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Treating the Wireless Spectrum as a Natural Resource

by Patrick S. Ryan

Editors' Summary: As this Article demonstrates, most experts agree that the electromagnetic spectrum is a vital natural resource. Yet European and U.S. governments fail to treat it as such. The author looks at contributions made by two scholars, Ronald Coase's public trust doctrine and Garrett Hardin's tragedy of the commons, and examines their influence on the debate surrounding the electromagnetic spectrum's classification as a natural resource. The author then addresses sustainability concerns and argues that as is the case with all natural resources, a balance between overexploitation and underexploitation is needed in the management of the spectrum.

I. Introduction

Is the electromagnetic spectrum a natural resource, and, if so, should it be treated as such? This first question has already been answered to some extent in both Europe and the United States. In short, everyone appears to agree that the electromagnetic spectrum is, to some extent, a natural resource. Indeed, concurrence on this point is overwhelming, even at the highest political levels. However, this Article will argue that in spite of its universally recognized categorization as a natural resource, the electromagnetic spectrum has not been accorded the same level of protection (in the form of laws related to its access) as other public natural resources and treasures. Its classification as a natural resource is little more than an illusory promise to the public: in labeling it a "natural resource," European and U.S. governments do not fulfill their implicit promise to treat it as such.[1] As a result, the electromagnetic spectrum does not derive a benefit from the various rights ascribed to other natural resources.

First, this Article will show that both Europe and the United States do in fact agree that the electromagnetic spectrum is a natural (and a national) resource. This otherwise simple point will be explored in considerable detail in order to show that many high-level government and policy sources have affirmed and reaffirmed the proposition that the wireless spectrum is a natural resource. Second, this Article will review economic analyses developed by the famous resource allocation scholars Ronald H. Coase and Garrett J. Hardin. These scholars have carefully investigated economic approaches to other natural resources and have made award-winning proposals[2] regarding the management of public commons. Finally, this Article will conclude that two environmental law paradigms should be applied to spectrum management: (1) the principle of sustainable consumption; and (2) the principles of underexploitation and overexploitation.

II. The Electromagnetic Spectrum *Is* a Natural Resource

A. The Position in the United States

The U.S. Supreme Court has stated numerous times in the past several decades that the electromagnetic spectrum is a "scarce"[3] "natural resource."[4] In spite of these assertions,

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1. *See* Interchange Assocs. v. Interchange, Inc., 557 P.2d 357 (Wash. Ct. App. 1977). This case clearly defines "illusory promise," a concept that is often found in U.S. contract law:

> An "illusory promise" is a purported promise that actually promises nothing because it leaves to the speaker the choice of performance or nonperformance. When a "promise" is illusory, there is no actual requirement upon the "promisor" that anything be done because the "promisor" has an alternative which, if taken, will render the "promisee" nothing. When the provisions of the supposed promise leave the promisor's performance optional or entirely within the discretion, pleasure and control of the promisor, the "promise" is illusory.

Id. at 360.

2. The Nobel Prize in Economic Sciences was awarded to Coase in 1991 "for his discovery and clarification of the significance of transaction costs and property rights for the institutional structure and functioning of the economy." Coase's work is cited often in the discussion of wireless economics. For an overview of Coase as presented by the Nobel Commission, see *Nobelprize.org*, *at* http://nobelprize.org/economics/laureates/1991/ (last visited June 20, 2005).

3. *See* Red Lion Broad. v. Federal Communications Comm'n, 395 U.S. 367, 376 (1969) (calling the electromagnetic spectrum a "scarce re-

economic models have not yet been adapted to accommodate the special features of the electromagnetic spectrum as a natural resource. The traditional curriculum of natural resource economics emphasizes many areas similar to the electromagnetic spectrum, such as fisheries models,[5] forestry models,[6] and minerals extraction models, i.e., fish, trees, and ore,[7] at an international level.[8]

In recent years, however, other resources, notably air, water, the global climate, and environmental resources in general, have become increasingly controversial in U.S. policymaking. This controversy is illustrated by the statement of President George W. Bush—widely viewed after the Kyoto Accord as an "environmentally unfriendly" president[9]—who issued a written position (in the form of a presidential memorandum) stating clearly and unequivocally that the electromagnetic spectrum is "*a vital and limited national resource*."[10] Even President Bush, who often takes extreme positions on environmentalism (positions considered somewhat extreme even by conservative Republican standards),[11] acknowledges that the electromagnetic spectrum is a vital national resource.

Based on the assertions of the Court, the president, and academics, it can safely be concluded that the policy of the U.S. government is that the electromagnetic spectrum is a scarce natural (and national) resource. As will be seen, however, in spite of this highly unusual consensus throughout different layers of government and academia, the government does not treat the spectrum like other natural resources.

The U.S. Department of the Interior (DOI) and the U.S. Environmental Protection Agency (EPA), which is charged with the protection of natural resources, exerts practically no control over the wireless spectrum. One exception involves emissions limits, where EPA has set some exposure guidelines regarding certain forms of electromagnetic radiation.[12] However, these guidelines only cover the dangers of electromagnetic exposure and, accordingly, do not address the protection and useful exploitation of the spectrum itself. Although it is unclear if—or how—EPA could manage the electromagnetic spectrum, EPA's sister organization, the DOI, has a long and successful track record in passing com-

source"); Federal Communications Comm'n v. League of Women Voters, 468 U.S. 364, 377 (1984) (noting that "[t]he fundamental distinguishing characteristic of the new medium of broadcasting . . . is that [b]roadcast frequencies are a scarce resource").

4. *See* Columbia Broad. Sys., Inc. v. Democratic Nat'l Comm., 412 U.S. 94, 173-74 (1973) (making a direct link between the electromagnetic spectrum and natural resources and tying the spectrum further to ownership paradigms: "At the outset, it should be noted that both radio and television broadcasting utilize a natural resource—electromagnetic spectrum . . . [a]nd, although broadcasters are granted the temporary use of this valuable resource for terminable three-year periods, 'ownership' and ultimate control remain vested in the people of the United States.").

5. *See*, *e.g.*, Margaret Ross Dochoda & Joseph F. Koonce, *A Perspective on Progress and Challenges Under a Joint Strategic Plan for Management of Great Lakes Fisheries*, 25 U. TOL. L. REV. 25 (1994). The authors describe a key natural resources "[s]trategic [p]lan" by which Great Lakes fishery agencies in Canada and the United States are committed to the following: (1) consensus on management actions with interjurisdictional implications; (2) accountability for performance; (3) communication of environmental management needs; and (4) cooperation in measuring and predicting effects of fishery and environmental management needs.

6. *See, e.g.*, Jennifer Woodward, *Turning Down the Heat: What United States Laws Can Do to Help Ease Global Warming*, 39 AM. U. L. REV. 203 (1989). Jennifer Woodward describes how deforestation contributes to serious environmental problems in two ways. First, the large-scale burning of forests—as a method of clearing land—releases large quantities of carbon dioxide (CO_2) into the atmosphere. Second, because trees absorb CO_2 through photosynthesis, large-scale deforestation reduces one of the known natural CO_2 storage units at a time when such a reservoir is most needed.

7. *See, e.g.*, Philip F. Schuster & Roger F. Dierking, *Future Prospects for Mining and Public Land Management: The Federal "Retention-Disposal" Policy Enters the Twenty-First Century*, 26 ENVTL. L. 489 (1996). The authors describe and critique the Mining and Minerals Policy Act (MMPA) of 1970. The authors note, for example, that the congressional intent behind the MMPA was to develop a rational plan for world market fluctuations in mineral availability while developing environmentally and technologically sound domestic mineral extraction and consumption programs. The MMPA was intended to give laudable form to a national agenda that rationally balances and harmonizes the government's retention policy with the nation's mineral disposal needs. Market forces will continue to affect the federal retention-disposal policies for mining and property rights in mineral claims.

8. *See, e.g.*, Elli Louka, *Cutting the Gordian Knot: Why International Environmental Law Is Not Only About the Protection of the Environment*, 10 TEMP. INT'L & COMP. L.J. 79 (1996). The article deals with the question of how international law, given its particularities and limitations, currently addresses and could optimally address the problem of regulation of internal resources and global commons. The law review article attempts to build on Justice Oliver Wendell Holmes' work in order to reveal "some order, some rational explanation, and some principle of growth for the rules" of international environmental law. *Id.* at 70 (citing O.W. Holmes, *The Path of Law*, 10 HARV. L. REV. 457, 465 (1897)).

9. Shortly after taking office, President Bush announced that he was withdrawing from the Kyoto Accord on Global Warming. This highly controversial move was condemned the world over, but particularly in Europe. Eighty percent of Europeans opposed President Bush's position, and the debate that followed helped to label him as a very environmentally unfriendly president. *See, e.g.*, *Bush Withdrawal From Kyoto Condemned by 80 Percent of Europeans*, AGENCE FRANCE PRESSE, Aug. 15, 2001, *available at* http://www.climateark.org/articles/2001/3rd/wifrkyot.htm (last visited June 20, 2005) (a European poll that condemns President Bush's position on the Kyoto Accord); Greenpeace, *U.S. Withdraws From Kyoto Protocol*, *at* http://www.greenpeaceusa.org/features/kyotonotext.htm (last visited Jan. 10, 2004) (detailing Greenpeace's position on President Bush's withdrawal from Kyoto and quoting a senior Greenpeace official as saying that "Bush ignores the economic benefits of U.S. leadership on 21st century energy technology"). *But see Climate Change: Kyoto's Last Stand*, ECONOMIST, July 19, 2001, at 65, *available at* http://www.economist.com (subscription required) *and Atmospheric Pressure: How to Make Treaties Stick*, ECONOMIST, Apr. 17, 2003, *available at* http://www.economist.com (subscription required) (both articles detailing the various oppositions to President Bush's withdrawal from Kyoto, suggesting that several aspects of the Kyoto treaty are not based on sound science, suggesting that his position may actually reflect sound economic policy, and noting that further studies still need to be concluded).

10. George W. Bush, *Presidential Memo on Spectrum Policy*, June 5, 2003, *available at* http://www.whitehouse.gov/news/releases/2003/06/20030605-4.html (last visited June 20, 2005) (emphasis added).

11. *See* Christie Whitman, *Republicans Need to Make Room for Moderates*, SEATTLE POST-INTELLIGENCER, Jan. 16, 2004, at B7. The article is written by a Republican and former U.S. Environmental Protection Agency (EPA) Administrator who discusses the extreme views that the Republican party has taken with respect to environmental policy:

> I also often had to battle extremists within my own party. I remember a Republican leader in [the U.S.] Congress telling me not to use the word "balance" when talking about environmental policy—it implied that we were giving too much away to the environmentalists. Moderate [Republican] voters who are concerned about the environment were often left frustrated.

12. *See* U.S. EPA, *Ionizing & Non-Ionizing Radiation*, *at* http://www.epa.gov/radiation/understand/ionize_nonionize.htm (last visited July 28, 2005) (describing the various forms of electromagnetic signals, their division into different frequencies, and the critical distinction between ionizing and non-ionizing radiation).

prehensive legislation that requires it to actively manage and guarantee public access to fish and wildlife,[13] minerals,[14] the national parks,[15] mining,[16] land management (federal lands),[17] and Indian land trusts.[18]

Instead, these organizations that deal with natural resources every day have very little or nothing to do with the electromagnetic spectrum. Furthermore, policymakers, academics, and lawyers are faced with a total vacuum of information as to how they may help; such an idea is new, for we continue to believe in the doctrine of scarcity and have not yet begun the important process of reforming our thinking about different ways to manage the resource. In spite of declarations made by the president and the Court, the only government agency that deals extensively with the spectrum is the Federal Communications Commission (FCC), the same governmental division that limits free speech and viewer content[19] and that has no experience whatsoever with the administration of other natural resources.

13. *See, e.g.*, Division of Congressional & Legislative Affairs, U.S. Fish & Wildlife Service, Digest of Federal Resource Laws of Interest to the U.S. Fish and Wildlife Service (2005), *available at* http://laws.fws.gov/lawsdigest/indx.html (last visited June 20, 2005).

14. *See, e.g.*, Department of Congressional Affairs, Minerals Management Service, 2003 Facts and Figures Book (2004), *available at* http://www.mms.gov/ooc/newweb/congressionalaffairs/congress.htm (last visited June 20, 2005) (contains exhaustive material on alternate energy legislation, congressional testimony, offshore programs, and other details).

15. *See, e.g.*, Legislative and Congressional Affairs, National Park Service, National Park Service Public Laws of the 108th Congress: 2003-2004 (2005), *available at* http://www.nps.gov/legal/laws.htm (last visited June 20, 2005).

16. *See, e.g.*, Office of Surface Mining, *Surface Mining Law*, *at* http://www.osmre.gov/smcra.htm (last visited June 20, 2005).

17. *See, e.g.*, Stewardship End Result Contracting, 69 Fed. Reg. 4174 (Jan. 28, 2004), *available at* http://www.blm.gov/nhp/spotlight/forest_initiative/stewardship_contracting/stcontrFedRegBLM0128.pdf (last visited June 20, 2005).

18. *See, e.g.*, U.S. DOI, *Bureau of Indian Affairs*, *at* http://www.doi.gov/bureau-indian-affairs.html (last visited June 20, 2005) (the Bureau of Indian Affairs has responsibility for the administration and management of 55.7 million acres of land held in trust by the United States for American Indians, Indian tribes, and Alaska Natives.

19. During the 2004 Super Bowl, a major controversy erupted when Justin Timberlake pulled off part of Janet Jackson's bustier and exposed one of her breasts. This somewhat bizarre scene would have been legal in cable format. It was illegal, however, only because it was sent over the airwaves. While it may seem unwarranted for the FCC to police such incidents, Congress requires it to do so. This responsibility is derived from outmoded regulation that distinguishes the way the airwaves are regulated, i.e., the FCC can regulate airwave content, from the way that wires and cables are regulated, i.e., the FCC is prohibited from regulating wire and cable content. In most parts of the United States, there is more than 80% penetration in cable or satellite (like cable, satellite content is not regulated in the same way), and most people cannot tell the difference between cable and non-cable stations. For example, when flipping through stations, there is no real way to differentiate between channel 5, an airwave-based FCC station, e.g., the American Broadcasting Company (ABC), and channel 23, a cable, noncontent-regulated station, e.g., Music Television (MTV). Both stations (ABC and MTV) come through on cable these days in most homes, and the handheld television remote control used to change channels does not differentiate between FCC-regulated material that also is transmitted over the airwaves and less-restrictive cable content. *See Transatlantic Cleavage*, Economist, Feb. 5, 2004, *available at* http://www.economist.com (subscription required) (describing the Jackson event and noting the FCC inquiry). *See also* Kathleen Q. Abernathy, Written Statement on Protecting Children From Violent and Indecent Programming, Before the Committee on Commerce, Science, and Transportation, U.S. Senate, Feb. 11, 2004, *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-243910A1.pdf (last visited June 23, 2005). Abernathy discusses the FCC's role in broadcasting: "The law holds that broadcasters, because they make licensed use of publicly owned airwaves to provide programming to the general public, have a statutory obligation to make sure that their programming serves the needs and interests of the local audience."

B. The Position of Europe and of International Organizations Based in Europe

The European Union's Green Paper on Radio Spectrum Policy declares that the "*radio spectrum is an essential and increasingly scarce resource*."[20] Although the Radio Spectrum Decision[21] that resulted from the Green Paper consultation process (surprisingly) did not overtly categorize the spectrum as a natural resource, responses to the Green Paper from many European organizations were strongly in favor of making such a declaration. While such input does not equate to official European policy, it does indicate a clear trend among many nations and organizations to designate the wireless spectrum as a natural resource.

1. The Position of the European Parliament and of Various European Countries

Comments regarding the Green Paper from various European governmental and quasi-governmental sources show unanimous support for the conclusion that the spectrum is a natural resource. These comments include the following:

- **The European Parliament** filed a draft report in response to the Green Paper, where it stipulated in its very first recital that the "radio spectrum is a vital and scarce natural resource."[22]
- **The Irish government** called the wireless spectrum an "international natural resource."[23] The Irish government manages radio spectrum within its Department of Communications, Marine and Natural Resources.[24] As the department name suggests, Ireland categorizes and manages the wireless spectrum along with other national treasures. Unsurprisingly, Ireland has one of the world's richest histories of dealing with the wireless spectrum as a

20. Commission of the European Communities, Green Paper on Radio Spectrum Policy in the Context of European Community Policies Such as Telecommunications, Broadcasting, Transport, and R&D, COM(98)596 (Sept. 12, 1998), *available at* http://europa.eu.int/ISPO/infosoc/telecompolicy/en/sgp.doc (last visited June 23, 2005) (emphasis in original).

21. Decision No. 676/2002/EC of the European Parliament and of the Council of March 7, 2002 on a regulatory framework for radio spectrum policy in the European Community (Radio Spectrum Decision), 2002 O.J. (L 108) 1, *available at* http://europa.eu.int/information_society/policy/radio_spectrum/docs/policy_outline/decision_6762002/en.pdf (last visited June 23, 2005).

22. Committee on Industry, External Trade, Research and Energy, European Parliament, Draft Report on the Commission Communication to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions on "Next Steps in Radio Spectrum Policy—Results of the Public Consultation on the Green Paper," COM(99) 538-C5-0113/2000-2000/2073(COS) (Mar. 24, 2000), *available at* http://www.europarl.eu.int/meetdocs/committees/itre/20000418/404724_en.doc (last visited July 28, 2005).

23. *See* Presentation of John A.C. Breen, Irish Department of Communications, Marine and Natural Resources, ITU World Radio Conferences: An Overview (undated presentation), *available at* http://www.dcmnr.gov.ie/files/1 (last visited Jan. 15, 2004).

24. *See generally* Irish Department of Communications, Marine and Natural Resources website, *at* http://www.dcmnr.gov.ie/ (last visited June 24, 2005).

natural resource. In fact, it was in County Galway, on Ireland's western fringe, where Italian radio pioneer Guglielmo Marconi set up one of the first transatlantic wireless stations. On June 15, 1919, the station, using generators fueled by Irish peat—another natural resource[25]—notified London of the successful flight of two British aviators.

- **The Finnish government** told the European Parliament that "[t]he development of [new services] increases competition for available space on the spectrum and underlies its importance as a scare natural resource."[26]
- **The Czech Republic** notified the European Commission that the "frequency spectrum is a limited natural resource that is, according to the Constitution of the Czech Republic, [the] property of the State."[27]

2. The Position of European Private Enterprise

Not only do European governments, governmental organizations, and international organizations support the natural resources proposition, but so do some of the world's most important players in private industry. The positions of this group include the following:

- **Alcatel**, one of the world's largest telecommunications equipment providers,[28] has eloquently captured the essence of the resource debate in a document that it prepared on software-defined radio (SDR), stating that "[t]he radio spectrum is a unique, *ubiquitous natural resource* shared by a wide variety of services. Unlike many other natural resources, it can be repeatedly reused . . . ."[29]
- **British Telecom** told the European Commission that "harmonisation of spectrum usage is not just a [sic] 'nice to have' it is essential in the context of a scarce but *vital natural resource* coming under increasing pressure from a number of divergent needs."[30]
- **Air France** filed a comment to the Green Paper, stating that the "spectrum is a *natural resource* and . . . the only acceptable and legitimate criterion for accessing to it, [sic] is its use in the general interest of the public."[31]

3. The International Position

After reviewing the positions of the European Parliament, various European countries, and private industry, it should come as no surprise that international organizations based in Europe also support the principle that the radio spectrum is a natural resource. The positions of this group include the following:

- **The North Atlantic Treaty Organization** (NATO) filed a comment to the Green Paper proclaiming that "[f]rom the NATO perspective the radio spectrum has always been an extremely valuable finite *natural resource* of each nation."[32] Presumably, this position is shared by the 19 countries that are Members of the NATO alliance. At a minimum, this position represents the majority viewpoint of the military branches of these countries.[33]
- **The International Telecommunications Union** (ITU) has, unsurprisingly, also noted in documents sourced in its Development Bureau[34] that the "radio-frequency spectrum is an inexhaustible *natural resource* available in all countries and in outer space."[35] Other ITU documents have mirrored this argument, declaring that "the radio frequency spec-

25. Peat is the most important natural resource of Ireland and northern Ireland. *See* Brian Graham, *Ireland*, *in* MICROSOFT ENCARTA ENCYCLOPEDIA 1 (2004).

26. Address to the European Parliament by Olli-Pekka Heinonen, Finland Minister of Transport and Communications, on Spectrum Policy, European Parliament Committee on Industry, External Trade, Research, and Energy (Oct. 12, 1999), *available at* http://presidency.finland.fi/netcomm/news/showarticle1348.html (last visited June 24, 2005).

27. MINISTRY OF TRANSPORT AND COMMUNICATION, NATIONAL TELECOMMUNICATIONS POLICY OF THE CZECH REPUBLIC 4 (translation from Czech, Apr. 26, 1999), *available at* http://www.mdcr.cz/text/archiv/NTPang-appendix.doc (last visited June 25, 2005).

28. Alcatel is one of the world's strongest industry players. As of early 2003, the company's recovery from the telecom slump placed it above rivals Ericsson, Lucent, and Nortel in revenue and recovery prospects. Kevin J. Delaney, *Alcatel: Revenue Outpaces Rivals—French Company Forecasts Operating Profit in 2003*, WALL ST. J., Feb. 5, 2003, at B3.

29. Cengiz Evci, *Optimizing and Licensing the Radio Frequency Spectrum for Terrestrial 3G Users*, 1 ALCATEL TELECOMM. REV. 19, 27 (2001), *available at* http://www.alcatel.com/atr/abstract.jhtml?repositoryItem=tcm%3A172-14811635 (last visited July 28, 2005). The author of the report also captures other core philosophical issues central to this concept, indicating that large vendors are beginning to embrace the idea that resources should be free and open. For example, he states the following:

> First, in principle, why should someone pay for a natural resource that is freely available? Air, rivers, oceans and beaches are comparable resources which are free and have a price attached only when supplementary services are added. . . . [S]ome uses [of the spectrum] are linked to national interests, such as defense, security forces, astronomy and meteorological services, while others are the keys to competitive markets. . . . Even then, these services are so widely available to the general public that they may be listed as public services which should be made available nationally [for the public].

Id. at 22.

30. BRITISH TELECOM, RESPONSE TO THE GREEN PAPER ON RADIO SPECTRUM POLICY FOR THE EUROPEAN COMMUNITY §3(e) (1998), *available at* http://europa.eu.int/ISPO/spectrumgp/sgpcom/bt.pdf (last visited July 22, 2005) (emphasis added).

31. EUROPEAN AFFAIRS, AIR FRANCE, COMMENTS ON THE GREEN PAPER FROM THE EUROPEAN COMMISSION ON RADIO SPECTRUM POLICY (1999), *available at* http://europa.eu.int/ISPO/spectrumgp/sgpcom/airfrance.htm (last visited July 22, 2005) (emphasis added).

32. *See* NATO FREQUENCY MANAGEMENT BRANCH, RESPONSE TO THE COMMISSION OF THE EUROPEAN COMMUNITIES GREEN PAPER ON RADIO SPECTRUM POLICY (undated), *available at* http://europa.eu.int/ISPO/spectrumgp/sgpcom/nato.pdf (last visited July 22, 2005) (emphasis added).

33. The NATO Alliance Members as of June 2005 include the following 26 countries: Belgium; Bulgaria; Canada; Czech Republic; Denmark; Estonia; France; Germany; Greece; Hungary; Iceland; Italy; Latvia; Lithuania; Luxembourg; Netherlands; Norway; Poland; Portugal; Romania; Slovakia; Slovenia; Spain; Turkey; United Kingdom; and the United States. *See* NATO's website on the Internet at http://www.nato.int.

34. *See* International Telecommunications Union (ITU), *Telecommunications Development Bureau*, *at* http://www.itu.int/itud (last visited June 24, 2005).

35. ITU-D STUDY GROUP, ITU, GUIDANCE ON THE REGULATORY FRAMEWORK FOR NATIONAL SPECTRUM MANAGEMENT §1.1 (2001) (Doc. No. 1/182-E) (filed by France).

trum is a scarce natural resource like minerals, ground space, etc."[36]

III. Natural Resources, the Commons (Redux), and Sustainable Consumption

If the electromagnetic spectrum is a natural resource—which most experts believe it to be—then it should be managed more like one. Instead of recognizing this resource as such, the United States and countries in Europe relegate the management and supervision of this natural resource to technocrats who deal with telecommunications and speech. Of course the spectrum as a natural resource has other crossovers that do not exist in other resources; it is a medium for communication, and the FCC's role in supervising content may still be relevant. However, the principle role of the FCC is the regulation of communication, not resources, and it has sometimes done this with very limited success and great delay.

Let us assume that the spectrum will—at some point or another in the future—be managed in a way that is consistent with its classification. In this regard, one of the hot topics today involves the concept of "sustainable consumption," which is a corollary to the established natural resources principle of "sustainable development."[37]

Another area to be analyzed in this section involves pollution, a topic central to Coase's 1960 article, in which he cites the example of factory smoke and the harmful effects that such smoke has on people in neighboring communities.[38]

A. Coase and Hardin: A Common Point of Departure for Environmentalists and Spectrum Advocates Alike

We have seen that the electromagnetic spectrum is not covered by the principles and laws that protect other natural resources,[39] which is somewhat unfortunate. In fact, several common core academic principles form the same conceptual foundation for environmentalists, natural resource specialists, and spectrum advocates alike. This section reviews the contributions made by two scholars, Coase and Hardin, to the debate surrounding the electromagnetic spectrum's classification as a natural resource.

1. Coase and the "Coase Theorem"

As previously mentioned, one of the most famous of these academic principles is found in the work of Coase—the well-known economist. In his 1959 article *The Federal Communications Commission*,[40] he maintains that the government's policy of giving the spectrum away for free could instead be replaced by an auction system. Coase's 1960 article *The Problem of Social Cost*[41] expands on this idea, arguing that economists should consider transaction costs in their theoretical pricing models.

Coase has repeatedly indicated that *both* articles are based on the same study on broadcasting, even though the 1960 article does not discuss broadcasting directly.[42] Economist George J. Stigler later labeled Coase's conclusions the "Coase Theorem,"[43] which was perhaps best summarized by Coase in the 1991 lecture that he gave in Stockholm when he received the Nobel Prize for it:

> [T]he Coase Theorem demonstrates . . . that government actions (such as government operation, regulation or taxation, including subsidies) could not produce a better result than relying on negotiations between individuals in the market. Whether this would be so could be discovered not by studying imaginary governments *but what real governments actually do*. My conclusion: Let us study the world of positive transaction costs.[44]

Coase's suggestion that legal academics and economists study "what real governments actually do" and that we analyze positive transaction costs[45] is a profoundly simple but nonetheless extremely useful proposition. Coase's work is the underlying principle for the spectrum trading movement. Spectrum advocates regularly cite Coase's studies as central building blocks for their work, even if today they dis-

36. ITU-D Study Group, ITU, Introduction of Economic Criteria in Spectrum Management and the Principles of Fees and Charging in the CEPT §3.2.1 (1999) (Doc. No. 1/069-E) (filed by the United Kingdom).

37. *See generally* United Nations, *Division for Sustainable Development*, *at* http://www.un.org/esa/sustdev/ (last visited July 28, 2005).

38. Ronald H. Coase, *The Problem of Social Cost*, 3 J.L. & Econ. 1 (1960).

39. An important exception to this lack of protection is standard setting with regard to electromagnetic frequency guidelines.

40. Ronald H. Coase, *The Federal Communications Commission*, 2 J.L. & Econ. 1 (1959).

41. Coase, *supra* note 38.

42. The first footnote in *The Problem of Social Cost* states that "[t]his article . . . arose out of the study of . . . [b]roadcasting which I am now conducting. The argument of the present article was implicit in a previous article dealing with the problem of allocating radio and television frequencies . . . ." Coase, *supra* note 38, at 1 n.1. Coase again reiterated this point in his short autobiography, which appears on the Nobel Prize website, noting that "[t]he main points [of the Coase Theorem] were already to be found in *The Federal Communications Commission*," and further explaining that "[h]ad it not been for the fact that . . . economists at the University of Chicago thought that I had made an error in my article on *The Federal Communications Commission*, it is probable that *The Problem of Social Cost* would never have been written." Nobelprize.org, *Ronald H. Coase–Autobiography*, *at* http://www.nobel.se/economics/laureates/1991/coase-autobio.html (last visited June 24, 2005).

43. Ronald H. Coase, 1991 Alfred Nobel Prize Lecture in Economic Sciences, The Institutional Structure of Production, Dec. 9, 1991, *reprinted in* R.H. Coase, Essays on Economics and Economists 10 (University of Chicago Press 1994) (Coase discusses his article, *The Problem of Social Cost*, and says that the "Coase Theorem [was] named and formulated by George Stigler, although it is based on work of mine . . . I do not disagree with Stigler").

44. *Id*. at 11 (emphasis added).

45. Coase's practical suggestion involving positive transaction costs shows us that allocations of entitlements do matter for efficiency:

> The argument has proceeded up to this point on the assumption that there were no costs involved in carrying out market transactions. This is, of course, a very unrealistic assumption. . . . Once the costs of carrying out market transactions are taken into account it is clear that such a rearrangement of rights will only be [undertaken] when the increase in the value of production consequent upon the rearrangement is greater than the costs which would be involved in bringing it about. When it is less, the granting of an injunction (or the knowledge that it would be granted) or the liability to pay damages may result in an activity being discontinued (or may prevent it being started) which would be undertaken if market transactions were costless. In these conditions the initial delimitation of legal rights does have an effect on the efficiency with which the economic system operates.

Ronald H. Coase, *The Problem of Social Cost*, *reprinted in* Foundations of Environmental Law and Policy 8, 13 (R.L. Reversz ed., 1997).

agree with certain aspects of those studies.[46] Likewise, environmentalists have analyzed Coase's views from virtually every angle with regard to their application to issues involving natural resources.[47] Since there are so few safety valves available to citizens as a means to keep government action in check—and the government's actions tend to favor lobbies and antiquated systems—one of the proposals that this author has made is that the "public trust doctrine" could be used as a citizen's tool for reclaiming public goods.[48]

2. Hardin and His "Tragedy of the Commons"?

In addition to Coase's theorem, other theoretical bases that are equally important to environmentalists and natural resource specialists is the concept of the "commons" and the related question regarding the manner in which the government should treat the commons. First, we must understand what is meant by a "commons."

A commons is a resource that is open to all. In his famous essay, *The Tragedy of the Commons*,[49] Hardin uses a herdsmen's pasture as an example of a commons. The "tragedy" develops when each herdsman, acting out of individual interest, continuously sends cattle to graze on the pasture; ultimately, too many cattle graze, thereby ruining the pasture for all. The theory is that herdsmen will be greedy and will want to derive as much benefit as they can from the common pasture. The resulting feeding frenzy and overexploitation destroy the pasture, the cattle that feed upon that pasture, and, eventually, the environment.

William H. Rodgers Jr. has called Hardin's essay "[p]erhaps the most influential article ever written in the environmental field,"[50] an opinion shared by many environmentalists. Likewise, nearly every spectrum advocate has discussed Hardin's thesis at one point or another.[51] Generally speaking, spectrum advocates fear that a similar "grazing" tragedy will occur if too many broadcasters are allowed unbridled access to the same electromagnetic "pasture." With regard to the electromagnetic spectrum, this fear takes the form of harmful interference (while harmful interference is the cause célèbre for regulation in an analog world, it takes on a completely different relevance with ultra wideband (UWB) and SDR.[52]

Rather than focusing extensively on Coase's allocation theories or on Hardin's theory of the tragedy of the commons (many other texts have addressed these topics with great success),[53] this Article acknowledges the importance of these theories[54] to both environmentalists and spectrum advocates, thus helping to set the stage for the application of the public trust doctrine to the environment (where the doctrine has already been applied) and to the spectrum.

B. Sustainable Consumption

In a strict sense, a nondepletable resource like the electromagnetic spectrum *should not* be consumed; however, because of legacy technologies, large parts of the spectrum are, in fact, "consumed" in the sense that some parts of the spectrum are not made available to users.[55] Electromagnetic spectrum usage occurs in increments of seconds or nanoseconds (which will be all the more true in a future all-digital world, as analog transmissions are replaced by zeroes and ones), and a given frequency is only occupied for the precise period needed to transmit or receive a signal. We know that the electromagnetic spectrum is finite in scope[56] and limited by geographic range (a signal can only transmit so far)[57];

46. *See* Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J.L. & Tech. 1, 48-49 (2002) (reviewing Coase's 1959 propertization proposition and then suggesting that the 1960 article itself disproves that proposition because of the high transaction costs that would be involved in a propertization model); 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, 338 (2001) [hereinafter Hazlett, *Wireless Craze*], *available at* http://jolt.law.harvard.edu/articles/pdf/14HarvJLTech335.pdf (last visited July 28, 2005) (citing both of Coase's articles and discussing their importance as a starting point for allocation theory); Thomas W. Hazlett, *Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & Econ. 529 (1998). The article discusses the history of spectrum pricing, focusing on the important historical contributions of Coase and Leo Herzel. The article was written for a symposium, which, in part, was a tribute to Coase's important contributions to wireless spectrum management.

47. *See* William H. Rodgers Jr., Environmental Law 44 (West Publishing Co. 2d ed. 1994) (stating that "all of the teaching materials on environmental law pay homage to the famous article by Ronald Coase"). Daniel S. Levy & David Friedman, *The Revenge of the Redwoods? Reconsidering Property Rights and the Economic Allocation of Natural Resources*, 61 U. Chi. L. Rev. 493 (1994) (labeling the Coase Theorem "one of the most influential" theories in law and economics and analyzing its application to natural resources).

48. Patrick S. Ryan, *Application of the Public-Trust Doctrine and Principles of Natural Resource Management to Electromagnetic Spectrum*, 10 Mich. Telecomm. & Tech. L. Rev. 285 (2004), *available at* http://ssrn.com/abstract=556673 (last visited June 24, 2005).

49. Garrett Hardin, *The Tragedy of the Commons*, 162 Science 1243 (1968). *See also* Garrett Hardin, *The Tragedy of the Unmanaged Commons: Population and the Disguises of Providence*, *in* Commons Without Tragedy: Protecting the Environment From Overpopulation—A New Approach 162, 168 (Robert V. Andelson ed., 1991) (indicating that, after years of his article's having received scholarly attention and critiques, "[t]he title of [the] 1968 paper should have been 'The Tragedy of the *Unmanaged* Commons'").

50. Rodgers, *supra* note 47, at 39. *See also* Carol M. Rose, *Scientific Innovation and Environmental Protection: Some Ethical Considerations*, 32 Envtl. L. 755, 759 (2002) (stating that nearly all environmental law textbooks include a selection from Hardin's article in the introduction).

51. *See* Lawrence Lessig, The Future of Ideas: The Fate of the Commons in a Connected World 229 (Vintage Books 2002) (citing an excerpt from the writings of spectrum propertization-advocate Thomas Hazlett, who discusses the "commons" problem, and stressing that Hazlett believes that there is a tragedy while Lawrence Lessig does not).

52. UWB and SDR are new technologies that can use the electromagnetic spectrum in new efficient ways through variants of "spread spectrum" technology. For an overview, see Ryan, *supra* note 48.

53. *See* Stuart Buck, *Replacing Spectrum Auctions With a Spectrum Commons*, 2002 Stan. Tech. L. Rev. 2, *available at* http://stlr.stanford.edu/STLR/Articles/02_STLR_2/index.htm (last visited July 28, 2005) (presenting a recent and well-researched analysis of commons theory as it applies to wireless spectrum allocation).

54. *But see* Lessig, *supra* note 51, at 22-23 (challenging Hardin's proposal, distinguishing "nonrivalrous goods," which are not subject to such a "tragedy" at all, and noting that there is by no means a consensus that such a "tragedy" exists even for all rivalrous goods).

55. *See* Black's Law Dictionary 312 (7th ed. 1999) (defining "consumption" as the use of a thing in such a way that it is exhausted or worn out completely).

56. *See* National Telecommunications & Information Administration, *U.S. Spectrum Allocation Chart*, *at* http://www.ntia.doc.gov/osmhome/allochrt.html (last visited June 24, 2005) (noting that the radio spectrum covers 3 kilohertz to 300 gigahertz (GHz)).

57. Kevin Maney, *"Megahertz" Remains a Mega-Mystery to Most*, USA Today, Feb. 13, 1997, at 4B. Maney describes the way in

nonetheless, when a particular frequency is not used, it remains in its original, natural state. This means that it is in exactly the same condition both before and after its use. It is thus *nondepletable* and *instantly renewable*.

In this sense, unlike other natural resources, i.e., resources that do not renew themselves, the electromagnetic spectrum *cannot be depleted*: it does not disappear like the trees in a deforested area, and it cannot be exhausted like the contents of a coal mine that has been emptied. Further, exploitation of the spectrum does not have the kinds of negative environmental consequences associated with the clear-cutting of a forest,[58] strip mining,[59] and blast fishing near a coral reef.[60]

Nevertheless, the spectrum is a natural resource, and ecological equilibria exist for this resource just as they do elsewhere in nature. Even with new technologies such as UWB and SDR, spectrum use can theoretically reach a level of "sustainable consumption."[61] A full discussion of this topic is better saved for electrical engineers, economists, and futurists. However, to the extent that regulations continue to allow legacy analog technologies to operate, while simultaneously preventing the public from using large swaths of frequencies, e.g., unused broadcasting channels, the public may never know the electromagnetic equivalent of sustainable consumption. In fact, regulatory restrictions limit public use of the spectrum, which means that frequencies that are not being used by the public are de facto "consumed" just as much as a mine that has been emptied of its precious metal or a tree that has been picked bare of its fruit.

1. Not All Devices Are Created Equal

In a given frequency range, if a "dumb" analog device and a "smart" device are operating simultaneously, then the inefficient "dumb" device will be the de facto occupier of the spectrum in which it was designed to operate.[62] Put another way, analog transmissions are a form of consumption, and while this consumption may be sustainable for a time, at some point in the future their consumption of the electromagnetic spectrum will become unsustainable as more and more digital devices enter the market.[63] Thousands of new wireless devices and uses will require much more efficient use of the spectrum, making the present analog monopoly unacceptable over time. Old technologies and methods of consumption will have to give way to new technologies and methods, just as fossil fuel-burning cars are now gradually being replaced by hybrid units[64] and will ultimately run emission free.[65]

New environmental legislation, influenced by the public trust doctrine, could theoretically provide some protection to the electromagnetic spectrum. Environmental law professor Rodgers has told us that the public trust-based language of the National Environmental Policy Act, §101(b),[66] is "expansive and tantalizingly vague, but it also is strongly prophetic"[67] because it addresses resources that are nonconsumptive and renewable (like the electromagnetic spectrum):

> [The public trust doctrine] has given rise to a number of court-inspired constraints on public-resource decisions, including protecting current public uses, giving preferences to *nonconsumptive* and *renewable* uses, and preventing the subordination of public uses to private development decisions.[68]

Regardless of the angle used, a balance must be struck, as is the case with all natural resources. If we assume that legacy analog technologies unduly consume the electromagnetic spectrum, either today or 20 years from now, a paradox becomes clear. In today's market, some of the cheapest products available are those that exploit the electromagnetic spectrum in the most *in*efficient way. Analog radios and televisions are still much cheaper than their digital counterparts; new businesses that broadcast using digital technologies must subsidize their newer, more efficient digital devices in order to jumpstart the market.[69] In fact, the exact op-

which airwaves are measured and the different properties that airwaves possess. Low-frequency waves can travel far and curve with the earth, but they cannot carry much information. High-frequency waves can travel only a short distance before breaking up, and they will not curve over the horizon, but they can carry much more information.

58. *See* Federico Cheever, *Four Failed Standards: What We Can Learn From the History of the National Forest Management Act's Substantive Timber Management Provisions*, 77 OR. L. REV. 601, 615-17 (1998) (defining and giving a historical interpretation of "clearcutting," describing its application in the United States, and explaining the damage that it causes to the environment).

59. *See* Wendy B. Davis, *Out of the Black Hole: Reclaiming the Crown of King Coal*, 51 AM. U. L. REV. 905, 928 (2002) (detailing the long-term side effects of strip mining, particularly in Appalachia, where resulting floods and mudslides still damage homes and crops).

60. *See* Robin Kundis Craig, *Taking Steps Toward Marine Wilderness Protection? Fishing and Coral Reef Marine Reserves in Florida and Hawaii*, 34 MCGEORGE L. REV. 155, 188-89 (2003) (discussing the many threats to coral reefs, including blast fishing or fish poisoning, removal of coral reefs for jewelry, etc.).

61. *See* James Salzman, *Sustainable Consumption and the Law*, 27 ENVTL. L. 1243, 1246-50 (1997) (analyzing "sustainable consumption" and noting that pollution and waste are caused by the unsustainable consumption of goods and resources).

62. *See* Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 HARV. J.L. & TECH. 287, 347 n.239, *available at* http://jolt.law.harvard.edu/articles/pdf/v11/11HarvJLTech287.pdf (last visited June 24, 2005) (describing the economic trade offs of "smart" versus "dumb" devices).

63. *See* Tony Hallett, Silicon.com, *700 Million Wi-Fi Users by 2008* (July 25, 2003), *at* http://www.silicon.com/news/148-500001/1/5322.html (last visited June 24, 2005) (noting that Pyramid Consulting has projected wireless fidelity (Wi-Fi) (meaning wireless networking) growth to reach 700 million users within six years).

64. *See* Jasmine Abdel-Khalik, *Prescriptive Treaties in Global Warming: Applying the Factors Leading to the Montreal Protocol*, 22 MICH J. INT'L L. 489, 517 (2001). The author describes the promise of hybrid and hydrogen-powered cars and noting that hydrogen-powered motor vehicles are expected to replace conventional fuel-powered cars within the time range of a generation. In fact, these vehicles are already on the market. Hydrogen-powered cars would only emit water, avoiding CO_2 emissions entirely. The hydrogen flows into fuel cells, which initiates a chemical reaction that produces electricity. Until these fuel-cell vehicles are available, hybrid cars offer a fuel-efficient and emission-reducing alternative.

65. *Id.*

66. 42 U.S.C. §4331(b) ("it is the . . . responsibility of the Federal Government . . . to improve and coordinate Federal plans, functions, programs, and resources, to the end that the nation may . . . fulfill the responsibilities . . . *as a trustee of the environment* . . ." (emphasis added)).

67. RODGERS, *supra* note 47, at 857.

68. *Id.* at 858 (citing Illinois Cent. R.R. v. Illinois, 146 U.S. 387 (1892), among other cases) (emphasis added).

69. *See Sirius Satellite Plans Service in 3 Cities in February 2002*, REUTERS BUS. REP., Nov. 14, 2001 (noting that "[a] predominant portion of customer acquisition costs . . . stem from equipment subsidies"). *See also* Brian Bergstein, Associated Press, *Satellite Radio Set for Takeoff in U.S.* (June 1, 2003) (noting that both XM and Sirius

posite could take place: producers could, and perhaps should, reflect the total product cost in the selling price of their devices,[70] including the consumption cost associated with economic inefficient use, i.e., analog devices' effective "burning" of the spectrum by not taking advantage of interweaving, interference filtering, and other advanced protocols, and the costs of disposal.[71]

When applied to today's wireless market, analog devices should be the *most* expensive if they are to reflect: (1) their truly inefficient exploitation—their consumption—of the electromagnetic spectrum; and (2) the fact that they will have to be recalled and destroyed at some time in the future when they are replaced by digital-generation devices. Many analog devices, e.g., analog cordless phones, have already ended their useful life cycle, or they soon will.

Government regulation that requires new, more efficient (or more environmentally friendly) technologies to replace old, inefficient ones is not new, and can be accomplished either through voluntary tax incentives or through forcing change by legislative action. For example, in order to promote better use of natural resources, environmentalists have promoted tax incentives for the use of clean-running automobiles over standard fossil fuels[72]; the federal government has banned the use of freon and has even criminalized its import[73]; and in the mid-1990s laws were passed to require manufacturers to eliminate the use of certain batteries that use mercury.[74] Along these lines, it would not be incongruous to pass legislation that would either promote (through tax incentives) or require (by prohibiting) the use of digital devices because of their more efficient use of the electromagnetic spectrum. As we have seen, the spectrum is a natural and national resource that can be inefficiently used by the continued manufacture and market placement of outmoded analog technologies.

2. Can We Provide Incentives for the "Negroponte Switch"?

One of the most central aspects of technological convergence is the capability to provide services by air that previously were provided by wire, e.g., wireless telephone service, and vice versa, e.g., cable television.[75] For this reason, Massachusetts Institute of Technology Media Lab[76] founder Nicholas Negroponte famously pointed out that the generation that grew up watching television over the airwaves and using wired telephone connections would give rise to a generation that would do the opposite, i.e., would watch television delivered by a wire and use wireless phones.[77] Now, in 2005 (almost 15 years after Negroponte's comment), the concept of the "Negroponte switch" is conventional wisdom. However, the regulatory response to this switch still lags very far behind the reality of the situation.

Taking Negroponte's observation one step further, convincing arguments have been advanced that the economic cost of analog broadcasts, i.e., the cost of consumption, is so great, particularly in broadcast television, that all analog broadcasts should simply be turned off, thereby forcing the market to switch either to digital alternatives or to cable.[78] In fact, in many developed countries (particularly Belgium),[79] cable penetration is well above 80%, making the vast electromagnetic "roads" and "freeways" reserved for broadcast television a tremendously wasted resource. However, the social costs related to the fact that these resources are not

hope to be able to eliminate the manufacturer equipment subsidy in a few years), *available at* http://www.thecybertruckstop.com/Communication/satelliteradio.html (last visited July 19, 2005).

70. *See* Jon D. Hanson & Douglas A. Kysar, *Taking Behavioralism Seriously: Some Evidence of Market Manipulation*, 112 HARV. L. REV. 1420, 1553-71 (1999). The authors propose "enterprise liability" as a mechanism for incorporating risk into the price of products. This argument is mostly related to tort liability; however, it could be applied to environmental concerns, or it could be applied as a way to incorporate the costs of a device's inefficient use or resources.

71. Proposals to do this have recently been the subject of EPA discussions. *See* U.S. EPA, *EPA Cell Phone End-of-Life Management Meeting*, Feb. 28, 2005, *at* http://www.epa.gov/epaoswer/osw/conserve/plugin/pdf/cellproj.pdf (last visited July 19, 2005).

72. *See generally* Union of Concerned Scientist, *The CLEAR Act: Tax Incentives for Clean, Efficient Vehicles*, *at* http://www.ucsusa.org/clean_vehicles/advanced_vehicles/page.cfm?pageID=1143 (last visited July 19, 2005).

73. *See* Saleem S. Saab, *Move Over Drugs, There's Something Cooler on the Black Market—Freon*, 16 DICK. J. INT'L L. 633 (1998).

74. 42 U.S.C. §§14300-14336 (commonly referred to as the Battery Management Act). The original bill that became the Act was H.R. 2024, 104th Cong. (1996), *reprinted in* H.R. REP. NO. 104-530, at 1 (1996).

75. *See* JONATHAN E. EUECHTERLEIN & PHILIP J. WEISER, DIGITAL CROSSROADS 226 (MIT Press 2005).

76. The Massachusetts Institute of Technology (MIT) Media Lab is related closely to the MIT OpenSpectrum ListServ. The author of this Article is a participant in this ListServ, and many ideas incorporated into this work have been inspired from it.

77. Negroponte has said that others probably offered this idea first, but George Gilder's constant use of the term "Negroponte switch" gave the idea staying power. Quoting from Gilder:

> In 1989 the most weighty wisdom on the future of media was the "Negroponte switch"—the theory launched by Nicholas Negroponte of MIT's Media Lab that what currently goes by air—chiefly broadcast video—would soon switch to wires (fiber optic and coax), while what currently goes by wires—chiefly voice telephony—would massively move to the air.
>
> In *Life After Television* I urgently touted the Negroponte switch. I still believe it brilliantly captures the key vectors of change. Shortly afterward, though, I began to have my doubts that the victory of fiber as a delivery system would be quite so total as I had imagined. After all, the spectrum of electromagnetic vibrations is essentially infinite, and several companies, led by Motorola, were offering wireless local area network (LAN) equipment operating at Ethernet or Token Ring data rates in the 18 [GHz] band—a frequency previously used chiefly in outer space. Moreover, BIIC, Photonics and other firms were offering LANs in the infrared bands of the spectrum—up in the terahertz and beyond—previously used in the air only by low-data-rate TV remotes (although infrared pulses were the medium of fiber optics).

George Gilder, *Life After Television, Revisited*, FORBES ASAP, Feb. 1, 1994, *available at* http://www.discovery.org/scripts/viewDB/index.php?command=view&id=39 (last visited July 28, 2005).

78. *See* THOMAS W. HAZLETT, THE U.S. DIGITAL TV TRANSITION: TIME TO TOSS THE NEGROPONTE SWITCH 15 (AEI-Brookings Joint Ctr. Working Paper No. 01-15, 2001) (suggesting that the analog TV spectrum, if appraised based on personal communications services auction rates, is far too valuable to keep active and that it would probably make more sense to switch as soon as practicable and use the money from auctioning to subsidize a universal service that is in the "public interest").

79. Cable networks are the most widespread in Belgium, Luxembourg, and the Netherlands. In these countries, 90% to 96% of total households are passed by cable, a percentage that ranks among the highest in the world. *See* EUROPEAN UNION, INFORMATION SOCIETY INDICATORS IN THE MEMBER STATES OF THE EU (2000), *available at* http://www.eu-esis.org/Basic/basic2000_7.htm (last visited June 24, 2005).

available for other uses is not built into consumer products, and consumers are harmed because these resources are unable to be used for other services, e.g., wireless Internet. Also, the disposal and switch-over costs from analog to digital products are, today, not built into the products' pricing structures, e.g., analog technology should be far more expensive than digital technology, and the manner in which the market will sustain the coexistence of different policies over time is uncertain.[80] As noted above, it might be time for regulators to intervene and help force the hand of the "Negroponte switch" (just as it has done to avoid the harmful exploitation of other natural resources like fossil fuels and freon gas).

IV. Underexploitation and Overexploitation

We have seen here that governmental regulations constrain users of the electromagnetic spectrum to operate within very limited frequency allocations, which can cause overexploitation, i.e., unsustainable consumption. American Telephone & Telegraph (AT&T) Wireless, for example, must operate *only* within its allocated license area, which may theoretically be oversubscribed in Denver, Colorado, or in any market where sales are very strong. Those same frequencies, however, may be undersubscribed in Austin, Texas. Consequently, overexploitation in Denver could leave consumers unable to maintain phone calls, e.g., "dropped" calls, thus incurring social costs and resource inefficiencies, while the theoretical corollary of underexploitation in Austin would leave valuable wireless frequencies unused.

Underused spectrum does not necessarily reflect a lack of demand for that spectrum; instead, it illustrates only a lack of demand for a particular part of the spectrum, which has been designated for a particular use in accordance with FCC spectrum allocation requirements. Under the centrally planned command-and-control system, entrepreneurs cannot use the spectrum for any purpose other than the one for which it is authorized. Thus, although only 11% of the television spectrum is in use at any given time, this percentage does not necessarily translate to a lack of demand for the remaining 89%. While there may be a lack of demand for the remaining 89% of the *television broadcast* spectrum, other possible uses of that spectrum, e.g., for mobile technologies, wireless Internet, and other services, are prohibited from occupying this valuable resource since existing rules only allow television broadcasts over that particular spectrum. And, although market mechanisms are beginning to open up and encourage subleasing of excess spectrum,[81] there is no evidence to date that this system will work. It is all theory.

In addition to harm caused by high pollution transmission levels that can theoretically cause damage to humans, overexploitation can cause electromagnetic pollution in two additional forms: (1) overcrowding and interference in frequencies that are oversubscribed[82]; and (2) a (small but growing) number of "pirate" users who are frustrated with regulations and who consequently build sites that operate with unconventional antennas in order to gain access to or to enable transmission of wireless Internet, e.g., modified booster antennas crafted from soup cans, called "cantennas."[83] Federal regulations do not solve pirate radio problems that are exacerbated by the systematic underuse of spectrum that is not yet available for access.[84] Overexploitation in certain frequency bands can be the product of pent-up demand, which is manifested by the *thousands* of applications for low-power frequency modulation (FM) radio stations that have been made, as well as through the existence of many pirate radio stations.[85]

Furthermore, underexploitation of a natural resource can be as problematic as overexploitation. Thomas W. Hazlett sets this idea up as the opposite of the "tragedy of the commons" by calling it the "tragedy of the *un*commons," in which severe access restrictions leave socially valuable uses untappable.[86]

Overexploitation and underexploitation of the electromagnetic spectrum are not unlike traditional resource-allocation problems found in other areas of economics, especially since the government does not allow consumption of the electromagnetic spectrum to be allocated by market forces. Resistance to change in the existing system is great (particularly among television broadcasters, the "great squatters"), and it is not unlike the resistance in the 1980s to changes in European agricultural production policies that induced farmers to produce millions of gallons of excess wine and butter, metaphorically known as "wine lakes" and "butter mountains" because of their mammoth propor-

80. *See* Salzman, *supra* note 61, at 1270-75 (suggesting that "extended producer responsibility" should apply in order to build in the price of the device's disposal into its manufacturing cost).

81. *See* Press Release, FCC, FCC Adopts Spectrum Leasing Rules and Streamlined Processing for License Transfer and Assignment Applications, and Proposes Further Stems to Increase Access to Spectrum Through Secondary Markets (May 15, 2003) *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-234562A1.pdf (last visited June 24, 2005).

82. Alan S. Kay, *WiFi Promise Vs. Reality; The Wireless Technology Gets Put to the Speed Test*, WASH. POST, Apr. 20, 2003, at H9 (explaining that other devices that operate within Wi-Fi's 2.4 GHz frequency band, such as microwave ovens and cordless telephones, can "pollute" the Wi-Fi frequencies and impede performance).

83. *See* John Patrick, ZDNet.com, *Are You a WiFi Pirate?* (Aug. 21, 2002), *at* http://zdnet.com.com/2100-1107-954659.html (last visited July 28, 2005) (reporting that antennas made from potato chip cans may increase the reception of Wi-Fi signals from a few feet to several miles); Desa Philadelphia, *Global Briefing*, TIME, Oct. 28, 2002, at A5 (describing "cantennas" made from soup or potato chip cans). *See also* Super Cantenna website, *at* http://www.cantenna.com (last visited June 24, 2005).

84. "Wardriving" is a movement of users who drive around urban areas and pinpoint locations where they can gain free access to wireless networks. This activity is a form of piracy. *See generally* Patrick S. Ryan, *War, Peace, or Stalemate: Wargames, Wardialing, Wardriving, and the Emerging Market for Hacker Ethics*, 9 VA. J.L. & TECH. 1 (2004), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=585867 (last visited June 24, 2005).

85. *See* Jesse Walker, *The FCC's Absurd New Crusade: REBEL RADIO*, NEW REPUBLIC, Mar. 9, 1998, *available at* http://www.radio4all.org/news/newrep-micro.html (last visited July 19, 2005) (noting that most pirate radio stations cause little harm to broadcasters, but that the FCC targets them because of broadcaster power in government). *See also Blacks Protest FCC for "Pirate" Radio*, NEW PITTSBURGH COURIER, Oct. 14, 1998, at A1 (describing a large group of pirate radio station operators who organized a large protest and who declared themselves to be "organized and broadcasting as . . . several thousand free radio stations . . . as a form of civil disobedience" in protest of the FCC, large corporations, and government control). *See generally* Pirate Radio Central, *at* http://www.blackcat systems.com/radio/pirate.html (last visited June 24, 2005); Christian Pirate Radio, *at* http://www.mycpr.com/ (last visited June 24, 2005); Seton Hall's Pirate Radio, *at* http://www.wsou.net/ (last visited June 24, 2005).

86. Hazlett, *Wireless Craze*, *supra* note 46, at 382.

tions.[87] In short, farmers had become accustomed to receiving comfortable subsidies. When the government set out to change these production policies, farmers blocked plazas and freeways by dumping tons of excess fruit and vegetables and created social mayhem for a period of years by establishing blockades and supply restrictions.[88] The policymakers' flawed theory was that a stable cycle of production and destruction of excess wine and butter was perhaps unavoidable, and maybe even preferable to the instability of the market. Ultimately, modern economic-allocation theory prevailed over centralized planning—except, that is, in the area of wireless spectrum allocation.

The electromagnetic spectrum has its own wine lakes and butter mountains: broadcasting frequencies are underused, not because of problems with demand, but instead because the government will not allow them to be used for anything but television broadcasting. These frequencies could be put to use for other purposes. Massive growth in wireless fidelity (Wi-Fi) (meaning wireless networking), for example, can be seen by its presence in Starbucks® coffee shops[89] and on university campuses,[90] and some cities are offering wireless access for free at airports and other public areas.[91] And the growth of Wi-Fi is just beginning.[92] Interestingly, numerous companies, e.g., AT&T, T-Mobile®, and other companies that *also* hold exclusive licenses for cellular, personal communications services, and other uses, are scrambling to use the limited—but open—2.4 gigahertz (GHz) frequencies. As with the centrally planned production of butter and wine, the centralized plan that (happily) created a new market in 2.4 GHz has attendant risks involving the possibility of overconsumption in the limited open spectrum and underconsumption of other areas of the electromagnetic spectrum, e.g., television channels, which are prohibited from offering Internet. Ultimately, this problem can create an ecological imbalance and harm the consumer.

V. Conclusion

Empowered by government regulations, broadcasters, like the European farmers of the 1980s, are consuming the electromagnetic spectrum and creating electromagnetic butter mountains while their sister telecommunications companies are scrambling to build out a limited area of open Wi-Fi spectrum. As has been done with other natural resources, a mechanism must be developed to allay these problems and to set an ecological balance of the electromagnetic spectrum.

87. *See* Thomas Moore, *Of Wine and Lakes*, FORTUNE, Jan. 7, 1985 (noting that Europe spent $800 million in 1984 to get rid of excess wine that was created by subsidies); William R. Doerner, *The European Community's "Butter Mountain" and "Wine Lake,"* TIME INT'L, Oct. 1, 1990, at 24 (describing the wine lakes and butter mountains and discussing the excessive overproduction of the 1980s that stemmed from subsidies).

88. *See* Doerner, *supra* note 87 (describing the protests in the south of France).

89. *See VoiceStream Expands Wireless Web Access in Starbucks Outlets*, WALL ST. J., Aug. 21, 2002, at C9 (noting that as of August 2002, 500 Starbucks outlets had been installed and more than 2,000 outlets would be outfitted with Wi-Fi wireless access by the end of the year).

90. Michelle Kessler, *Public Wi-Fi Networks Growing Rapidly*, USA TODAY, June 2, 2003, at 11E (noting the rapid expansion of Wi-Fi networks at university campuses and many other public and semi-public locations).

91. Jesse Drucker, *AT&T Wireless to Add Wi-Fi Service*, WALL ST. J., Jan. 28, 2003, at D2 (discussing a plan by AT&T to set up Wi-Fi service at 475 hotels and at many airports and other public places).

92. The White House has specifically designated Wi-Fi as one of the major growth areas in an annex to the *Presidential Memo on Spectrum Policy*, *supra* note 10. The annex states that there is massive demand for wireless services, noting that there are more than 140 million wireless telephone customers and that Wi-Fi systems are becoming ubiquitous. *See* White House, *Fact Sheet on Spectrum Management*, June 5, 2003, *at* http://www.whitehouse.gov/news/releases/2003/06/20030605-5.html (last visited June 24, 2005). Unfortunately, the government proposes to free up additional "commons" Wi-Fi-type frequencies in the 5 GHz range. *Id.* While it is in the public's interest to have more commons-type frequencies available, the characteristics of the 5 GHz frequencies are such that they cannot penetrate obstacles. Thus, they will be of little use indoors or for any mobile services.