Enforcing Property Rights: Extending Property Rights Theory to Congestible and Environmental Goods

David W. Barnes
ENFORCING PROPERTY RIGHTS: 
EXTENDING PROPERTY RIGHTS THEORY TO 
CONGESTIBLE AND ENVIRONMENTAL GOODS 

David W. Barnes

INTRODUCTION

The property rights literature has focused the attention of scholars on the social, economic, and legal implications of alternative systems of ownership, management, and control of property. The usual topics explored are the implications of alternative systems for production by firms, for allocation of scarce resources in society, and for the efficient coordination of production and allocation decisions. The focus of property rights theory has been on "the interconnectedness of ownership rights, incentives, and economic behavior." While this statement of the purview of property rights theory sounds as though it would be all encompassing, the literature has directed its attention to a small set of alternative specifications of property rights. Discussions of property rights and resource allocation have largely focused on what has been referred to as the "(c)ompetition for and transferability of the ownership right in the marketplace." The recognition of "externalities" associated with private ownership, such as the polluting by-products of a private production proc-

* Assistant Professor of Law and Economics, Syracuse University College of Law and Maxwell School of Citizenship and Public Affairs; A.B. Dartmouth College; J.D. University of Pennsylvania; Ph.D. Economics, Virginia Polytechnic Institute and State University; Member Pennsylvania Bar.
2. Id. at 1137.
ess, has broadened the usual scope of inquiry beyond the private versus common ownership dichotomy. This broader view extends the inquiry of property rights theory into the realm of welfare theory in which the overall social implications of private choices are examined. An examination of the externalities associated with private choices in the context of their overall social effects suggests the need for some form of regulation of private choices. Whenever private choices are limited by government regulation or by societal norms, the organization and content of those constraining institutions will affect both private choices and the welfare of society. Thus, property rights may be viewed through the context of institutional structures which embody both rights and their related sanctions. An institutional structure is the entire body of laws, regulations, ordinances, and norms that constrains private choice with respect to the use of a particular resource. These structures may range from a formal system of regulation, such as that embodied in the Clean Air Act,4 to an accumulated and mutually recognized body of rules of social behavior, such as the common law of real property. From an institutional structure comes a set of property rights which specify in varying degrees of particularity those rules of behavior with respect to a resource that individuals are expected to follow. In effect, it is the change in the assignment of property rights through an institutional structure which results in "regulation." In a mixed private-property-with-governmental-regulation society such as ours, where the rights incident to the production and possession of property are highly regulated, the implications of the choice of institutional structures and property rights systems are particularly important. This article presents and applies a framework for analyzing institutional structures and societal responses to changes in property rights systems.

The model presented focuses specifically on regulatory agencies. It does not emphasize the behavior of regulators, although an understanding of their motivations and incentives is crucial to a complete description of institutional structure.5 The aim is rather to use the private/common ownership dichotomy as a foundation upon

which to build a more comprehensive analysis of property rights.\(^6\)

Once erected, the property rights model is used to explore the institutional milieu in which the regulators and the regulated interact. The institutional framework is the "given" with respect to which persons interacting within the society adjust. This model presents a systematic way of describing the institutional ballpark within which the game of using resources is played. In so doing, it offers a slightly different perspective on a number of variables traditionally considered relevant to policy analysis.

The model developed here addresses the issue of the costs of enforcing government regulations affecting resource use, particularly clean air laws. Previous studies have separately considered the behavior of enforcers\(^7\) and of regulated firms\(^8\) as well as general considerations relevant to the choice of enforcement tools.\(^9\) This article provides a methodology for combining these contributions and analyzing in a comparative statics framework\(^10\) the changes in the level of enforcement costs resulting from a change in property rights regulating resource use.

Section II expands the traditional notion of property rights by incorporating the theory of public goods. In Section II.A., public goods theory is used to describe how types of goods or resources vary from one another in terms of how users of resources and producers and consumers of goods derive benefits from their production or consumption. By understanding how goods are different from one

\(^{6}\) See, Barnes, _Back Door Cost-Benefit Analysis Under a Safety-First Clean Air Act_, NAT. RES. J. (1983) (forthcoming) (which uses this model to examine the implications of regulators' motivations and behavior).


\(^{8}\) See, e.g., Downing & Watson, _The Economics of Enforcing Air Pollution Controls_, 1 J. OF ENVT'L ECON. & MGT 219-36 (1974).


\(^{10}\) A comparative statics approach is one in which a model is used to describe what the system being examined looks like before and after changes in factors influencing that system occur. It does not explain the dynamics of how the change occurs but rather compares the before and after status of the system. The difference between a comparative statics approach and a dynamic approach in this article is the same as the difference between examining whether more enforcement officials must be used to enforce a change in the Clean Air Act and examining the process by which new enforcers are employed, trained, and sent out into the field.
another, we will appreciate how legal rules allocating rights to those goods may vary systematically. One relevant characteristic of goods discussed is the ease or difficulty of protecting one's right to be rewarded by society for producing units of a good or one's right to consume units of a good once acquired. Section II.B. describes how the manner in which legal rules specify property rights affects the cost of enforcing rights to goods and resources. Throughout Section II rights to the resource "clean air" are compared to rights to resources with different public goods and enforcement characteristics.

Section III completes the property rights enforcement model by adding a dollar measure of the costs of enforcement and deriving a relationship which describes for any fully specified property rights system the cost of enforcing those rights. The model allows for comparison of a variety of alternative enforcement technologies as well as a calculation of the optimal level of enforcement activity, that is, the level of costs of enforcement activity which is justified by the associated benefits.

Section IV uses the property rights model to describe the characteristics that are most relevant to the enforcement of a particular regulatory structure, the Clean Air Act. After describing the Clean Air Act in property rights terms, the property rights model is used to examine the enforcement cost implications of these changes in rules governing resource use which are implicit in amendments to the Clean Air Act. Amendments embodied in P.L. 95-95, the Clean Air Act Amendments of 1977,11 and in H.R. 5252,12 a leading bill to amend the Clean Air Act currently before the 97th Congress, are considered as examples. The model highlights the variety of technical and quantitative measures necessary to appreciate the interrelationship between regulatory structure and enforcement costs and necessary to estimate the enforcement cost implications of changing a set of property rights.

II. EXPANDING THE NOTION OF PROPERTY RIGHTS

A system of property rights related to a particular resource describes rules of behavior with respect to that resource. Economic agents, those consuming or producing the resource, must either follow these rules or ignore them at the risk of paying associated penal-

ties. When the resource is one regulated by an administrative agency, the goals and purposes of the regulation are often set forth in statutes establishing the institutional structure. Rules for behavior of both the agency and regulated economic agents as well as guidelines for enforcing the rules are also set forth in various statutes or regulations. The laws establishing the institutional structure, including rules for behavior and enforcement, comprise a set of property rights relating to a particular resource. For instance, the property rights system with respect to clean air is comprised of the Clean Air Act of 1970 as amended,13 supplemented by the regulations promulgated by the Administrator of the Environmental Protection Agency (EPA); the decisions of administrative and judicial bodies; the implementation plans of the various states; and the rules emanating from air quality control region guidelines and municipal ordinances.

With respect to any resource that is available only in limited quantities, property rights will specify norms of behavior for two types of economic agents, pure consumers and pure producers of that resource. The rights assigned to consumers and producers are analogous in property law terms to the rights to usus and usus fructus respectively. Usus is the right of the beneficiary (the economic agent assigned the right) to the bare use of real or personal property without enjoying its income or profit. Thus, while usus does not imply the right to reap rewards from society from the use of a resource, it does imply the right of a consumer to diminish the quantity of the resource available to other consumers. The right to "rewards from society" is embodied in the usus fructus which is conceived of as the right to the income or profit resulting from the production and/or transfer of resources.14 Rewards or profits are associated with increasing the supply of a given resource.

It is important to note that firms as well as individuals may be pure consumers (quantity decreasers) with respect to some resources and pure producers (quantity increasers) with respect to others. For that

---

14. The modified notion of usus fructus here is not to be confused with the legal concept of usufruct — the right to use and enjoy the fruits or profits of an estate or thing belonging to another. Usus fructus here implies not only a jus fruendi, the right to take and enjoy the fruits and avails of the productive mechanism, but also a jus disponendi, power to transfer ownership in whole or in part of a good (such as the resource produced). The ownership of the good produced is presumed to reside at least initially in the party to whom the usus fructus is assigned. For more on these distinctions see Roscoe Pound, The Changing Role of Property in American Jurisprudence, Conference on the Use and Disposition of Private Property, 31-46. Conference Series No. 12 (1953).
matter, an economic agent may be a consumer and producer with respect to the same resource. An electric utility consumes (decreases the available quantity of) electricity in the process of producing (increasing the quantity of) electric power. In the property rights model the focus in these definitions is on the role rather than the identity of a particular economic agent. Thus, the electric utility, for example, must be regarded as a consumer for some purposes and as a producer for others.

A. Property Rights and Consumption Characteristics of Resources

1. Consumption Characteristics of Congestible Public Goods

Public goods theory describes characteristics of the process of consuming resources and the process of reaping rewards from productive activity. The characteristic of jointness in consumption is readily applicable to real world situations in its "congestible public goods" formulation. A good is characterized by jointness in consumption if many consumers may use a given number of units of the good at the same time without diminishing the utility each derives from consumption. For instance, several dozen cross-country skiers may simultaneously use a hundred-acre forest without ever encountering one another and thereby diminishing the pleasure of another’s experience. Three thousand simultaneous skiers would undoubtedly invade each other’s serenity, however. For the pure public good, any number of simultaneous users may consume the resource without interfering with one another’s consumption. Because this extreme situation seems implausible, we look at goods as "congestible," that is, susceptible of being overcrowded in the forest example, or, in general, having the characteristic that if too many people consume the same limited resources simultaneously, they will interfere with the benefit derived by each. In essence, then, the theory of congestible public goods describes the derivation of a relationship between the benefits received by each consumer from the supply of a

15. For more examples of jointness in congestible public goods, see infra text at note 16.
16. See, e.g., Inman, A Generalized Congestion Function for Highway Travel, 5 J. OF URBAN ECON. 21-34 (1978). The author described the relationship between these three variables in the context of a public highway. His exercise is formulated in terms of the benefits flowing to the user, B, as a function of facility size, i.e., the number of units, X, and the number of simultaneous highway users, N; B = g(X,N). He hypothesized that for highway travel, where B is speed (benefits per user) in miles per hour, N is volume of traffic (number of simultaneous users), and X is highway scale, one would observe that as the volume of traffic increased the flow of benefits would decrease and at an accelerating rate, i.e., dB/dN<0, d²B/dN²<0.
good, the number of units of the good supplied, and the number of simultaneous consumers of the good.

In the context of a regulated resource such as clean air, the level of benefits per user is described in general terms by the preamble to the Clean Air Act as that level of purity needed to protect the public health and welfare and the productive capacity of the Nation's population.\(^\text{17}\) The level of benefits may be more precisely determined by reference to the national primary and secondary ambient air quality standards, the national standards for hazardous air pollutants, and state and local air quality standards. In this same context, the number of simultaneous consumers is that number of economic agents permitted to use (decrease the supply of) clean air during the same time period. These consumers may be firms or individuals and their consumption may result either in a considerable or de minimis decrease in air quality, or, as it might be viewed, in the quantity of clean air. Breathers of the air, for instance, are consumers in that they consume quantities of clean air and emit pollutants; but their overall impact on this congestible public good is negligible.

The quantity of the congestible public good supplied for a given set of geographic and meteorological conditions describing a body of ambient air will depend on the amount of clean air "produced." Clean air is produced (increased in quantity) by removing pollutants from emissions — "cleaner air" means "more units of the good clean air." As for any other production process, a functional relationship can theoretically be derived between the quantity of clean air made available to consumers and inputs into the production process by producers (including but not limited to pollution control devices).\(^\text{18}\)

2. Combining Consumption Characteristics With Property Rights Notions: The Resource Cost Curve

A resource cost curve which indicates the number of units of a good required to provide a given level of benefits per consumer for varying numbers of simultaneous consumers handily captures the jointness characteristics of the regulated resource in question. For example, for twelve consumers each to derive pleasure from a lolli-


\(^{18}\) Regulators are required under the Clean Air Act to derive such a functional relationship in the process of evaluating permits for constructing or modifying stationary sources which will have the potential to emit quantities of pollutants over a specified minimum. See, for instance 42 U.S.C. § 7475 (1976 & Supp. Pamph. 1981).
pop, each must have his own lollipop. For twelve consumers each to derive pleasure from a candle, perhaps just one candle will suffice because all can share in the light from the flame. A curve on a graph depicting the number of lollipops necessary to provide a given level of benefit to consumers will necessarily increase as the number of consumers increases. By contrast, the resource cost curve for candles need not increase over some (perhaps small) number of simultaneous consumers. In this lollipop/candle example, the jointness characteristic describes the ability of simultaneous consumers to share the congestible good. Sharing a candle with others decreases the benefit received by each consumer less than sharing a lollipop does.

In general terms, it can be said that for a given regulated resource the benefits per user are a function of the number of units of the resource available and the number of simultaneous consumers. Thus, we would generally expect the "benefits function" to increase with the number of units supplied, depending on how the good enters the utility functions of consumers, and to decrease with the number of simultaneous consumers, depending on the jointness properties of the good. Often, as with the Clean Air Act, we wish to examine alternative institutional structures, i.e., different property rights assignments, through which a given level of benefits is provided to each consumer. The resource cost curve depicting the relationship between the number of units of the congestible good and the number of simultaneous consumers for a given level of benefits describes the "consumption characteristics" of the good. For the typical congestible public good, the number of units of the good required to provide a given level of benefits will, at least after the point where "congestion" sets in, be an increasing function of the number of simultaneous consumers for a given level of benefits.19 Each consumer of a congestible public good, i.e., a good characterized by less than perfect jointness, has a negative impact on the level of benefits derivable by others from a fixed supply of the resource. Beyond some finite number of consumers of the candle (or even better, a swimming

---

19. J.C. Head characterized the congestible public good as a good for which a given unit, once produced, can be made at least partially available, though in varying degrees of quality, to more than one individual. The benefits flowing to one consumer from the provision of one unit of the congestible public good are not totally eliminated by the simultaneous consumption of others. Head, Public Goods and Public Policy, 17 Public Finance 197-221 (1962).
ENFORCING PROPERTY RIGHTS

additional consumers ( sharers of the candle’s light or fellow swimmers) will detrimentally affect the others’ enjoyment of the resource. The point at which the addition of more consumers begins to affect others’ enjoyment is called the congestion point.

Property rights notions can be incorporated into this consumption relationship to expand our understanding of the impact of institutional structure on consumption characteristics. A number of relevant characteristics of any property rights assignment can be described under four general categories or component parts of the assignment, labeled the direction (D), inclusiveness (I), content (C), and sanction (S) components. These components of an assignment describe respectively what types of users may consume the supply of the resource, how many may simultaneously consume the resource, the level of benefits to which each consumer is entitled, and how one may protect one’s right to consume the resource.

A resource cost curve graphically describing the consumption characteristics can be drawn for any given property rights assignment fully specified with respect to its direction and content. The inclusiveness characteristic (number of simultaneous consumers) is represented by a particular point on the resource cost curve which indicates for various numbers of consumers, N, the number of units of the good, x, needed to provide a given level of benefits, B. A change in the inclusiveness of the property rights assignment for consumers, usus, is represented by a movement along the resource cost curve to a higher or lower number of consumers. The sanction component relates not to consumption properties directly but how the right to usus is to be enforced. A change in the sanction component will have no direct impact on the resource cost curve; it is considered at another point in the analysis.

Figure 1 depicts a resource cost curve, RC¹; for a given property rights assignment with respect to usus, R², which is specified by its four component parts, D⁰, C⁰, I¹, S⁰. The shape of the curve will depend on the consumption characteristics of the resource, specifically, the jointness properties. The jointness property describes the degree to which consumption by one consumer interferes with simultaneous consumption by others. Perfect jointness occurs when consumption

---

20. See infra text and notes at notes 23-28.
by one does not decrease the benefits others derive from their simultaneous consumption of the same units of the resource.

In Figure 1, for example, for any number of consumers between zero (O) and \( N^c \), the resource is characterized by perfect jointness. The level of benefits each consumer derives from his simultaneous consumption of \( x \) units of the resource is unaffected by simultaneous consumption by up to \( N^c \) additional consumers. Our hypothetical resource may be trout stocked in a fishing pond. Simultaneous fly-fishing by a limited number of other anglers will not decrease the benefits (perhaps measured in probability of catching a fish) which each angler derives. But an increase in the number of fishermen beyond \( N^c \) necessitates an increase in the number of fish stocked in order to maintain the same probability that each will catch a fish. The point at which the resource cost curve is not differentiable, that is, where the resource cost curve starts to curve upwards after being straight, \( (N^c, x^c) \), is defined as the congestion point.

The resource cost curve can be derived for goods with any characteristics ranging from pure private goods through intermediate and congestible goods to pure public goods. None of these variations causes any particular difficulty for the analysis. Note, for instance, the curve labeled \( \text{RC}^c \) in Figure 2. The good described in resource cost curve \( \text{RC}^c \) is neither purely public, purely private, nor traditionally congestible in the sense that there is a nondifferentiable congestion point. It has no range of increasing number of consumers over which the number of units of the good need not increase to maintain the level of benefits per person as for the public or congestible good. This intermediate good reflects Head's description of being available, though in varying degrees of quality, to more than one consumer.\(^{21}\) In this example, to maintain quality, the number of units of the good must be increased continuously but at a rate slower than the rate of increase in numbers of consumers.\(^{22}\)

A change in the property rights assignment will alter the jointness characteristics of the resource and cause a shift in the curve. Choices among alternative types of consumers can be compared by the "intensity" of use by various types. Intensity of use describes the severity or degree of interference by a particular type of consumer with the simultaneous consumption of others. By his use of the

\(^{21}\) Head, supra note 19, at 197-221.

\(^{22}\) This is reflected by drawing a resource cost curve with a slope between zero and one, as shown.
Resource Cost Curves Reflecting Changes in Property Rights Specifications

Key:  
\[ RC^0 = RC^0; R^0(D^0, C^0) \]  
\[ RC^1 = RC^1; R^1(D^1, C^0) \]  
\[ RC^2 = RC^2; R^2(D^0, C^1) \]  
where the changing superscripts indicate a change in the curve, RC, due to a change in the property rights assignment, \( R_m \), which affects its shape and location. The change in property rights is due to a change in one or more components of the right, as from \( D^0 \) to \( D^1 \) or \( C^0 \) to \( C^1 \).
resource, the more intensive consumer causes a greater decrease in the level of benefits derived by simultaneous consumers than does the less intensive consumer. Thus, in Figure 1, if more intensive consumers are permitted to make use of the resource, the congestion point will be further to the left, for example, at $N_i$ rather than $N_c$. The curve reflecting the consumption characteristics given this change in the direction of the property rights assignment is labeled $RC'$. In the fishing pond example, a change in direction may be made by permitting fishermen trolling lures behind motorboats to join the fly fishermen in the fun. Previously as many as the number $N_c$ anglers could fly-fish without congesting (interfering with each other’s use of) the resource. Now, because a number of new consumers, trollers, less than $N_c$ may interfere with the chances of fly fishermen catching fish, the new congestion point ($N_i$, $x_0$) is to the left of the old congestion point. This shift in the consumption curve is a result of a change in the direction of the right to usus. A change in the content of the property rights assignment will also shift the resource cost curve. The curve describes the number of
units of the resource needed to provide a given level of benefits to each consumer. If the level of benefits, implied by the content component of the property rights assignment, is increased, more units of the good must be supplied for any given number of simultaneous consumers. The curve RC₂ in Figure 1 reflects increase in the content component of the property right assignment with respect to usus. For example, this change might represent a decision to increase the probability that each fisherman will catch at least one fish, or to increase the number of fish each is likely to catch.

B. Property Rights and Enforcement-Related Properties of Resources

The public goods notion of nonexcludability is relevant to the enforcement cost issue. Nonexcludability is the inability of the producer, due to physical and legal barriers, to enforce the right to appropriate the full social benefits realized from its supply of goods, the right to usus fructus. This lack of effective exclusive control also extends to consumers who, having acquired a number of units of goods for their own consumption, are unable to prevent others from consuming those units because they lack effective exclusive use. Generally, both the rights to usus and usus fructus must be enforced. For public goods with complete jointness in consumption and from which consumers cannot be excluded, however, only the usus fructus needs to be enforced. Once these complete jointness goods are produced, consumers are guaranteed to receive the associated benefits from consumption; simultaneous consumption by others does not limit the benefits they derive and others cannot be legally or physically prevented from simultaneously consuming.

23. Nonexcludability is traditionally presented as a physical inability to prevent non-paying consumers from benefiting from the provision of goods, e.g., the outdoor circus, national defenses, lighthouses. Ronald Coase examined the possibility of private provision of traditionally nonexcludable resources by altering the legal structure. Coase, The Lighthouse in Economics, 17 J. OF LAW & ECON. 357-76 (1974). James M. Buchanan similarly argues that, given sufficient flexibility in the assignment of legal rights, physical exclusion is possible in almost all imaginable cases. Buchanan, An Economic Theory of Clubs, 32 ECONOMICA 1-14 (1965). Both the natural and physical properties of goods and the availability of suitable legal rights are relevant to nonexcludability. Because the degree of nonexcludability affects the enforcement costs, both aspects must be considered.

24. As we will see, clean air is such a good. Once clean air is produced (by cleaning emissions) breathers of the air can not be excluded from benefiting. If those who clean up the air have a right to be paid for this costly productive activity, they will have to enforce this right to usus fructus.
If a resource is characterized by complete nonexcludability then the producer to whom the *usus fructus* has been assigned and the consumer to whom the *usus* has been assigned will be unable at any cost to prevent non-entitled producers and consumers from benefiting from the provision or acquisition of the good. Degrees of nonexcludability imply different amounts of enforcement "effort" required to protect one's right to appropriate returns or to consume. The model presented here quantifies this effort by determining the number of enforcement units necessary to protect one's right given both the natural or physical characteristics of the resource and the relevant legal milieu.

1. Enforcement Units

It is reasonable to suppose, at least initially, that the number of enforcement units required increases as the number of units of the resource the rights to which are to be protected increases. Thus, if the number of enforcement units, designated eu, were a function only of the number of units of the good to be protected one could describe an upward sloping enforcement curve such as EU° depicted in Figure 3. It is possible that after some point there will be economies of scale that cause the rate of increase in the number of required enforcement units to decrease as one endeavors to protect rights to larger numbers of units of the good. This is not, however, a necessary conclusion. There may instead be diseconomies of scale. The number of enforcement units needed and the presence of economies or diseconomies of scale will depend on the nature of the resource, that is, the physical or natural barriers to enforcing one's rights, as well as on legal restrictions. The nonexcludability characteristics of the resource stemming from natural and legal barriers are embodied in an enforcement relation which associates the number of units of the resource the rights to which are being protected to the number of enforcement units required to protect them. Figure 3 portrays an enforcement relation labeled EU° which indicates that the number of enforcement units required depends on both the number of units of the resource, x, and the given property rights system with respect to *usus*, R_u, and *usus fructus*, R_f.

Enforcement units, eu, measured on the abscissa axis, are identically comprised technological inputs to the enforcement process. A simple example of an enforcement unit is a watchperson and dog. Each unit is identically composed of one watchperson and one dog. This combination of inputs underlies a single enforcement relation,
that is, a single technology which is unvaried as different numbers of units of the good are to be protected. Each type of enforcement unit represents a single technology of enforcement. Different technologies are not compared on the same axis but may be compared by relation to a common denominator such as cost per unit or total cost to protect a given number of units of a good. Enforcement relations can theoretically be derived for those enforcing the right to either *usus* or *usus fructus*.

2. Enforcement Relations

Note that by relating back to the components of property rights assignments — direction, content, inclusiveness, and sanctions — one can explore how the enforcement relation shifts as changes in the institutions described by those property rights occur. Changes in any of these components will affect the number of inputs invested in the enforcement process. The direction of the assignment of the right to *usus* or *usus fructus* indicates what types of consumers and producers will be enforcing rights. Characteristics of the type of economic agent entitled to consume or appropriate returns from supplying resources may imply the availability enforcement technologies. For example, a public or governmental body protecting its own property can make use of the Federal Bureau of Investigation, which is available only under limited circumstances to the private consumer. Assigning rights to appropriate returns from a productive activity — *usus fructus* — to a governmental unit such as a municipal electricity-generating plant may, on the other hand, restrict the technologies available because of due process considerations.\(^{25}\)

The inclusiveness of the rights as well as market considerations will dictate how many consumers are entitled simultaneously to consume the units of a resource and how many producers are entitled to appropriate returns from productive activity. The rights to *usus* may be assigned to a single consumer, as in the archetypal private goods case or to a group of consumers of any larger size, as for public parks. The rights to *usus fructus* may be assigned to a single producer, as in the legal monopoly situation, or to all producers of a given resource. The impact of the inclusiveness of the property right

\(^{25}\) See Jackson v. Metropolitan Edison, 419 U.S. 345 (1974) (indicating that a stricter due process requirement should be used for public utilities).
The Enforcement Relation Indicating the Number of Enforcement Units Required to Protect Property Rights

Number of Units of the Resource

Enforcement Units

Key: \( EU^0 = \text{eu} (x; R^0, R^0_0 (D^0, C^0, I^0, S^0)) \)
\( EU^1 = \text{eu} (x; R^1, R^1_0 (D^1, C^1, I^1, S^1)) \)

on the enforcement relation depends on its effect on economy-of-scale considerations, the ability to coordinate enforcement efforts, and on external or spillover effects of enforcement activities.²⁶

²⁶ Economies of scale in enforcement means that as more units of the good are produced or are available to be consumed the additional effort required to protect property rights to these goods declines. Because the enforcement curve is a total curve rather than a marginal curve, economies of scale are reflected in an EU curve which increases at an increasing rate as in Figure 3. The extent to which this is true will vary for each good and perhaps for each enforcement technology, but we can say that the ability to take advantage of economies of scale requires either that one enforcer be in charge of enforcement of the rights to enough of the units of good that the efficiencies of scale can be obtained or that enough holders of the rights can coordinate their enforcement activities.
The content of the property right describes the benefits to be derived by each consumer in exercising the right of *usus* and by each producer in securing returns from productive activity. Examples of changes of levels of benefit on the consumption side have already been given. In that context, a higher level of benefits per user requires a greater supply of the good in question. On the production side, the right to appropriate returns may be more or less remunerative to the rights holder; it might be assigned to nonprofit as opposed to for-profit organizations, or to industries where the rate of return is otherwise regulated. The content specification, the level of benefits to be secured by protecting one’s right, will be a factor in determining the *level of enforcement* to be used to protect such rights. The lower the benefit from enforcing one’s rights, the less one will be willing to invest in protecting those rights. The cost-minimizing enforcer of rights will equate the marginal value product which measures the incremental resulting benefit of the additional dollar spent on enforcement with the marginal costs of another violation of his rights.

The sanction component of the rights to *usus* and *usus fructus* may specify not only how enforcement activities will be organized (collectively or individually, for example) but also what those enforcement activities will be. The property right with respect to *usus* may permit homeowners to shoot a thief on sight or require that an injunctive order be sought to evict the trespasser. The farmer may be permitted to enforce his right to secure returns by setting land mines at the boundaries of the field, or he may be limited to less convincing deter-

Spillover effects, which are closely interrelated with economies of scale, can be illustrated in the following manner. Everyone in a neighborhood protects his home by some efforts that supplement public police activities. Even though the rights to individual houses are assigned to individual homeowners, neighborhood-watch programs coordinate the efforts of neighbors to protect their property and may reduce total enforcement costs. Similarly, if all of one’s neighbors participated in the neighborhood watch, that person would benefit from the program even if he did nothing; and if another home were to be built in the neighborhood, the neighborhood-watch program would probably not have to expand to include this home in its protection. Even without coordination of their activities, if each of one’s neighbors sat on his front porch with a shotgun, their protection would spill over to the passive person’s property and benefit him, making his house safer from intruders even if he did nothing. These are spillover benefits and affect the total amount of enforcement effort needed for protection.

27. See supra text at note 22.

28. In a sense, this is where the theory of the costs of enforcing property rights began. In his 1967 article, Harold Demsetz relates the impetus for redefining property rights to a change in the benefit-cost calculus. In this context Demsetz recognizes that enforcement costs will vary with the type of ownership in general terms of negotiation costs and maximization of the present value of resources owned in these ways. Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347-73 (1967).
rents. Whatever is the specification of how enforcement units may be employed, the enforcement relation describing the number of enforcement units needed to provide a given level of protection will be affected.

As changes in any of the components of the rights — direction, inclusiveness, content, and sanction — occur, the enforcement relation described in Figure 3 will shift. This enforcement relation is a function, therefore, not only of the number of units of the resource the rights to which are being protected, but also of the given specifications of the rights to \textit{usus}, \textit{R}_u, and \textit{usus fructus}, \textit{R}_f. In evaluating the impact on the level of enforcement costs of changes in property rights assignments, various considerations are relevant. These include the impacts on the ability to achieve such economies of scale in enforcement as are available; impacts on the productivity of a particular enforcement technology for each configuration of property rights components; impacts on the ability of economic agents of different numbers and of different types to coordinate efforts and to exploit alternative technologies; impacts on the level of protection that will minimize costs for a given enforcer of rights; and impacts on the external effects of each enforcer's activities.

For a particular policy problem, the enforcement relation will describe the total investment in a single specific enforcement technology necessary to protect all units made available to a given group of simultaneous consumers. Amendments to the rights assignment, changes in the specifications of a given property right, are reflected in shifts of the enforcement curve. For instance, the curve \textit{EU}\textsubscript{0} in Figure 3 may represent the relationship between the number of fish stocked in the pond by all producers of fish and the number of watch-person-dog teams required to ensure that the suppliers get paid by all fishermen who catch their fish. Assume that a producer only collects when one of his fish is caught. \textit{ED}\textsubscript{1} describes the result of a change in the inclusiveness of the property rights assignment with respect to \textit{usus fructus}. If one producer supplies all of the fish, that is, the right to be paid for this productive activity is assigned to one individual (rights to \textit{usus fructus} are completely exclusive or "noninclusive"), fewer enforcement units will be needed to enforce the rights to returns from supply relative to the situation where many producers were involved (more inclusive \textit{usus fructus} rights). Among other sources of savings in the single producer situation is the fact that the producer need not inspect a recently hooked trout to see if
he supplied it because he supplied all of them. The result is an enforcement curve, $EU'$, above and to the left of the previous curve, $EU^c$, representing more efficient enforcement.

Similar property rights changes and descriptions of the effects of such changes on the enforcement curve can be presented for the direction, content, and sanction components of the rights assignment. For instance, a shift in the enforcement relation similar to that in Figure 3 indicating more efficient enforcement might occur if the sanction component of the property right were to specify that the producers' rights to *usus fructus* would be enforced by a collectivity such as the government. In that case, one enforcement organization would arrange to collect fees from all users of the good supplied and allocate those fees to the producers. An alternative specification might forbid producers from combining or conspiring for any business purpose, including enforcement, thereby requiring inefficient individualized enforcement efforts. Generally, the effect of such a scheme would be to shift the enforcement curve below and to the right of $EU^c$ representing an increase in the number of enforcement units relative to the number of units of the resource protected.

Using these concepts for policy purposes requires a method for comparing enforcement strategies which can examine the implications of different property rights systems with respect to those enforcement strategies. Determining the magnitude of the enforcement effort in dollar cost terms would allow the policymaker to make these comparisons of strategies for the purpose of enforcement policy planning. The discussion therefore now turns to a further examination of the operation and function of this enforcement strategy methodology.

### III. Property Rights and Enforcement Policy Planning

#### A. The Level of Costs

1. The Enforcement Input Cost Curve

   The common denominator for comparing enforcement technologies is the dollar costs of employing inputs (enforcement units) to

---

29. For example, antitrust considerations may prevent certain concentrations of enforcement resources.
the overall enforcement process. For each enforcement technology the cost per unit can be calculated. An enforcement input cost curve can be drawn describing the dollar cost of acquiring the inputs to the enforcement process in the fixed proportion specified by the given technology underlying the enforcement relationship and including the costs of administrative as well as other inputs. If changes in quantity demanded for these inputs do not affect the price at which the inputs are supplied, then the enforcement input cost relationship will be linear and represented as a ray as shown, for example, by EIC\(^1\) in Figure 4. The ray will begin at the origin of the axes and have a slope equal to the dollar cost of the inputs comprising one enforcement unit. This will be the case where the quantity of enforcement efforts demanded by the enforcers of the rights is small relative to total market demand.

Where inputs are specialized to a particular enforcement process the input cost relationship may reflect an upward sloping nature of the supply curve facing the purchaser of enforcement inputs. In the context of clean air, for instance, if the Orsat analyzer, used to make a dry molecular weight determination of samples of gases taken from smokestacks, is not used for any other purpose or by anyone but the Environmental Protection Agency enforcers of clean air property rights, then the cost per unit may change as the quantity of clean air demanded increases. In Figure 4, EIC\(^2\) reflects a case where any increases in quantity of the good demanded by the enforcer are large enough to be forthcoming from suppliers only at higher prices.

Generally, the enforcement input cost curve will describe the changes in the cost of acquiring the inputs required by a particular enforcement technology as the number of enforcement units increases. It is estimated by reference to market input costs. The quantities demanded by enforcers relative to market demand and the supply elasticities will be relevant considerations.

2. The Derivation of an Enforcement Planning Curve

From the resource cost, enforcement, and enforcement input cost relationships determined by reference to the various components of the property rights assignment and the public goods characteristics of the resource as well as market considerations, an enforcement planning schedule can be derived. For any choice of institutional structure, the planning schedule indicates the dollar costs associated with
enforcing a particular property rights assignment and concisely summarizes information contained in the previously described relationships.

This planning schedule can be derived graphically for a given set of property rights as follows. In the simple example shown in Figure 5, it is assumed that the same technology is used for the enforcement of the rights to *usus* and *usus fructus*. Given the property rights assignment with respect to *usus* for any given number of users, $N^1$, the resource cost curve in Quadrant I of Figure 5 yields the number of units of the resource, $x^1$, needed to provide a given level of benefits specified in $RC^1$. The enforcement curves in Quadrant II reveal that
enforcing the right to appropriate returns from the production of \( x_1 \) units of the good using the specified technology requires \( eu_{1} \) units of enforcement, while the enforcement of the right to consume requires \( eu_{2} \) enforcement units. Assuming that there are no spillovers from the enforcement of *usus* to the enforcement of *usus fructus* or vice versa, a total of \( eu^{1} = eu_{1} + eu_{2} \) enforcement units will be needed to enforce fully all rights with respect to \( x_1 \) units of the good. The enforcement input cost curve in Quadrant III reveals that the total number of enforcement units can be obtained at cost of \( EIC_{1} \) which reflects the total enforcement costs in dollar terms to all enforcers of both rights. The enforcement planning curve in Quadrant IV presents the unique association between the number of users to whom the right to consume is assigned and the total cost of ensuring that the flow of benefits to those entitled consumers and producers is protected.

This operation of tracing through the various curves can be carried out for all numbers of potential users. The resulting enforcement planning curve \( EP^{o} \) describes how the level of enforcement costs changes as the number of users changes. The shape of this curve is determined by the jointness and excludability characteristics of the resource, the property rights assignments, the enforcement technology, and market factors. Thus, public goods theory, property rights theory, and relevant features of a particular enforcement problem are combined in the enforcement planning curve.

3. Comparing Alternative Techniques of Enforcement

In the simple case presented the technology relied upon to enforce the rights of both *usus* and *usus fructus* is assumed to be the same. As such, the enforcement technology is assumed to remain constant even when there is an increase in the number of units of the good and, consequently, in the corresponding rights to be protected. In the usual planning process, however, the policymaker will want to consider and compare the costs of alternative technologies for enforcement, both as the number of units of the good provided increases and as the requirements for enforcing *usus* and *usus fructus* differ. The enforcement planning curve described above is a device for making these comparisons and for evaluating different technologies required for enforcing different rights.

Consider the comparison of alternative technologies for enforcement of a single right. Figure 6 depicts enforcement relationships that describe, for three different types of enforcement technologies,
Figure 5
The Derivation of an Enforcement Planning Curve

Quadrant II

Quadrant I

Quadrant III

Quadrant IV

Key: $RC^o = R_C^o; R^o$
$EU^o = eu^0 (R^o)$
$EU^{oI} = eu^{oI} (R^o)$
$EU^o = EU^o + EU^{oI}$
$EP^o = EP; R^o, R^{oI}$
the number of enforcement units required to enforce the right to use fishing ponds of varying sizes. The ordinate axis in each curve represents the number of units of the good to be consumed (the size of the pond in circumference) while the abscissa measures the number of enforcement units of each type used to detect intruders. Because an enforcement curve must be drawn for each technology, there are three sets of axes as well as three associated enforcement input (enforcement unit) cost curves. The pair of curves labeled "Technology A" represents the watchperson-dog technology which is effective for small ponds but becomes increasingly expensive in resource terms for larger ponds, as the shape of the curve in the upper graph reflects. Technology B is the watchperson/motorboat technology which, as the curve reflects, requires a much higher number of enforcement units per acre for small ponds than for large ponds. Technology C describes the photoelectric cell technology for detecting intruders and reflects a per unit resource investment that increases at a constant rate as the size of the pond increases. The costs per enforcement unit, which vary as indicated by the lower three curves in Figure 6, are constant per unit as quantity demand increases, except for the specially designed photoelectric cell, the supply of which is obtained at increasing costs per unit.

While the enforcement curves and enforcement input cost curves for the alternative technologies must be drawn on separate sets of axes, the enforcement planning curves from each can be compared on the same diagram. Figure 7 presents the enforcement planning curves for the alternative technologies A, B, and C. Note that the characteristics of the three enforcement technologies are reflected in the individual diagrams in Quadrants IIA, IIB, and IIC but may be compared as to cost by examining the planning curves in Quadrant IV. In Quadrant IV, the heavy line indicates the technology of minimum cost for fully enforcing the rights of various numbers of users of the good in question. This example reveals that, in order to minimize cost, one may have to switch to a different enforcement technology as the number of consumers grows larger or smaller. This device enables the policymaker to choose among alternative technologies for a given set of property rights. Thus, as seen in Quadrant IV of Figure 7, if there are to be fewer than \( N_1 \) users of the resource, technology A is cost minimizing. For any number of consumers between \( N_1 \) and \( N_2 \) technology B is the least expensive. If there are more than \( N_2 \) users, technology C is the least expensive.

The enforcement planning curve is the construct of particular utility to those who wish to balance the costs and benefits of a specific
Figure 6
Comparative Enforcement Costs of Alternative Technologies

Technology A
(watchperson-dog)

Technology B
(watchperson-motorboat)

Technology C
(photoelectric cell)
FIGURE 7
Enforcement Planning Curves of Alternative Technologies

Pond size

Technology A (watchperson-dog)  Technology B (watchperson-motoboat)  Technology C (photoelectric cells)

Total Enforcement Input Cost
institutional structure. An analysis which examines the characteristics of the resource cost curve, the enforcement relations, and the total cost curve as well as the way changes in the property rights assignments affect those relationships sheds light on why the cost of enforcing rights varies in a systematic way with alternative property rights assignments. The use of an enforcement planning curve provides a bottom line. It provides a means of comparing the enforcement cost associated with different institutional choices and varying technological constraints.

B. Choosing the Degree of Protection

The discussion to this point has assumed that the persons assigned the rights of *usus fructus* desire to enforce those rights fully by ensuring that there are absolutely no violations. While a wide variety of relationships can now be examined by using the enforcement cost model just described, the model has not yet explicitly recognized a number of important features in the enforcement cost picture — notably, how the benefits from enforcing and violating the rights assignment will affect the costs of enforcement. Quite reasonably, the crime and punishment literature in economics takes issue with the naive assumption that property rights are fully enforced. As influential as any in this discussion are the contributions of Gary Becker and George Stigler.

Rather than take a property rights approach to the enforcement problem, Becker sought to answer the normative question "how many resources and how much punishment should be used to enforce different kinds of legislation?" Becker and Stigler rely on the economic nature of crime to determine how many violations will occur. Two examples of this economic nature of crime can be presented in terms familiar to the property rights approach. A violation of the rights to *usus* is the using or consuming of a good to which the user or consumer has not been assigned a right. This violator is taking the economic benefit to be derived from consumption without any right to do so. A violation of the right to *usus fructus* is the failure to pay to the party assigned that right the returns due him from his productive activity. An economic motivation may be one of the reasons for the violation of this right.

30. Becker, supra note 9, at 169.
32. Becker, supra note 9, at 170.
Less than full enforcement may occur for a variety of reasons. Significant among these are that the amount of money available (budgeted, in an administrative context) for purchasing enforcement units is limited, and that full enforcement may not maximize the goals of the enforcer, whatever they may be. The first of the two reasons is straightforward and is related to the second. Because resources for enforcement are limited, the enforcer will seek to use only as many as are worthwhile. That is, if the costs of employing another unit of enforcement exceed the additional benefits to be gained thereby, the employment of that unit of enforcement will not be worthwhile. This explanation of less than full enforcement is a simple benefit maximizing model.

The optimization rule for efficient level of enforcement is for the rights holder or his agent, the enforcer, to the extent their incentives are identical, to maximize the benefits derived from the units of the resource supplied minus two costs: the harm from violations of the right plus enforcement costs. The benefits derived from production and consumption are implied in the content component of the property rights assignment. The cost of enforcement units is available from the enforcement input cost curve. The harm resulting from violations is related to the benefits to be derived from production and consumption.

To determine the optimal degree of protection to be afforded a given set of property rights, it is necessary to establish a relationship between the number of enforcement units used and the number of rights violations that occur. A “violation” is interpreted as an unauthorized transfer of the benefits from consumption or production of one unit of the resource from the rights holder to the “violator.” For simplicity, assume that a fixed amount of loss of benefits, ho, results from each violation. The number of violations, V, is a function of both the number of units of the good available, x, and the number of enforcement units actually employed, eu; that is, V = v(x, eu). The total harm may be simplistically described as the

---

33. Note that this functional form implies that one particular kind of enforcement technology represented by eu is used. More or fewer violations might occur if a different type of enforcement technology is employed. It is possible to use the optimization process to determine the appropriate number of units of each type of enforcement team when more than one enforcement technology is used either to enforce a given kind of right or to enforce the different rights. Such an optimization would reveal that the maximum net benefit will be achieved when possessors of the rights employ the enforcement units of each type until the marginal cost of hiring another unit of each type is equal to the marginal cost of hiring each other type and equal to the additional harm to holders of the rights being protected.
product of the number of violations times the benefits cost per violation, $h$ times $V$. Equally important in the cost calculus is the harm to society caused by having to devote resources to enforcement. Enforcement input costs will increase as the number of enforcement units employed increases.

Balanced against the harm resulting from violations and from devoting otherwise productive resources to enforcement are the benefits derived by the rights holders, which are a function of the property rights assignment, particularly the number of units of the good involved and the number of simultaneous holders of the right. For any point on the resource cost curve, the optimal level of enforcement is the utilization of that number of enforcement units which equates the reduction in harm from decreasing violations through the employment of another enforcement unit, the "marginal benefit product," with the marginal cost of that additional enforcement unit. The collection of the optimal number of enforcement units for different points on the resource cost curve defines an optimal enforcement relation between the number of units of the resource supplied and the number of enforcement units used. This relationship describes the optimal degree of protection of one's assigned property right.

The net gain maximization indicates that the rational enforcer would invest in additional enforcement units until the incremental cost of adding another unit equals the value of the harm prevented thereby. The marginal conditions for maximizing the net gain function are satisfied at the intersection of the well-behaved marginal harm and cost curves in Figure 8. In this figure, the line $C_{eu}$ represents the net gain function.

34. Because there are many sources of cost in the enforcement process and numerous alternative strategies, it would be useful to be able to consider these costs individually. Using the maximization approach, we can break down the enforcement process to study a particular type of cost. For instance, Becker analyzes the impact of severity of punishment on deterrence. See Becker, supra note 9, at 170-75. We can examine this factor by separating from other enforcement costs the costs associated with levying penalties; courts, trials, jails, fines, even social costs of incarceration. If $C^1$ is a function describing the cost of other enforcement units and $C^2$ describes costs associated with levying punishments, $P$, then the maximization problem becomes: $\max L = b(x; N) - h^0 v(x, eu, P) - C^1(eu) - C^2(P)$.

In this formula, in calculating the net gain to pollution control we subtract from the benefits, $b$, which are a function of the number of units of the goods supplied, $x$, and the number of simultaneous users, $N$, both the harm, $h$, resulting from violations of the regulations, $v$, which are a function of the amount of pollution reduction expense which emitters must bear, $x$, the level of enforcement activity, $eu$, and punishments for those violators apprehended, $P$, as well as the costs of the enforcement $C^1$ (eu) and of the punishments, $C^2$(P). The relevant first order conditions are:
resents constant marginal costs of employing enforcement units; the curves $hV_{eu}$ represent the combinations of declining violations and associated harms as more enforcement units are employed. For the curves $C_{eu}$ and $hV_{eu}$, the number of enforcement units at the point of intersection, $eu^*$, represents the benefit maximizing level of enforcement for a particular property rights assignment. The corresponding intersection points of the other curves with $C_{eu}$ at $eu^1$ and $eu^2$ represent the benefit maximizing levels of enforcement for the property rights structures embodied in those curves.

This graph is useful in demonstrating that changes in the property rights assignment affect the optimal number of enforcement units employed. If there is an exogenous increase in the benefit to be derived from each unit of the resource and, consequently, the harm resulting from a violation of the right to that unit increases (for example, the EPA determines that the reduction of pollution by one percent not only prolongs your life but improves your sex life), then the marginal harm curve, $hV_{eu}$, will shift to the right, becoming $h^2V_{eu}$, reflecting an increase in additional harm per violation.

There is no reason to assume an increase in violations from this example, but if violations per enforcement unit were to increase, then the marginal harm curve would be less steep, reflecting a smaller decrease in violations per additional enforcement unit, as in $h^2V_{eu}$. Each of the changes affects the optimal number of enforcement units and in turn, therefore, affects both the enforcement curve and the enforcement planning curve. Similar shifts can be demonstrated for changes in the other components of the property rights structure.

In general, the number of units of enforcement that maximizes net benefits for a given number of units of the good and enforcement technology, including punishment, will be less than the number re-

\[
\frac{dL}{dP} = -h^o \left( \frac{dv}{dP} \right) - \frac{dc^1}{dP} = 0 \text{ or } -h^o \left( v_p \right) = C_p^2 \\
\text{and } \frac{dL}{deu} = -h^o \left( \frac{dv}{deu} \right) - \frac{dc^1}{deu} = 0 \text{ or } -h^o \left( v_{eu} \right) = C_{eu}^1.
\]

These formulae mean that the investment in punishments should be raised until the reduction in harm from decreasing violations equals the increase in associated costs. Becker notes that there will be costs associated with levying the fine that may not be borne by the enforcer. The policymaker is encouraged to include fairness (or the costs of unfairness), due process, equity, and other such considerations in the balancing process. Becker also notes a trade-off between increasing the number of enforcement units and changing the severity of the punishment. Many portions of his model can be incorporated into this analysis.
required to enforce the property rights fully. This can be seen in Quadrant II of Figure 9. Full enforcement (no violations) will not occur unless the harm from an additional violation is high. Only where the cost of harm from an additional violation is exceedingly high is there likely to be a correlation between the cost of enforcement and the value of the reduction of violations such that maximum net benefit is derived only when no violations occur. Under the optimal enforcement strategy, enforcement units will be employed until the dollar cost of reducing additional violations reaches that high amount of harm from a violation. An examination of a particular cost function and enforcement technology will yield the appropriate degree of enforcement necessary to maximize net benefits. The effect of choosing a less-than-full enforcement curve is to shift the enforcement planning curve downwards and to the right as in Quadrant IV of Figure 9.
IV. Property Rights Enforcement in a Regulatory Context

A. Introduction

Property rights with respect to clean air are established by a variety of administrative, legislative, and judicial bodies on federal, state, and local levels. A particular regulatory scheme can be described by the model developed above and the enforcement cost implications of altering the property rights implicit in a particular
regulatory institutional structure can be analyzed. As an example, this section considers the regulations promulgated under the Clean Air Act to control pollution from stationary sources.

The resource cost curve in this context, as in the general model, describes the number of units of the good needed to provide a given level of benefits to varying numbers of simultaneous consumers. In the context of the Clean Air Act, consumers of the air are of two types which may be broadly categorized as breathers and emitters. The statute itself provides a definitional distinction between the two groups. Section 109 of the Act[^35] describes primary and secondary standards as those air quality standards necessary to protect the public health and the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutant in the ambient air. Breathers are those for whose benefit the standards are designed — those whose health and welfare is endangered by airborne pollution. Emitters are those whose consumption of clean air endangers the breathers.

The Clean Air Act regulations for a particular air quality control region are promulgated without regard to the number of breathers in a particular region. The level of benefits described in the national primary and secondary standards is uniform across the country. Rules designed to prevent significant deterioration of air quality designate areas as clean or dirty air areas according to a plan of projected desirable use or non-use. The designation of an area as "dirty" could be associated with the presence of large numbers of breathers, as in an urban center, but the classification actually results from the emitters' activities, not the breathers' presence. Because the number of "simultaneous breathers" is not relevant to the regulatory scheme, the horizontal axis of the resource cost curve diagram measures only the number of simultaneous emitters. The number of breathers is outside of the model not because of the way the model is designed but because of the regulatory design which is directed only to emitters.

To reflect enforcement cost characteristics accurately, the model must describe the actual property rights structure embodied in the standards and regulations[^36]. As will be shown, the cost of reducing pollution depends only on the constraints imposed on the production process of emitters and the cost of enforcement depends only on the

emitters' strategies of compliance or violation. While the enforcer's decision whether to pursue a particular violator may actually depend on the number of breathers who are affected by the pollution, the regulations setting forth performance standards do not take into account the number of breathers. This is so because clean air regulations operate by ensuring that emitters reduce pollution — produce units of pollution reduction — which in turn increases the amount of clean air available to all. As a congestible public good characterized by jointness and nonexcludability, the clean air "produced" by regulated emitters is then consumed by breathers, who do not interfere with each other's consumption and cannot be excluded from deriving the benefits of clean air. Emitters are "regulated" — forced to produce pollution reduction — because the return from such production is negative in the sense that emitters, as producers of clean air, bear the cost of pollution reduction without recompense except to the extent that these producers can pass the cost on to buyers of their products. If all costs could be passed on, and the producer suffered no loss of profit, the emitter would not object to installing any devices requested by the EPA, which is hardly the case. Thus, in the regulatory context of the Clean Air Act, it is the enforcement of the right to usus fructus, the right to returns from production, which is the focus of the property rights enforcement model. The following sections develop and apply the model to the Clean Air Act regulations.

B. The Resource Cost Curve

The resource cost curve measures the total dollar investment in pollution reduction by emitters required by the regulations for various numbers of emitters in an air quality control region (AQCR), given a fixed level of air quality to which each breather is entitled. The dollar investment in pollution reduction is a measure of the number of units of the good supplied. Turning low quality (dirty) air into higher quality (clean) air is a production process which supplies units of the good "pollution reduction." The resource cost curve represents the functional relationship between the number of emitters in an AQCR and the number of pollution reduction units to be produced. The shape of the resource cost curve for any AQCR will

37. See Barnes, supra note 6 (discussing the EPA's enforcement strategy).
39. See infra text and note at note 87.
depend on the types of emitters subject to EPA control in the area, the restrictions placed on the emitters, and the air quality in the region.

Under the provisions of the Clean Air Act as amended in 1977, the level of air quality dictates the rules constraining emitters. Clean air regions are those which have an air quality exceeding that specified by the national primary and secondary air quality standards, the national standards for hazardous air pollutants, and relevant state and local modifications of these standards. Such regions are also subject to rules for the prevention of significant deterioration of air quality, the PSD rules, which specify maximum allowable increases in the concentration of controlled pollutants over a baseline concentration. Dirty air regions are those which do not meet these various standards. Under the 1977 Amendments to the Clean Air Act, dirty air areas are subject to the nonattainment provisions which are designed to improve air quality in those areas that have not attained the national standards for air quality by requiring new emitters to demonstrate a net benefit resulting from their proposed use of the air.

Diagramatically, the resource cost curve for each type of area appears as shown in Figure 10. In each type of area, an initial number of emitters, \( N^*_c \), for the clean air area and \( N^*_d \), for the dirty air area is assumed. The congestion point in the Clean Air Act context, \( N_c \), is reached when so many emitters are releasing pollutants into the air in an AQCR that the applicable standards are violated. Thus, the clean air area may be defined as one in which \( N^*_c \) (the initial number of emitters) is less than \( N_c \); the dirty air area is one in which \( N^*_d \) is greater than \( N_c \). The upward sloping nature of both curves in Figure 10 indicates that emitters must produce some pollution reduction even in clean air areas. Once the congestion point is passed, increased efforts by new emitters to produce pollution reduction are required and, therefore, the slope increases. On a practical level, it has been suggested that costs of removal of pollutants from emissions generally increase sharply as percentage removal required increases. This observed relationship can be incorporated into the

41. See 42 U.S.C. Subchapter I, Part C; id. § 7473 (Increments and Ceilings).
43. See Downing & Watson, supra note 8, at 220.
resource cost curve. Using the resource cost curve as a starting point, it is possible to examine the implications of changing the direction and content components of the property rights assignment in this specific regulatory context. First, however, the enforcement relationship is described in its Clean Air Act application.

**FIGURE 10**

Resource Cost Curves for Clean Air and Dirty Air Areas

C. *The Enforcement Curve*

In the Clean Air Act context, the enforcement curve relates the quantities of resources devoted to protecting or enforcing property rights to clean air to the quantities of resources devoted to the production of clean air. By hypothesis, the more resources emitters of pollution must devote to pollution abatement, the more they will, *ceteris paribus*, resist compliance with emission control regulations. In the general property rights model, protecting the right to consume a good that is not a pure public good requires prevention of unauthorized simultaneous consumption by others. Under the Clean Air Act, all emitters are entitled to consume the air so long as they comply with rules requiring abatement. As a result, the enforcement task is to force emitters to bear the costs of compliance with those rules. For any complete specification of a property rights assign-
ment, it is possible, in a world of full information with respect to firms' compliance responses, to derive a relationship describing the number of enforcement units needed to ensure compliance with environmental regulations. With this starting point, the effect of altering the direction, inclusiveness, or content of the rights assignment on the enforcement relation can be described. Figure 11 presents such a point with the vertical axis measuring dollars of pollution reduction expenses to be borne by the emitters and the horizontal axis indicating the corresponding number of enforcers (perhaps inspector-engineer-attorney teams, with their support staffs).

**Figure 11**

An Enforcement Relation for the Clean Air Context

![Graph of an enforcement relation](image-url)
D. Enforcement Planning and Changes in Regulatory Structure: The Impact of Changing Air Quality Standards

With the basic curves described in Figures 10 and 11, resource cost curves for clean air/dirty air areas and an enforcement relation, consider how the property rights model can be used to examine the enforcement cost implications of a change in the regulations governing resource use. Three sections of the Clean Air Act Amendments of 1977 require the review and potential adoption of standards for various pollutants.44 Two of these are concerned with emissions of nitrous oxides and require an immediate review of present standards and the adoption of a new primary standard for NO$_2$ concentrations measured over a period not greater than three hours.45 The third section sets in motion machinery for controlling radioactive pollutants.46 The generally desired impact of changing the standards or adopting new ones is to change the quality of the air. An improvement in required air quality such as would be mandated by the stricter NO$_2$ standards is an increase in the level of benefits assigned to breathers of the air. This is a change in the content (C) component of the property right to clean air. Because a revision of standards implying an increase in air quality means that emitters must bear additional costs in order to comply with new regulations and standards, these amendments represent a change in the direction of the assignment as well. Recall that the direction component of the property right assignment indicates which types of emitters are entitled to use the air.47 In this light, the amendment respecifies characteristics of proper use of the air, implicitly specifying who may and may not use the air in an AQCR.

The cumulative effect of altering the context and direction components of the rights depends on whether it would be more or less costly to comply with the regulations before or after the new regulation is adopted. In the case of the NO$_2$ standard, the impetus for change from the previous annual arithmetic mean standard was the scientific advance recognizing that short-term exposure to NO$_2$ can be hazardous to health. The National Academy of Sciences concluded shortly before the 1977 Amendments were passed that the air quali-

45. 42 U.S.C. §§ 7408(c), 7409(c).
47. See supra text following note 22; supra text and notes at notes 36-38.
ty standard should consist of a short (hourly) standard and a long (yearly) exposure limit. It is quite likely that this new short exposure limit will make it more expensive for stationary sources such as nitric acid plants or stationary gas turbines to comply with the regulations. The increase in total cost of compliance to existing and entering emitters is reflected in the upward shift of the resource cost curve from $RC_o$ to the curve $RC_1$ in Quadrant I of Figure 12.

A shift in the enforcement relation may also occur as a result of this amendment. Recall that a shift in the enforcement curve results from a change in the marginal productivity of enforcement units in ensuring compliance with regulations. Because the costs of monitoring and testing emission levels vary for different types of pollutants, the enforcement planner must recognize that, for one pollutant compared to another, an enforcement team might have to work longer to prevent violations of regulations. Similarly, the expense in terms of enforcement teams may be higher or lower for long (yearly) standards than for short (hourly) standards. Extending enforcement to a new type of emitter is a change in direction of the property rights assignment, since the regulations in effect apply to new types of economic agents entitled to consume the air. The direction change requires a reevaluation of the enforcement effort per dollar of required pollution reduction expense to be borne by the new category of polluter.

The impact of a change in direction may be more easily seen in the context of the new standards for radioactive pollutants. For these standards, enforcers either may have to take greater precautions to avoid contamination in the process of detecting violations, or, for those enforcers not operating in the field, may have to work with particularly complex models of dispersion and interactive effects of radioactive emissions from a given source. The combined effect on the enforcement curve of changes in the direction and content components of the respecified property rights is reflected in the shift from $EUI_e$ to $EUI_{ne}$ in Quadrant II of Figure 12.

A change in the inclusiveness of the assignment may also result from changing standards for emissions of particular pollutants. The adoption of an hourly standard for emission of $NO_2$ may mean that

49. See supra at Figure 3.
50. See supra text following note 25.
Enforcement Planning Curve — Effects of Clean Air Amendments

Key:

\[ R_C^0 = R_C^0; (R_0^0 (D_0^0, C_0)) \]
\[ R_C^1 = R_C^1; (R_0^1 (D_0^1, C_1)) \]
\[ E_{IC}^0 = e_{IC} (x; R_{IC}^0 (D_0^0, C_0, S)) \]
\[ E_{IC}^1 = e_{IC} (x; R_{IC}^1 (D_0^1, C_1, S)) \]
\[ E_{IP}^0 = E_{IP}^0; R_0, R_P^0 \]
\[ E_P^1 = E_P^1; R_0, R_P^0 \]
more emitters will come under the scrutiny of the EPA. This would be a change in the inclusiveness of the property rights assignment, since the rights would be assigned to a different number of emitters. If the marginal productivity of enforcement units is higher when there are fewer firms required to engage in a given dollar amount of pollution reduction, then this change in the inclusiveness of the assignment would shift the enforcement relation as hypothesized in the shift of the enforcement curve from EU₃ to EU₄ in Quadrant II of Figure 12.

Adoption of new standards need not involve a change in the technology of enforcement, that is, the enforcement tools available to the enforcing agency. An example of the type of amendment to the Clean Air Act that might shift the enforcement curve because of a change in the sanction component is the adoption of a new economic penalty for noncompliance. Section 120 of the Act as amended in 1977 provides for the collection of a penalty equal to the economic value to the firm of the delay in compliance, thus eliminating, in theory if not in practice, any gain from noncompliance. A strict penalty such as this adds a more powerful weapon to the enforcement teams' arsenal without much increase in cost. Even the estimation of the amount of cost savings by the violating firm is made at the violator's expense. If this leads to increased compliance by emitters, then the marginal productivity of enforcement units will have increased, as indicated by the shift of the enforcement relation from EU₄ to EU₅ in Quadrant II of Figure 12.

The enforcement planning curve traced out in Quadrant IV of Figure 12 to reflect the impact of these shifts demonstrates the increase in enforcement costs associated with the 1977 Amendments. For instance, for a population of emitters of size N at the time of the 1977 Amendments, the planners take into account an increase in enforcement costs from ECₐ to EC as the enforcement planning curve shifts from EPₐ to EP. This shift in the enforcement planning curve represents the increase in the total cost of regulation enforcement of a given number of emitters under the amendments. Note that the cost of hiring each enforcement input team does not necessarily change when the Clean Air Act is amended; the curve shift from EPₐ to EP occurs independently of such factors. The cost of hiring at-
torsneys, engineers, and their support staffs is determined by market forces outside of the regulator's control. Thus, the enforcement input cost curve in Quadrant III of Figure 13 does not shift.

Congress already requires that the Administrator of the EPA, in cooperation with state, interstate, and local air pollution control agencies, prepare the data needed to make these projections and submit detailed estimates and cost studies to Congress annually. In particular, the Clean Air Act specifies the preparation of estimates for the cost of carrying out the provisions of the Act and a study of the costs of program implementation by affected units of government. The estimates of pollution reduction costs provide basic data for the relevant portions of the resource cost curve in Quadrant I. The enforcement costs depicted in Quadrants II and III necessarily form part of the mandated study of program implementation expense. Ultimately, changes in these areas can be reflected in the enforcement planning curve in Quadrant IV of Figure 12.

E. Some Impacts of Proposed Clean Air Act Amendments

Just as the effect of past amendments can be estimated, the enforcement cost implications of proposed amendments can be predicted. The property rights model can be used to highlight reasons for changes in the level of enforcement costs. In large part, H.R. 5252, rather than amending the existing environmental property rights, amends the way in which rights are established. H.R. 5252 is directed towards the relationship between federal and state agencies in reviewing implementation plans, the role of the states in issuing permits, and the power of agencies to grant extensions of time limits for states to reach pollution reduction goals. None of these concerns is explicitly designed to modify the air quality to

52. Id. § 7612(a).
53. Id.
54. Existing studies on EPA programs as a whole focus more on the expenditures by emitters than on the enforcement cost implications of the strategic interactions between enforcers and emitters. See, e.g., U.S. EPA LEGAL COMPILATION, VOL. V, GUIDELINES AND REPORTS 2399 (Reports to Congress as required by 42 U.S.C. § 7612); COUNCIL ON ENV'TL QUALITY, ENVIRONMENTAL QUALITY VOLS. 1-12 (Reports transmitted to Congress from the President as required by § 201 of the National Environmental Policy Act of 1969, 42 U.S.C. § 4341 (1969 & Supp. 1980). But see Downing & Watson, supra note 8, at 230-33 (where this strategic interaction is explored).
57. Id.
58. Id. § 105.
which breathers are entitled nor is any likely to have direct effects on the level of enforcement costs, even though there may be indirect effects on that level. Thus, the applicability of the basic property rights model used to describe the Clean Air Act regulatory efforts would remain largely unchanged.

The effect on air quality of other changes in rights arising from many of the proposed amendments is not obvious, but even more obscure are the enforcement cost implications of the proposals. Two such changes appear in § 107 of H.R. 5252.\(^{59}\) They are: (1) an amendment permitting five occasions per year during which the maximum allowable increases over baseline concentrations prescribed under the rules for prevention of significant deterioration (PSD) may be exceeded,\(^ {60}\) instead of one occasion as now allowed under § 163(a) of the Clean Air Act;\(^ {61}\) and (2) a redefinition of what constitutes “best available control technology” (BACT) for the purposes of applying PSD and nonattainment rules.\(^ {62}\) The property rights model can be used to evaluate the associated enforcement cost implications of these proposed changes.

1. Exceeding the Maximum Allowable Increases Under the PSD Rules

The rules for prevention of significant deterioration (PSD rules) limit the amount of the decrease in air quality in every clean air region. The procedure under the PSD rules is to specify, in terms of concentrations of various pollutants, an air quality which serves as a reference point. Emissions may increase concentrations of these pollutants, but only by a limited amount, called the “maximum allowable increase” in concentration, over existing concentration levels.\(^ {63}\) State implementation plans were required under the 1977 Clean Air Act Amendments to ensure that actual concentrations exceeded this maximum allowable increase no more than once per year.\(^ {64}\) H.R. 5252 permits the maximum to be exceeded five times per year, which results in a lower resultant average air quality relative to the current law. Nevertheless, it results in a higher

---

59. Id. § 107.
60. Id. § 107(a)(2) (1981).
63. 42 U.S.C. § 7473(a).
64. Id.
resulting average level of quality than occurred under the original Clean Air Act, under which the air was allowed to deteriorate to a level of quality specified in the national standards.\textsuperscript{66}

Property rights analysis of this change under H.R. 5252 follows the same general lines as the analysis of changing air quality standards done previously, except that where the standard for oxides of nitrogen examined above becomes stiffer, this requirement is more lax. Accordingly, the benefits per breather, the level of air quality, declines through this change in the content component of the property right. While the change in investment in pollution reduction may be very slight and few emitters will save a great deal of money (issues to be examined by the policymaker or enforcement planner), a slight change in the requirements for being an emitter in a particular AQCR creates a change in the direction of the assignment as well as a change in content. The main changes in the property rights assignment, then, are in direction and content. The result is that the resource cost curve shifts down slightly from $R_{Co}$ to $R_{C1}$, as shown in Quadrant I of Figure 13, indicating that compliance with the proposed regulations by emitters is less costly. This shift would have a corresponding effect on the enforcement planning curve in Quadrant IV, a shift downward from $E_{Po}$ to $E_{PI}$, indicating that enforcement would be less costly if this amendment were adopted. It is unlikely that this change would have a noticeable impact on the efficiency of enforcement units in preventing violations; thus, the only direct impact on the planning curve comes from the change in compliance cost.

2. Redefining "Best Available Control Technology" (BACT)

As part of the PSD rules, the 1977 Amendments instituted preconstruction review requirements mandating that no major emitting facility be constructed in any area covered by the PSD rules unless the proposed facility is subject to the best available control technology for each pollutant regulated by the Clean Air Act.\textsuperscript{66}

\textsuperscript{65} Thus, air in a clean air area with a baseline twenty-four hour sulfur dioxide concentration of 100 micrograms-per-cubic-meter ($\mu g/m^3$) would be allowed to deteriorate in quality to 365 $\mu g/m^3$, the national primary air quality standard, 40 C.F.R. § 50.4, before the PSD rules, 42 U.S.C. Subchapter I, Part C, were adopted in 1977 but only to 105 $\mu g/m^3$ under the PSD rules, 42 U.S.C. § 7473(b)(1). A one-time per year exceedence of this 105 $\mu g/m^3$ standard is permitted under the present Clean Air Act, 42 U.S.C. § 7473(a), but the amendment would allow this maximum allowable increase to be exceeded five times per year. H.R. 5252, 97th Cong., 1st Sess. § 107(a)(2) (1981).

\textsuperscript{66} 42 U.S.C. § 7475(a)(4).
Enforcement Planning Curve — Shift Accompanying Amendment to Five Exceedences per Year

Key:
- $RC^0 = RC^0; R^0(D^0,C^0)$
- $RC^1 = RC^1; R(D^1,C^1)$
Under those Amendments the "best available control technology" was "an emission limitation based on the maximum degree of reduction of each pollutant ... which the permitting authority, on a case-by-case basis, ... determines is achievable for such facility" taking a variety of costs into account. By contrast, H.R. 5252 redefines "best available control technology" as the applicable standard of performance established under section 111 of the Clean Air Act, which sets forth general standards of performance for new sources (NSPS) and section 112, which establishes national emission standards for hazardous air pollutants under the Act. Under those sections, standards of performance are determined for categories of sources so that the best system of continuous emission reduction is not determined for each source individually but for all sources of that type as a group.

67. Id. § 7479(3) (emphasis added).
68. Id.
70. Id. § 7412.

Under S 112 the Administrator establishes general standards for hazardous air pollutants which, without a waiver, no emitting source may violate and for which no source specific work practices may be adopted.

In Northern Plains Resource Council v. EPA, 645 F.2d 1349 (9th Cir. 1981), the Ninth Circuit relied on this case-by-case determination to permit two coal-fired electric power plants to use a scrubber technology to reduce emissions instead of the more sophisticated baghouse control system. As the court stated:

The EPA is [sic] promulgating an NSPS [new source performance standard under Section III] is also obligated to take into account the 'costs of achieving such emission reduction and any nonair quality health and environmental impact and energy requirements.' Section III(a) of the Act, 42 U.S.C. § 7411(a). That examination, however, can only be a generalized consideration of the technology and its effects on those factors based on data from many varied sources. Under the PSD program, the BACT determination is supposed to be source-specific. What may be applicable to
Given that the section 111 review is general and represents data for a variety of plants of a given type, there are likely to be some stationary sources that would do better than average and others whose appropriate level of control would be lower than average, considering cost and meteorological factors. The effect of this change from a case-by-case approach to a category-based standard would depend on whether the EPA has used the case-by-case approach more to stiffen requirements or has used it more to relax them.

It is clear that in practice emitters have relied on the provisions in section 169(3) to obtain exemption from the stiffer general requirements of section 111. In *Northern Plains Resource Council v. EPA, (Northern Plains)* the Ninth Circuit Court of Appeals held that the EPA had a rational basis for permitting an emitter to adopt a wet scrubber technology rather than a more sophisticated baghouse control system to reduce particulate emissions from a coal-fired electric utility plant. The wet scrubber technology was held to be BACT even though it permitted “a particulate matter emission rate in excess of the 1978 NSPS regulations and . . . [was] surpassed by known baghouse technology.” According to the court, employing more sophisticated technologies in conjunction with the wet scrubber would have involved “a great deal of additional expense for a very small increase in particulate removal.”

Assuming that the application of section 169(3) in this case is typical, the enforcement cost implications of the H.R. 5252 amendment of this section can be explored.

To the extent that case-by-case review of BACT under section 169(3) permits the relaxation of pollution reduction standards, H.R. 5252 precludes such relaxation by proposing category-based BACT standards tied directly to established control levels in the Act. Following the *Northern Plains* example, repealing section 169(3) would result in a small change in the content component of the property rights and a major change in the direction component. Under the case-by-case review of BACT in *Northern Plains*, air quality most plants may not be appropriate for a particular facility. The EPA under its regulations is obligated to assure that an individualized inquiry is made on the matter.

---

645 F.2d at 1359, n.29.
73. 42 U.S.C. § 7479(3).
74. 42 U.S.C. § 7411.
75. 645 F.2d 1359 (9th Cir. 1981).
76. 645 F.2d at 1360. The 1971 NSPS regulations were determined to be the applicable ones and the facility did meet that lower standard, 0.10 lbs. per million BTU in 1971, as opposed to 0.03 lbs. per million BTU in the 1978 NSPS regulations.
77. Id. at 1361.
would decrease somewhat as a result of the use of the wet scrubber technology over more advanced technology. Eliminating this less sophisticated technology as an alternative, as section 107(d) of H.R. 5252 seems to require, would yield higher air quality, though the increase might be very small. The level of benefits to breathers of air, the air quality, is still embodied in the content component of the property rights assignment. The direction component indicates what types of emitters may operate in the AQCR. The H.R. 5252 amendment indicates that only those operators complying with the section 111 BACT definition will be allowed to construct new plants. As a result of the changes in direction and content, the resource cost curve shifts from RC\textsuperscript{o} to RC\textsuperscript{1} in Quadrant I of Figure 14. The shift in the resource cost curve from RC\textsuperscript{o} to RC\textsuperscript{1} in Figure 14 illustrates the Ninth Circuit's observation that this increase in air quality comes only at "a great deal of additional expense."\textsuperscript{78} This effect on the resource cost curve accounts for the shift in the enforcement planning curve from EP\textsuperscript{o} to EP\textsuperscript{1} in Quadrant IV of Figure 14.\textsuperscript{79}

The mere requirement of more expenditure by emitters on pollution reduction without any corresponding change in the efficiency of enforcement teams would imply a movement along the EU\textsubscript{ii} curve from eu\textsuperscript{o} to eu\textsuperscript{1} as the content of the right to produce (and pay for) reduced emissions changes, reflecting increased expenditure. The enforcement planning curve would not be affected. The adoption of one technology for control rather than another, which the H.R. 5252 amendment requires, may, however, have an effect on the efficiency of enforcers of the rights to clean air. If enforcement teams spend less time ensuring that each dollar of pollution reduction expense is borne by the emitters as a result of this amendment, then the enforcement curve will shift up and to the left, as from EU\textsubscript{ii} to EU\textsubscript{iii} in Quadrant II of Figure 14. To determine the likelihood of such an in-

\textsuperscript{78} Id.

\textsuperscript{79} In the environmental context, any increase in emitters' expenditure that affects air quality always affects both the direction and content components of the right. Yet, these components are not inseparable. An increase in expenditures that does not affect air quality, as an emitter opposing a regulation might allege, would affect only the direction of the assignment. For the purely private good, the lollipop, we would have a change in content which would shift the resource cost curve even without a change in direction, if each of the ten individuals allowed five minutes of lollipop-licking time had their allotments increased to ten minutes, thereby requiring additional units of the good, lollipop. The same is true with some congestible goods such as the candle; longer availability of candlelight to each entitled person would require production of additional units of the good, candle. It is because the emitters both diminish air quality (as users) and increase air quality (as producers of pollution reduction) that the simultaneous changes in direction and content appear in the Clean Air Act context.
Enforcement Planning Curve —
Shift Accompanying Amendment of PSD BACT Definition
crease in efficiency, the direction component of this rights assign­
ment must be examined, since those operators affected must now
use a new technology.

An immediate effect on enforcement would coincide with the
switch from the case-by-case analysis to determine the best technol-
gy for each new stationary source to the ascertainment that a new
source is installing the best available control technology for that
category of sources as predetermined by sections 110 and 112 of the
Act. In that case each enforcement team would require less time to
evaluate whether qualifications for permits are met. Whether, in
general, this would be a large or small portion of preconstruction
review effort is difficult to say a priori, but the direction of such an
effect would be reflected in the shift from EU₁ to EU₂ in Figure 14.
This shift, combined with the changing resource cost curve, would
yield a new enforcement planning curve, EP₂ in Quadrant IV of
Figure 14. This curve represents the enforcement planning curve
under H.R. 5252 by accounting for the expected efficiency of en-
forcement under the category-based approach to BACT.

Once a given standard and technology are applied and in place,
there will likely not be any great change in enforcement as regards
the detection of violations. The scrubber technology, in which par-
ticles are separated from emissions by first dampening the emissions
with a spray of water and then settling the particles out of the water
by the use of settling ponds, is quite different from the baghouse
system, which removes particulates from emissions by passing the
exhaust gas through filters in an enclosed area.80 In either case,
however, the detection of a violation of performance standards
depends on the quantity of particulates still present in the emissions
after passing through the different devices. Federal regulations
specify one method for determining particulate concentration that
does not appear to depend on removal technology.81 This suggests
that the detection portion of the enforcement process would be no
different after the H.R. 5252 amendment. Enforcers would be equal-
ly efficient in detecting operating violations of the standard, and so
compliance inspection efforts should not change.

In some cases, however, the EPA might require that the emitter
adopt "a design, equipment, work practice, operational standard, or
combination thereof" instead of a uniformly applicable emission

80. See Nat'l Lime Ass'n v. EPA, 627 F.2d 416, 424-25 (D.C Cir. 1980) (comparing these
techniques).
standard as discussed in the above situation. Inspections to determine compliance with such specification standards as work practices are likely to be quite a different process from inspections of emissions to establish compliance with a predetermined level of particulate emission. Although the same type of enforcement team (engineer-lawyer with support staff) is involved, work practice compliance inspection will entail greater inspection efforts. The relative efficiency of enforcement units in ensuring compliance under the different approaches would be reflected in the enforcement curve. An amendment eliminating a work practice or operational standard which is difficult to enforce as an option would shift the enforcement curve up and to the left as from EU\textsubscript{\textit{a}} to EU\textsubscript{\textit{b}} in Quadrant II of Figure 14, with a corresponding effect in the enforcement planning curve.

Application of the PSD rules BACT definition would not always result in relaxed standards for new sources, even though Northern Plains indicates that such a result can occur. Section 7479(3) of the Clean Air Act requires that “no event shall application of 'best available control technology' result in emissions of any pollutants which will exceed the emissions allowed by an applicable standard established pursuant to section 7411 or 7412,” implying that, whenever possible, the BACT controls will be more stringent. The higher cost associated with meeting a more stringent standard would be reflected both in a change in the content and direction of the right to emit pollutants and in a shift of the resource cost curve in the opposite direction of that suggested by the Northern Plains analysis, resulting in greater pollution reduction cost and greater enforcement cost. (Compare R\textsubscript{1} with R\textsuperscript{c}; EU\textsubscript{\textit{a}} with EU\textsubscript{\textit{b}} in Figure 14.)

F. The Optimal Level of Enforcement of Clean Air Act Provisions

Recall that in contemplating the resource cost curve, the discussion focused on the right to \textit{usus}, or the right to consume the resource in question and thereby decrease its available quantity. In the Clean Air Act context, only the enforcement of the right to \textit{usus fructus}, the right to obtain the returns due from productive activity,

---

82. 40 C.F.R. § 52.21(b)(12) (1982).
84. 645 F.2d 1359 (9th Cir. 1981).
need be described. This is true in the context of controlling externalities such as pollution because ensuring that the emitters appropriate the returns from the reduction in air pollution also ensures that breathers benefit from clean air. The strange nature of the right to usus fructus in this regulatory context is, however, that the returns to productive activity are negative. The emitters must produce the good, pollution reduction, and bear the costs of doing so. The returns appropriated in this context, then, are negative. It is because returns are negative, that is, because emitters must bear the costs of pollution reduction, that they must be forced to produce. Once this production takes place, however, breathers, who do not then interfere with each other's simultaneous consumption, cannot be excluded from reaping the consumption benefits from clean air.

In the context of usus fructus, the content component of the right indicates the benefits to which polluters are entitled, or, in other words, the returns to their productive activity. There are likely to be two sources of negative returns to the emitters; the costs of pollution reduction itself, and the costs associated with the enforcement process. The degree of protection of the breathers' right to clean air chosen by the enforcers will depend, among other things, on emitters' responses to regulatory requirements.

Current models of emitters' incentives to comply focus on the producers' desire to minimize the sum of expected costs of control devices and the expected costs of compliance and enforcement actions imposed on the firm. The cost of control devices includes all of the components measured on the vertical axis of the resource costs curve — capital and installation costs as well as operation, maintenance, monitoring, and certification costs. The expected compliance cost is a function of the number of violations detected by the enforcers times the anticipated penalty per violation. Because the producing firm has a choice of bearing either the cost of compliance or the cost of penalties, the content component of the right to usus fructus will be affected by regulations altering either cost. The precise impact of the content component on the enforcement curve can only be determined by reference to models of behavior for the firm and for the enforcer.

The solution to the question of what is the optimal response by an

87. See Downing & Watson, supra note 8, at 228-33.
enforcement agency to a producing firm’s behavior requires a model of the interaction of the decisionmaking of two economic agents, which is outside the scope of this article.88 It can be said, however, that for a given set of property rights and behavior by the enforcers, the firm can adapt its behavior to minimize costs. The enforcement agency, for a given set of property rights and behavior by the firm, also can minimize its cost, which equals the sum of enforcement expenditures and the harm resulting from violations. Generally, the determination of the optimal level of enforcement follows the net gain maximization model discussed above in section III.B. The rational enforcer would invest in additional units of enforcement (in the H.R. 5252 example, by reducing the number of allowable exceedence occasions in AQCRs or by making standards more stringent according to the definition of BACT) until the incremental cost of increased enforcement equals the value of the harm prevented. As in the general model, the marginal conditions for maximizing the net gain function would be satisfied at some point coinciding with less than full enforcement, and some violations would be expected. Similarly, for a given set of regulations defining the right to usus fructus producing firms would maximize the net benefit of the property rights assignment by minimizing their costs (cost of control devices and cost of compliance versus cost of penalties). It is the interaction of the behavior of enforcement agencies and producing firms which ultimately determines the optimal level of enforcement of property rights in the Clean Air Act context.

As the content component of the right to usus fructus changes, the optimal enforcement and noncompliance positions of control agencies and producing firms change. The precise interaction of changes in the relationships affecting decisionmaking is unknown. As in the general optimal enforcement model, this shift could depend on any number of factors affecting incentives to violate or comply with regulations, such as increased penalties; or incentives to enforce regulations, such as the newfound awareness of health benefits or even political benefits to be derived from strict enforcement. All of these variables can be reflected in a change in the enforcement planning curve.89

88. But see, for instance, the attempts by Gary Becker, supra note 9, to model this process. It may be necessary to resort to the variety of models of duopoly behavior to predict the outcome of this interactive process. If so, the industrial organization and pricing literature will be a relevant input to the environmental policymakers’ decision process.

89. See supra discussion at section III.

V. Conclusion

The model presents a tool for breaking down institutional structures into parts small enough to enable fruitful examination. Rights assigned to various types of economic agents have been separately considered. The rights to *usus* and *usus fructus* are defined in such a way as to make them useful in analyzing various changes in institutions. The definitions distinguish between individuals on the basis of the nature of their relationships to property rather than by other traditional economic categories such as rich versus poor or utility maximizers versus profit maximizers. As such, it fits squarely within the standard set for property rights theory by Furubotn and Pejovich. The model describes how the content of property rights affects the allocation and use of resources in specific and predictable ways by elaborating on one side of the cost-benefit analysis which determines how property is to be used and how public policy relating to resource use can rationally be formulated. It uses the logic of economics to explain the development of property rights, including the nature of changes in their content. To provide this explanation, the model focuses attention on how institutional structures embodying property rights assignments may be viewed as responding to the problem of minimizing the cost of ensuring compliance with those property rights. By empirically estimating the relationships described here, administrators and policymakers can more rationally assess alternative structures for achieving various policy goals. Various systems can be compared according to the benefits likely to accrue from each and the costs of enforcement of each.

A comparative statics model has been developed to describe how the level of costs of enforcing environmental regulations would respond to various amendments to the Clean Air Act. By viewing amendments as changes in property rights, the model has focused attention on how the institutional arrangements created by the Clean Air Act regulate the interaction between economic agents with respect to the resource in question — pollution reduction, or clean air. The interactions take place in two general contexts of relevance to the level of enforcement costs. The first is the relationship between supply of the good, pollution reduction, and consumption of the good. This relationship is described by the resource cost curve, which reflects consumption characteristics of the good by functionally relating the number of emitters in an AQCR to the number of

90. Furubotn, *supra* note 1, at 1137.
units of the good, here measured in dollars of pollution reduction, required to provide a given level of benefits to each breather. Second, the enforcement curve describes the interactions between suppliers (producers) and the agents responsible for enforcement. This curve reflects the resource commitment necessary to ensure compliance with the rights assigned with respect to *usus fructus*, here the perverse right to bear costs of pollution reduction. An attempt has been made to capture the relevant influences of this institutional structure on the interactions of enforcers and producers in the components of the related property rights: direction, inclusiveness, content, and sanctions.

This multidimensional approach to property rights theory can be contrasted with previous contributions to the property rights literature which focused in large part on the public versus private nature of ownership of resources. In the environmental area, for instance, so-called property rights solutions to environmental problems involve converting common property resources such as air and water into privately owned resources by means of schemes permitting a market for exchangeable pollution rights. The focus here is not only on form of ownership, which is captured in permissible simultaneity of consumption, that is, in inclusiveness, but also on other policy variables such as the characteristics of permitted use, and the characteristics of how rules governing type and simultaneity are to be enforced to ensure that the benefits accrue to the designated parties.

This approach to public goods theory can be contrasted with traditional public goods theory. Characteristics of jointness and nonexcludability have traditionally been associated with goods. This article emphasizes that both characteristics are affected not only by inherent characteristics of the good but also by the legal milieu in which these goods are consumed and produced. For instance, the jointness property associated with a good will be determined not only by how many users can simultaneously consume a given number of units for the good without decreasing the benefits received by others but also by what types of users are legally permitted to consume. The nonexcludability characteristic of a good is here interpreted as more than the technical inability to prevent people from reaping the benefits of another’s productive activities, which is the traditional view. It also includes the legal inability of the appropriate economic agent to acquire payment for the productive services. In the model developed here an institutional or legal notion of jointness and nonexcludability
is combined with traditional economic notions and with a theory of the characteristics of property rights.

Combining these assorted tools of economic theory allows the policymaker to sort out the factors influencing the cost of enforcing property rights protected by regulatory agencies. The model, properly applied, reflects the actual structure of regulatory policies and incorporates the interaction between enforcers and violators of rights. The conceptual foundation is broad enough and the model is flexible enough to apply to the enforcement of rights to private goods as well as to the congestible public good analyzed in this article, thereby introducing a basic theory for anthropological, sociological, and economic studies of the enforcement of property rights.