking to impede that right. Though it is unlikely they could sue in court for the right to pollute, those affected would be prohibited from seeking relief in court.¹¹³ Fourth, the interferer again is entitled to pollute, but liability is the chosen path instead of exclusion. That is, the interferer has the greater right, but the interfered-upon can compensate them to cease their interfering activities and move away.

This fourth possible rule has almost never played out in court. The 1972 Arizona Supreme Court case of *Spur Industries, Inc. v. Del E. Webb Development Co.* remains the best known (and perhaps only) case of Calabresi and Melamed's Rule Four playing out.¹¹⁴ In *Webb*, a developer planned to build a retirement community on the edge of a growing town in Arizona.¹¹⁵ Unfortunately, the planned community was encroaching on a long established cattle feedlot, which emitted noxious, farm-related odors. When the developer sued to get the feedlot removed, the court found that while the lot did make an enjoynable nuisance, the developer had actually initiated the harm by "coming to the nuisance."¹¹⁶ In other words, the developer expanded into an area it knew would be noxious to live in.¹¹⁷ The feedlot had to relocate to abate a harmful nuisance to the community; but as the junior user who had entered an area with a knowable nuisance, the developer had to compensate the feedlot for the move.¹¹⁸ But this is a unique situation that seldom arises in regular nuisance law.

In order to decide which of the Calabresi-Melamed rules should

112. *Boomer v. Atl. Cement Co.*, 26 N.Y.2d 219, 226 (N.Y. 1970).

113. Smith, *supra* note 98, at 1012.

114. *Id.* at 1010.

115. *Spur Indus., Inc. v. Del E. Webb Dev. Co.*, 108 Ariz. 178, 182 (1972).

116. *Id.* at 184.

117. *Id.* at 184-85.

118. *Id.*

apply, it is necessary to first determine where the entitlements lie: whether the interfered-upon or the interferer has a better claim, and what kind of compensation should be given. To do this courts rely on two different methods. They can follow a centralized method in line with Judge Learned Hand's cost-benefit analysis, where the actors' activities are weighed for their respective benefits, and damages are assigned according to the relative costs that the activities impose on others.¹¹⁹ Alternatively, courts follow a decentralized cheapest cost-avoider method, where liability is assigned to the actor who can most affordably avoid causing harm. That actor can then weigh the costs of liability against the benefits of the activity and make an economic decision as to whether the activity is worthwhile.¹²⁰ Whichever method is followed, the result should be a determination of which party has a prior claim, if one provides a greater public benefit that should be privileged, or if one can mitigate the harm cheaper and more easily than the other. Once the parties have shown where their rights and entitlements lie, they can be assigned to one of the Calabresi-Melamed rules.

Underlying these determinations is the problem of information costs. Courts are often ill-suited to properly assess what is valuable activity and, in the case of insubstantial property rights, where boundaries lie. The courts usually rely on exclusion, applying mostly the first (and occasionally the second) Calabresi-Melamed rule, giving the actor who can show she has a prior right the ability to exclude all intrusions.¹²¹

Enjoinment may eliminate the problem of information costs, in that it is a cheap and easy ruling whenever a superior rights holder complains of interference. However, it can cause excessive exclusion, in that it will also block non-harmful, and even socially beneficial, interference.¹²² Further determinations can be made, such as whether the nuisance activity is in fact reasonable given the location, effect, and benefit of the nuisance.¹²³ Indeed, this reasonable use doctrine is an important aspect of nuisance law, in that where a reasonable use is found, there is not a nuisance.¹²⁴ Again information costs affect the courts' ability to find reasonable use. In technically complex or socially important cases, though, standards created through previous judicial determinations, legislative action, administrative schemes, or private contracting can establish clear

119. Smith, *supra* note 98, at 1022.

120. *Id.* at 1023.

121. *Id.*

122. *Id.* at 1024.

123. *Id.* at 974.

124. *Id.*

standards for reasonable use, and in that way help prevent excessive exclusions.¹²⁵ It is vital that the decisions reached are made with due consideration of the technical and physical aspects of the property, as well as how it is used by its owners.

IV. APPLICATION TO RADIO SPECTRUM

Examining other, established areas of property law can facilitate the development of a more capable system for managing radio ownership rights. They can show how different systems have worked, and where they have failed, and thus help avoid making obvious mistakes. From their example one can determine whether a Commons or a Property model is preferable. They also demonstrate the necessity of clearly and thoroughly describing *ex ante* rules of delineating property, and *ex post* rules for when interference occurs. Water and nuisance law both provide apt parallels to radio law, in that they deal with usufructuary resources and harm respectively.

To begin, radio spectrum will not function in a perfect Commons system, at least not without theoretical impossible advancements in radio technology.¹²⁶ Even if Shannon's Law did not preclude any ability for a radio Commons system—the constant threat of interference would lead to a Tragedy of the Commons—there are other reasons why it is inappropriate. For instance, the Eastern United States uses a system that resembles a Commons, but only because it is abundant there, and the historic rights of riparian owners could be privileged. Yet even there, this only resembles a semicommons rather than a true Commons (certain private entities that border the resource have exclusive rights, not everyone). A Commons could possibly be workable in radio as everyone is technically “riparian” (analogously, the radio “stream” is continually all around us), but there would still remain other possibilities for a tragedy to occur.

In fact, Commons systems are still based on liability rules, which would then still need to be clearly defined. For a technically complex resource like radio, special regulatory bodies would still have to make liability rules. Thus, even if the FCC were to allow free access to radio, it would still have to make these rules and govern radio. So, a radio Commons is mostly moot because the problems with current radio regulation would still need to be dealt with.

This leads to a second basic point: because radio spectrum is a vital resource that society increasingly relies on, a pure Coasean

125. *Id.*

126. *See* Yoo, *supra* note 19, at 2195.

market dictated only by economic incentives also cannot work. A pure Property Rights system largely resembles a pure free market system where management is left to the owners; their interests prevail and they regulate and govern their property as they see fit. But radio, like water, is too important to leave in the hands of private owners. Radio spectrum requires a regulating body capable of establishing and protecting the rights of radio users, particularly those of the consuming public, just as water needs environmental protection boards to ensure supply and safety. Whether this regulator should be the FCC is questionable. There is little love for the current regime, with even FCC officials speaking critically.¹²⁷ However, change will have to come either from Congress, or through rulemaking within the FCC itself; either way it will require political and economic determinations of proper policy.

As with water, any property rights scheme for spectrum will first require clearly determining where property boundaries lie. Allocation of radio spectrum has historically been done by the FCC through an applications process, though the recent success of auctions has made that approach more attractive.¹²⁸ If the government can get billions of dollars auctioning off spectrum, instead of giving it away in applications, it should. Nevertheless, the regulator will have to determine the extent of the allotments, possibly set at boundaries like those described by De Vany and Matheson.¹²⁹ And because bleed-over interference at boundaries is inevitable, the regulator will also have to establish acceptable levels of interference, which the spectrum owners will have to live with. Just as courts and legislators have determined what constitutes harmful noise and air pollution, regulatory rules of what is harmful radio interference are needed.

No matter how they establish the rules, a regulator must ensure that spectrum owners know where their rights lie. It may be appropriate to give spectrum owners greater rights than they enjoy now. For instance, an affirmative right to transmit may give owners more faith in their property than the promise not to be interfered upon that they enjoy now. Similarly, allowing alienability of spectrum rights would be a positive change. This would allow for greater dealings among spectrum owners and allow them to bargain over the boundaries and interference issues. These might serve to normalize radio rights, instead of setting it off as a unique and rarified resource as it currently is. Regardless of what rules are

127. See Goodman, *supra* note 3, at 359.

128. Sohn, *supra* note 5, at 671.

129. See Weiser & Hatfield, *supra* note 1.

adopted, these sorts of ex ante rules are vital for any property system—owners must know what they have and how they can use it.

The next step required to create a viable property system for radio spectrum will be to protect the ex post rights of spectrum owners. It is not enough for spectrum owners to have property rights, they must also be able to enforce them when they are interfered with. Again, it is important to establish acceptable levels of interference so that only serious violations are adjudicated. Once a spectrum owner has suffered serious interference, the proper relief must also be determined. These determinations can follow the lead established by nuisance law. For instance, a fair-use rule should be used to ensure that interferers who do not cause serious harm can continue to operate—it would be wrong for incumbents to block new users merely because their transmissions may occasionally clash. Further, use of the Calabresi-Melamed model can help determine a fitting result. Injunctive relief is largely improper for spectrum, in that it is over inclusive and leads to the ugly possibility of holdouts who extort high payoffs with the threat of costly litigation.¹³⁰ Nevertheless, there could be situations where the governing body determines that the owner's use is important enough, or the interference is so debilitating, that injunctive relief is proper.

Ultimately, because interference is often non-harmful or results from some other, more valuable use, liability rules should more often apply.¹³¹ If liability rules were then matched with a cheapest cost-avoider scheme, emerging technologies could blossom in the existing spectrum environment, while incumbent owners could rely on being compensated for their relative loss. This would be because new users would get enough value from their new use to justify paying off incumbents. In a similar vein, Rule Four of the Calabresi-Melamed model could have a life within spectrum, if incumbent broadcasters were likened to the hog farm in *Spur*. They would have the prior right to pollute (or interfere on new entrants) but should not also hold up progress. Instead they get compensated for moving out of the way of beneficial new entrants. In radio, both parties are concurrently interfering and interfered upon; in radio the difference between Rule Two and Rule Four is merely who has the prior right. The party with the better claim for value created by their use should have the right to continued use. If the prior user has the weaker claim, they should be seen as the interferer and forced to leave, though compensated for their pains. Again, the rules that govern

130. Sineway, *supra* note 5, at 698.

131. *Id.*

these determinations should be made through a technically competent regulator, or at least through a politically interested Congress, and not through ignorant court rulings.

What must always serve as the guiding light of any scheme is the importance of the public consumer, and the value he gets from being able to utilize radio spectrum, whether in wireless internet, GPS, or even old fashioned uses like AM and CB radio. After all, the companies that pay billions of dollars for access to radio spectrum do so in order to get customers. If the public is dissatisfied with the product they receive, then everyone suffers. The FCC's current mandate to make a rapid, efficient radio communication service nation-wide,¹³² should be updated to align with modern goals and concerns of radio use.

However, unlike water, there is little benefit to not using radio spectrum. It is not a resource that can be degraded to the harm of all life, nor does it have important aesthetic qualities that make it valuable just to have around. Except for the issue of interference, there is little reason not to completely exploit spectrum; indeed, economically, it should be exploited to the maximum amount that interference allows. Because a commons scheme would allow for maximum utilization of spectrum (in that all broadcasters have free access to spectrum), some have argued for a hybrid property rights-commons scheme to avoid the ultimate problems that come with all broadcasters having free access. It would likely be an allocation of a swath of spectrum (the above 5 MHz range has been suggested) where commons would apply.¹³³ This would have the added benefit of giving emerging technologies a place to experiment.

Moreover, certain uses of radio spectrum are necessary to the public, but do not have clear economic benefit. These include underwater communication (which requires exclusive use of the very lowest bands of spectrum to work), emergency services, and radio astronomy.¹³⁴ Any regulating body must ensure that these key services continue by assigning them secure, protected bands that cannot be sold. Also, these bands should be highly protected from interference by creating white bands around them—particularly for emergency services, as firefighting crews reliant on radios in smoke-filled buildings cannot afford the possibility of, say, a nearby cell phone interrupting a communication.¹³⁵ These uses could be considered like environmental regulations protecting water, though

132. See 47 U.S.C. § 151 (2014).

133. In 2002, the FCC's Spectrum Task Force proposed this exact scheme. Sohn, *supra* note 5, at 672.

134. Goodman, *supra* note 3, at 283.

135. Hazlett & Leo, *supra* note 4, at 1086.

they are still based on the exploitation of the resource, instead of conservation.

CONCLUSION

Radio spectrum is a valuable resource that will only increase in value in the future, but how it is currently regulated is insufficient. Spectrum owners deserve a regulator that can capably assign rights, and then provide clear adjudicative rules when those rights are violated. Interference from other broadcasters inherently affects the ability of receivers to function fully. Rules based on what has worked out in other areas of law like water and nuisance can dictate where violations occur, and what proper relief is. These rules would have to create clear *ex ante* and *ex post* rights for determining where property interests lie and how harmful interference is determined and recompensed. A strong, capable, technocratic regulator, with clear, practical goals is necessary to govern radio. The FCC as it is now is not fit, though it can change itself or be amended through Congressional action. It will have to rework the *ex ante* and *ex post* rules for broadcasters, likely at the expense of incumbents who have been used to the system as it has worked for almost 80 years. But hopefully a clearer system will be the result, one that will allow the promised future of wireless to flourish while guaranteeing the public its right to clear signals.