Full Title: Towards an updated theory of property rights

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Abstract

Property rights have an important impact on economic exchange, since their assignment, in combination with the corresponding governance regimes in place to enforce those rights, structure the interaction of actors in the market. As Demsetz articulated, new property rights emerge in response to adjustments in economic values associated with changes in the market that affect the relative costs and benefits of the internalization of externalities (Demsetz, 1967). Theoretically sound, his theory obviates the question of sustainable scale by its implicit assumption of the absence of trade-offs between increased economic activity and environmental degradation. New

developments in the understanding of property rights and the ecological impact of economic activity necessitate a reformulation of Demsetz' seminal property rights theory.

Replicating Demsetz' article structure, this paper is organized into three sections. The first discusses advances in the theoretical understanding of the concept and role of property rights in organizing social systems. Section two updates the investigation into the emergence of property rights through an ecological economics framework. The final section outlines some principles relevant to the bundling of property rights and the appropriate ownership and governance structures associated with these bundles, in light of the Rio+20 focus on sustainable development, with particular attention paid to the Common Asset Trust framework. Grounding the discussion of property rights regimes in the empirical case of groundwater governance in the state of Vermont, the author traces the evolution of property rights in groundwater from open-access to private to correlative to common.

Keywords: property rights, common asset trust, ecological limits, future generations

Introduction

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1. Concept and Function of Property Rights

Property rights are instruments of society that help decision units to form expectations with respect to other decision units, and to specific resources. More specifically, property rights specify who benefits, who is harmed, and who pays who in order to modify action that transgressed a property right. In this paper, I will maintain accordance with Demsetz' primary assumption that the main allocative function of property rights is the internalization of beneficial and harmful effects. However, I will expand on the analysis by including a review of the property rights literature that builds off of Demsetz, with particular attention paid to resource

characteristics, types of externalities, and the definition of efficiency. I will include a discussion of how property rights are protected, a concept inextricably linked to how the property rights emerge.

According to the property rights literature, market transactions are not defined by the exchange of the goods and services involved, but rather the exchange of the rights to the benefit stream provided by that good or service (Alchian and Demsetz; Demsetz, 1967; Furubotn and Pejovich, 1972). The assignment of property rights allows us to determine who has the current right to the benefit stream of the good/service in question, who has the right to limit another actor's rights to that benefit stream, and who has the responsibility to compensate whom when one actor's actions affect the benefit stream of another. Without a social contract serving as an enforcement mechanism, however, property rights have no standing. Therefore, society must determine who holds which rights, which bundles of rights are assigned to what goods/services, and how those rights are to be enforced.

Our definition of property and property rights has broad implications for how markets will function, and how we will measure efficiency, distribution, and scale. A property right, broadly defined, "is an enforceable authority to undertake particular actions in a specific domain." (Commons, 1968) This implies that property rights are not relationships between people and objects, but rather the combination of economic and social relations that outline the position of persons with respect to a particular benefit stream (Furubotn and Pejovich, 1972). In essence, property rights are social constructions that reflect views about the relative value and scarcity of specific resources (Bromley, 1991) and clarify expectations with respect to degree of control over specific resources (Demsetz, 1967).

Property rights are correlative: to one actor is an assignment of a right to a benefit stream, to another is the assignment of a duty to not interfere with that benefit stream. Whereas the property rights holder maintains exclusive rights to benefit stream in question, this could represent a single private owner, the state, or a collection of individuals. The duty-bearers represent all other actors in the economy, since they all forgo a claim to that benefit stream. Modern property rights scholars discuss the importance of clearly defining these property rights through contract (Barzel, 1989; Libecap, 1986)

The question naturally arises regarding how the rights will be enforced and how transgressions of rights will be mediated. In the absence of some sort of enforcement mechanism to protect the social contract, property

rights have little value or function. Therefore, society must determine who holds which rights, which bundles of rights are assigned to which goods/services, and how those rights are to be enforced. Figure 1a illustrates the full extent of any property right, consisting of the quadrilateral relationship between the benefit stream, the rights-holder, the duty-bearers, and the enforcement mechanism (Bromley, 1991).[1] An individual's right to a specific benefit stream, however, cannot be analyzed in a vacuum. The extent of any given right-holder's right to a benefit stream depends on how actions in that domain interact with other rights in other domains.[2]

Figures 1a. Figure 1b.

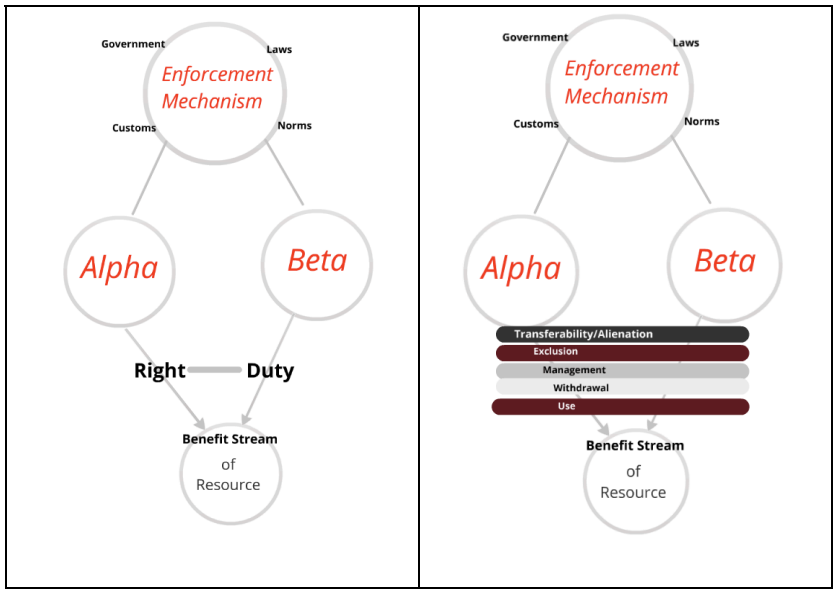

Figure 1a. Visual representation of the quadrilateral relationship between economic actors, the benefit stream, and the enforcement mechanism. *Figure 1b.* Key rights bundles for common-pool resources, as described by Schlager and Ostrom, overlaid on 1a.

In some cases, these rights are well-defined, but not always. It is important here to discuss a series of legal correlates (Bromley, 1991; Commons, 1968; Hohfeld, 1917). Up to this point, we have focused simply on the rights-duty correlate. In a case where property rights are not well-defined (ie. No contract exists), however, one party is said to have privilege if they can appropriate the particular benefit stream, while the other actor is denied rights. For example, if a factory disposes of chemicals in a river, which negatively impacts the fish

[1] It is important to note here that the enforcement mechanism represents any governance structure within which enforcement of the property rights can happen. This includes private, state, and common property regimes. Accepted norms and cultural mores compose part of the enforcement mechanism. Section 3 of this paper further discusses these different property rights regimes.

stock and hence the recreational fishermen. Neither the fishermen nor the factory have the explicit right to a certain quality of water in river. The factory owner, however, can dispose of its waste in the river, which negatively affects the fishermen. The factory owner has presumed the right to affect the quality of the river, which is a privilege. The fishermen, with no recourse, are said to be without rights. The quality of the river in this case is the benefit stream, which nobody currently has a property right over. In this situation, there is an absence of rights of existence. In the property rights literature, this situation characterizes an open-access regime, in which property rights are not clearly defined. Barzel discusses the constant flux of appropriation of rights to specific benefit streams from open-access status.

If society was to declare that property rights to the river quality should exist, the question then becomes, who should get those rights. In much of the early modern property rights literature, the initial endowments were deemed irrelevant (Coase, 1960; Demsetz) as long as the rights were clearly defined and transferable. New property rights would naturally emerge as economic actors sought to maximize the value of resources (Demsetz, 1967), and market trading would lead to the most efficient outcome (Furubotn and Pejovich, 1972). In essence, according to modern economic property rights literature, society should not determine who gets the rights, but rather, should create the enabling environment in which rights can be traded in order to allocate the resource to the highest value use. Several authors have recognized that wealth effects are an integral part of the analysis.

These early economic models assumed that zero transaction costs (Alchian and Demsetz, 1973; Coase, 1960; Demsetz, 1967; Furubotn and Pejovich, 1972) obtained. Subsequent modern property rights theorists have expounded upon models with positive transaction costs that still recognize the tendency of property rights to emerge for the purpose of efficiency (Barzel, 1997; Eggertsson, 2003; Libecap, 1989). Namely, rational actors attempting to maximize profits will seek to reduce transaction costs wherever favorable. This increases economic efficiency. It has been noted, however, that the efficiency of property rights arrangements is situation-specific (Eggertsson; Larson and Bromley, 1990). Although some have argued that changes in constraints that increase the ability for individuals to trade by definition represents an efficiency gain (Buchanan, 1988), others note that some government intervention that restricts certain property rights may

actually increase welfare by reducing uncertainty and therefore strengthening the functioning of the price mechanism (Barzel, 1997).

This leads us to the primary distinction between legal property rights and economic property rights. Although inextricably linked, economic property rights deal more specifically with the right-holders claim to the economic benefits derived from their management of the resource (Barzel, 1997). This distinction is extraordinarily important, and lays the foundation for takings law.

The modern property rights literature builds from the four basic postulates of economic theory and maintains the individual as the primary unit of analysis (Anderson and McChesney, 2003).[3] Many scholars have questioned whether marginal analysis is appropriate in all circumstances, namely in the presence of irreversibilities or public goods (Bromley, 1991). The assignment and definition of property rights is a policy decision that effects the potential definition of efficiency within the market economy. In essence, when society grants a specific user or group of users property rights to a specific benefit stream, it imposes a duty on the rest of society to respect that right. Otherwise put, it denies the rest of society the right of use of that benefit stream. Furthermore, these reciprocal rights and duties become obsolete without an enforcement mechanism—a third party that governs disputes between competing conceptualizations of property rights.

As discussed earlier, property rights are often bundled together. In the property rights literature, ownership of a resource is equated with the possession of a particular bundle of property rights. Though variations exist in description of the bundles (Demsetz, 1967; Furubotn and Pejovich, 1972; Libecap, 2009; Schlager and Ostrom, 1992), there is general agreement that the bundles consist of three elements: 1) use rights; 2) usufructory rights; and 3) alienation rights. Further differences persist as to which combinations of rights are necessary to maximize efficient use of resources (Libecap, 1989; Schlager and Ostrom, 1992).

Demsetz discusses that the primary condition to achieve internalization of externalities is the establishment of a clear ownership title that can be exchanged. Ownership has been defined as "consist[ing] of the right to use it, to change its form and substance, and to transfer all rights in the asset through, e.g. sale, or some rights

[3] "1. Individuals choose under conditions of scarcity; no one has as much of the world's riches as he would like. 2. Individuals act rationally to pursue their self-interest by continually adjusting to the incremental marginal benefits and incremental costs of their actions. 3. Scarcity and rational behavior result in competition for resources, and societal rules govern how this competition proceeds. 4. Given individual rationality and self-interest, a system of well-specified and transferable property rights encourages positive-sum games with mutual gains from trade."

153 through e.g., rental." (Furubotn and Pejovich, 1972). However, most authors acknowledge that clear
154 ownership title should not be interpreted as unrestricted rights (Demsetz; Furubotn and Pejovich).
155 Situations often arise where multiple parties have rights to different slices of the same resource—conflicting
156 rights to different aspects of the resource itself and the benefit stream theretofore derived (Bruce et al.,
157 1993). These 'tenure niches' can span temporal, area, technology, and use attributes (Bruce et al.). Empirical
158 studies suggest, however, that ownership, as previously defined, is not as important as control over possible
159 uses of the resource (Ostrom, 2003). Some have suggested that the very definition of ownership must include
160 the concept of control, and a debate continues as to whether ownership should be defined by residual control
161 rights or residual benefits rights (Mahoney, 1995).

162 Leaving aside for now the question about whether alienability is necessary to achieve efficiency, which we
163 return to in section 2, we take a closer look at the bundles of property rights. Ostrom and Schlager specify
164 two classes of property rights that include five distinct property right types obtaining in common-pool
165 resource situations. Figure 1b shows these five categories overlaid on our conceptual understanding of
166 property rights. Importantly, different types of resource users have different types of property rights.
167 Operational rights include the rights to use and keep the yields from a resource, while collective-choice rights
168 describe the rights to change the shape, form, and location of a resource, including the rights of exclusion and
169 alienability.

170 An important conceptual layer introduced by Ostrom is the distinction between the rights to the resource
171 itself, or to the resource units. In the case of a lake, for example, my right of access could include any number
172 of non-subtractive uses, such as swimming or canoeing. The rights of withdrawal include rights to extract
173 resource units from the resource, such as irrigating water to water my crops.

174 Management rights are constrained by the conflicting property rights with owners of other benefit streams of
175 the lake. For example, my management decisions regarding the lake may impact another party in another
176 part of the watershed. The ability to manage a resource heavily impacts the ability to increase the value of
177 that resource. Furthermore, the exclusion rights allow me to determine who may or may not enter, or
178 benefit from, the lake. Finally, with alienability rights one can benefit from incremental changes in values by

allowing the owner to transfer the rights to the resource to another party. This final right of transferability creates conditions for mutual gains through trade.

We begin to see that property rights, by definition, convey the right to bestow effects on others whether positive or negative (Demsetz, 1967). An externality is an effect, whether a cost or a benefit, on another party not involved in the decision-making process. Theoretically externalities exist because the cost of 'internalizing' the effect into the current decision-making process exceeds the benefits of doing so. Therefore, if the full costs of the transaction were to be internalized, the excessive costs would prevent the proposed transaction.

At this point, the foundation for the discussion has been laid out. We can see that property rights serve an important stabilizing function in society, by shaping relations amongst persons and thus framing the discussion about what an efficient outcome would look like. We now turn to a discussion about how these rights actually emerge in a society, and the tools that a society has to protect those rights.

2. Emergence of Property Rights

Changes in knowledge, whether in information or in technology, produce changes in production functions, market values, and aspirations (Demsetz, 1967). Generally, old property rights assignments which came into existence with a different set of information about technology and markets, change when economic values change. Demsetz hypothesizes a natural evolution of property rights emerging to achieve greater economic efficiency. I modify this hypothesis, claiming instead that property rights emerge to address market failures, imperfections, and missing markets as new information becomes available. Thus, Demsetz' claim fits inside of this expanded hypothesis, but recognizes that the efficiency criteria is insufficient to explain all changes, or lack of changes, in property rights. The expanded hypothesis contextualizes economic analysis, framing the economy as a subset of the social system, and the social system as a subsystem of the global ecosystem.

Modern property rights theory, as discussed in the previous section, evaluates property rights on the extent to which they increase economic efficiency by facilitating the allocation of resources to their highest value use. This view of efficiency, and its implicit normative assessment of value, remains wed to an un-contextualized marginal analysis that does not recognize biophysical limits to economic activity. In an effort to correct this bias, I propose the

integration of property rights analysis within the tiered economic framework of achieving sustainable scale, just distribution, and allocative efficiency. Ecological economists have recognized that the natural environment's capacity to serve as both a source and sink for economic activity necessarily bounds the potential size of the economy. In a world of abundant natural resources and limited economic activity, costs associated with the internalization of externalities greatly outweigh the benefits of externalization. As the scale of economic activity pushes up against ecosystem carrying capacity, the costs of externalization begin to exceed the costs of internalizing them. Modern property rights assignments and regimes are ill-equipped to adapt to this current reality, resulting in economically-inefficient outcomes and a systemic inability to enable the development of a green economy.

Where Demsetz argues that changes in technology or the emergence of new markets are the external factors that would necessitate a change in property rights, I would add to this list the carrying capacity of the environment. In the theoretically assumed case of unlimited natural resources, unlimited supplies of energy, and unlimited waste absorption capacity of the environment, the inclusion of this concept would be rendered irrelevant. However, as many have pointed out (Boulding; Daly; Georgescu-Roegen, 1977; Soddy, 1921), the size of the economy is by definition bound by the limits of the earth's capacity to provide the raw materials for economic activity, the sinks to absorb the waste byproducts of that activity, and amount of energy required to perform those transformations of raw material into more usable forms.

Economists view institutions as exogenous parameters. Therefore, the potential calculations of economic efficiency are bounded by the institutional rule structures in existence (Libecap, 1986; North, 1990; Ostrom, 1988). In the event that property rights are redefined, this changes the institutional rule structure. Therefore, calculations of optimal efficiency are highly dependent on the overarching rule structure (Bromley, 1991). As Demsetz points out, however, shifting societal relations change relative values, thus necessitating changes in property rights and rule structures. These rule structure changes comes about in order to increase economic efficiency, since within the status quo arrangement, the costs of internalizing the externalities exceeds the benefits of maintaining them.

Several detailed empirical studies have traced the emergence of property rights (Libecap, 1986; North, 1990). The studies find that efficiency concerns, by themselves, do not necessarily promulgate changes in property rights. Instead, they find that institutional arrangements and the power of actors are particularly important in preventing such changes. Economically efficient outcomes, they find, are the exception, discounting

Demsetz' "overoptimistic" description of property rights emergence. Property rights remain constrained by current technological capacity and current institutional arrangements.

Demsetz contends that economic value optimization is the driving force. This is true in raising the issue of previously unidentified externalities. But then it passes to the negotiation of actors to determine how best to assign rights. Institutional structure matters here: current distribution impacts structure of rights chosen. This means that Pareto optimality measures of efficiency are not a valid form of measuring efficiency. Pareto efficiency criteria has been attacked on multiple fronts, as inherently normative (De Alessi et al., 2003) or particularly distortive for failing to account for initial endowments (Bromley). Attempts at a positivist approach to measuring efficiency claim that any adjustments to previous constraints that increase the ability for individuals to trade by definition represents an efficiency gain that can be measured absent distributional bias (Buchanan, 1988). This approach has of course received criticism for its own normative bias about what constitutes efficiency and the potential scope of the market price mechanism.

Early property rights literature extolled private property rights, and the power of the price mechanism, in helping transfer resource to highest value use and encourage long-term investment (Alchian and Demsetz, 1973; Coase, 1960; Demsetz, 1967; Furubotn and Pejovich, 1972). Later studies found that no single property regime could be predetermined or applicable in all situations (Eggertsson and Eggertsson, 1990; Libecap, 1986), though analysis revealed an implicit recognition of the price mechanism in determining value of the resources in question. The revealed preference of prices in the market assumes the existence of two voluntary actors. If a trade occurs, the theory postulates that both sides are inherently made better off, since nobody would enter into a trade if it made them worse off.[4] A theoretical problem arises, however, when we extend the analysis of rights inter-temporally to include future generations.

As discussed above, a contextualized economics would take into account the concept of sustainable scale. The concept of sustainable scale places a normative bias in favor of the minimization of negative anthropogenic effects on the global ecosystem, and implicitly recognizes a belief that future generations should inherit a world in which they can survive. Carrying our discussion of rights forward, this implicit recognition requires

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[4] Behavioral economists have found that this assumption often does not hold true, and that many consumer decisions do not follow the assumptions of the rational actor.

the question: do future generations have the right to inherit resources of a particular quality? If the answer is no, the following discussion is moot.

A solid argument can be made in favor, however. For most of human history, change was too slow to measure. With the industrial revolution, change sped up, but in general we saw a gradual improvement in quality of life, and the expectation that each generation would be better off than the one before. We now see that our activities are imposing negative externalities on future generations. Inalienable property rights for future generations would help eliminate this externality. (Heilbroner)

Therefore, if we entertain the idea that future generations actually have a right to a certain environmental quality, that right would correspond with the current generation's duty to respect that right. At present, the current generation appropriates resources with relative impunity from future generations, exerting their privilege over management of those resources. The privilege of the current generation corresponds with the absence of rights of future generations. (Bromley, 1991)

Analyses in the modern property rights tradition (Barzel, 1989; Demsetz, 1967) postulate that in the presence of private property rights, the interests of future generations is taken into account through the net present value calculations of the resource. This, however, grants the determination of value to the current generation (Bromley, 1991). It has been noted, however, that actions taken today create path-dependent consequences in the future that would dramatically adjust cost-benefit valuations, and no appropriate assessment of that future value is warranted (Krutilla, 1967). Furthermore, analysis has shown that the optimal strategy in both private and common rights regimes could be liquidation and destruction of the resource (Larson and Bromley, 1990).

At a microeconomic level, optimal economic efficiency is considered the point at which marginal benefits equal marginal costs. Marginal analysis is inadequate for addressing ecological thresholds, beyond which spontaneous degradation of the system takes place, with uncertain outcomes, and often with a significant time lag between human activity and ecological outcome. Thus, reliance on marginal analysis, by definition, does not take into account the impact of complete depletion of the resource. In an attempt to incorporate this idea into marginal decision-making analysis, some economists have advocated for the use of full replacement costs of the resource in cost/benefit calculations. Many conventional economists still contend, however, that the marginal

costs of restoration could exceed the marginal benefits. Once a resource has been depleted below its minimal viable stock, restoration can be very expensive. Therefore, it will be important to determine replacement costs depending on the extent to which we have approached the ecological threshold, since costs will vary with the proximity to the threshold. Although some attempts have been made within the field of resource economics to incorporate the depletion costs of a resource, these calculations largely attempt to subordinate the scale question into the allocation question.

Currently, there is no information about the exact replacement costs of particular ecosystem services, though Costanza et. al. did estimate the value of aggregate global ecosystem services (Costanza et al.). Several authors, however, have criticized the oversimplicity of the calculations. The current level of benefit derived from an ecosystem service depends heavily on the quantity of the current vitality of that service, but the calculations standardized the derived benefit regardless of the current vitality of the service. Similar to the issue stated in the previous paragraph, a more detailed analysis is necessary to account for this changing benefit structure. The Costanza et al study, which synthesized the results of several other studies, stimulated additional attempts to value ecosystem services. These studies primarily monetize the benefit stream of these given services, which can thus more appropriately help the market determine the true extent of externalities of current economic activities.

Two issues arise here. First, due to the inconsistencies in monetary valuations of non-monetary services—there is no market, and therefore no revealed price—accurate net present values are difficult to ascertain with any reliable accuracy (and, as discussed earlier, in the case of future generations, impossible). Therefore, if current value of nature's services is artificially low, due to limitations of current scientific understanding, one optimal strategy could be complete liquidation or destruction of the resource (Larson and Bromley). In the case of irreversible effects, the true costs can never be truly ascertained. Second, monetizing the benefits from a stream of services uses discount rates. Demsetz claims that private property rights create a broker in the current for future generations, by using these discount rates to take future generations into account in the determination of net present value. This implies, by definition, the assignment of management rights of a resource to the current generation, constrained only by their determination (estimate) of the value of a particular resource in the future. In the presence of inalienable property rights, however, discounting may not be appropriate. If future generations hold a property right to a certain quality

of natural resources, then current management rights to a resource are constrained by the inability to degrade such a resource.

The determination of the future's level of entitlement is difficult to determine. What level of quality in the future would have an undue cost born by the current generation? Here, we recognize the importance of our initial conception of rights and of framing economic analysis. From a traditional economic perspective, using Pareto optimality as the efficiency criterion, the status quo by definition is efficient, and any changes should be viewed with respect to the net present value calculated by the status quo. As discussed earlier, though, the current status quo is a situation of presumptive rights by the current generation. However, if new property rights emerge as a result of new information, and some of the new information reveals that previously undefined rights have distorted market incentives, should the effects of the new property rights assignments be compared to the status quo, which represents a perverted calculation of net present value due to the erroneous inclusion of a presumptive right in the initial calculation? In essence, the result of the clarification of a situation formerly defined by the 'presumptive rights—no rights' correlate to one of a 'rights—duty' correlate is actually a correction of a previous market distortion. Therefore, since economists agree that different Pareto optimal solutions will be achieved depending on the initial endowments, then an assessment of efficiency should not use the status quo as the benchmark against which the property rights reassignments are judged (Bromley, 1991). Said another way, the mere existence of these externalities questions whether Pareto optimality is an appropriate efficiency criterion.

An additional set of variables also have an effect on the emergence of the property rights. Particularly, the physical characteristics of the resource will impact the emergence of the rights regime (Ostrom, 1990). Furthermore, the type of good in question, specifically the extent to which the good can be made excludable (Musgrave) and the extent of subtractability of the good (Samuelson). Most of the theoretical framework of the modern property rights theorists explain the emergence and existence of property rights in commodities and market goods. Goods and services with public goods characteristics do not seem to fit extraordinarily well in this model. Furthermore, where disperse effects exist, the market mechanism is insufficient (Calabresi and Melamed, 1972).

As society confronts ecological limits, the extent of presumed property rights are redefined to more clearly articulate the extent of the rights. In particular, the explicit delineation of property rights of previously open-access resources attenuates the management rights in other domains that affect the new rights. For example, the granting of rights to a certain level of water quality to the future, constrains the ability of current generations to manage that resource in a way that destroys the resource.

Another option would be to grant a property right to nature itself. This would recognize nature's right to exist. In particular, nature could be granted the right not to be degraded by human activity. This discussion becomes difficult, especially within an economic analysis framework, since, similar to future generations, nature cannot negotiate its terms, and thus prevents determination of exchange values. However, I present the case as illustrative since 1) new national and international conventions have been proposed such as the Universal Declaration on Rights of Mother Earth, and 2) economic analysis as a tool, if constrained solely to the use of exchange value, will fail to understand the importance of intrinsic value and how it relates to economic analysis. The emergence of stewardship rights depends on institutional structures and power distribution in society.

New information and scientific knowledge could cause previously unrecognized externalities to be recognized, such as the negative impact of current activity on future generations. New technologies could reveal previously unknown management methods that change our ability to deal with certain externality effects. In both of these situations, property rights could be adjusted to account for the new information, which would change the extent of specific claimant rights. An example of groundwater in Vermont may help here.

The legal status of groundwater in the state of Vermont has gradually shifted over the past 30 years. This evolution of property rights with respect to groundwater helps ground the previous theory in empirical reality. Since Vermont's founding, the absolute ownership rule governed groundwater use in the state, which meant property rights of a landowner extended to the subsurface water, and thus no limits could be placed on the use of their own property (Stephen, 1991). Demsetz's assertion would offer an explanation of why the culture of the white colonial settlers of Vermont prevailed, since their assignment of private property rights allowed for a more economically

efficient allocation of Vermont's natural resources, thus optimizing general welfare[5]. This system of absolute private property rights would perpetuate so long as no technological advances or the emergence of new markets or, as I propose, the approach of carrying capacity, would recognize the need to internalize the externalities associated with current arrangement of decision-makers.

Act 250, Vermont's landmark environmental legislation passed in 1970, recognized that the actions of some actors had effects on others. The state decided that the property rights of some citizens (the rights of the current citizens and property owners to enjoy the benefits stream of the preservation of the status quo character of Vermont) took precedence over the property rights of others (the right to perform any and all economic or other activity on their physical property). This legislation could have been the recognition of externalities created following the creation of the interstate system, and influx of a new population, or the newfound societal awareness of environmental degradation caused by development activities. Regardless of the instigating factors, this property rights shift corresponds to the idea that external influences necessitate new property rights designations when costs of externalities exceed the benefit of internalizing them.

The Groundwater Protection Act (GPA) of 1985 supplanted the absolute ownership doctrine with correlative rights. Similar to riparian rights in surface waters, correlative rights limit use according to quantity of aquifer water available and individual need for use (Commons, 1985). It basically states that two households sharing the same groundwater source must leave enough water for their neighbor; in the past absolute rights of the water beneath your feet meant one household could have pumped the source dry without consequence. Here we see that a society can define the access and withdrawal rights to a resource, as discussed by Ostrom. When confronted with the mediation of conflicting property rights, for example two neighbors both desiring to maximize their level of extraction, the state intervened to declare that the rights of withdrawal of one actor extend only so far as to not diminish the withdrawal rights of another actor.

The passage of Act 144 in 2006 continued the trajectory of groundwater protection, establishing a committee responsible to study potential groundwater regulation regimes for the state, identify potential funding for groundwater mapping, analyze any localized links between water supply shortages and groundwater withdrawals, and investigate appropriate extraction rates for commercial bottlers. In addition, the Act temporarily restricted new

[5] Ethical implications of his argument are left alone here.

388 groundwater extraction and required new or expanding water bottlers to provide a geologic cross section and
389 groundwater contour map of an area surrounding the proposed source. This represents a situation of modified
390 private property rights (Rose-Ackerman, 1986) whereby classes of ownership rights and use rights were redefined.

391 Here we can see how the expanded hypothesis of property rights emergence, that includes the approach to
392 environmental carrying capacity, becomes relevant. Society recognized that there were in fact limits to the
393 regenerative capacity of the groundwater supply, instigated by the combination of a multiple year drought in the
394 beginning of the decade, and increasing economic quantity demands on groundwater. There were several incidences
395 in Vermont of aquifers that had been pumped dry. Property rights again evolved to correspond to this new
396 environmental reality, and worked to help reduce uncertainty. Although legally no user could extract water in such
397 quantity as to inhibit the ability of the others to exercise their right to the use of groundwater, the regulatory
398 mechanism of the state failed to protect this property right. As Bromley discussed, rights and duties are only
399 effective in so far as their ability to be managed. The failure of the state to provide this protection necessitated a
400 strengthening of the governance mechanism by redefining entitlements.

401 The recommendations of this exploratory committee paved the way for the passage of Act 199 in 2008, which
402 officially declared groundwater to be a public trust resource. This last shift towards common rights to an adequate
403 supply of water represents, in some ways, the necessary evolution of property right assignments when the economic
404 system has confronted the boundaries of the regenerative capacity of the environment. In essence, society has
405 determined that the sustainability of the natural resource is inherently important. This could be viewed as
406 recognizing the intrinsic value of natural systems or, alternatively, as inalienable rights for present and future
407 generations.

408 The state of Vermont has therefore decided to set up a governance regime that codifies the fiduciary responsibility
409 of the state to manage Vermont's groundwater for current and future generations. In order to do this, the state of
410 Vermont has determined that it must set the appropriate scale of the economy with respect to usage of groundwater.
411 As discussed earlier, the inherent characteristics of groundwater are important to determine its governance. Since the
412 contamination of groundwater supplies is essentially irreversible, and high transaction costs exist to determine an
413 exact threshold beyond which sustainable use is impossible, it is best to operate here on the precautionary principle.

There are many variations of the precautionary principle. One option would be a Polluter Pays Precautionary Principle (Costanza and Cornwell, 1992).

3. Coalescence and ownership

In sections 1, we investigated the allocative function of property rights as the internalization of beneficial and harmful effects. We traced how resource characteristics, types of externalities, and the definition of efficiency affect our analysis. We then turned to a discussion of how property rights are protected through various rules. In section 2, we saw that in addition to efficiency concerns, property rights emerge to address market failures, imperfections, and missing markets as new information becomes available, especially as we approach ecological limits. We then grounded our expanded theory in the historical example of the emergence of property rights to groundwater in Vermont. In this chapter we investigate the implications of these discussions of ownership, and evaluate the emergence of Common Asset Trusts as modified instruments that address governance issues addressed in this paper.

In light of the emphasis on 'the institutional architecture for sustainable development' for Rio+20, this paper proposes that the existence of environmental externalities that lead to ecological scarcity of common-pool resources necessitates the inevitable emergence of unique property rights regimes for natural resource management. This re-conceptualization of property rights, with its associated bundling that implicitly recognizes the inalienability of rights of future generations, creates the necessary bounds within which discussions of 'sustainable' or 'green' development must take place. Common Asset Trusts capitalize on the clear delineation of property rights, which help markets function more effectively, the economies of scale that reduce transaction costs, and the enforcement power of the state.

As many have pointed out (Eggertsson, 1990a; Larson and Bromley, 1990; Libecap, 1986; Schlager and Ostrom, 1992), no particular type of property rights regime can be predetermined. Local regimes have limitations, and scale is important due to boundary definition (Ostrom, 2002). Even in cases where alienable rights to water may make sense, those rights would correspond only to the resource units flowing from the resource, the governance and management of the resource itself must be addressed in the design of the property rights

system. Most productive activities are defined by a complex web of rights, ranging from exclusive up to and including open-access (Barzel).

Bromley discusses a central theoretical inconsistency with the concept of private property rights regimes inherently decreasing transaction costs, and thus allowing for the greater internalization of externalities. Bromley argues that private property rights maximize the number of atomistic actors, which actually increases the potential for externalities because there are more boundaries over which negotiations must happen, and thus more potential for externalities. The logical conclusion reached in attempts to increase efficiency in the midst of increased atomistic individualization is either state intervention or economic consolidation to reduce the number of boundaries, potentially in the form of Common Asset Trusts.

Bromley discusses that markets are not an ideal allocative mechanism when the governance of a resource is characterized by a) high transaction costs, b) large and important nonmonetary benefits and costs; c) uncertainty over the future, and d) potential irreversibilities. He argues that "markets are wonderful arrangements for those goods and services that conform to certain characteristics. Among these necessary traits are 1) highly divisible factors of production and outputs; 2 the absence of public goods, 3. The absence of externalities in use (no joint costs), 4 an absence of irreversibilities, and 5 a clear and precise structure of property rights."[6]

Groundwater, like many common-pool resources, has several characteristics similar to a public good, and others similar to that of a market good. In particular, groundwater is characterized by subtractability (rivalness), low excludability, irreversibility in some cases, time lag, indivisibility of the resource system, fuzzy boundaries, hydrogeological uncertainty, high data costs, and information asymmetries (Theesfeld, 2010). This requires a unique set of governance structures to best determine the ideal property rights regime to manage the resource.

In the case of groundwater, two distinct but important measurement factors must govern its usage: its quantity and quality. In traditional economic theory, market price is said to be zero in the face of abundance. This argument assumes an analysis limited to the current time period measurement. Once we open the possibility of rights for future generations, calculations of scarcity must be adjusted to include this inter-temporal dimension. Additionally,

[6] He leaves out issues of scarcity, which imply the inherent rivalry of a particular resource.

there could exist an abundance of physical quantity of groundwater, as in the case of Vermont in aggregate[7], while simultaneously exist a threat to the long-term quality of that water.

Once the boundary is determined by ecologically-scientific methodology, society as a whole can determine the policy instrument most appropriate to deal with just distribution. This can take several forms. One option, the resource could be publicly managed, and declared a public trust resource, essentially codifying the property right of future generations to a clean supply of water as inalienable. In essence, this framework grants the current generation operational rights to the groundwater resource, which include access and withdrawal rights. In addition, it bestows management and exclusion rights to the current generation, however, these rights are bounded by the responsibility to maintain the benefits stream of the resource for future generations. Therefore, it allows the current generation the right to determine the optimal form of management rules for use of the resource, with the caveat that this right does not extend to the absolute right to destroy the resource. It does, however, allow the current generation to determine the rules governing who should be excluded from access to the benefit stream associated with the use of the resource. For example, the current generation could decide that nobody has the right to access groundwater, that everyone has the right to x gallons per year for free, or that only those that pay for use have the right to enjoy the resource. In light of the new property arrangement whereby future generations maintain perpetual rights to the benefit stream, the current generation's rights of management and alienation are both attenuated. The current generation may still maximize the net present value of the resource, under the constraint that degradation of resource is minimized.

As opposed to public property, however, a Common Asset Trust, CAT, could be created. A Common Asset Trust helps to reduce the agency cost problem that arises when government regulators do not have to bear the consequences of their regulatory actions. The CAT institutionalizes the protection of resource, and turns the regulators into trustees whose responsibility is the protection of those rights who are currently a missing market. In the event that a CAT is established, the current generation could determine whether the revenue generated should be reinvested in natural capital restoration or protection, in infrastructure development, or redistributed to society. One argument in favor of the redistribution of fee revenue is that the conservation efforts will have a negative externality on the current generation manifest in the increase in current prices. Another argument in favor of redistribution

[7] Situationally-scarce supplies of water in certain municipal service areas, where water demand of the population exceeds capacity in that specific jurisdiction. This is a question of boundary definition of the unit of analysis, and I will here discuss Vermont in aggregate.

would be to increase political feasibility, since as several empirical studies show, current institutional arrangements often block shifts that they view as reductions in their current level of rights. Current redistribution of revenue from usage fees could be justified, as long as this expenditure does not come at the expense of preservation of the resource. Alternatively, revenue generation could support public good expenditure related to the resource.

Structurally, in order to ensure the preservation of the resource, the governance structure must include some important components, as we saw in Table 1. Namely, it must look to protect the quantity of the resource, as well as the quality of that resource. Limits must be placed both on the quantity levels extracted, as well as the permissible amounts of quality degradation. The type of degradation is particularly important, such as whether the pollution has short-term or long-term effects.

This management can be done through a combination of regulatory, economic, and voluntary/advisory policy instruments. Regulatory measures could set limits to land use, determine wastewater treatment practices, permit quantities of extraction, limit levels of point-source and nonpoint-source pollution. This relates to groundwater's characteristics as a public good. Economic policy instruments relate to water's role as a market good, and could include setting of price, severance taxes, etc. Voluntary/advisory policy instruments deal primarily with information. This builds off of the important work of Ostrom in the management of common-pool resources, and behavioral economists, relating to the extent to which actor participation in agenda setting and problem definition inform the degree of rule-breaking and deviance. In the end, all three of these policy tool categories will only be effective to the extent that the state has the capacity to enforce the new conception of property rights. In order to fulfill its fiduciary responsibility the state must appropriately fund the enforcement mechanism to guarantee the inalienable rights of future generations explicitly outlined in Act 199. The CAT could be designed to use revenue from usage to cover enforcement activities.

4. Conclusion

This discussion reflects a normative assumption that natural resources are worth preserving, and that future generations have a claim on current natural resource benefit streams. Alternative analytical tools will be necessary to address the inadequacy of efficiency calculations and marginal analysis for assessing the impact of property rights on natural resource use. As several scholars have pointed out, a key threat to collective action is state disregard for local, commons management systems. Additional empirical research into cases of

societal transitions from private property to public trust designations of specific benefit streams of natural resources are needed. A governance network analysis framework will help identify the key institutional structures and dynamics that either promote or discourage an enabling environment for the appropriate sustainable use of natural resources.

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