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Partial enclosure of the commons[☆]

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ABSTRACT

We examine the efficiency, distributional, and environmental consequences of assigning spatial property rights to *part* of a spatially-connected natural resource while the remainder is competed for by an open access fringe. We refer to this as *partial enclosure of the commons*. We obtain sharp analytical results regarding partial enclosure of the commons including: (1) While second best, it typically improves welfare relative to no property rights, (2) all resource users can be made better off, (3) positive rents arise in the open access area, and (4) the resource maintains higher stocks. Under spatial heterogeneity, we also characterize spatial regions that are ideal candidates for partial enclosure — typically, society should seek to enclose those patches with high environmental productivity and high self-retention, but whether high economic productivity promotes or relegates a patch may depend on one's objective.

1. Introduction & background

A substantial body of analysis and evidence highlights mismanagement of fisheries, pastures, forests, groundwater, pollution sinks, antibiotic resistance, among other tragedies of the commons.[1] A large literature proposes economic instruments as solutions, including taxes, effort restrictions, fully-delineated property rights, tradeable permits, and spatial zoning with taxation or with unitization.[2] Under certain conditions, each of these instruments has benefits and may even 'solve' the tragedy of the commons, and provide first-best outcomes.[3] Yet issues of wealth redistribution, heterogeneity, high political and economic costs, and other practical political economy issues can impede the performance of such instruments and may explain why we rarely observe them being implemented in their pure form as economic models would suggest.[4] Instead, we tend to observe hybrids where only part of the resource is subsumed within a market structure.

Indeed the failure of many natural resource management institutions has been explained by the potential mismatch between the spatial scale of management and that at which environmental processes operate. For instance, Scott (1955) states that "the property must be allocated on a scale sufficient to insure that one management has complete control of the asset." Yet, in practice, decision makers are often able to partially assign property rights to a fraction of the natural resource, leaving the remainder to be competed for by an open access fringe. This is the case for migrating fish species, which traverse exclusive economic zones and are subject to harvest on the high seas by an open access

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[1] Seminal works include Hardin (1968), Ciriacy-Wantrup and Bishop (1975), Ostrom (1990), and Maler (1990); see Stavins (2011) and Laxminarayan and Brown (2001) for empirical evidence.

[2] See Rubio and Escriche (2001), Rosenman (1984), Weitzman (2002), Benchekroun (2003), Quérou and Tomini (2013), Costello and Deacon (2007), Montgomery (1972), Stranlund and Dhanda (1999), Raffensperger (2011), Sanchirico and Wilen (2005), Kim and Mahoney (2002), Kaffine and Costello (2011), and references therein.

[3] The OECD report (Le Gallic, 2006) provides a survey of many market-like instruments used to solve these problems.

[4] E.g. see Brito et al. (1997), Karpoff (1987), Johnson and Libecap (1982), Besley (1995), and Libecap and Wiggins (1985).

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fringe.[5] Other examples include deer and waterfowl, which are only partially enclosed on private lands, and wildebeest, zebra and other hunted species, which migrate through private lands, public lands and even natural reserves. Even rights to groundwater and oil stocks are often related to property rights at the surface,[6] and are not matched with the spatial scale of the resource.

We refer to this situation as 'partial enclosure of the commons,' and note as a starting point that this institution will not internalize all externalities, and will thus be a second best alternative to sole ownership of the entire resource domain.[7] While the owner of the enclosed area may behave somewhat like a sole owner, resource mobility induces a spatial externality, so the open access fringe influences the enclosed area and may affect the enclosed owner's behavior and vice versa. Despite notable advances on the use of economic policies to internalize various externalities, the literature on *partial* property rights is sparse, and the use of partial enclosure remains an unresolved issue. We contribute by analyzing the efficiency, distributional and environmental consequences of its application. Under what conditions will assigning rights in this way achieve economic, distributional, or environmental improvements over the pure open access case? And if we are to proceed with partial enclosure of the commons, what guiding principles can be generated to design these institutions? The remainder of this paper is devoted to addressing these, and related questions.

We develop and analyze a discrete-time model of partial enclosure of the commons. The model is simple enough to maintain analytical tractability, but contains all of the components essential to describe this ubiquitous institutional arrangement. It is meant to be generically applicable to a wide range of natural resources with certain characteristics. The dynamics of a natural resource are both temporal and spatial. We model space as a set of mutually-exclusive and exhaustive patches and keep track of natural resource stock in each patch.[8] Any given patch may be unregulated (i.e. open access — a situation in which current economic returns govern entry, exit, and extraction) or may be managed by an owner who maximizes her private discounted benefits. Owing to spatial movement, behavior in the open access region has important consequences for the sole owner, and vice versa. The ensuing spatial and temporal externalities represent a potentially damaging market failure that induces a dynamic spatial game across patches with different characteristics.

The existing literature tends to consider natural resources as perfectly enclosed by one or more owners; thus property right delineation is not an issue. Indeed, an extensive literature (Levhari and Mirman (1980), Pintassilgo et al. (2010), among others) analyzes non-cooperation between a small number of owners of common pool natural resources in a closed game setting (there is no open access fringe). In our model, we explicitly treat spatial externalities and resource dynamics, we implicitly assume cooperation among agents with a claim to the enclosed area, but we allow for non-cooperation between the partial enclosure and a (spatially connected) open access fringe of arbitrarily large size.

To the best of our knowledge, only a single existing paper addresses the issue of partial enclosure of natural resources (Fisher and Laxminarayan, 2010).[9] It focuses on uncertainty, instrument choice, and the congestion problem resulting from the enclosure of some resource pools on other open-access resource pools. By contrast, we investigate whether partial enclosure may increase (aggregate or patch-specific) resource stock levels and/or aggregate economic value (or individual profits). We highlight the influence of spatial externalities and environmental heterogeneity on the optimal assignment of partial property rights.

Our paper is also related to an early literature on incomplete contracting among many owners of an oil reserve. That literature focuses on transaction costs as an impediment to effective contracting. Industry concentration (Libecap and Wiggins, 1984), imperfect information (Wiggins and Libecap, 1985), and incentive compatibility (Libecap and Smith, 1999) all play important roles in contracting success. While our paper shares some similarities with that literature (they both relate to the problem of overextraction when a resource is mobile and property rights are incomplete), several important differences remain. Our main theoretical focus is on renewable resources (whose stocks grow) that may disperse in asymmetric ways. And by *partial enclosure* we not only refer to the fact that the resource may disperse out of an owner's patch, but that not all patches are owned, so there is an open access fringe who competes with the enclosure owner. The importance of spatial effects is also present in the literature on learning externalities and agglomeration economies: it is emphasized how investment decisions made by one agent may influence others who learn from his experience (Lucas, 1988; Porter, 1998). In our setting, it is the physical diffusion or dispersal of the resource across space that gives rise to interesting spatial externalities. Given environmental heterogeneity, this diffusion effect may have different impacts from one region to another, emphasizing the importance of careful selection of the region in which property rights will be assigned; this is a central focus of our analysis.

The remainder of the paper is organized as follows. The model is presented in Section 2. Welfare and distributional results are provided in Section 3. Section 4 presents results on the siting of partial enclosure of the commons. Extensions and robustness checks are discussed in Section 5. Results are illustrated in an example in Section 6, and Section 7 concludes.

2. Model & results

A natural resource stock (denoted by x) is distributed heterogeneously across a discrete spatial domain consisting of N patches. Patches may be heterogeneous in size, shape, economic, and environmental characteristics, and resource extraction can potentially occur in each patch. The only requirement for spatial delineation is that patches must be homogeneous intra-patch. The resource can migrate from patch to patch. In particular, denote by $D_{ii} \geq 0$ the (constant) fraction of the resource stock in patch i that stays within patch i in a single time period and $D_{ij} \geq 0$ the fraction that migrates from patch i to patch j. Some resource may flow out of the system entirely, so the dispersal fractions need not sum to one: $\sum_j D_{ij} \leq 1$. This follows the recent literature from the natural sciences (see, e.g., Siegel et al., 2003; Watson et al., 2011; Nathan et al., 2002) that models dispersal of passive "Lagrangian particles."[10] Time is treated in discrete steps.

5 Indeed the world's oceans are a compelling illustration: 58% of the ocean constitutes the high seas, which are effectively open access, while the remainder is delineated to individual states in exclusive economic zones. Even though rights are fully delineated within these zones, species such as tuna and billfish traverse these jurisdictions and are exploited in the open access high seas.

6 The "rule of capture" of groundwater and mineral resources in the United States is historically based on the concept that each landowner has complete ownership of resources under his land, and has an unlimited right to use them. This *Absolute Ownership Doctrine* has led to over-exploitation issues in areas where the number of users has grown so that the use of the resource, even if it is limited by land ownership, gets close to that of an open access outcome. It is now commonly rejected because of the existing diffusion/dispersal process of the resource.

7 Taxes are a possible alternative, but a tax in only one region (analogous to partial enclosure) would be second best. Indeed, Sanchirico and Wilen (2005) show that a first best outcome would require the use of spatially differentiated taxes (one for each region).

8 In the biological sciences, this is referred to as a "metapopulation."

9 Colombo and Labrecciosa 2013 analyze the oligopolistic exploitation of a productive asset under private and common property arrangements. They assume that, under private exploitation, the resource is parceled out. Each firm owns and manages the assigned parcel over the entire planning horizon. Thus, fully delineated property rights exist over the entire domain of the resource. As such, they abstract from situations where the resource is fully mobile, and do not analyze (as we do) the impact of spatial externalities and environmental heterogeneity on the assignment of partial property rights.

10 Alternative models of dispersal can be found in Sanchirico and Wilen (2005). We discuss in Section 5.3 alternative specifications and their implications for our main results.