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Analysis

The role of farmers' property rights in soil ecosystem services conservation

Sébastien Foudi

Basque Centre for Climate Change (BC3), Alameda Urquijo 4, 48008 Bilbao, Spain

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ABSTRACT

This paper analyzes the role of property rights in soil conservation. The conventional wisdom in soil conservation and property rights argues that tenants invest less than landlords in sustainable management practices and tend to overexploit soil biota services. The paper examines how this issue is linked to bioeconomic considerations. In an optimal control approach to the modeling of soil ecosystem services exploitation, the paper shows how economic, biological and ecological variables drive the rewards of investment in soil conservation through agricultural practices.

1. Introduction

The relationship between the conservation of natural resources, property rights and time preferences is an old issue in economics. Gray (1913) wondered whether "…private property in natural objects [is] favorable or unfavorable to the realization of the ideals of the conservationists?" Conventional wisdom claims that property rights provide individuals with the opportunity to reap the rewards of their investment (Demsetz, 1967). Secure property rights are a necessary condition to initiate long-term management perspectives of resources and they then create incentives to invest in natural resources conservation (Kiss, 2004; Skonhoft and Solstad, 1998; Smith, 1975; Swanson and Barbier, 1992). This question has largely concerned the governance of open access resources since the work of Gordon (1954) and Hardin (1968). When an agent is the owner of a resource, he has access, can withdraw, manage, exclude others and alienate the resource (Ostrom, 2000) and can make long term decisions. But when this agent cannot monitor the use of the resource, he has short-term preferences due to imperfectly protected property rights and this results in a de facto open access situation (Ostrom, 2000; Skonhoft and Solstad, 1998).

The assignment of property right raises the problem of transaction costs (Coase, 1960) and of imperfect information on conservation issues on private lands (Polasky and Doremus, 1998). As regard transaction costs, the ability of property rights' contracts to conserve resources in the long run has been questioned and studied in a principal agent setting between a tenant and an owner of the resource. It has been shown that where there is no regulation, the tenant has no conservation incentive in the long run and focuses on production objectives in the short run whereas the owner is interested in the value of the resource in the long term. The objectives of these two agents do not tally and the resource is mined over time when the tenant activities are not regulated. Both the type and the terms of the rental contract are instruments of regulation (Costello and Kaffine, 2008; Dubois, 2002; Lichtenberg, 2007). In the case of agricultural land, it has been argued that shared tenancy reduces the overuse of soil resource in the short run (Dubois, 2002). Lichtenberg (2007) studies the decisions landlords have to limit the tenant's ability to overexploit soil under cash and share rental contracts. He shows that under risk neutrality, share rental contracts combined with landlord investment in conservation measures can achieve the first-best allocation that maximizes the expected value of production during the lease period and the expected present value of the land at the end of the lease period. However, empirical evidence cannot be asserted that owners are more likely than renters to undertake conservation practices (Soule et al., 2000). Costello and Kaffine (2008) show that the uncertainty about the renewal of a fishery concession regime induces the user to overexploit the resource and that a renewal target for the resource, corresponding to the sole-owner's harvest path, might be used by the owner to provide incentives to use the resource efficiently. Moreover, a limited time of the tenure in a concession regime can also serve the long run objective of resources conservation.

The assignment of property rights for natural resources conservation likewise raises the question of the conflicts generated by these

E-mail address: sebastien.foudi@bc3research.org.

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resources with economic activities like stockbreeding and farming. These conflicts modify the effects of the determinants of renewable resources extinction in the Clark (1973) models as shown by Skonhoft (1999). Omitting the nuisance generated by wildlife and focusing only on the benefits it generates would lead to misleading conclusions and unintended welfare impacts on resource users (Skonhoft, 1998).

Would such ecological conflicts condition the conventional wisdom on soil conservation? Could it be that a tenant exerts less detrimental effort than a landlord farmer? Could tenancy be a way to recover soil resources for landlords? This paper seeks to answer these nested questions and identify under which bioeconomic circumstances property rights incentivize conserving soil resources. The model focuses on the exploitation of ecosystem services generated by soil biota at the farm scale and integrates both the dis-services and the services generated by soil biota. Moreover it accounts for the impacts of agricultural practices (land use and agricultural effort) on the renewing of soil biota. In this model, the tenant is a farmer with short term preferences, driven by short term profit motives when he has to decide his optimal land uses and level of agricultural effort. The landlord is a landlord farmer interested in both production and soil conservation values. The objective of the model is not to study the terms of the contract between a tenant and a landlord but rather to compare the behavior of these two types of farmers. Thus the type and terms of the contract are not explicitly set in the model but rather discussed based on the literature and on the contributions of the model. This model departs from the literature on land tenure and soil conservation as it introduces dynamics in soil services. Moreover, it departs from the models of (de facto) open access resources since it focuses on soil biota, a resource that can be exploited not only through the harvest effort but also through land uses.

Soil biota play an important role in the generation of soil ecosystem services and land productivity (Barrios, 2007) and provide intermediate services to agriculture (Fisher et al., 2008). However, soil biota have diverse functions and a part of these species is also pests to agricultural productions. Pest eradication being non optimal for farmers (Christiaans et al., 2007), they have to deal with this nuisance cost. Soil biota in this model will be introduced via the services and dis-services they produce.

The economic valuation of ecosystem services allows dependence and relationship between economic activity and the ecosystem services to be measured (EPA, 2009; MEA, 2005; TEEB, 2010). Swinton et al. (2007) review these techniques for agricultural services. More generally, valuation techniques assume that the linkages between the function of ecosystem services, the net benefits derived by society and their values can be identified and quantified (Fisher et al., 2008; Turner and Daily, 2008). In the case of agricultural services generated by soil biota, the identification of services has been addressed and understood very recently in the field of economic ecosystem services. Quantification of the services is even more rarely introduced in bioeconomic approaches (Barrios, 2007; Omer et al., 2010). The contribution of the paper to the impact of property rights on soil resources remains therefore theoretical. In order to account for the divergence of interests of tenant and owners between the production and conservation, a production function approach for soil ecosystems services is introduced in an optimal control approach that enables the arbitrage between degradation of the natural services by external inputs and conservation of soil biota input to be considered.

The article is organized as followed. Section 2 proposes a bioeconomic model of soil biota exploitation in agriculture. Section 3 studies the optimal choices of a risk neutral farmer in terms of land uses and agricultural effort. Section 4 discusses the circumstances under which property rights favor conservation soil biota. Section 5 concludes.

2. A Bioeconomic Model for Soil Ecosystem Services and Dis-services

The farm is a heterogeneous environment of C patches α_{ikt} representing the share of land devoted to land use $i=1,\ldots C$ at time t while under land use k at the preceding period. Let B_{it} be the stock of soil biota on patch i at time t. Soil biota are considered as a metapopulation representing both the destructive (pests) and the resource biota of the soil providing land fertility.

2.1. Land Uses

Land use choices influence the renewing of the resource through its carrying capacity. Indeed, as the farmer changes his land uses he changes the habitat the resource is living in and thus changes the carrying capacity.[1] The effective carrying capacity κ_{it} is thus specific to plot i and to time t and it can be written as a linear function of a potential intrinsic carrying capacity, κ_i:

$$\kappa_{it} = \sum_{k=1}^{C_2} \alpha_{ikt}\kappa_i = \alpha_{i.t}\kappa_i. \tag{1}$$

As the share of the habitat increases, the effective carrying capacity reaches its potential intrinsic carrying capacity.

In a patchy environment, the population is subject to migration processes from one patch to another. The dispersal process is represented as a multiple sources dispersal process: "many patches contribute biomass to one common pool" (Sanchirico and Wilen, 1999). The dispersal is assumed to be a function of land uses; when the farmer assigns a particular crop to a patch he modifies the specific soil biota. The patch specific resource is then:

$$B_{it} = \sum_{k=1}^{C_2} \alpha_{ikt} B_t = \alpha_{i.t} B_t. \tag{2}$$

2.2. Influences of External Inputs on Soil Biota

The agricultural effort of production (E) can have both a negative and a positive impact on soil biota. Let R1 be the assumption under which the use of external input affects negatively the resource (Barrios, 2007; Dominati et al., 2010; Swift et al., 2004). Let R2 be the assumption under which the agricultural effort has a positive impact on the resource (Monkiedje and Spiteller, 2002; Roper and Gupta, 1995). A Schaefer function $H_i(E_{it},B_{it})$ represents this influence. A multiplicative function is relevant for random impacts of a randomly distributed population (Clark, 1979). This function is convenient to capture the non linearity in the impact of the agricultural practices onto the soil biota.

$$H_i(E_{it}, B_{it}) = \varphi_i B_{it} E_{it} \tag{3}$$

where φ_i is a productivity coefficient. Under R1, this coefficient is the usual catchability coefficient, under R2 it measures the propensity of the external input to increase the resource.

2.3. Renewing of Soil Biota

The patch specific growth of the resource is decomposed in a natural growth function G and the impact function H. Under R1, the evolution of the pool soil biota (the stock of resources over all patches) is then given by:

$$\begin{aligned} B_{t+1} &= \sum_{i=1}^{C_2} G_i(B_{it}) - H_i(E_{it}, B_{it}) \\ &= \sum_{k=1}^{C_2}\sum_{i=1}^{C_2} \alpha_{ki,t+1} B_t \left[1 + r_i\left(1 - \frac{B_t}{\kappa_i}\right) - \varphi_i E_{it}\right] \end{aligned} \tag{4}$$

[1] Swanson (1994) considers that the carrying capacity in the logistic growth function must be a function of the habitat available for the resource.