Variable Compliance Incentives in Conservation Policies in a Dynamic Setting

Sandra Rousseau

CEDON, KU Leuven, Warmoesberg 26, B-1000 Brussels, Belgium,
Sandra.Rousseau@kuleuven.be

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Abstract
The analysis jointly considers the dynamic aspects of conservation programs with incomplete compliance and allows land users' behaviour to change over time. A distinction is made between compliance and participation incentives. Under conditions that are frequently observed in practice, we find that compliance incentives of program participants are variable over time, which can have a significant impact on the efficacy of conservation policies. We match existing enforcement policies with the rational actor model to demonstrate the effects of different kinds of penalty and monitoring schemes for a range of program participant characteristics. Land users are shown to have sizeable incentives to participate in compensation schemes, but their incentives for compliance with program requirements are considerable lower.

Keywords: Compliance; Monitoring and enforcement; Policy instruments; Conservation policy; Penalty schemes

I. Introduction

Looking at the design of actual conservation policies, regulatory enforcement is generally acknowledged to be a necessary condition for successful outcomes (see, e.g., Gibson et al. 2005). Indeed, empirical data corroborate the assumption that compliance with currently implemented conservation schemes is less than perfect and effective enforcement strategies are needed. Choe and Fraser (1998, 1999), mention some available evidence on the non-compliance with conservation schemes for the UK. For instance, in relation to the Countryside Stewardship Scheme, Land Use Consultants (1995) found that on 24% of the sites visited, farmers were not fulfilling their contractual obligations. Giannakas and Kaplan (2005) discuss compliance with the US program stimulating the adoption of on-site resource conservation activities on highly erodible lands: over 11000 producers have been cited for violations on approximately 114 hectares with a total of nearly 16 million dollars in denied benefits (Claassen 2000). Also, Ellefson et al. (2007) found that US program administrators estimated that only in a very few instances forest practices were always being correctly applied.

Looking at the literature, surprising little consideration is given to land users' actions once they have joined a conservation scheme. Therefore, in our model we allow land users to imperfectly comply with a program's requirements. The reason behind the imperfect compliance is that land users' actions cannot be directly observed and that these actions can only be verified through costly monitoring, which results in informational asymmetries. We concentrate on compensation payments for conservation practices, but the results will also allow us to comment on the use of command-and-control instruments. Incomplete monitoring was identified as a very important factor in the practice of environmental regulation (see, for example, Sandmo 2002; Rousseau & Proost 2005) and its implications will be the focus of this contribution.

Most previous models considering compliance to conservation programs, such as Choe and Fraser (1998; 1999) and Giannakas and Kaplan (2005), did so in a static framework. A notable exception is Fraser (2004) who studies compliance decisions by risk adverse farmers who face targeted monitoring strategies in a two period model. Fraser (2004) concentrates on reducing the extent of non-compliance by participants in the non-target group by exploiting the risk aversion of participants. In our model, we explicitly incorporate the dynamic aspects of conservation programs into a multi-period model and allow land users' behaviour to change over time. This dynamic analysis allows us to model the deterrence effect of being excluded from the conservation program if the land user is caught cheating. The risk of losing all future rents from participation provides an additional deterrence effect and increases potential compliance by participants. Moreover, the dynamic analysis allows us to investigate the impact of using a cumulative fine whereby the penalty if caught not complying is to repay (with interest) all previous compensation payments made. As we discuss later, this type of fine is often used in practice. In the model, we also explicitly distinguish between incentives to participate and incentives to comply, and investigate how the effectiveness of monitoring and enforcement depends on land and land users' characteristics such as differences in land yield and compliance costs. The model thus matches existing enforcement policies with the rational actor model and demonstrates the impact of different penalty and inspection schemes for a range of program participants' characteristics. Importantly, the model shows that participants' compliance patterns are not necessarily constant over time and land users might switch between compliance and non-compliance. These switches can, however, be discouraged by increasing monitoring stringency. It also shows that land users have strong incentives to participate in the program, while compliance incentives once they participate are typically much weaker.

In section II we present the assumptions, set-up and results of our model. We formulate two propositions concerning compliance incentives and participation decisions respectively. In section III we discuss these results in more detail and compare compensation schemes with command-and-control regulations. Next, in section IV, we perform a simulation exercise to obtain more insight into the dynamics of the model. In section V, we conclude.

II. Model

We analyse a multi-period model with a finite horizon where the index *t* represents the period ranging from *0* to *T*. We normalize the timing of the game such that each land user *i* decides about participation in the conservation program in the first period, *t=0*. In the last period, *t=T*, the proposed contract ends. This policy horizon is exogenously determined and typically represents the minimal number of years a particular conservation practice must be implemented to comply with the regulation, i.e. the contract duration. A case in point is the US Healthy Forest Reserve Program, which specifies three enrolment options: 10-year cost-share agreements, 30-year easements, and 99-years easements. Another example can be found in the UK Environmental Stewardship Scheme, where a contract for Entry Level Stewardship Agreements lasts five years. The model is built in order to investigate land users' reaction to compensation payments for implementing conservation practices.

2.1 Assumptions

We assume that land users are risk averse and that they maximize the net benefit from their land. The surface of each site is assumed to be equal to unity. However, one person can own several plots of land. Initially, none of these lands have been put to a conservation use and no conservation practices are being implemented. The cost of changing land use practices in order to enhance biodiversity for land user *i* is equal to c_i. In each period, the land user has to lay out this cost c_i in order to remain in compliance and these costs vary between different land users[1]: $c_i \in [\underline{c}, \overline{c}]$ with $\underline{c} \geq 0$. We assume that this cost interval and the distribution of

[1] In reality start-up costs tend to be higher than continuing compliance costs, because they include learning and conversion costs, changes in suppliers or fixed investment costs such as building fences or planting trees. Note

costs is commonly known to both government and land users, but that only the land users themselves know their real values.[2]

Conservation measures not only impose costs on land users, they also influence the potential yield Y_{it} from the land. Some conservation policies such as implementing buffer strips to fight nitrogen runoff or introducing organic farming tend to decrease the current and/or future yield of the land, while other policies such as erosion reducing measures might increase the value of the land. In this model, we explicitly incorporate changes in land values over time. If land user *i* does not adopt the conservation measure in period *t*, the yield obtained from the land is assumed to remain intact[3]: $Y_{it} = Y_{it-1}$ and the initial, exogenously given, value of the land is represented by Y_{i0}. If land user *i* adopts the conservation measures in period *t*, the land yield compared to period *t-1* evolves as follows: $Y_{it} = Y_{it-1}\left[1+\alpha\right]$ with $\alpha<0$ if the land value decreases after implementing a particular conservation measure, $\alpha>0$ if the value increases and $\alpha=0$ if the value remains constant.

The compensation scheme imposed by the regulator determines a payment s for each land user who implements a particular conservation practice in each period. The regulator is responsible for ensuring the participants' compliance. To this end, the regulator randomly performs inspections[4] with a probability p_t in each period *t*. Each inspection involves a cost and the exogenously determined regulatory budget is limited so that it is not possible to induce full compliance of all program participants. Further, we assume that an inspection can perfectly determine the compliance status of the land user. A violator who is caught in period *t* has to pay a fine $F(t)$ and is permanently excluded from that particular program.

Thus, the expected net income from taking part in the conservation program will depend on the future decisions concerning compliance with the requirements necessary for receiving the compensation payment. In the initial period, $t=0$, an individual will decide whether or not to participate in the conservation program. Next, in each period *t*, a land user *i* maximizes the expected utility derived from the net income π_{it} of the land from *t* until the end of the model horizon *T*. The utility of the land user is assumed to be quasi-linear and is determined by the

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that these costs do not include the potential loss or gain in land revenues. The changes in land revenues are modeled separately to make the distinction between the two types of regulatory effects clear: the first is the direct costs of implementing the regulation and the second is an indirect effect on potential land revenues.

[2] If the regulator would perfectly know each land user's compliance cost, he would be able to perfectly predict which land users would be compliant and which not. Thus, if the available budget is sufficiently large, monitoring would be perfect and all potential violators would be deterred.

[3] This is of course not the only way of modelling the changes in land values over time and we use a normalisation. However, it is the difference between the values of the implementing conservation measures or not that is crucial to the model.

[4] We do not incorporate targeting inspection strategies into the model since would not significantly change the results with respect to the impact of having cumulative penalties and the option of banning detected violators from the program. Harrington (1988) showed that state dependent monitoring increases deterrence compared to random monitoring under a binding budget constraint. Also, for a discussion of the potential of targeting strategies in conservation policy see Fraser (2004). We assume that in each period inspections are randomly executed among all participants. So land users inspected in a previous period and found in compliance can be inspected again in the next period. However, this random inspection probability p_t can vary between periods.

yield of the land, the cost of compliance, the expected fine and the compensation payments. The indirect utility V_{it} obtained by land user i in period t is:

$V_{it} = Y_{it}$ if the land user does not participate in the program,

$V_{it} = Y_{it} + s - c_i$ if the land user participates and is in compliance,

$V_{it} = Y_{it} + s - p_t R(F(t))$ if the land user participates and is in violation,

with $R(F(t)) \equiv \beta F(t) + \frac{\gamma}{2} F(t)^2$ representing the disutility per period of incurring the risk of having to pay a fine. Land users are thus assumed to be risk averse with respect to fine payments[5]. Using the Arrow-Pratt measure of risk aversion and in order to have a positive risk premium, the assumption of risk aversion imposes three conditions[6] on the parameters β and γ:

$$-\frac{V''}{V'} = -\frac{\gamma}{\beta + \gamma F(t)} > 0 \Rightarrow \gamma < 0 \; and \; \frac{\beta}{\gamma} > F(t)$$

$$\text{and} \qquad \frac{\gamma}{2} F(t) > 1 - \beta.$$

2.2 Enforcement aspects

Compensation payment schemes implemented in reality typically specify a fine that equals the cumulative sum of all compensation payments increased by compound interest that were already paid to the violator in previous periods: $F(t) = \sum_{k=1}^{t} [1+r]^{k-1} s$ with r representing the interest rate. A European example where such a penalty scheme is used is the compensation scheme for afforestation on agricultural land in Flanders. In the US, this type of fine is also often used in practice: for instance, the US Program for Wild Rice, Fruit and Vegetable Provisions states that, for serious planting violations, *'all DCP[7] payments previously paid to producers for the farm for the applicable year must be refunded, plus interest and no further DCP payments will be made for the applicable farm'*. The US Grassland Reserve Program specifies that for violations of rental agreements or restoration agreements *'the Commodity Credit Corporation may require the participant to refund all or part of any payments received, with interest'*. The restitution of all payments received so far means that fines are increasing in time and thus deterrence is also mounting over time. In this article, we compare the deterrence effects of the cumulative fines popular in reality with those of a constant fine. In the case of a constant fine, we have $F(t) = \bar{F}, \forall t$.

[5] Note that we assume that the agricultural yield from the land is an exogenously given function. Obviously, this is a simplification since in practice land yields are uncertain, risky outcomes depending on any number of factors such as whether conditions. In this paper we focus on the direct impact of having a cumulative penalty and do not look at interactions occurring as a result of introducing two types of uncertainty (i.e. agricultural yield and fines) in the land users' utility function. However, this is certainly an interesting extension to study.

[6] The second and third conditions can be met since the possible fine is limited to the cumulative sum of past payments.

[7] DCP stands for the Direct and Counter-Cyclical Payment Program and it falls under the 2002 US Farm Bill.

Furthermore, we assume that the sanction imposed on dissenting land users also implies that the violators cannot receive any future compensation payments. This is again a common feature of real life conservation practices. For instance, the US Healthy Forest Reserve Program states that, when a violation is detected, *'the participant will forfeit all rights for future payments under the cost-share agreement, and must refund all or part of the payments received, plus interest, and liquidated damages'*.

2.3 Compliance and participation decisions

First, we examine the compliance decision in the last period $(t = T)$ and, through backward induction, we can subsequently optimize the compliance decision of the land users in the previous periods and the participation decision in period 0.

Compliance decision of program participants

In the last period *T,* a land user who participates in the program decides to comply with the requirements if the total expected revenue from compliance exceeds the total expected revenue from violating the rules:

$$Y_{iT-1}[1+\alpha]+s-c_i \geq Y_{iT-1}+s-p_T R(F(T)) \quad (1)$$

This gives:

$$c_i-\alpha Y_{iT-1} \leq p_T R(F(T)) \quad (2)$$

For land users to comply, the net cost of compliance with the program's obligations has to be lower than the expected fine. Note that the net cost of compliance consists of the direct compliance costs corrected for the impact on the land values. The condition for land users' compliance can be rewritten as:

$$p_T \geq \frac{c_i-\alpha Y_{iT-1}}{R(F(T))} \equiv \tilde{p}_{iT} \quad (3)$$

Hence, land users only comply with policy requirements if the inspection frequency is sufficiently high for the disutility associated with a given fine *F(T)*. So, a land user will always comply in period T if $c_i \leq \alpha Y_{iT-1}$, even if $p_T=0$. This condition never holds for $\alpha<0$. Also, when $c_i > \alpha Y_{iT-1} + R(F(T))$, condition (3) never holds and the land user would be in violation in period T, since compliance would require $p_T>1$ which is impossible.

More generally, land users in period t < T comply if, with a discount factor $\delta = [1+r]^{-1}$:

$$\begin{aligned} &Y_{it-1}[1+\alpha]+s-c_i+\sum_{k=t+1}^{T}\delta^{k-t}\pi_{ik}\left(Y_{it-1}[1+\alpha]\right) \\ &\geq Y_{it-1}+s-p_{t-1}R(F(t))+\left[1-p_{t-1}\right]\sum_{k=t+1}^{T}\delta^{k-t}\pi_{ik}\left(Y_{it-1}\right)+p_{t-1}\sum_{k=t+1}^{T}\delta^{k-t}Y_{it-1} \end{aligned} \quad (4)$$

with $\pi_{it}\left(Y\right) \equiv \pi_{it}\left(Y \middle| p_t, F, s, c_i, \alpha\right)$ representing total utility from expected land revenue for land user i in period t for a given land value Y at the start of the period under the assumption that the land user makes the privately optimal decision for given parameters p_t, F, s, c_i and α in each consecutive period. This implies, for instance, that $\pi_{iT}\left(Y\right) = 0$ and that $\pi_{iT-1}\left(Y\right) = \max\left\{Y\left[1+\alpha\right] + s - c_i, Y + s - p_T R\left(F\left(T\right)\right)\right\}$. The last term in expression (4) reflects the fact that detected violators are banned from the program. Thus, land users comply in period t < T if

$$p_t \geq \frac{c_i - \alpha Y_{it-1} + \sum_{k=t+1}^{T} \delta^{k-t} \pi_{ik}\left(Y_{it-1}\right) - \sum_{k=t+1}^{T} \delta^{k-t} \pi_{ik}\left(Y_{it-1}\left[1+\alpha\right]\right)}{R\left(F\left(t\right)\right) + \sum_{k=t+1}^{T} \delta^{k-t} Y_{it-1} - \sum_{k=t+1}^{T} \delta^{k-t} \pi_{ik}\left(Y_{it-1}\right)} \equiv \tilde{p}_{it} \qquad (5)$$

The parameter $\tilde{p}_{it}$ is determined as the ratio of the potential gain when the violator is not caught and the potential loss when the violator is caught. Indeed, when a violation remains undetected, the impact on the land users' income consists of the gain in compliance costs in period t corrected for the impact on land yield plus the discounted effect on future revenues. On the other hand, when a violation is detected by the agency, the impact on income equals the disutility of the fine and the expected effect on future revenues of being banned from the program. Thus land users comply in period t if the monitoring effort is sufficiently stringent to make the risk associated with violating the rules unprofitable. Note that a land user would comply in every period t, even if $p_t=0$, when $c_i \leq \alpha Y_{i0}$. This is only possible for $\alpha>0$. Also, a land user would violate in every period, even if $p_t=1$, when $c_i > \alpha\left[1+\alpha\right]^{T-1} Y_{i0} + R\left(F\left(T\right)\right)$ for $\alpha>0$ or when $c_i > \alpha Y_{i0} + R\left(F\left(T\right)\right)$ for $\alpha<0$.

In summary, if a land user decides to participate in the conservation program, we find that his compliance decision can be described by proposition A.

<u>Proposition A:</u> *The compliance decision of the land users who participate in the conservation program is described as follows:*

If $c_i \leq \alpha Y_{i0}$*, then the land user complies in each period t,* $0 < t \leq T$ *(case I).*

If $\alpha Y_{i0} < c_i \leq \alpha\left[1+\alpha\right]^{T-1} Y_{i0} + R\left(F\left(T\right)\right)$ *for α>0 or if* $c_i \leq \alpha Y_{i0} + R\left(F\left(T\right)\right)$ *for α<0 (case II), and*

a) if $p_t \geq \tilde{p}_{it}$*, then the land user complies in period t,* $0 < t \leq T$

b) if $p_t < \tilde{p}_{it}$*, then the land user violates in period t,* $0 < t \leq T$.

If $c_i > \alpha[1+\alpha]^{T-1} Y_{i0} + R(F(T))$ *for α>0 or if* $c_i > \alpha Y_{i0} + R(F(T))$ *for α<0, then the land user never complies (case III).*

Conservation measures often imply different compliance costs and private benefits for different land users. For instance, the implementation costs as well as the benefits of erosion measures such as planting grass rows between fruit trees or installing buffer strips are likely to depend on the slope or the type of soil of a particular plot. These variations in private costs and benefits imply that land users make different compliance and participation decisions and we distinguish three categories.

In case I, it is always profitable for *low-cost land users* to implement the conservation measures even without compensation. Indeed, their conservation costs are already covered by the increase in private land value after implementation. Thus, the compliance decisions of these low-cost land users are independent of the enforcement policy. Rational land users with perfect information would already have implemented these measures. However, in reality due to, for instance, incomplete information, these profitable opportunities are not always realized. Alternatively, these land users might not be able to undertake the actions to increase land value due to binding financial constraints. As such the compensation payment acts as an instrument to lessen the budget constraint of the land users.

The *high-cost land users* in case III will always decide to violate the program's rules if they choose to participate in it. Indeed, their compliance costs are always higher than the disutility associated with the highest possible fine, corrected for the change in land yield. Even with perfect monitoring, $p = 1$, it is not optimal for these land users to comply. Due to the information asymmetries these high-cost land users cannot be a priori identified and if monitoring frequencies are sufficiently low, these land users will still participate in the program even when they do not intend to comply, as is discussed in the next section. Thus this case is relevant when one wants to investigate the number of potential participants and their likely compliance decisions for a new conservation program in a region.

The compliance decisions of *medium-cost land users* (case II), however, depend on the monitoring policy. When the probability of inspection is sufficiently high in all periods $\left(p_t \geq \tilde{p}_{iMax} \equiv \max_t \tilde{p}_{it}, \forall t\right)$, these land users fulfil the program's requirements during the complete time horizon. If the monitoring stringency is not sufficiently high in one or more periods, these land users will only execute the necessary management changes in those periods where the product of the inspection frequency and the fine (i.e. the expected sanction) is high enough. Thus, these land users are likely to switch between compliance and non-compliance: they comply in a particular period t if $p_t \geq \tilde{p}_{it}$ and violate in that period if $p_t < \tilde{p}_{it}$. Finally, if $p_t < \tilde{p}_{iMin} \equiv \min_t \tilde{p}_{it}$ in each period, these medium-cost users will never comply with the program if they to decide to participate.

Consequently, if the regulator wants to maximize compliance among participants of conservation schemes, the expected fine for each participant needs to be sufficiently high and the following conditions need to be met (see equations (3) and (5)):

$$p_T R(F(T)) \geq c_i - \alpha Y_{iT-1} \qquad \textit{for period } T$$

$$\textit{and} \quad p_t R(F(t)) \geq c_i - \alpha Y_{it-1} + \sum_{k=t+1}^{T} \delta^{k-t} \pi_{ik}\left(Y_{it-1}\right) - \sum_{k=t+1}^{T} \delta^{k-t} \pi_{ik}\left(Y_{it-1}[1+\alpha]\right) \qquad (6)$$

$$+ p\left\{ \sum_{k=t+1}^{T} \delta^{k-t} Y_{it-1} - \sum_{k=t+1}^{T} \delta^{k-t} \pi_{ik}\left(Y_{it-1}\right) \right\} \qquad \textit{for period } t < T$$

This implies that the expected fine needs to be tailored according to specific land characteristics such as soil type or slope, if the regulator wants to achieve full compliance of program participants. Even though, the regulator has two possible instruments at its disposal (inspections and fines), once one of these policy instruments is determined, the specification of the other one is also fixed. While it is possible to formally derive the optimal monitoring and enforcement strategy, the informational requirements to implement this optimal strategy are huge in reality. Therefore, it is highly unlikely to encounter an optimal monitoring and enforcement policy in actual conservation programs.

However, it might be interesting to allow the inspection probability to vary over periods. In the first periods compliance incentives from the expected refund are at their minimum, but compliance incentives from being banned from the program are at their maximum. In the later periods compliance incentives from the expected refund become larger and those from being banned from the program become smaller. Thus, several monitoring strategies can be used to stabilize compliance rates over time and reduce compliance switches, as we will illustrate in the simulation discussed in section IV: 1) high inspection frequencies in the early periods and lower frequencies in later periods, if incentives from the expected refund dominate those from being banned, 2) low inspection frequencies in early periods and higher once in later periods, if incentives from being banned dominate, and 3) low inspection frequencies in the early periods, higher ones in middle periods and lower ones again in later periods, if neither of the incentives dominates the other.

Participation decision

Once we know land users' compliance decisions if they would participate in the program, we can derive the conditions under which it is optimal for them to actually join the conservation program. We examine the land user's participation decision at $t = 0$ for each of the cases mentioned above. This is formally described in proposition B.

<u>Proposition B:</u>

If $\sum_{k=0}^{T}\delta^k \pi_{ik}\left(Y_{i0}\right) \geq \sum_{k=0}^{T}\delta^k Y_{i0}$ *, the land user participates in the program and*

a) *if* $c_i \leq \alpha Y_{i0}$ *(case I), then the participant always complies with the requirements*

b) *if* $\alpha Y_{i0} < c_i \leq \alpha\left[1+\alpha\right]^{T-1} Y_{i0} + R\left(F\left(T\right)\right)$ *for α>0 or if* $\alpha Y_{i0} < c_i \leq \alpha Y_{i0} + R\left(F\left(T\right)\right)$ *for α<0,*

and if $p_t \geq \tilde{p}_{it}$ *(case IIa), then the participant complies in period t,*

and $p_t < \tilde{p}_{it}$ *(case IIb),then the participant violates in period t.*

c) *If* $c_i > \alpha\left[1+\alpha\right]^{T-1} Y_{i0} + R\left(F\left(T\right)\right)$ *for α>0 or if* $c_i > \alpha Y_{i0} + R\left(F\left(T\right)\right)$ *for α<0 (case III), then the participant always violates the requirements.*

If $\sum_{k=0}^{T}\delta^k \pi_{ik}\left(Y_{i0}\right) < \sum_{k=0}^{T}\delta^k Y_{i0}$ *, the land user does not participate in the program.*

Land users will participate in the compensation program if they can obtain rents from participation. These rents can arise from the payments the land user receives corrected for the net compliance costs (if the participant is compliant) or corrected for the disutility associated with the expected fine (if the participant is in violation). Thus, only in very specific circumstances, land users will not participate; i.e. if the increase in land value is small or negative, or if land values decrease, the compensation payment is low, the compliance costs are high and expected fines are high in all periods. Importantly, when *α>0* these conditions are never fulfilled if the fine is equal to the cumulative sum of payments received. Indeed, land users are always better of participating than not, since they can never lose more than they gain, as is illustrated in the simulation in section IV. Only if *p=1*, land users might be indifferent between participating or not. Thus, compensation programs that sanction non-compliant participants by requiring refunds of all payments received so far do not discourage would-be violators from enrolling in the program.

On the other hand, compensation schemes that impose a fixed fine on violators rather than a cumulative refund can discourage some land users who would be violating the requirements from participating in the program. However, this option does not solve the compliance problem since there would still be land users who participate in the program and violate the program requirements. Also some land users who would comply if they participated do not enrol in the program, since the compensation payments are not sufficient to cover their compliance costs and they can thus save on compliance costs by not participating at all.

III. Discussion

In this section we discuss the implications of the model for compensation schemes and compare them to an alternative policy instrument, namely command-and-control regulation.

3.1 Compensation schemes

The results described above imply that compensation payments schemes are likely to attract too many participants and are insufficiently selective. Without enforcement, only 'case I' land users of proposition A $\left(with\ c_i \leq \alpha Y_{i0}\right)$ would be compelled to take part in the conservation scheme and comply, no matter how high the subsidies are. All other land users would also enrol in the program, but they would not comply. In that case, an informational campaign would suffice since the compliant land users always profit from implementing the conservation measures even if they do not receive any compensation. If many land users fall under case III of proposition A, compensation schemes are completely ineffective since all these land users would participate without ever complying. The number of land users in this case can be made smaller by increasing the fine imposed on violators. Thus, for a scheme using a cumulative fine, this implies increasing the compensation payment so as to shift land users from case III to case II and, depending on the detection frequency, more participants will comply with the program. This highlights the crucial role of monitoring and enforcement in obtaining the desired environmental goal as formulated by the policy maker. However, a compensation scheme is interesting to use if many land users fall into case II of proposition A. In this instance, it is possible to motivate land users to both participate in the program *and* to comply with the requirements. However, this desirable outcome can again only be obtained if the monitoring and enforcement pressure, i.e. fines and inspection frequencies, is sufficiently high.

In summary, the results stress the immense importance of including a monitoring and enforcement strategy in the design of a conservation schemes for land users. Also, note that the distribution of land users into the three different categories is likely to depend on the type of conservation measures under consideration.

3.2 Compliance with command-and-control regulation

We now briefly comment on the properties of an alternative policy instrument. Rather than using compensation payments, the regulator could decide to use command-and-control regulation such as forcing the use of specific land use practices[8]. Land users in a particular region would then be legally obliged to implement certain conservation measures. Note that this is a special case of the previously discussed compensation programs with the payment equal to zero and a fixed fine. The land users can again choose to comply with the rules or

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[8] Previously, the selection of policy instruments for conservation has been studied by, among others, Babcock et al. (1997), Wätzold and Schwerdtner (2005) and Moons and Rousseau (2007).

not. With a probability p_t land users are inspected and, when a violation is detected, violators have to pay a fine $\overline{F}$ and are forced to comply in that period at a cost c_i.

Land user i complies with the regulation in period t if:

$$\begin{aligned} &Y_{it-1}\left[1+\alpha\right]-c_i+\sum_{k=t+1}^{T}\delta^{k-t}\pi\left(Y_{it-1}\left[1+\alpha\right]\right)\geq \\ &Y_{it-1}-p_tR\left(\overline{F}\right)+\left[1-p_t\right]\sum_{k=t+1}^{T}\delta^{k-t}\pi\left(Y_{it-1}\right)+p_t\left[\delta Y_{it-1}-c_i+\sum_{k=t+2}^{T}\delta^{k-t}\pi\left(Y_{it-1}\right)\right] \end{aligned} \tag{7}$$

Thus we can comment on the minimum inspection probability necessary to ensure compliance from a particular type of land user (depending on their compliance costs and the evolution of land yields). However, the gains associated with violating the rules are no longer the expected payments minus the disutility associated with the expected fine, but are equal to the avoided compliance costs minus the decrease in the disutility associated with the expected fine and plus the change in land value compared to complying in the period. For a sufficiently high fine, low-cost land users are always compliant since implementing the measures is less costly than paying the expected fine. Medium-cost land users will be compliant if the inspection frequency is sufficiently high, they will be in violation for low inspection probabilities, and they will be switching between compliance and non-compliance for intermediate inspection levels. High-cost land users will never comply, since the disutility of the expected fine(s) is less than the compliance costs.

Since fines cannot be set indiscriminately high in practice[9], we assume that the fine needed for perfect compliance is not implementable. Thus, using command-and-control policies rather than compensation payments still does not guarantee compliance. However, the allocation and use of government funds differs considerably: using command-and-control allows the regulator to spend more on monitoring and enforcement (since no compensation payments are needed) thus increasing the likelihood of compliant behaviour by landholders.

IV. Simulation

In order to gain insight into the dynamics of the model, we perform a simple fictitious simulation exercise for a compensation scheme. For a three period setting with the parameters $Y_{i0}=10000$, $\delta=0.95$, $\beta = 15.1$, $\gamma = -0.01$, $c_i=500$ and a cost-covering subsidy $s=500$, we check the land user's compliance and participation decisions for inspection frequencies ranging from zero to one (with an identical inspection probability p_t in period $t=1,2,3$) and for different given values for the parameter α. This simulation is an illustration of case II presented in proposition A.

In each period land users compare the expected pay-off in current and future periods following compliance in the current period with the expected pay-off in current and future

[9] Fines are limited in practice because firms' wealth is limited, measurement and judicial errors occur and due to justice considerations (see, among others, Polinsky and Shavell 2000).

periods following non-compliance in the current period. The comparison between pay-offs following compliance and those following non-compliance implies different threshold values for the inspection frequency that are essential in defining land users' compliance behaviour. If the inspection frequency in a particular period equals or exceeds this threshold level, land users comply in that period and if it does not exceed the threshold level, land users do not comply. For instance, for period 3, we find that a land user complies

if $p_3 \geq \tilde{p}_{3a} \equiv \frac{c_i - \alpha[1+\alpha]^2 Y_{i0}}{R(F(3))}$, when he complied in period 1 and in period 2, or

if $p_3 \geq \tilde{p}_{3b} \equiv \frac{c_i - \alpha Y_{i0}}{R(F(3))}$, when he violated in period 1 and in period 2, or

if $p_3 \geq \tilde{p}_{3c} \equiv \frac{c_i - \alpha[1+\alpha] Y_{i0}}{R(F(3))}$, when he violated in only one of the previous periods.

For periods 1 and 2 similar – but more complex – expressions for these threshold levels can be derived. Different compliance patterns can thus be distinguished depending on the exact level of monitoring.

We only look at the cumulative refund setting since the fixed fine can be interpreted as a special case of this more general setting. We explicitly distinguish between positive and negative changes in land values following the implementation of conservation practices.

In a first example, see figure 1a, assuming a decrease in land value $(\alpha = -0.01)$, land users comply in period 1 for low (but non-zero) inspection levels, comply in periods 1 and 3 for slightly higher inspection levels and comply in all periods for moderate to high inspection levels. The increasing compliance levels overall reflect the increase in fine levels over time and thus the increase in the costs of violating over time since inspection frequencies are constant in this particular exercise. Moreover, the land user finds it beneficial to participate in the program only for low inspection frequencies. Either the risk of being caught in non-compliance in period 2 becomes too large or the cost of compliance is too large and participation is no longer profitable. This also illustrates the suggestion made earlier that using variable inspection frequencies over time could increase compliance. In this case, in order to stimulate compliance with a restricted monitoring budget, the inspection frequency could be smaller in period 1 than in period 2 and could again be increasing in period 3.

INSERT FIGURE 1 ABOUT HERE

In a second example a similar picture emerges (see figure 1b). Assuming increasing land value $(\alpha = 0.01)$ due to implementing the required measures, land users always violate for very low inspection frequencies, comply in period 1 for low inspection frequencies, comply in periods 1 and 3 for slightly higher frequencies and comply in all periods for moderate to high inspection frequencies. The beneficial effects on land values of implementing the required conservation measures clearly stimulate compliance. Looking at the participation decisions, land users would always enrol in the program, as was shown by the model.

By comparing the two examples, we can also comment on the deterrence effect of the being banned from the program, which was identified in section 2.3. When land values decrease after implementing the required conservation measures, the deterrence effect of being banned from the program decreases and, similarly, when land values increase after implementation of the conservation measures, the being banned effect increases. Note that the refund effect is identical in both examples since the subsidy amount to be refunded is identical. As mentioned before, the being banned effect is largest in the first periods. Thus, we expect that the minimal inspection frequency needed to induce compliance in the first period is smaller, when the being banned effect is larger or when $\alpha > 0$. Indeed, we see in figure 1b that compliance in period 1 is obtained for an inspection frequency $p > 0.01$, while for $\alpha < 0$ (figure 1a) compliance in period 1 is only obtained for $p > 0.03$. Moreover, in order to illustrate the refund effect, we compare the inspection frequencies needed to induce compliance in the three periods between the example presented in figure 1a and a - further identical - example with a subsidy of 600 euro instead of 500 euro. We then find that the inspection frequency needed to induce compliance in the first period remains the same, namely 0.035. This is logical since the being banned effect is now identical between the two cases. However, the inspection frequency needed to induce compliance in the second and third period is lower when the subsidy amount is higher. In the second period the inspection frequency needed to have compliance among program participants decreases from 0.14 to 0.13 and in the third period from 0.06 to 0.055 when the subsidy increases from 500 to 600 euro per period. This clearly illustrates the refund effect.

This simulation exercise shows that the effectiveness of a conservation program is crucially determined by the monitoring and enforcement policy. It also illustrates the varying compliance patterns over time for program participants associated with cumulative refunds.

V. Concluding remarks

The model developed here shows that incomplete enforcement is of great importance to the regulator in designing compensation schemes. Monitoring and enforcement strategies critically influence participants' compliance decisions. However, the participation decision itself is influenced to a considerably lower extent and compensation programs are likely to attract too many (non-complying) participants. Thus, compliance with regulations cannot be guaranteed without effort from the regulator and this has its implications for the government budget. Resources availability for monitoring and enforcement is therefore essential if the regulator wants the funds spent on compensation payments to show the expected environmental return. Monitoring and enforcement aspects should thus be more plainly incorporated in conservation policies and part of the programs' budgets should be explicitly earmarked toward this end. Evidence of a growing awareness at the European level can be found in the annex to the EC communication COM(2006)216 *'Halting the loss of biodiversity 2010 – and beyond'* which states that "*Key actions include… ensuring compliance, control and enforcement at national, regional and local levels"*. Unfortunately no further specifications are provided. Designing adequate monitoring and enforcement strategies is thus one of the upcoming challenges for European conservation policy. These enforcement strategies will have to give attention to the fact that land users differ with respect to costs and benefits and thus that different expected penalties will have to be applied to different land types. The institutional feasibility of implementing these expected penalties should be studied in more detail. While it seems feasible and implementable to vary monitoring probabilities according to land type, varying penalties as a function of land types is likely to more difficult on equity and political grounds.

Furthermore, it is important to consider alternative monitoring and enforcement strategies that depend on the site characteristics as well as non-monetary sanctions. These non-monetary sanctions can include imprisonment, mandatory compliance orders, warnings, withdrawal of environmental licenses as well as cross-compliance conditions in agricultural subsidy schemes.

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Figure 1: Compliance and participation with cumulative refund